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CUMBERLAND PLAIN ASSESSMENT REPORT

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Terms and acronyms used in the Cumberland Plain Assessment Report

Term	Acronym	Description
Action		Activities that directly support the fulfilment of one or more Commitments in the Plan. Actions may be amended using adaptive management throughout the life of the Plan.
Active restoration		When entering a biodiversity stewardship agreement, a landholder can elect to undertake active restoration management actions which generate additional biodiversity credits. They include actions to restore or improve ecological features in a landscape, such as habitat enhancement, targeted supplementary planting to augment habitat and the control of high threat exotic vegetation. See also Required management actions
Adaptive Management		Adaptive management is a structured, iterative approach to help determine how management actions can be most effective in achieving the Plan's outcomes. It allows the implementation of the conservation program to respond to changing circumstances, and ensure the actions are delivering the commitments and meeting the outcomes.
Already Protected Land		Already protected land is used to describe areas with an existing designation of protection from development for environmental reasons, including national parks, nature reserves, biodiversity stewardship sites and other protected lands, such as conservation agreements.
Asset Protection Zone	APZ	An APZ is a buffer zone between a bushfire hazard and buildings. It is managed to minimise fuel loads and reduce potential radiant heat levels, flames, localised smoke and ember attack. The appropriate APZ distance is based on vegetation type, slope and the nature of the development.
Assisted regeneration		Assisted regeneration is the practice of fostering natural regeneration and recolonisation after actively removing ecological impediments (e.g. invasive species, fish barriers) and reinstating appropriate abiotic and biotic states (e.g. environmental flows, fire regimes). See also Ecological restoration, Natural regeneration, Reconstruction
Australian Government Department of Agriculture, Water and the Environment	DAWE	The Australian Government department responsible for environment protection and conservation of biodiversity amongst other things.
Avoidance		An area of land which has been avoided from urban capable land in the biodiversity certification footprint due to its high biodiversity value. Note this is distinct from areas avoided for other reasons such as steep slopes and riparian buffers.
BioBanking agreements		Biobanking agreements were administered under the repealed *Threatened Species Conservation Act 1995*. These agreements are now called biodiversity stewardship agreements (BSAs) under the *Biodiversity Conservation Act 2016*
BioBanking Assessment Method (under the Threatened Species Conservation Act 1997)	BBAM	The BioBanking Assessment Method (BBAM) has been replaced by the Biodiversity Assessment Methodology (BAM) under the *Biodiversity Conservation Act 2016*

Term	Acronym	Description
Biodiversity		Biodiversity is biological diversity - the full variety of living things – referring to plants, animals, fungi and bacteria. It is considered at all scales, from the genetic variation between individuals, to species and the populations they form, and also the complex arrangements of ecosystems.
Biodiversity Assessment Method	BAM	The BAM assesses the impact of actions on threatened species and threatened ecological communities, and their habitats, and the impact on biodiversity values. The BAM provides the processes for identifying biodiversity values, impacts of proposed development and quantifying and describing credits that can be created on BSAs.
Biodiversity certification		Biodiversity certification is a streamlined biodiversity assessment process for areas of land that are proposed for development provided for under the *Biodiversity Conservation Act 2016*. The process identifies areas that can be developed after they are certified and measures to offset the impacts of development. Where land is certified, development may proceed without the usual requirement for site by site assessment of biodiversity impacts.
Biodiversity Certification Area		The land proposed to be biodiversity certified, comprising urban capable lands and transport corridors.
Biodiversity Certification Assessment Report	BCAR	A BCAR is an assessment report done through the Biodiversity Assessment Method that details the types and amounts of impacts from undertaking development actions on a site, including prescribed impacts, avoidance and amelioration. It also identifies opportunities from the development.
Biodiversity Conservation Act 2016	BC Act	The *Biodiversity Conservation Act 2016* establishes the Biodiversity Offset Scheme and allows for the biodiversity certification of land. This is the NSW Act which sets out provisions relating to strategic biodiversity certification, as well as many other issues such as the listing of threatened entities and key threatening processes.
Biodiversity Conservation Regulation 2017	BC Regulation	Provides supporting regulatory detail under the *Biodiversity Conservation Act 2016*
Biodiversity Conservation Trust	BCT	The BCT is a statutory not-for-profit body established under Part 10 of the *Biodiversity Conservation Act 2016*. It was established to encourage and support landholders across NSW to participate in private land conservation.
Biodiversity Development Assessment Report	BDAR	A BDAR is an assessment report prepared by an accredited person that identifies how the proponent proposes to avoid and minimise impacts. It also identifies any potential impact that could be characterised as serious and irreversible according to specified principles, as well as the offset obligation required by the likely impacts on biodiversity of the development or clearing proposal, expressed in biodiversity credits. The BDAR must be provided to the approval authority as part of their development, or a major project proposal, or a clearing application.
Biodiversity Investment Opportunities Map	BIO Map	A map of core areas and corridors identified in western Sydney. Used to calculate impacts to, and protection of, important landscape features and as a surrogate for connectivity

Term	Acronym	Description
Biodiversity Offsets Scheme	BOS	The BOS is a framework to avoid, minimise and offset impacts on biodiversity from development and clearing, and to ensure land that is used to offset impacts is secured in-perpetuity with an appropriate level of funding to ensure management actions identified are implemented.
Biodiversity risk weighting	BRW	The BAM uses a biodiversity risk weighting to evaluate the ecological risks of threatened entities from the biodiversity offsets scheme. The biodiversity risk weighting is comprised of two components: • Sensitivity to loss – this considers the increased threat posed to an entity from offsetting the loss of habitat or population, and • Sensitivity to potential gain – this considers the ability of a species to respond to improvements in habitat condition at an offset site
Biodiversity Stewardship Agreement	BSA	These are agreements are used for landholders wishing to generate and sell biodiversity credits under the Biodiversity Offsets Scheme (BOS)
Biodiversity Stewardship Site	BSS	The site secured under a BSA. Credits generated by establishing a biodiversity stewardship site can be generated and sold through the BOS.
Biodiversity values		Biodiversity values refers to vegetation integrity, habitat suitability and biodiversity-related values such as threatened species abundance, vegetation abundance, habitat connectivity, threatened species movement, flight path integrity and water sustainability as identified in the *Biodiversity Conservation Act 2016* (NSW) and regulations which are considered in the Biodiversity Assessment Method.
Biodiversity Values Map		The Biodiversity Values Map identifies land with high biodiversity value that is particularly sensitive to impacts from development and clearing. The map forms part of the Biodiversity Offsets Scheme Threshold which is one of the triggers for determining whether the Biodiversity Offset Scheme applies to a clearing or development proposal. The map is prepared by the Department of Planning, Industry and Environment under Part 7 of the *Biodiversity Conservation Act 2016* (BC Act) (OEH, 2019).
BioNet Atlas		NSW database managed by EES containing data on species records
BioNet Vegetation Classification		NSW database managed by EES containing data on PCTs
Category 1 matters		Matters that need detailed assessment in the Strategic Assessment Report. These matters are reliant on the Strategic Assessment Area, have some potential to be impacted (directly, indirectly or cumulatively), and are addressed in detail.
Category 2 matters		Matters that do not need further assessment in the Strategic Assessment Report. These matters are not reliant on the Strategic Assessment Area, are subject to no or very low risk of impacts (directly, indirectly or cumulatively), and are not addressed further in the Assessment Report.
Class of action approval		Class of action approval describes the projects covered by the approval that do not need individual referral, assessment or approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) provided they are undertaken in accordance with the endorsed final strategic assessment. See also strategic assessment.
Classes of actions		Classes of actions that are covered by the Plan are: Nominated area development (urban and employment lands), major transport infrastructure, and utilities infrastructure.

Term	Acronym	Description
Commitment		A commitment is a defined milestone in the Plan which is met through the delivery of the actions.
Commitments and actions		The Cumberland Plain Conservation Plan (the Plan) will deliver a range of commitments that will maximise biodiversity conservation outcomes in Western Sydney for threatened species, populations and ecological communities
Connectivity		Connectivity links, as defined by the Biodiversity Assessment Method, are those that connect different areas of habitat, facilitating movement of threatened and more common species across their distribution. The presence of significant biodiversity links on a site contributes to the biodiversity value of that subject land at the landscape scale. Connectivity can be identified at different scales depending on the target species and can include recognised biodiversity corridors, a local corridor identified by a council, flyways for migratory species or a riparian corridor of a stream, wetland or estuary.
Conservation lands		Conservation lands are sites of high biodiversity identified for as potential for reserves or biodiversity stewardship agreements under the Plan, including locations where ecological restoration may also occur.
Conservation Plan		A conservation plan describes how a conservation program will manage and offset the impacts on biodiversity from projected growth, over time and across the Plan Area. The Cumberland Plain Conservation Plan (Plan) will be provided to the NSW Minister for Environment in making an application for strategic biodiversity certification and to the Commonwealth Minister for the Environment for endorsement as part of strategic assessment.
Conservation Priorities Method		The Conservation Priorities Method is a systematic and repeatable method for determining and prioritising new conservation lands. The method was used to determine the strategic conservation area. The method combines detailed spatial information about biodiversity values with an analysis of planning and land use constraint data in order to assess the feasibility of implementing conservation lands as commitments under the Plan.
Conservation program		The conservation program is a package of commitments and actions to offset the residual impact of the proposed development on biodiversity values and to ensure that the Plan's outcomes are delivered.
Cumberland IBRA subregion (or 'Cumberland subregion')		Interim Biogeographic Regionalisation for Australia (IBRA) was developed by the Commonwealth Government as a key planning tool to identify land for conservation. It has since become an improved spatial mapping and information source on vegetation communities and ecosystems across Australia. The Cumberland IBRA subregion is the main focus of this Plan, with most of the Plan Area occurring within this subregion.
Cumberland Plain		The Cumberland Plain is a relatively flat, broad geographic basin located within the Cumberland IBRA subregion, identified by dominant older shale and younger alluvial geology.
Cumberland Plain Assessment Report	CPAR or this Assessment Report	The Cumberland Plain Assessment Report has been prepared to meet the statutory requirements for the strategic assessment and strategic biodiversity certification. It assesses the impacts of proposed development on biodiversity and other values protected under NSW and Australian Government biodiversity legislation.

Term	Acronym	Description
Cumberland Plain Conservation Plan		The Cumberland Plain Conservation Plan (Plan) is a strategic conservation plan being developed to manage and offset the impacts on biodiversity from projected growth in Western Sydney. The Plan will deliver a conservation program to protect and enhance biodiversity at a landscape scale while balancing the future needs of the local community.
Cumulative impacts		Cumulative impacts are those which continue to add to each other as time progresses. Many cumulative impacts can be avoided or minimised through strategic conservation planning.
Derived native grasslands	DNG	Derived native grassland is a "native grassland" remaining after the removal or dieback of previous woody canopy vegetation (shrubs or trees), to a point where woody vegetation has less than 10 per cent cover (Benson, 1996).
Development Control Plan	DCP	A Development Control Plan provides detailed planning and design guidelines to support the planning controls in the Local Environmental Plan developed by a council. Each council is required to publish their Development Control Plan/s on the NSW Planning Portal.
Digital Elevation Model	DEM	A gridded layer of elevation that represents a terrain's surface.
Direct impacts		Direct impacts are those which result in a negative change to biodiversity condition from undertaking an action such as clearing.
District Plan		An integrated land use, transport and infrastructure plan outlining the local priorities and actions for implementing the Greater Sydney Region Plan, A Plan for Growing Sydney. There are five District Plans for the Western City, Central City, Eastern City, North and South districts.
District Plans		District plans are integrated land use, transport and infrastructure plans outlining the local priorities and actions for implementing the Greater Sydney Region Plan, A Plan for Growing Sydney (hyperlink). There are five District Plans for the Western City, Central City, Eastern City, North and South districts.
Ecological function		Ecological function is the potential of an ecosystem to deliver a service that is itself dependent on ecological processes and structures. It considers how species interact with and affect their environment and involves any process or set of processes that can cause change or may be changed by external influences.
Ecological restoration		Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed through actively managing restoration. It is also sometimes called rehabilitation or revegetation. See also Natural regeneration, Assisted regeneration, Reconstruction.
Ecological Sustainable Development	ESD	Defined as using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased. Additional definitions can be found under Section 6 of the *Protection of the Environment Administration Act 1991* (NSW) and Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
Ecosystem Credit Species	ECS	Ecosystem Credit Species under the BAM

Term	Acronym	Description
Ecosystem processes		The numerous interactions between different components (both living and non-living) of an ecosystem that support the biological elements of the system (EPA, 2015).
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	EPBC Act	The EPBC Act is the Australian Government's central piece of environmental legislation, which provides a framework to protect and manage items identified in the nine categories of Matters of National Environmental Significance.
Environmental Planning and Assessment Act 1979 (NSW)	EP&A Act	This is the NSW Act which provides a legal framework for land use planning, how land is to be developed and managed; and provides a framework for the creation of environmental plans. It is administered by the NSW Department of Planning, Industry and Environment.
Environmental Planning Instruments	EPI	Environmental Planning Instrument is the collective name LEPs and SEPPs, not including DCPs.
Environmental zones		Environmental zones or 'E zones' are identified in LEPs and are used to identify land that is of important environmental value. There are four 'E zones' including E1 (National Parks and Nature Reserves), E2 (Environmental Conservation), E3 (Environmental Management) and E4 (Environmental Living).
Excluded land		Land that is already protected or developed for urban and other purposes or, for other reasons, was not considered for inclusion in the biodiversity certification. These lands include: • Existing protected land, including reserves and established offset sites • Commonwealth land, such as Orchard Hills Defence Establishment • Lands already assessed as part of another development approval (Bingara Gorge), lands progressing through an alternate development assessment (Mount Gilead and Menangle Park) • Lands already developed (existing urban areas and urban land zones)
Existing North West and South West Growth Areas		The new term for the North West and South West Growth Centres.
Extent of occurrence	EOO	The area contained within the shortest continuous imaginary boundary which can be drawn to encompass all known, inferred or projected sites of present occurrence of a species or ecological community, excluding cases well outside an entity's normal distribution.
Facilitated impacts		Impacts that result from further actions (including actions by third parties) which are made possible or facilitated by the action
Finalised priority assessment list	FPAL	This is the list of species, ecological communities, and key threatening processes that have been nominated and approved for assessment by the Minister responsible for the EPBC Act
Future Transport Strategy 2056		The Future Transport Strategy is a 40-year strategy which will guide NSW transport investment over the longer term. It is an update of the 2012 Long Term Transport Master Plan for NSW.
Greater Macarthur Growth Area	GMAC	One of the four nominated areas that the NSW Government has identified as the key focus for urban development to 2056 in Western Sydney.

Term	Acronym	Description
Greater Penrith to Eastern Creek Investigation Area	GPEC	One of the four nominated areas that the NSW Government has identified as the key focus for urban development to 2056 in Western Sydney.
Greater Sydney Commission	GSC	The Greater Sydney Commission is leading strategic metropolitan planning for the Greater Sydney region. Their strategic plans serve to make Greater Sydney more productive, liveable and sustainable for future generations.
Greater Sydney Region Plan		A 20-year integrated land use, transport and infrastructure plan outlining the priorities and actions for Greater Sydney.
Greater Sydney Regional Plan		Also known as 'Greater Sydney Region Plan - A Metropolis of Three Cities'. It is a 20-year integrated land use, transport and infrastructure plan outlining the priorities and actions for Greater Sydney.
Important Koala habitat		Important koala habitat is the term used to describe both primary and secondary corridors. It is the area that is critical to the long-term viability of koalas (primary corridors) as well as the areas (if enhanced) that would support the population (secondary corridors).
Important population		Important populations are defined in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) (DoE, 2013) as: *"Any population of a vulnerable species which meets the definition of an important population in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) as follows:* *'A population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:* • *key source populations either for breeding or dispersal* • *populations that are necessary for maintaining genetic diversity, and/or* • *populations that are near the limit of the species range"* For the purposes of the SAR, important populations are also defined as including any population of an endangered or critically endangered species. Under the EPBC Act, all populations of an endangered or critically endangered species are considered to be important for the survival and recovery of the species.
Indirect and offsite impacts		Indirect and offsite impacts include downstream, downwind, upstream and facilitated impacts e.g. fertilisers washed into river systems, extraction of raw materials and construction of a dam for irrigation water facilitates water use. See Significant Impact Guidelines for more detail
Indirect impacts		Indirect impacts include downstream, downwind, upstream and facilitated impacts e.g. fertilisers washed into river systems, extraction of raw materials and construction of a dam for irrigation water that facilitates water use. See Significant Impact Guidelines for more detail.
Interim Biogeographic Regionalisation for Australia	IBRA	Interim Biogeographic Regionalisation for Australia (IBRA) was developed by the Commonwealth Government as a key planning tool to identify land for conservation. It has since become an improved spatial mapping and information source on vegetation communities and ecosystems across Australia.

Term	Acronym	Description
Knowledge Based Method	KBM	Assumed presence using a knowledge-based method was used to define species polygons for species where expert reports were not prepared or adequate species records were not available to complete a Species Distribution Model (SDM). KBMs mapped species habitat based on vegetation mapping plus additional habitat or geographic elements.
Koala movement corridors		Koala movement corridors are areas of habitat (often but not always linear) which facilitate the movement and dispersal of koalas between habitat patches which would otherwise be disconnected. Koala movement corridors facilitate Koala population dispersal, which protects against localised extinctions, as Koalas require large, connected areas of important habitat for feeding and breeding.
Land Category		The Plan and the spatial viewer identify a number of land categories including: • **Certified** – Urban Capable: Urban capable land is land identified for future development that will seek approval to be both biodiversity certified under the *Biodiversity Conservation Act 2016* (NSW) and strategically assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). This category identifies where future urban development is likely to occur subject to other approvals. • **Excluded** – Excluded land is land which has been excluded from the Plan and for which NSW strategic biodiversity certification and the Commonwealth strategic assessment will not be sought. • **Non-Certified** – avoided for biodiversity purposes/ avoided for other purposes/ Western Sydney Aerotropolis: Non-certified land has three sub-categories including: o Land that has high biodiversity values to be protected and has been avoided from the urban capable land for this reason o Land that cannot be feasibly developed due to the topography (slope) of the land or having an environmental feature such as a riparian corridor o Land affected by the 1 per cent annual exceedance probability flood and other non-certified land within the Western Sydney Aerotropolis that is not included in the other non-certified categories
Land Use and Infrastructure Implementation Plan	LUIIP	A LUIIP provides an overview of future land uses and the proposed sequence of development to ensure new jobs and homes are delivered in time with infrastructure.
Local Aboriginal Land Council	LALC	A LALC is an autonomous body which is governed by Boards elected by local Aboriginal community members every two years. LALCs were established under the Aboriginal Land Rights Act 1983 as the elected representatives for Aboriginal people in NSW. The Plan Area includes three LALCs: Deerubbin, Tharawal and Gandangara.
Local Environmental Plan	LEP	An LEP is an environment planning instrument that guides planning and development decisions within a local government area in NSW. This is achieved through zoning and development controls, which provide a framework for the way land can be used.

Term	Acronym	Description
Matters of National Environmental Significance	MNES	Matters of national environmental significance are defined under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as: • Listed threatened species and communities • Migratory species • Wetlands of international importance (listed under Ramsar) • Commonwealth marine environment • World Heritage properties • National Heritage places • The Great Barrier Reef Marine Park • Nuclear actions • A water resource, in relation to coal seam gas development and large coal mining development
Monitoring Evaluation Reporting	MER	MER is the process of tracking and reviewing projects over time to ensure outcomes are met. For the Plan, it will provide assurance that conservation program outcomes and commitments are being satisfied and clarity for delivery partners on how to appropriately measure and report in a coordinated manner.
Native vegetation		Native vegetation is any plant native to NSW prior to European settlement, defined in Part 5A of the Local Land Services Act 2013. It can also include any plant, living or dead, in mapped Category 2-vulnerable land and generally excludes marine vegetation. Native vegetation species when occurring together form native vegetation communities, which in NSW are called Plant Community Types (PCTs).
Natural regeneration		Natural regeneration is an approach to restoration that relies on spontaneous or unassisted natural regeneration as distinct from an 'assisted natural regeneration' approach that depends upon active intervention. See also Assisted regeneration, Ecological restoration, Reconstruction.
Nature Conservation Trust agreements	NCT agreements	Protected land under Nature Conservation Trust agreements
Nominated area		A nominated area is an area in Western Sydney identified for future growth which seek approvals through the Plan under the *Biodiversity Conservation Act 2016* (NSW) and *Environment Protection and Biodiversity Conservation Act 1999* (Cth). These areas include: Wilton Growth Area, Greater Macarthur Growth Area, Western Sydney Aerotropolis, and Greater Penrith to Eastern Creek Investigation Area.
Non-offsettable grassland	NoG	Non-offsettable grassland comprises grassland vegetation zones with a vegetation integrity score of <15 and does not require offsetting for the associated PCT under the BAM
NSW (Mitchell) Landscapes		The Mitchell Landscapes were mapped in 2002 using a combination of landsystems in the west of NSW and geology and Digital Elevation Model (DEM) in the east of NSW. There have been a number of new versions since the original mapping. The most recent is version 3.1 (OEH, 2018).
NSW Environment Energy and Science	EES	The NSW Government department responsible for environment protection and conservation of biodiversity amongst other things. Formerly known as Office of Environment and Heritage (OEH).

Term	Acronym	Description
NSW Government Department of Planning, Industry and Environment		The NSW Government department responsible for effective and sustainable planning and the development of industry to support growth in NSW
NSW Koala Strategy		The NSW Koala Strategy identifies a set of short-term actions as part of a longer-term goal to stabilise and increase koala populations. The strategy encompasses four key pillars: koala habitat conservation, conservation through community action, safety and health of koala populations and building knowledge and education.
NSW listed candidate species		A candidate Species Credit Species required assessment of potential impacts within the nominated areas as part of the BAM assessment, with the results documented in the BCAR
NSW Office of Environment and Heritage		A former office of the NSW Government from 2011 to 2019. Now known as NSW Environment Energy and Science
Outcome		An outcome is a reported or measurable result of a desired goal. In the Plan, it is the intended environmental, economic or social impact or value of delivering the Plan's commitments.
Outer Sydney Orbital	OSO	Outer Sydney Orbital (Stage 1) from Palmyra Avenue to the Hume Motorway and remaining Outer Sydney Orbital 1 provides for a future north south motorway and freight rail line.
Plan Area		The Plan Area covers around 200,000 hectares and includes the Cumberland IBRA subregion and some minor areas of the adjacent Sydney Cataract and Wollemi IBRA subregions. It extends from 10 kilometres north of Windsor to Picton in the south, and from the Hawkesbury-Nepean River in the west to east near Liverpool. It includes sections of eight Local Government Areas – Wollondilly, Camden, Campbelltown, Liverpool, Fairfield, Penrith, Blacktown and Hawkesbury.
Plant Community Type	PCT	PCTs are the community-level grouping used in NSW's planning and assessment tools and vegetation mapping programs. They are identified in the BioNet Vegetation Classification (VIS) database.
Precinct planning		Precinct Planning ensures that nominated areas are strategically planned and infrastructure is delivered in a coordinated manner. The program identifies the development intent and development capacity across an entire precinct, through the allocation of housing choices, built form, infrastructure, and environmental and open space desires.
Prescribed impact		A prescribed impact, in the Biodiversity Offset Scheme, is an impact to a particular factor affecting biodiversity which must be considered. These are: impacts or potential impacts to habitat features (such as caves and cliffs, rocks, man-made structures and non-native vegetation) as well as impacts on habitat connectivity, threatened species movement, water bodies and water-related processes that sustain threatened species.
Primary Koala Corridors		Primary koala corridors are connected areas of koala habitat that are contiguous (gaps between trees less than 100 metres) and greater than 380 hectares in width.
Priority Conservation Lands	PCL	PCLs were identified as part of the Cumberland Plain Recovery Plan methodology report (DECCW, 2010)

Term	Acronym	Description
Protected matters search tool	PMST	The Australian Government PMST identifies whether MNES or other matters protected by the EPBC Act are likely to occur in an area.
Ramsar Wetlands		A list of Wetlands of International Importance, identified in the Ramsar Convention, signed in Ramsar, Iran and maintained by the Commonwealth.
Reconstruction		Reconstruction is an ecological restoration approach where the appropriate biota needs to be entirely or almost entirely reintroduced as they cannot regenerate or recolonise within feasible timeframes, even after expert assisted regeneration interventions. See also Natural regeneration, Assisted regeneration, Ecological restoration.
Required management action		A Required management action is an action for a biodiversity stewardship site required to improve the condition of native vegetation or species habitat. These could include activities such as native vegetation management (restoring native vegetation, retaining and managing regrowth, nutrient control), pest animal control, weed management, among others.
Reserves		Reserves are conservation lands of high biodiversity value typically managed by National Parks and Wildlife Services or council. Reserves can include national parks, nature reserves, regional parks, council reserves and community reserves.
Riparian		Riparian refers to lands that relate to waterways and parts of the landscape influenced by streams and flowing fresh water. The riparian buffer is defined in BAM as being within a certain distance from the top of the bank of a waterway of particular order.
Saving Our Species program	SOS	The Saving Our Species program is an initiative in which the NSW Government is investing $100 million over five years (from 2016 to 2021) to protect threatened species from extinction (OEH, 2016)
Secondary Koala Corridors		Secondary koala corridors are movement corridors that are less than 50 metres wide or not connected at both ends to other koala habitat.
State Environmental Planning Policy	SEPP	A SEPP is an environmental planning instrument that deals with matters of State or Regional environmental planning significance.
Serious and irreversible impacts	SAII	As defined in Guidance to assist a decision-maker to determine a serious and irreversible impact (OEH, 2017a). An SAII is one that: • Will cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or • Will further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or • Impact on the habitat of a species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or • Impact on a species or ecological community that is unlikely to respond to measures to improve habitat and vegetation integrity and is therefore irreplaceable

Term	Acronym	Description
Special Infrastructure Contribution		Levy contributions from developers to fund the delivery of state and regional infrastructure required to support a growing population, such as roads, public transport, health facilities, emergency services, schools, and open space and provide for biodiversity management.
Species Credit Species	SCS	Species Credit Species under the BAM
Species Distribution Model	SDM	SDMs are statistical models used to estimate the relationship between species records at sites and the environmental and/or spatial characteristics of those sites. Once this relationship has been estimated, the SDM can be used to predict other locations in the landscape where the species is likely to occur. Species Distribution Modelling was undertaken for Commonwealth listed Category 1 species within the Cumberland subregion where adequate species records were available to develop a model.
Strategic Assessment		Strategic assessments are landscape-scale assessments under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Unlike project-by-project assessments, which look at individual actions, they can consider a much broader set of actions over a much larger scale and timeframe, such as a plan, policy or program.
Strategic Assessment Agreement		The strategic assessment agreement is the formal agreement between the Commonwealth Minister for Environment and the State of NSW to enter into the assessment. It is a mandatory requirement under national environment law, and formally establishes the expectations of both parties.
Strategic Assessment Area		The Strategic Assessment Area is the area assessed for impacts to matters protected under Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) from development under the Plan and where conservation outcomes can be achieved. The Strategic Assessment Area is spatially aligned with the Plan Area.
Strategic Assessment Report	SAR	An assessment report done in accordance with the Terms of Reference for the SAR provided under the Part 10 Strategic Assessment Section 146 Agreement between the Commonwealth Minister for the Environment and the State of NSW under the EPBC Act
Strategic biodiversity certification		Strategic biodiversity certification is a form of biodiversity certification available only to planning authorities such as the Department of Planning and Environment, to support significant regional development and planning processes.
Strategic Conservation Area	SCA	The strategic conservation area was determined using the Conservation Priorities Method and represents large remnants of native vegetation with good connectivity, or areas with the potential to enhance connectivity in the Plan Area. The strategic conservation area will be used to identify potential conservation lands for further investigation.
Strategic Conservation Planning		Strategic conservation planning is a landscape-scale approach to assessing and protecting biodiversity upfront in planning for large-scale development. This strategic approach allows for the streamlined delivery of housing and infrastructure while protecting regionally important land for conservation and publicly accessible green space.

Term	Acronym	Description
Strategic Environmental Assessment	SEA	A Strategic Environmental Assessment (SEA) is prepared as part of the process of identification and protection of Transport Corridors. It provides an assessment of the environmental, economic and social impacts of reserving the corridor. SEAs are non-statutory documents that assist in the planning and decision making process for the community and Government. They are subject to public consultation and include justification for a preferred corridor alignment and provide information on the assessment of alternative corridor alignments
Structured decision-making		The Department applied a structured decision-making process during early development of the Plan to define a high-level biodiversity outcome for the Cumberland subregion that set the context and direction for the development of the Plan. The SDM was one of the first steps in a comprehensive conservation planning process for the Plan.
Structure Plan		A Structure Plan is a spatial representation of high-level land uses, environmental assets and transport infrastructure within a nominated area. It includes overarching planning principles, distribution of land uses, the phasing of precincts and identification of a high-level transport framework, the Blue–Green Grid and other key infrastructure.
Sub-Plan A		Sub-Plan A of the Cumberland Plain Assessment Report: Conservation Program and Implementation
Sub-Plan B		Sub-Plan B of the Cumberland Plain Assessment Report: Koalas
Subject Land		The Plan Area for the Biodiversity Certification Assessment Report, comprising the nominated areas and their urban capable lands. The BAM uses the term Subject Land to mean land to which the BAM is applied in Stage 1 to assess the biodiversity values of the land, including land within urban capable lands or proposed for biodiversity certification. For the Assessment Report, the terms 'nominated areas' and 'urban capable lands' are used instead of the term Subject Land.
Terms of Reference	ToR	Terms of Reference are a requirement under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) for undertaking a strategic assessment and are prepared in accordance with the Strategic Assessment Agreement. Terms of Reference outline the requirements for the Strategic Assessment Report, including how impacts to MNES should be assessed and how the overall outcomes of the Plan have been evaluated.
The assessor		A BCAR can only be prepared by a person accredited under the accreditation scheme developed under Section 6.10 of the BC Act. Throughout this report, an accredited person is referred to as 'the assessor'.
Threatened Biodiversity Data Collection	TBDC	The Threatened Biodiversity Data Collection is maintained in the NSW BioNet Atlas database and consists of profiles for threatened species, populations and ecological communities that occur in NSW.
Threatened Ecological Community	TEC	An ecological community may be listed as vulnerable, endangered or critically endangered under the *Biodiversity Conservation Act 2016* and/or *Environment Protection and Biodiversity Conservation Act 1999* depending on the level of threat and risk of its collapse.

Term	Acronym	Description
Threatening processes		A process is defined as a threatening process under the EPBC Act if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. The EPBC Act enables the listing of key threatening processes. A threatening process may be added to the list of key threatening processes in several circumstances, including where it could cause a native species or an ecological community to become eligible for listing under the EPBC Act as threatened.
Transport corridors		The transport corridors are part of the NSW Government's planning for the long-term transport needs of Western Sydney by identifying and protecting corridors of land that can be used to deliver road and rail infrastructure when needed in the future. The transport infrastructure will be constructed and delivered to 2056.
Urban capable land		Not all parts of the nominated areas are proposed for urban development. Urban capable lands are the areas directly impacted by the proposed urban and agricultural development. This refers to the areas within the nominated areas where the NSW Government has streamlined the delivery of priority housing and infrastructure through the biodiversity certification process.
Vegetation integrity score	VI score	A measure of vegetation condition. When scores for composition, structure and function are combined into a vegetation integrity score, they provide the rigour and transparency needed to make site-scaled comparisons and inform natural resource management decision making tools such as the BAM (OEH, 2017b)
Vegetation zones		A vegetation zone is an area of native vegetation that is the same PCT and has a similar broad condition state.
Western City District Plan		The Western City District Plan aligns with the Greater Sydney Region Plan, and provides more details regarding targeted planning objectives for the District, with associated actions to be undertaken to achieve the outlined objectives.
Western Parkland City		The Western Parkland City is one of the three proposed conglomerate cities which would make up Greater Sydney in the GSC's vision of a metropolis of three cities. The Western Parkland City would contain metropolitan clusters located around Greater Penrith, the Western Sydney Airport, Campbelltown-Macarthur and Liverpool. It includes areas across six Local Government Areas – Blacktown, Camden, Campbelltown, Fairfield, Liverpool and Penrith.
Western Sydney		A major region of Sydney comprised of 12 local government areas: Blacktown, Canterbury-Bankstown, Camden, Campbelltown, Cumberland, Fairfield, Hawkesbury, Liverpool, Parramatta, Penrith and Wollondilly.
Western Sydney Aerotropolis	WSA	One of the four nominated areas that the NSW Government has identified as the key focus for urban development to 2056 in Western Sydney.
Western Sydney City Deal		The City Deal is a 20-year agreement to deliver a transformation of Sydney's outer west. The Commonwealth and NSW Governments, together with eight local governments of Western Sydney, signed the Western Sydney City Deal on 4 March 2018.

Term	Acronym	Description
Western Sydney Parklands Trust		The Western Sydney Parklands Trust is a self-funded Government agency. Maintaining and expanding the Parklands' facilities is an important aspect of the Trust's core business. Business hubs, generally located on the perimeter of the Parklands, provide the sustainable funding base.
Wilton Growth Area	Wilton	One of the four nominated areas that the NSW Government has identified as the key focus for urban development to 2056 in Western Sydney.
Working group		Working groups will be established under the Plan to determine priorities and support delivery of the Plan’s commitments to meet outcomes for a specific area of focus. They will comprise relevant stakeholders and experts as required. Four working groups are proposed to be established under the Plan: compliance, koalas, weed control and pest and animal control.

biosis

OPENLINES
Environmental consulting

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 1: OVERVIEW

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

DOCUMENT TRACKING

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1 Introduction

The NSW Government has identified four areas for urban growth and other development ('nominated areas') and a series of transport corridors within and outside the nominated areas to support the future growth of Western Sydney for the next 36 years. These initiatives are identified under two key planning strategies:

- *A Metropolis of Three Cities - The Greater Sydney Region Plan* (Greater Sydney Commission, 2017)
- *Future Transport 2056* (Transport for NSW, 2018)

The nominated areas program represents the strategic prioritisation and delivery of new development as part of the long-term growth of Greater Sydney provided under the Greater Sydney Region Plan. The nominated areas are the key focus for development until 2056 and will be the centres of economic activity in Western Sydney.

The transport corridors are part of the NSW Government's planning for the long-term transport needs of Western Sydney by identifying and protecting corridors of land that can be used to deliver road and rail infrastructure when needed in the future. The transport infrastructure will be constructed and delivered over the next few decades.

The nominated areas program is administered by the NSW Department of Planning, Industry and Environment (the Department). The transport corridors program is administered by Transport for NSW, who are a major project partner.

The Department is progressing the approvals required for the development. As part of the biodiversity approvals required, the Department is preparing the Cumberland Plain Conservation Plan (the Plan) to provide long-term certainty for biodiversity and development in Western Sydney. The Plan sets out:

- Proposed development under the Plan
- A conservation program to achieve the Plan's objective and outcomes and offset the impacts of development on biodiversity values
- How the Plan will be implemented

The Plan will support two separate statutory approvals processes under State and Commonwealth laws required to address the impacts of the proposed development on biodiversity values, in accordance with:

- Strategic biodiversity certification under Part 8 of the *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

This Cumberland Plain Assessment Report (Assessment Report) assesses the potential impacts of the proposed development under the Plan on biodiversity values regulated under the BC Act and EPBC Act.

The strategic biodiversity certification and strategic assessment processes aim to reduce the costs and timeframes associated with regulation of the proposed development under the BC Act and EPBC Act and more effectively manage the biodiversity impacts of planned growth and improve biodiversity outcomes in the long term by:

- Removing duplication between NSW and Commonwealth biodiversity laws
- Replacing site by site assessments and approvals for individual projects that would generally be needed under both the BC Act and EPBC Act for the proposed development with a single and strategic approval approach

1.1 DESCRIPTION OF THE PLAN

The purpose of the Plan is to establish long-term certainty for biodiversity conservation and development in Western Sydney. The Plan supports the delivery of infrastructure, housing and jobs for Western Sydney in a planned and strategic way that also protects and maintains key biodiversity values of Western Sydney.

The Plan includes a conservation program of commitments and actions that seeks to improve ecological function and resilience in the Cumberland Plain and provide an enduring conservation legacy for Western Sydney.

The Plan comprises an overall Plan and a series of sub-plans that cover three key elements:

- Development – this covers the urban and industrial, infrastructure, agribusiness, and transport development under the Plan, including the scope and location of the development
- Conservation – this covers the conservation program and set of commitments to achieve the Plan's objective and to offset the impacts of the development on biodiversity values
- Implementation framework – this covers how the Plan will be implemented

The Plan is described in detail in Part 2.

1.2 PLAN TIMING

The Plan will be implemented over the period to 2056 and the Department is seeking that the approvals for the Plan have effect until this date. This timing aligns with implementation of the *Greater Sydney Region Plan: A Metropolis of Three Cities* (GSC, 2018) and the *Future Transport Strategy 2056* (Transport for NSW, 2018).

1.3 THE PLAN AREA

The Plan Area is shown in Figure 1-1.

The Plan Area is primarily within the Interim Biogeographic Regionalisation for Australia (IBRA) Cumberland subregion of the Sydney Basin Bioregion. It also includes some minor areas of the adjacent Sydney Cataract subregion. The area covered is approximately 200,000 hectares (see Figure 1-1).

The Cumberland subregion is a broad geographic feature bounded by the elevated lands of the Hornsby Plateau in the north, the base of the Blue Mountains to the west, the Woronora plateau in the south, and the Sydney CBD to the east.

The Plan Area for this project lies generally within the Western part of the subregion and extends from about 10 km north of Windsor south to Tahmoor (south of Picton), and from approximately Silverdale eastwards to Liverpool, and includes all or part of eight Local Government Areas (LGAs), being:

- Camden Council
- City of Blacktown
- City of Campbelltown
- City of Fairfield
- City of Hawkesbury
- City of Liverpool
- City of Penrith
- Wollondilly Shire

The vast majority of the proposed development occurs in the Cumberland subregion. Small parts of two of the nominated areas (Wilton and GMAC) occur in the Sydney Cataract subregion but are not in the areas intended for development.

The assessment areas differ for the Strategic Assessment Report (SAR) and Biodiversity Certification Assessment Report (BCAR) components of the report:

- For the SAR, the assessment area is called the Strategic Assessment Area and covers the area of the Plan
- For the BCAR, the assessment area is called the Subject Land and covers the nominated areas

1.4 PURPOSE OF THIS REPORT

The Assessment Report assesses the potential impacts of the proposed development under the Plan on biodiversity values and other matters regulated under the BC Act and EPBC Act. The Assessment Report is a single report prepared to meet the statutory requirements for both:

- A BCAR prepared in accordance with the Biodiversity Assessment Method (BAM) in accordance with the BC Act

- A SAR prepared in accordance with the Terms of Reference (ToR) for the SAR provided under the Part 10 Strategic Assessment Section 146 Agreement between the Commonwealth Minister for the Environment and the State of NSW under the EPBC Act (see Supporting Document A)

1.4.1 PURPOSE OF BCAR COMPONENT OF THE REPORT

The purpose of the BCAR component of this Assessment Report is to provide an assessment of the proposed development taken under the Plan in accordance with stages 1 and 2 of the BAM, including:

- Identifying and assessing the biodiversity values of the area covered by the proposed development
- Quantifying the impacts on biodiversity values of the proposed development
- Describing the commitments and actions to offset the impacts of the development, including the number and classes of biodiversity credits that would be required to be retired if the offset rules under the Biodiversity Conservation Regulation 2017 (BC Regulation) applied

As the proposed development has been determined by the NSW Environment Minister to be considered for approval under a ‘strategic biodiversity certification’, the offset rules under the BC Regulation do not apply and the Minister can determine any measure to be a conservation measure (see Section 2.1).

The BCAR component of this Assessment Report will be considered by the NSW Minister for the Environment in deciding to confer strategic biodiversity certification for the proposed development under the BC Act.

1.4.2 PURPOSE OF SAR COMPONENT OF THE REPORT

The purpose of the SAR component of this Assessment Report is to address the ToR and assess the impacts of the proposed development taken under the Plan on all matters protected by Part 3 of the EPBC Act (protected matters).

The SAR component of this Assessment Report will be considered by the Commonwealth Environment Minister in deciding to endorse the Plan under the EPBC Act. If the Plan is endorsed by the Minister, the Minister may subsequently consider approval of the proposed development in accordance with the endorsed Plan.

1.5 SCOPE OF THE DEVELOPMENT

The scope of the proposed development broadly comprises:

- Urban and industrial development within urban capable land in the nominated areas
- Infrastructure within urban capable land in the nominated areas, as well as ‘essential’ infrastructure in limited cases within avoided lands in the nominated areas
- Agribusiness within agribusiness lands in the Western Sydney Aerotropolis (WSA)
- Western Sydney Major Infrastructure Corridors (transport corridors) within and outside the nominated areas

Figure 1-1 shows the location of the four nominated areas and the transport corridors.

The nominated areas comprise:

- Greater Macarthur Growth Area (GMAC)
- Greater Penrith to Eastern Creek Investigation Area (GPEC)
- Western Sydney Aerotropolis (WSA) (excluding where there is overlap with the existing South West Growth Area)
- Wilton Growth Area (Wilton)

Not all parts of the nominated areas are proposed for development. The proposed development will occur within specified urban capable lands within each nominated area. These are shown in Figure 1-1.

Further details of the proposed development are provided in Part 2.

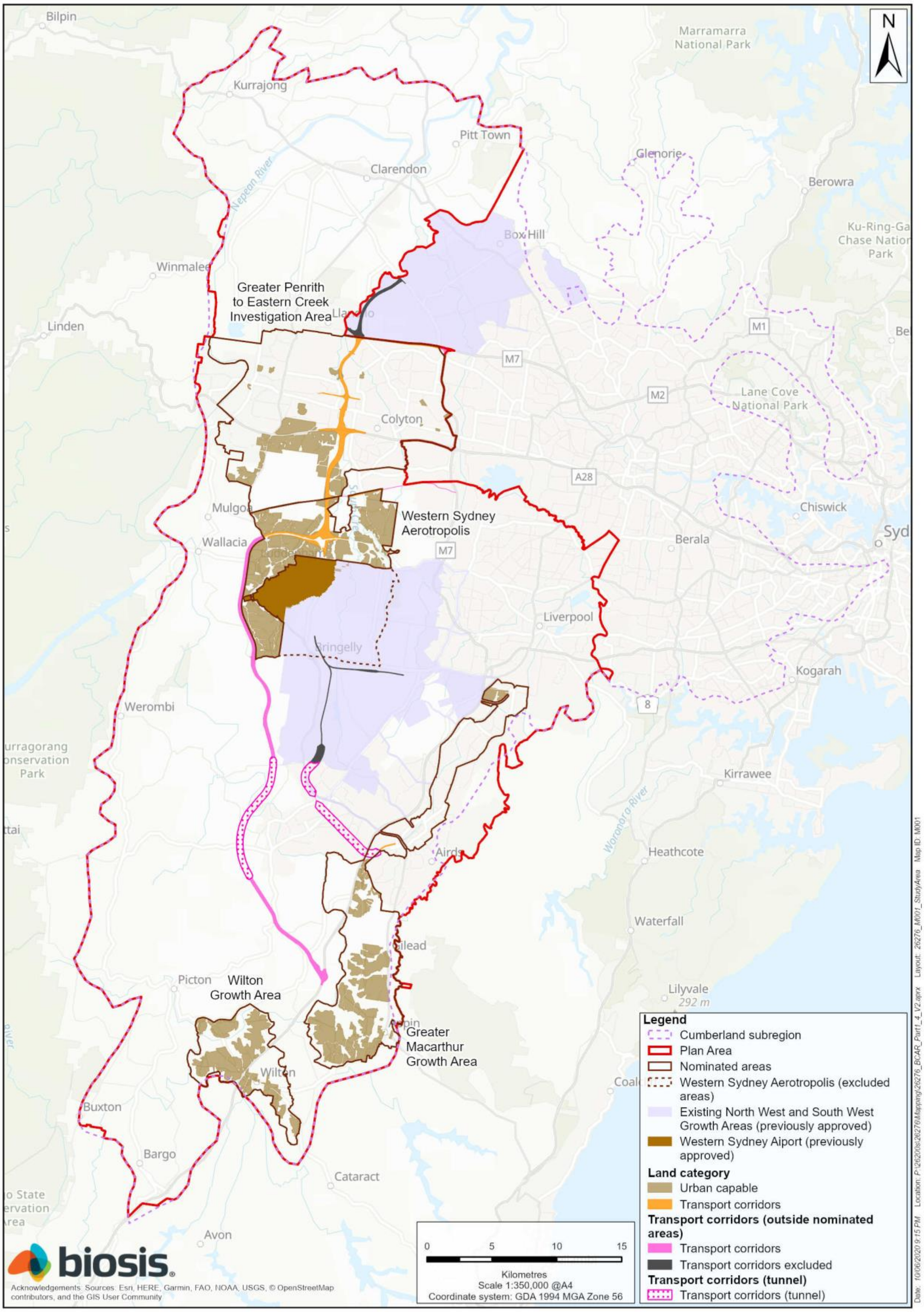

Figure 1-1: The Plan Area and location of nominated areas and transport corridors

1.6 APPROVALS BEING SOUGHT

The Department is seeking two separate statutory approvals for the impacts of the development on biodiversity values:

- Strategic biodiversity certification under Part 8 of the BC Act
- Approval under Part 10 of the EPBC Act

Table 1-1 shows what development is subject to assessment and approval under the BC Act and EPBC Act.

Table 1-1: Development being assessed for approval under the BC Act and the EPBC Act

Development	Biodiversity certification under BC Act	Approval under Part 10 of EPBC Act
The following development within the nominated areas: • Urban and industrial development • Infrastructure • Agribusiness • Transport corridors	✓	✓
Transport corridors outside the nominated areas*	-	✓

* Biodiversity certification may be sought for the transport corridors outside the nominated areas at a later date, and may be included as a modification or series of modifications to this biodiversity certification

Table 1-2 identifies the boundaries of the approval areas under the BC Act and EPBC Act and the effect of the approvals should they be granted.

Table 1-2: General boundaries of the approval areas under the BC Act and EPBC Act and effect of the approvals

	General boundaries of approval area	Effect of the approval
Biodiversity certification under BC Act	Land within the boundaries of the urban capable land and transport corridors within the nominated areas shown in Figure 1-1 Land that is avoided or excluded (see Chapter 14) is not included in the land proposed to be biodiversity certified	Development can proceed in these areas without further approval under the BC Act Development must be undertaken in accordance with any conditions of the biodiversity certification under the BC Act Any other necessary approvals must also be obtained for the development, including development consent under the *Environment Planning and Assessment Act 1979* (EPA Act)
Approval under Part 10 of EPBC Act	Land within the boundaries of the urban capable land and transport corridors within and outside the nominated areas shown in Figure 1-1, as well as 'essential' infrastructure within avoided lands in the nominated areas	Development can proceed in these areas without further approval under the EPBC Act Development must be undertaken in accordance with the Plan and any conditions of the Part 10 approval under the EPBC Act

1.7 WHO PREPARED THIS REPORT

The Department commissioned a project team to prepare the Assessment Report and undertake data collection on biodiversity values within the Plan Area. The project team preparing this Assessment Report is comprised of:

- Open Lines – Responsible for preparing this Assessment Report, particularly the SAR component of the report
- DAJ Environmental – Part of the Open Lines team responsible for preparing this Assessment Report
- Biosis – Responsible for:
  - Preparing the BCAR component of this Assessment Report

  - Leading the collection of data to meet the requirements of the BAM and ToR
  - Developing the native vegetation, Threatened Ecological Communities (TEC) and species maps of the Plan Area
  - Undertaking all BAM calculations to determine:
    - Amount of native vegetation, TECs and species habitat avoided and impacted
    - Number and class of biodiversity credits that would be required to be retired
- Ecoplanning – Provided support to Biosis in collecting field data to meet the requirements of the BAM and ToR

1.7.1 ACCREDITED ASSESSOR

A BCAR can only be prepared by a person accredited under the accreditation scheme developed under Section 6.10 of the BC Act. Throughout this report, an accredited person is referred to as 'the assessor'.

The BCAR component of this Assessment Report has been prepared by Jane Raithby-Veall from Biosis. Jane is a BAM accredited assessor (BAAS18134) taking the lead assessor role for the project. In preparing the BCAR, Jane has:

- Lead the development of the BCAR to ensure that it meets the requirements of the BAM
- Reviewed and approved all of the data that is part of the BAM process
- Reviewed and approved all components of the BCAR

Given the size and complexity of the project, Jane was supported by a range of people in preparing the BCAR component of this Assessment Report. They include:

- Accredited BAM assessors/ecologists and GIS operators within Biosis
- Accredited BAM assessors/ecologists within Ecoplanning
- Impact assessment specialists within Open Lines and DAJ Environmental
- Technical staff within the Department's Conservation and Sustainability Branch

1.8 IMPLICATIONS OF 2019/2020 BUSHFIRES

NSW experienced extensive bushfires throughout the spring and summer of 2019-20. As of 3rd February 2020, the fires had burnt 5.37 million hectares of land (approximately 7 per cent of NSW). This includes (DPIE, 2020):

- 37 per cent of the national park estate, including 81 per cent of the Greater Blue Mountains World Heritage Area
- 42 per cent of state forests
- 52% of heathland, 50% of wet sclerophyll and 37% of rainforest vegetation formations in NSW
- 25% of the most suitable koala habitat in eastern NSW (moderate, high and very high suitable habitat), particularly areas on the north coast, central and southern tablelands, central coast and the south coast

The full impact of the fires will not be understood for some time (EES, 2020).

Given the significance of these events, an initial assessment of the implications of the bushfires for the Cumberland Plain Conservation Plan and this Assessment Report was undertaken and is provided at Supporting Document G.

2 Regulatory context

This Chapter provides an overview of the key steps in the legislative processes for:

- Strategic biodiversity certification under Part 8 of the BC Act
- Strategic assessment under Part 10 of the EPBC Act

The key steps in the regulatory processes are shown in Figure 2-1.

These two processes are similar but differ in some respects. Both remove the need for site by site biodiversity assessment and approval of individual development actions. A key difference between the two processes is that:

- The EPBC Act process approves specific actions or classes of actions undertaken in accordance with an endorsed policy, plan or program that do not need further approval of biodiversity impacts
- The BC Act process approves a specific area of land that does not need further approval of biodiversity impacts

2.1 BIODIVERSITY CONSERVATION ACT 2016

Under Part 8 of the BC Act, individuals and planning authorities can seek strategic biodiversity certification from the NSW Minister for the Environment over areas of land. The biodiversity certification process requires that biodiversity values are assessed, and areas of high biodiversity value are identified and protected for conservation. Development can proceed in nominated areas with any remaining impacts on biodiversity offset through conservation measures.

Development on land that is biodiversity certified does not need further approval from planning authorities for impacts on biodiversity under the EP&A Act. In particular:

- The environmental assessment requirements for the approval of State Significant Infrastructure under Part 5.1 of the EP&A Act do not require an assessment of the impact on biodiversity
- An assessment of the likely impact on biodiversity of development is not required under Part 4 of the EP&A Act
- A consent authority is not required to take into consideration the likely impact on biodiversity when determining a development application under Part 4 of the EP&A Act
- An activity under Part 5 of the EP&A Act is taken to be an activity that is not likely to significantly affect any threatened species or ecological community under the BC Act, or its habitat
- A determining authority under Part 5 of the EP&A Act is not required to consider impacts on biodiversity

Impacts to biodiversity values on the land proposed for biodiversity certification, as well as the biodiversity benefits of the conservation program, are assessed through a BCAR. The BCAR is prepared by an accredited person in accordance with the BAM. The BCAR must be released for public comment prior to the Minister conferring biodiversity certification.

The Environment Minister may confer biodiversity certification if satisfied that the 'approved draft conservation measures' under the biodiversity certification adequately address the likely impacts on biodiversity values of the biodiversity certification, having regard to the BCAR. If the Minister is of the opinion that the biodiversity certification is likely to have serious and irreversible impacts on biodiversity values, the Minister must take those impacts into consideration and determine whether there are any additional measures that can minimise those impacts.

In determining the approved draft conservation measures under the biodiversity certification (including the number of credits that may be required to be retired), the Minister must have regard to the BCAR, but is not bound by the BCAR.

Planning authorities can apply to the Environment Minister to declare an application for biodiversity certification to be a 'strategic application'. Strategic biodiversity certification supports significant regional development and planning processes and provides an opportunity for impacts on biodiversity to be addressed at the landscape scale.

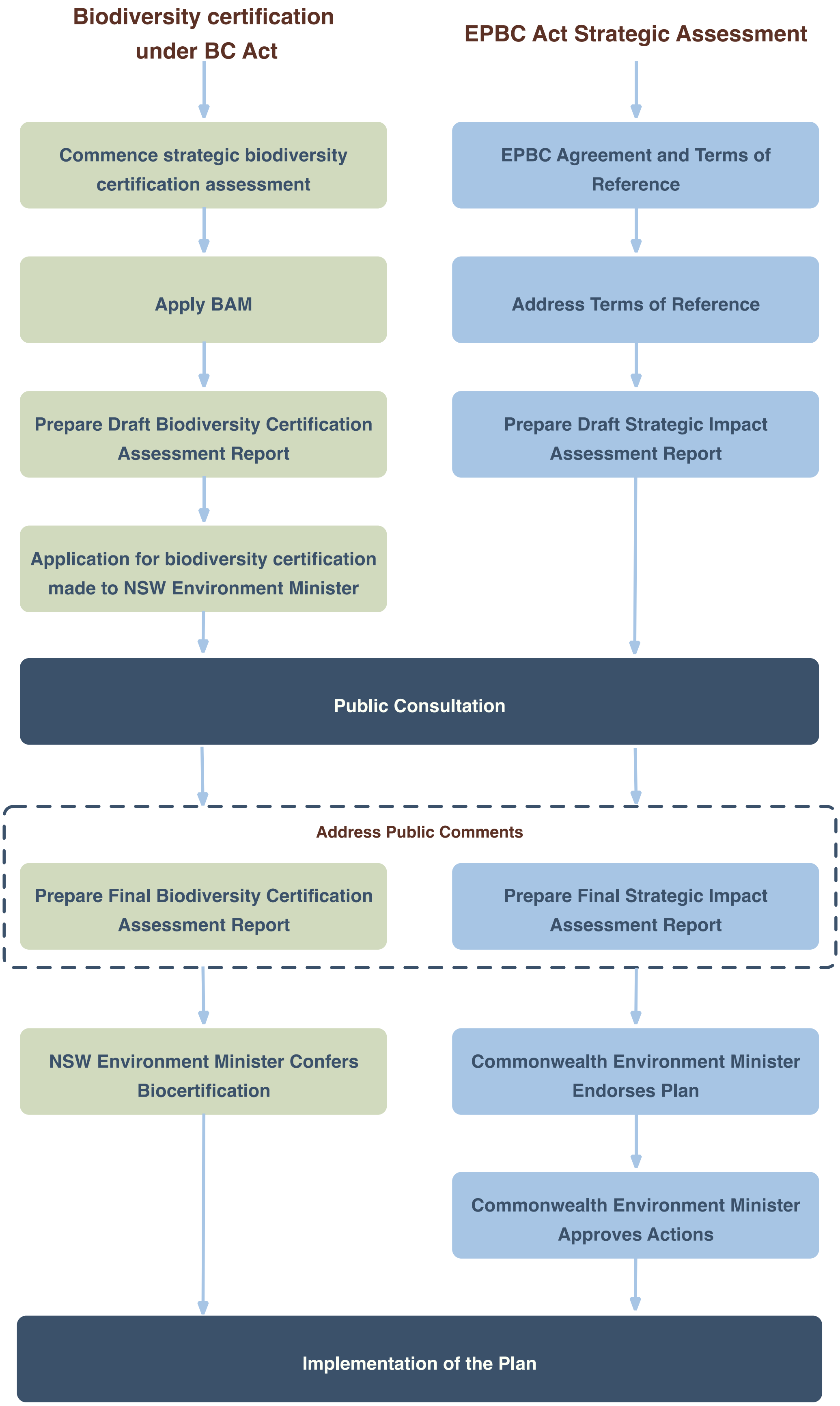

Figure 2-1: Key steps in the regulatory processes

In recognition of this, a wider range of conservation and other measures are available to proponents for strategic biodiversity certification to offset impacts on biodiversity values than for standard certification. A strategic biodiversity certification may propose a mix of conservation measures that includes credits to be retired, as well as:

- Reservation of land under the *National Parks and Wildlife Act 1974* (NPW Act)
- Adoption of development controls (or State infrastructure contributions) under the EP&A Act that conserve or enhance the natural environment
- Any other measures declared by the regulations to be approved conservation measures
- Any other measure that the Minister determines to be a conservation measure

The Minister is to take into account criteria in Clause 8.3 of the BC Regulation when declaring that an application for strategic biodiversity certification is a strategic application. The criteria are:

1. The size of the area of the land
2. Any regional or district strategic plan under the EP&A Act that applies to the area in which the land is situated
3. Advice provided by the Minister for Planning regarding the proposed biodiversity certification
4. The economic, social or environmental outcomes that the proposed strategic biodiversity certification could facilitate

The Environment Minister declared on 16 January 2019 that the project is a strategic biodiversity certification.

Under Section 8.22 of the BC Act, modifications may be made to a biodiversity certification once it has been conferred. Modifications can be made to the period of certification, the description of land that is biodiversity certified by extending or limiting biodiversity certification, as well as to conservation or other measures. Unless a BCAR is not required, an application for modification of a biodiversity certification is to be accompanied by a revised BCAR.

2.2 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

The EPBC Act is Australia's key piece of legislation to protect and manage Australia's nationally and internationally important flora, fauna, ecological communities and heritage places. The objectives of the EPBC Act include:

- Providing for the protection of the environment (especially matters of national environmental significance)
- Conserving Australian biodiversity
- Providing a streamlined national environmental assessment and approvals process
- Promoting Ecological Sustainable Development (ESD) through the conservation and ecologically sustainable use of natural resources.

Under Part 10 of the EPBC Act, the Commonwealth Minister for the Environment can agree to undertake a strategic assessment of the impacts of a policy, plan or program on matters protected under the EPBC Act.

The Agreement to undertake the strategic assessment was signed by the NSW Minister for Environment and Commonwealth Minister for the Environment on 12 November 2018 (see Supporting Document A)

The agreement must provide for a ToR to guide the preparation of an Assessment Report on the impacts of the policy, plan or program. The Assessment Report must be released for public comment. The ToR outlines what the Assessment Report must contain to allow the Commonwealth Minister to endorse the Plan.

Actions undertaken in accordance with a policy, plan or program endorsed by the Environment Minister do not require further assessment and approval for impacts on protected matters under the EPBC Act.

The Environment Minister may endorse a policy, plan or program if satisfied that the Cumberland Plain Assessment Report adequately addresses the impacts on protected matters to which the agreement relates (s 146(2)(f)) and that any recommended modifications to the policy, plan or program by the Minister have been made (s 146 (2f(ii))).

The agreement between the Commonwealth Environment Minister and the State of NSW provides that, in determining whether or not to endorse the Plan, the Minister may consider the extent to which the commitments for the protection and management of protected matters are enforceable and achievable over the life of the Plan.

The draft agreement also provides that, in determining whether this Assessment Report adequately addresses the impacts, the Commonwealth Environment Minister must have regard to the extent to which the Plan meets the objectives of the EPBC Act, including how the Plan:

- Protects the environment, especially protected matters under Part 3 of the EPBC Act
- Promotes ESD through the conservation and ecologically sustainable use of natural resources
- Promotes the conservation of biodiversity
- Provides for the protection and conservation of heritage
- Promotes a cooperative approach to the protection and management of the environment
- Assists in the co-operative implementation of Australia's international environmental responsibilities

Following endorsement, the Environment Minister may approve the taking of actions in accordance with the endorsed policy, plan or program subject to a range of general considerations (s 146F) and constraints on decision making (s 146G-M), including to not act inconsistently with a recovery plan or threat abatement plan for a protected matter (s 146K).

2.3 OTHER APPROVALS REQUIRED FOR THE PROPOSED DEVELOPMENT

A range of other planning and environmental approvals may be required for the proposed development, including:

- Planning approvals under the EP&A Act
- Aboriginal cultural heritage approvals under the *National Parks and Wildlife Act 1974*
- Built heritage approvals under the *Heritage Act 1977*
- Noise, water, air pollution approvals under the *Protection of the Environment Operations Act 1997*
- Water management approvals under the *Water Management Act 2000*

The proposed development will be implemented through a range of existing legislative and planning frameworks, particularly the EP&A Act. Implementation arrangements are described in Part 2.

3 Overview of environment within the Plan Area

This Chapter provides a brief overview of the environment within the Plan Area, including historical land-uses. A more detailed description of the environment within the Plan Area in accordance with Section 3.1 of the ToR, including the extent and quality of native vegetation and threatening processes, is provided in Chapter 28.

3.1 HISTORICAL LAND-USES

The Cumberland subregion has been greatly affected by historical and ongoing land-uses and land management practices. This is mainly due to topographic and geological characteristics that meant the subregion could support much greater agricultural and urban development than the surrounding sandstone areas.

Before European settlement, the subregion supported diverse native vegetation, including extensive grassy open forests, ironbark and turpentine forests, dry rainforests and floodplain forest, and wetland communities. Mammals such as echidnas, quolls, phascogales, bandicoots, koalas, gliders, and bettongs would have been common, along with many woodland birds such as the Hooded Robin, Brown Treecreeper, Speckled Warbler and Diamond Firetail (DECCW, 2011).

Hundreds of records of Aboriginal sites have been found across the Cumberland subregion, suggesting the subregion was an important area for Aboriginal people materially, socially and spiritually (DECCW, 2011). Records suggest Aboriginal occupation of the Sydney region occurred for at least 20,000 years, and possibly 40,000 years (Nanson, Young et al., 1987; Stockton, 2009; Stockton & Holland, 1974). There is evidence of extensive use of fire by Aboriginal people to manage the landscape, including to establish mosaics of native vegetation to facilitate hunting (Gammage, 2011).

European agricultural land practices were established by settlers in 1792, and by the middle of the 19th century most of the Cumberland subregion was either being grazed or cultivated (Tozer, 2003). Significant clearing for urban development, including residential, commercial and industrial land-uses, followed.

3.2 BIODIVERSITY VALUES

The biodiversity values of many parts of the Plan Area, particularly within the Cumberland subregion, have been lost or degraded as a result of both historical and ongoing patterns of land-use and land management practices.

The existing native vegetation communities in the Plan Area are shown in Figure 3-1. Existing native vegetation comprises 39 Plant Community Types (PCTs). Remaining areas are often of high conservation value. Much remaining native vegetation comprises TECs or habitat for species listed under the BC Act and EPBC Act.

Remaining native vegetation is also highly fragmented. In 2010, an estimated 2,446 individual remnants remained in the Cumberland subregion, ranging from less than one hectare to 3,598 hectares (DECCW, 2011). The eighty one largest patches (greater than 50 hectares) represent 51 per cent of the remaining native vegetation community extent (DECCW, 2011). While some flora and fauna species will persist in small native vegetation patches with active management, evidence is that larger patches have a better prospect for long-term survival (DECCW, 2011).

Evidence indicates that biodiversity loss significantly increases once habitat fragmentation by clearing exceeds 70 per cent of the landscape. This threshold has already been passed in the Cumberland subregion (DECCW, 2011). Only approximately 13 per cent of the pre-1970 extent of native vegetation in the subregion remains intact, with an additional 12 per cent occurring as heavily degraded communities (e.g. scattered trees) in disturbed areas (DECCW, 2011).

The vast majority (greater than 75 per cent) of the remaining native vegetation within the Cumberland Plain is privately owned. At 2011, approximately 8 per cent of native vegetation was protected in existing formal reserves (DECCW, 2011).

3.3 KEY THREATS

A principal threat to the biodiversity values of the Cumberland subregion is the further loss and fragmentation of habitat from clearing for urban development and agricultural land uses (DECCW, 2011), including illegal clearing.

Historial clearing has led to increasingly isolated and small remnants of native vegetation that are more susceptible to degradation, and provide less habitat values and support fewer species (DECCW, 2011).

The *Cumberland Plain Recovery Plan* (DECCW, 2011) identifies several other key threats, including:

- Weed invasion particularly by African olive, African lovegrass, and bridal creeper
- Altered fire regimes, particularly too frequent fire caused by arson
- Runoff of high-nutrient and turbid water from urban and agricultural areas

The ecological communities of the Cumberland Plain are particularly vulnerable to weed invasion due to their grassy understorey, relatively fertile soils and past agricultural uses. Weeds such as African olive (*Olea europaea* subsp. *cuspidata*), African lovegrass (*Eragrostis curvula*) and bridal creeper (*Asparagus asparagoides*) are well established, which displaces native plants and affects the regeneration of communities (DECCW, 2011).

Stormwater carrying high nutrient and sediment loads from impermeable surfaces such as roads may runoff into areas of native vegetation, which can encourage weed invasion in addition to the soil erosion issues.

Other threats identified in the Recovery Plan (DECCW, 2011) include:

- Impacts from recreational use of areas of native vegetation
- Grazing and mowing
- Altered hydrology
- Sedimentation and erosion
- Salinity
- Impacts of climate change

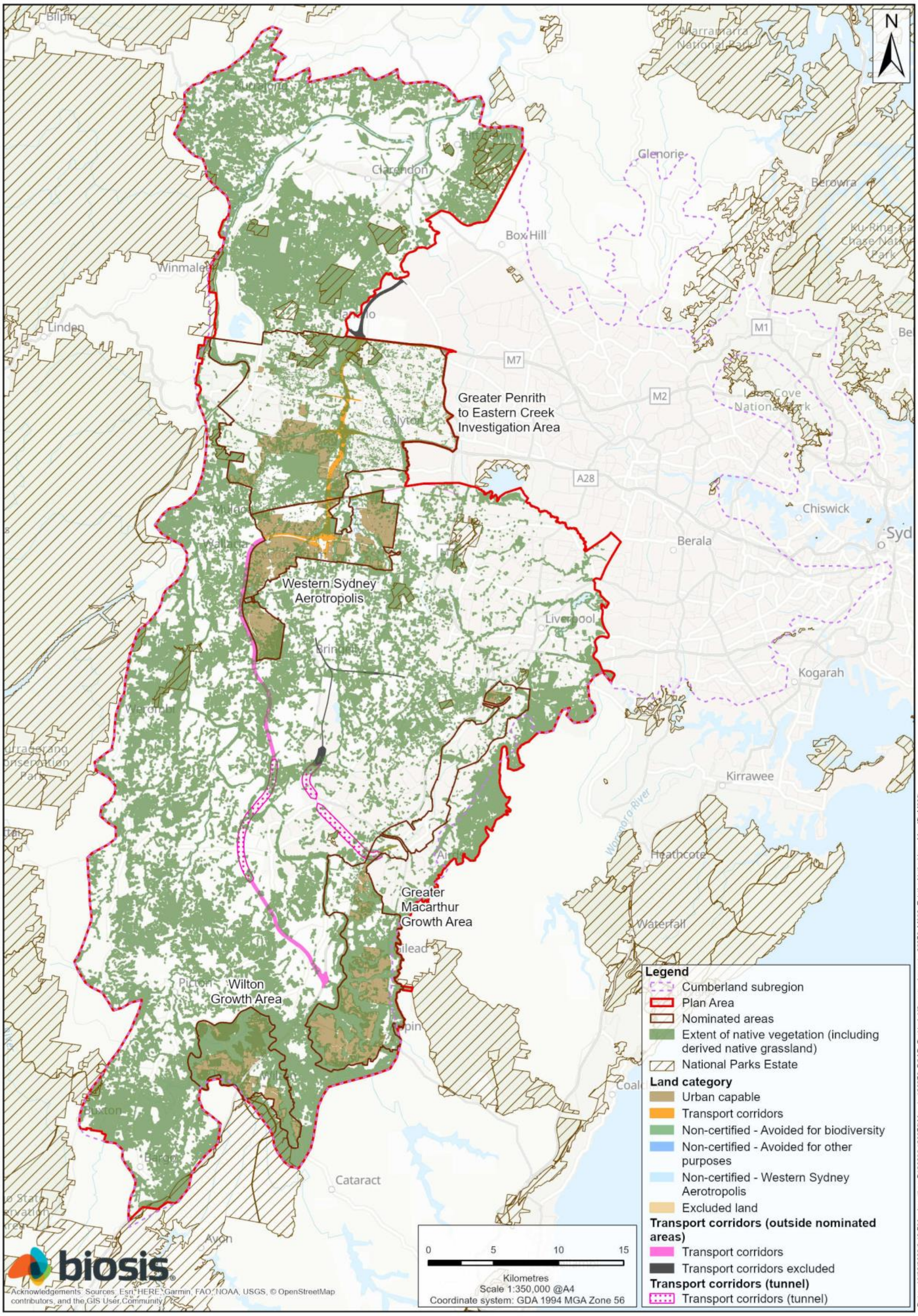

Figure 3-1: Existing native vegetation communities in the Plan Area

4 How to read this Assessment Report

4.1 COMPONENTS OF THE REPORT

This Assessment Report comprises both a BCAR prepared in accordance with the BAM under the BC Act and a SAR prepared in accordance with the ToR under the Part 10 Strategic Assessment Agreement of the EPBC Act.

The BCAR is mostly covered in Part 5, and the SAR part is mostly covered in Part 6. Where the requirements for preparing a BCAR and SAR are the same or similar, these requirements have been addressed jointly in a single part of this Assessment Report to avoid repetition and confusion.

Table 4-1 shows each main component of this Assessment Report and whether it forms part of the BCAR or SAR or both.

Table 4-1: Parts of this Assessment Report that comprise the BCAR or SAR or both

Report part	Description	BCAR	SAR
Part 1: **Overview**	Provides a general introduction to the project, this Assessment Report and the regulatory context. Includes details of the accredited assessor (as per BC Regulation clause 6.9 (f))	✓	✓
Part 2: **Description of the Cumberland Plain Conservation Plan**	Describes the Plan, including its development and conservation elements, and how it will be implemented	✓	✓
Part 3: **Assessment approach**	Provides details of the assessment approach, including methods for identifying relevant biodiversity values that need assessing in this Assessment Report and the methods for mapping native vegetation, TECs and species habitat	✓	✓
Part 4: **Minimising impacts**	Provides details of the processes and actions taken to avoid and minimise impacts, an assessment of indirect impacts, and how the Plan will approach adaptive management	✓	✓
Part 5A: **BCAR Stage 1 (biodiversity assessment)**	Covers the requirements of Stage 1 of the BAM (existing biodiversity values) not already covered in Parts 1, 3, and 4	✓	-
Part 5B: **BCAR Stage 2 (impact assessment)**	Covers the requirements of Stage 2 of the BAM (assessment of impacts) not already covered in Parts 1, 3, and 4	✓	-
Part 6A: **Strategic Assessment Report** **Part 6B:** **Strategic Assessment Report**	Covers the requirements of the ToR relating to identifying existing biodiversity values and assessing the impacts of the Plan on protected matters not already covered in Parts 3 and 4	-	✓
Part 7: **Evaluation of the Plan**	Evaluates the adequacy of the conservation commitments and actions (as per BC Act section 8.7 and EES draft *Guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification* (EES, 2019) and sections 4.6, 4.7, 5 and 6 of the ToR	✓	✓

4.2 HOW THIS REPORT ADDRESSES REGULATORY REQUIREMENTS

4.2.1 REQUIREMENTS FOR PREPARING A BCAR

The key requirements for preparing a BCAR under the BC Act are set out under:

- Part 8 of the BC Act
- Section 6.9 of the BC Regulation
- Appendix 10 of the BAM

Table 4-2 provides the key requirements for preparing a BCAR and identifies where each of these requirements are addressed in this Assessment Report, and specifically the BCAR component of this Assessment Report.

Table 4-2: Where requirements for preparing a BCAR are addressed in this Assessment Report

Minimum information requirements for a BCAR (taken from Appendix 10 of the BAM)	Maps and data requirements	Chapter of Assessment Report
Stage 1 biodiversity assessment		
Introduction		
Introduction to the biodiversity assessment: • Identification of urban capable lands • General description of development • Sources of information used in the assessment	• Site map • Location map	Chapter 7 Chapter 13 Chapter 18
Landscape context		
Identification of landscape features at the development site: • Bioregions and subregions, NSW landscape region and area • Native vegetation extent in the buffer area • Cleared areas • Rivers and streams classified according to Strahler stream order • Wetlands within, adjacent to and downstream of the site • Connectivity features • Areas of geological significance and soil hazard features • Site context components	• Site and Location maps showing landscape features	Chapter 18
Native vegetation		
Identify native vegetation extent within the development site, including cleared areas and evidence to support differences between mapped vegetation extent and aerial imagery	• Native vegetation extent, including cleared areas	Chapter 19
Describe PCTs within the development site: • Vegetation class and type • Area (ha) for each vegetation type • Species relied upon for identification of vegetation type and relative abundance • Justification of evidence used to identify a PCT • TEC status • Per cent cleared value of PCT	• Native vegetation extent map • PCTs map • Plot locations relative to PCTs map • TECs map • Plot field data • Plot field data sheets	Chapter 19 Chapter 20

Minimum information requirements for a BCAR (taken from Appendix 10 of the BAM)	Maps and data requirements	Chapter of Assessment Report
Vegetation integrity assessment of the development site: • Mapping vegetation zones • Patch size • Assessing vegetation integrity using benchmark data • Survey effort (number of plots) • Determining the vegetation integrity score	• Table of current vegetation integrity scores for each vegetation zone in development site • Patch size of intact native vegetation	Chapter 11 Chapter 19
Where use of local data is proposed: • Identify relevant vegetation type • Identify source of information for local benchmark data • Justify use of local data in preference to database values		N/A
Threatened species and habitat		
Identify ecosystem credit species associated with PCTs on development site, including: • List of species • Justification for exclusion of any ecosystem credit species	• Table of habitats/habitat components and sensitivity classes • Table of biodiversity risk weighting for species on site	Chapter 11 Chapter 21
Identify species credit species on development site, including: • List of candidate species • Justification for inclusions and exclusions of species credit species based on habitat features • Indication of presence based on targeted survey or expert report • Details of targeted survey technique, effort, timing and weather • Species polygons • Biodiversity risk weighting for the species • Threatened species survey	• Table of list of species credit species and presence status on site as determined by targeted survey, expert report or assumed presence • Species credit species polygons map • Table of species and habitat feature/ components and abundance on site • Table of biodiversity risk weighting for species on site	Chapter 11, including Attachment A Chapter 21
Where use of local data is proposed: • Identify relevant species • Identify aspect of species data • Identify source of information for local data • Justify use of local data in preference to database values		N/A

Minimum information requirements for a BCAR (taken from Appendix 10 of the BAM)	Maps and data requirements	Chapter of Assessment Report
Where expert reports are used in place of targeted survey: • Identify the relevant species • Justify the use of an expert report • Indicate and justify the likelihood of presence of the species and information considered in making this assessment • Estimate the number of individuals or area of habitat for the development site, and how the estimate was made • Identify the expert and their expert credentials	• Expert reports	Chapter 11 Chapter 21 Supporting Document C
Stage 2 Impact Assessment – Biodiversity values		
Avoid and minimise impacts		
Demonstration of efforts to avoid and minimise impact on biodiversity values in accordance with Chapter 8	• Table of measures to be implemented to avoid and minimise the impacts, including action, outcome, timing and responsibility • Urban capable land and transport corridor map	Chapter 14
Assessment of direct and indirect impacts unable to be avoided at the development site, including type, frequency, intensity, duration and consequence of impact	• Maps demonstrating indirect impact zones where applicable	Chapter 15 Chapter 23
Details of the adaptive management strategy proposed to monitor and respond to impacts on biodiversity values that are uncertain	N/A	Chapter 16
Impact summary		
Identification and an assessment of the impacts which are potential serious and irreversible impacts	• Map showing location of serious and irreversible impacts • Table of SAII considerations	Chapter 25
Identification of impacts requiring offset	• Map of impacts requiring offset	Chapter 26
Identification of impacts not requiring offset	• Map of impacts not requiring offset	Chapter 26
Identification of areas not requiring assessment	• Map of areas not requiring assessment	Chapter 26

Minimum information requirements for a BCAR (taken from Appendix 10 of the BAM)	Maps and data requirements	Chapter of Assessment Report
Ecosystem credits and species credits that measure the impact of the development on biodiversity values, including: • Future vegetation integrity score for each vegetation zone at the development site • Change in vegetation integrity score • Number of required ecosystem credits for the impact of development on each vegetation zone at a development site • Number of required species credits for each threatened species that is impacted on by development	• Table of PCTs requiring offset and the number of ecosystem credits required • Table of threatened species requiring offset and the number of species credits required • Submitted proposal in the Credit Calculator	Chapter 26
Biodiversity credit report		
Credit classes for ecosystem credits and species credits at the development site	• Table of credit class matching credit profile	Supporting Document E

4.2.2 REQUIREMENTS FOR PREPARING A SAR

The requirements for preparing a SAR are set out under the ToR under the Part 10 Strategic Assessment Agreement.

Table 4-3 provides the key requirements for preparing a SAR and identifies where each of these requirements are addressed in this Assessment Report, and specifically the SAR component of this Assessment Report.

Table 4-3: Where requirements for preparing a SAR are addressed in this Assessment Report

Section	ToR requirement	Chapter of Assessment Report
1. Purpose of the Strategic Impact Assessment Report	1.1 The purpose of the Report is to assess the impacts of actions taken under the Cumberland Plain Conservation Plan (Plan) on all matters protected by Part 3 of the EPBC Act ('protected matters')	Chapter 1
2. Description of the Plan being assessed	2.1 The Report must describe the Plan	Part 2
	2.1.1 The Report must provide a summary outlining its overall purpose, key elements, spatial extent, and timeframes, including how long the Plan will be in effect	Chapter 1 Part 2
	2.1.2 The Report must provide details about the key elements, including: a. The conservation commitments and outcomes to be delivered for protected matters b. The actions likely to be taken under the Plan over the short, medium and long term c. The legal and administrative frameworks to implement the Plan and the persons and authorities responsible for implementation	Chapter 7 Chapter 8 Chapter 9
	2.1.3 The Report must describe the need and justification for the Plan including the environmental, social and economic drivers for its development	Chapter 6
	2.1.4 The Report must describe the decision-making framework used in considering alternatives and developing conservation outcomes of the Plan. It should identify where alternative options that have been evaluated to reach	Chapter 6

Section	ToR requirement	Chapter of Assessment Report
	the final Plan have been published	
	2.1.5 The Report must describe how the principles of ESD (as set out in section 3A of the EPBC Act) are considered and promoted in the development of the Plan	Chapter 40
3. Description of the protected matters impacted by the Plan	3.1 The Report must describe the nature of the environment within the Strategic Assessment Area, and other areas outside the Strategic Assessment Area that may be impacted by actions taken under the Plan. This must include (at a minimum):	Chapter 28
	• 3.1.1 A description of historical and current land use.	Chapter 28
	• 3.1.2 The extent and quality of native vegetation present including detailed mapping of ecological communities and habitat for threatened species listed under the EPBC Act	Chapter 28 Chapters 29 to 31
	• 3.1.3 The nature of the environment, including ecosystem processes and threatening processes	Chapter 28
	• 3.1.4 A description of the landscape context for key environmental matters, including connectivity, habitat fragmentation and ecological processes	Chapter 28 Chapters 29 to 31
	• 3.1.5 A spatial map of areas that are already protected for environmental purposes, including Biobanking and Biodiversity Stewardship sites	Chapter 28
	3.2 The Report must identify and describe each protected matter that may be impacted directly, indirectly and cumulatively by actions taken under the Plan, including (at a minimum):	Chapters 29 to 35
	• 3.2.1 Key sites, and where relevant, key habitats for protected matters	
	• 3.2.2 Important populations of protected matters, including the consideration of the importance of both small and large areas of habitat, and their position within the landscape	
	• 3.2.3 Areas likely to be important for maintaining ecological processes (for example, habitat connectivity) for protected matters	
	• 3.2.4 Condition of protected matters, including where relevant, seasonal and annual variability, and their likelihood to alter over time	
	• 3.2.5 Key threatening processes	
4. Assessment of the impact of the Plan on protected matters	4.1 The Report must describe and assess the likely impacts of actions taken under the Plan on all protected matters	Chapters 29 to 35
	4.2 The Report must describe the method used to understand likely impacts on all protected matters of actions taken under the Plan. The level of the assessment will be proportionate to the level of likely risk to each protected matter. The method must:	Chapter 11
	• 4.2.1 Be appropriate for assessment at a strategic scale	
	• 4.2.2 Rely on the best available information	
	• 4.2.3 Discuss uncertainty, including reference to the technical data and information relied upon	Chapter 11 Chapter 13
	4.2 The Report must identify the data used in the assessment, any limitations it may have, where (or if) the data is available and where it can be accessed, including publicly accessed	Chapter 11 Chapter 13

Section	ToR requirement	Chapter of Assessment Report
	4.3 Describe and assess separately the likely impacts (if any) of actions taken under the Plan on the environment on Commonwealth land (as defined in section 528 of the EPBC Act)	Chapter 35
	4.4 The Report may also consider protected matters that are potentially eligible for listing as a result of inclusion in a final priority assessment listing held by the Commonwealth, or a recommendation to the Commonwealth Minister for listing by the Threatened Species Scientific Committee prior to the Report being submitted	Chapters 29 to 31
	4.5 The Report must include an analysis of the likely adverse impacts of actions of the Plan on protected matters. This must include (at a minimum) consideration of:	
	• 4.5.1 Information on the following: o Number and size of populations/important populations. o Extent (in hectares) of suitable habitat. o Extent (in hectares) and condition of protected matters. o Landscape connectivity and ecological processes. o Heritage listing and values	Chapters 29 to 35
	• 4.5.2 How impacts on protected matters will be avoided through land use planning and other measures, and what mitigation measures will be implemented to reduce impacts, including a description of the mitigation measures and how unavoidable impacts will be offset	Chapter 14 Chapters 29 to 35
	• 4.5.3 Potential indirect and cumulative impacts	Chapter 15 Chapters 29 to 35 Chapter 38
	4.6 The Report must include an analysis of the conservation benefits (beneficial impacts) of the Plan, including:	Chapter 8 Chapter 41
	• 4.6.1 How protected matters will be conserved, protected and managed within the Strategic Assessment Area and other areas related to the Plan	
	• 4.6.2 The adequacy of the commitments and actions under the Plan in protecting and managing protected matters, including the effectiveness of implementation and funding arrangements and who will be responsible for delivering on commitments	Chapters 29 to 35 Chapter 41
	• 4.6.3 How proposed commitments and actions involving environmental offsets meet the principles of the *Environment Protection and Biodiversity Conservation Act, Environmental Offsets Policy*, 2012 (DSEWPC, 2012)	Chapter 41
	• 4.6.4 How landscape connectivity has been maintained and improved, which may include opportunities for strategic ecological restoration of key corridors and areas adjacent to sites with high biodiversity values	Chapters 29 to 35 Chapter 41
	• 4.6.5 How adaptation to reasonable climate change scenarios has been considered	Chapter 41
	4.7 The Report must consider the extent to which the impacts on protected matters of actions taken under the Plan meet legislative obligations under the EPBC Act, including but not limited to:	
	• 4.7.1 Consistency with Australia's international obligations, including the Ramsar Convention	Chapter 33

Section	ToR requirement	Chapter of Assessment Report
	• 4.7.2 Consistency with recovery plans (section 146K of the EPBC Act)	Chapters 29 to 31
	• 4.7.3 Regard to objectives, conservation actions and other relevant information in conservation advices (section 146K of the EPBC Act)	Chapters 29 to 31
	• 4.7.4 Consistency with World Heritage management plans (sections 316 and 321 of the EPBC Act) and National Heritage place management plans (sections 324S and 324X of the EPBC Act)	Chapter 34
	4.7 The Report may also consider other Commonwealth policy guidelines on protected matters	Chapters 29 to 35
	4.8 The Report must include justification for key methods used in the assessment, including summaries of independent peer review processes and where the review/s are available to the public	Chapter 11
5. Evaluation of the overall outcomes of the Plan	5.1 The Report must evaluate the overall commitments and outcomes for protected matters taking into account likely impacts on protected matters from actions taken under the Plan	Chapters 29 to 35 Chapter 41
	5.2 The evaluation must include:	
	• 5.2.1 The extent to which protected matters are represented in areas to be protected or managed under the Plan or in existing protected areas in the bioregion/subregion	
	• 5.2.2 The extent to which the areas to be protected or managed under the Plan or existing protected areas in the bioregion/subregion will ensure the long-term viability of each protected matter	
	• 5.2.3 Whether there will be serious and irreversible impacts on any protected matter	
	• 5.2.4 An assessment of how the Plan meets the endorsement criteria set out in the Agreement at clause 8	
	5.3 The evaluation may also include consideration of:	
	• 5.3.1 The extent to which the commitments and actions under the Plan facilitate adaptation of biodiversity to climate change and address any significant vulnerabilities of protected matters under reasonable climate change scenarios	
	• 5.3.2 The likely effectiveness of the commitments and actions under the Plan in protecting and managing protected matters and risks and uncertainties	
6. Addressing uncertainty and adaptive management	6.1 The Report must identify key uncertainties and risks associated with implementing the Plan, responses to these and proposed adaptations to changing circumstances. Key uncertainties may include:	Chapter 16 Chapter 41
	• 6.1.1 Knowledge gaps in scientific understanding and responding to new knowledge	
	• 6.1.2 Assumptions made in assessing potential impacts and benefits	
	• 6.1.3 How changes to State and Commonwealth legislation, policies, plans and advice is to be accounted for in the management of the areas impacted by the Plan	
	• 6.1.4 Effectiveness or capacity to ensure the Plan is implemented	

<table>
<tr><th>Section</th><th>ToR requirement</th><th>Chapter of Assessment Report</th></tr>
<tr><td rowspan="3"></td><td>6.2 The Report must describe and assess the adequacy of the procedures proposed in the Plan to ensure an adaptive approach to implementation of the Plan. This must include:</td><td rowspan="3">Chapter 16
Chapter 41</td></tr>
<tr><td>• 6.2.1 How the results of monitoring will be used to understand the effectiveness of conservation outcomes for protected matters and improve implementation</td></tr>
<tr><td>• 6.2.2 How new information relating to protected matters and biodiversity, including legislative changes, may be assessed and accounted for in implementation of the Plan</td></tr>
<tr><td rowspan="5">7. Monitoring and Reporting and Auditing</td><td>7.1 The Report must describe and assess the adequacy of the monitoring programs, regular review, public reporting and independent auditing processes proposed in the Plan to:</td><td rowspan="5">Chapter 9
Chapter 16
Chapter 41</td></tr>
<tr><td>• 7.1.1 Ensure conservation commitments and outcomes for protected matters contained in the Plan are delivered</td></tr>
<tr><td>• 7.1.2 Enable implementation of the Plan to adapt where monitoring demonstrates delivery of the conservation actions are not leading to the predicted conservation outcomes</td></tr>
<tr><td>• 7.1.3 Enable implementation of the Plan to adapt to changed circumstances, where there are risks to protected matters</td></tr>
<tr><td>7.2 The Report must identify and analyse the likely circumstances and procedures that may result in the review or modification of implementation plans proposed to deliver on commitments and outcomes for each protected matter as described in the Plan, or abandonment of the Plan</td></tr>
<tr><td>8. Information sources</td><td>8.1 The Report must identify the sources of information and data relied upon including the reliability and currency of the data</td><td>Chapter 11
Chapter 13</td></tr>
</table>

Part 1 References

DECCW (2010) *Report on the methodology for identifying priority conservation lands on the Cumberland Plain* Department of Environment, Climate Change and Water NSW.

DECCW (2011) *Cumberland Plain recovery plan* Sydney, N.S.W.: Department of Environment, Climate Change and Water NSW. Retrieved from http://www.environment.nsw.gov.au/~/media/B867A5B1616049578763809F0729B4A7.ashx

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GSC (2018) *Greater Sydney Region Plan: A Metropolis of Three Cities - connecting people* NSW Government Greater Sydney Commission.

Nanson, G., Young, R., & Stockton, E. (1987) Chronology and palaeoenvironment of the Cranebrook Terrace (near Sydney) containing artefacts more than 40,000 years old *Archaeology in Oceania*, *22*(2), 72–78.

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 2: DESCRIPTION OF THE CUMBERLAND PLAIN CONSERVATION PLAN

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

DOCUMENT TRACKING

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Part 2 Contents

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5 Introduction

The NSW Department of Planning, Industry and Environment (the Department) has prepared the Cumberland Plain Conservation Plan (Plan) to establish long-term certainty for biodiversity conservation and development in Western Sydney. This Part describes the Plan, including:

- Planning context and need for the Plan (see Chapter 6)
- Development under the Plan (see Chapter 7)
- Conservation program of the Plan (see Chapter 8)
- Implementation framework for the Plan (see Chapter 9)

A summary of the Plan, including its purpose, key elements, and vision and objectives, is provided in Part 1.

This Chapter provides an introduction to the Plan, including:

- Purpose of the Plan
- Vision and objectives of the Plan
- Key elements of the Plan
- Structure of the Plan
- How the Plan was developed

5.1 PURPOSE OF THE PLAN

The purpose of the Plan is to establish long-term certainty for biodiversity conservation and development in Western Sydney. The Plan supports the delivery of infrastructure, housing and jobs for Western Sydney in a planned and strategic way that also protects and maintains Western Sydney's key native flora and fauna.

The Plan includes a conservation program of commitments and actions that seeks to improve ecological function and resilience in the Cumberland Plain and provide an enduring conservation legacy for Western Sydney.

5.2 VISION AND OBJECTIVES OF THE PLAN

The Plan provides a high-level vision and objective and defines a set of outcomes and commitments that aim to achieve the Plan's objective and meet regulatory requirements under the NSW *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The NSW Government's vision for the Plan is to "support Western Sydney's biodiversity and growth".

The objective of the Plan is to:

> *"Deliver biodiversity outcomes and support the ecological function of the Cumberland Plain, improving liveability and facilitating urban development in Western Sydney"*

5.3 KEY ELEMENTS OF THE PLAN

The Plan includes three key elements:

- Development – this covers the urban and industrial, infrastructure, agribusiness, and transport development under the Plan, including the scope and location of the development
- Conservation – this covers the conservation program and set of commitments to achieve the Plan's objective and offset the impacts of the development on biodiversity values
- Implementation framework – this covers how the Plan will be implemented

The key elements of the Plan are described in detail in Chapters 7, 8 and 9 respectively.

5.4 STRUCTURE OF THE PLAN

The Plan comprises an overall Plan and two Sub-Plans.

The overall Plan describes how the development will occur and how impacts to biodiversity values and other protected matters will be addressed through the Plan's conservation program and implementation framework, including a set of commitments to address the impacts.

The Sub-Plans contain more details on how the overall Plan will be implemented, including sets of actions for each commitment that set out how the commitment will be delivered. The Sub-Plans are:

- Sub-plan A – details the conservation program and its implementation, including the evaluation program
- Sub-plan B – details how Koalas will be protected under the Plan

5.5 HOW THE PLAN WAS DEVELOPED

5.5.1 PROGRAM LOGIC UNDERPINNING THE PLAN

The Plan was prepared on the basis of a program logic. The program logic describes how the vision, objective, outcomes, commitments and actions of the Plan link together:

- Outcomes – These are the environmental, social and economic outcomes of the Plan
- Commitments – These set out how the outcomes are going to be delivered
- Actions – These describe what will be done to deliver the commitments

The program logic underpinning the Plan is shown in Figure 5-1.

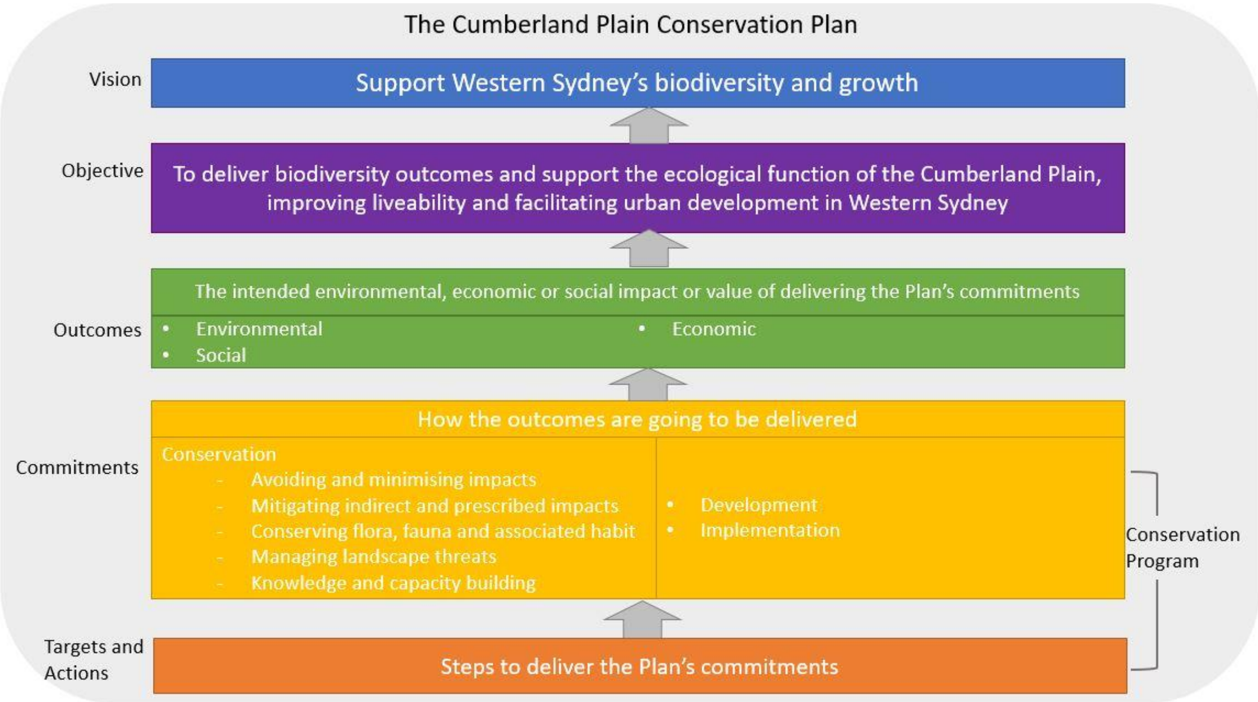

Figure 5-1: Program logic underpinning the Plan

5.5.2 COMMUNITY CONSULTATION ON THE PLAN

The Department has undertaken several community engagement processes to inform the Plan, including:

- Establishment of a People's Panel in 2018 comprising of 18 community members, with at least two representatives from each of the LGAs in the Strategic Assessment Area. The Panel participated in a series of workshops on the Plan

- Establishment of a Community Reference Group comprising non-government organisations, academic and key industry stakeholders in the biodiversity conservation sector. In 2019, the Community Reference Group provided a set of comments and recommendations that were considered in developing the Plan
- Targeted engagement with the Aboriginal community to seek early feedback on the Plan
- Six months of early engagement on the Plan with the Western Sydney community and key stakeholders between July and December 2019. This was done to inform stakeholders and seek preliminary feedback to support development of the Plan before it is released for public exhibition

6 Planning context and need for the Plan

6.1 INTRODUCTION

The Plan has been prepared as part of a broader and complex long-term planning process for Western Sydney that aims to address a range of key planning challenges facing Greater Sydney, such as population growth and housing affordability.

This Chapter sets out:

- Key planning challenges for Western Sydney
- Planning context for Western Sydney
- Need and justification for the Plan
- Alternatives to the Plan

6.2 PLANNING CHALLENGES FOR GREATER SYDNEY

Greater Sydney is subject to several key planning challenges, including relating to:

- Population growth and housing needs, including housing affordability and choice
- Job opportunities
- Access to transport
- Protecting the natural environment and amenity

6.2.1 POPULATION GROWTH AND HOUSING NEEDS

Sydney's continued rapid growth presents a substantial challenge to urban planners. Sydney is predicted to grow by an additional 1.7 million people by 2036 (GSC, 2018a). Residents already face significant barriers to home ownership because of issues around housing affordability. In 2018, Sydney was the third least affordable major housing market for middle incomes globally, with median house prices over 11 times the median household income (Cox & Pavletich, 2019).

To accommodate this growing population, 725,000 new homes will be needed, including approximately 210,000 homes in the Western Parkland City at the centre of the Western Sydney Aerotropolis (WSA).

6.2.2 JOB OPPORTUNITIES

Sydney is predicted to have an additional 817,000 jobs by 2036. Currently there is an imbalance in the distribution of workplaces within the city, with a significant number of jobs being located within the CBD of Eastern Sydney. The concentration of jobs in one location increases the costs associated with obtaining and operating commercial premises and increases barriers to setting up or expanding business operations in Sydney (GSC, 2018a).

6.2.3 ACCESS TO TRANSPORT

The suburban layout of Sydney encourages car use over alternative transport options, such as public transport or cycling. The concentration of jobs in Eastern Sydney also means that many residents in Western Sydney are subject to long commutes. Increased travel times and heavy reliance on cars for commuting decreases the quality of life of residents by decreasing accessibility to employment and services and increasing the costs of commuting. This impacts air quality and decreases opportunities to participate in social and recreational activities (GSC, 2018a).

6.2.4 NATURAL ENVIRONMENT AND AMENITY

The natural environment and built heritage of Western Sydney provides important social, cultural, aesthetic, economic, historic and environmental values within the Sydney region. The environment of Western Sydney is under significant pressure from historical and proposed new land uses (see Part 1) and balancing the protection of the environment and heritage with other urban development objectives is a significant planning challenge.

6.3 PLANNING CONTEXT FOR WESTERN SYDNEY

The NSW Government has prepared several strategies and plans to address the key planning challenges facing Greater Sydney in a coordinated and strategic manner. The key strategies and plans that form part of this planning framework, and their relationship to each other and the Plan, are discussed below.

6.3.1 WESTERN SYDNEY CITY DEAL

The Western Sydney City Deal is the single largest planning, investment and delivery partnership in the history of Australia, and involves the Australian and NSW Governments and eight local Councils in Western Sydney (GSC, 2018b). The Deal supports additional jobs, housing and liveability improvements in Western Sydney.

Under the City Deal, the NSW Government has committed to publish 5-year and 20-year housing targets for each local government area to deliver 185,000 new homes needed in the next 20 years.

The City Deal supports the delivery of the Western City District Plan that covers the nominated areas, and includes a commitment to conduct a strategic assessment under the EPBC Act to protect the environment and streamline environmental approvals for development in Western Sydney (DIRDC & DPC, 2018).

This Plan provides a mechanism to undertake this strategic assessment.

6.3.2 GREATER SYDNEY REGION PLAN

The Greater Sydney Region Plan is a 40-year vision for a global metropolis of three cities incorporating land use planning, transport planning and infrastructure planning. The Region Plan sets out a plan to manage urban growth by establishing a 'metropolis of three cities': Western Parkland City, Central River City, and Eastern Harbour City.

The Region Plan supports the delivery of the Western Parkland City by facilitating the nominated areas and transport corridors. The Region Plan also includes an action (number 72) to deliver strategic conservation planning and develop a conservation plan for Western Sydney. This Plan delivers on that action.

The Region Plan is guided by 10 overarching directions and 40 objectives for liveability and sustainability, productivity and infrastructure in Greater Sydney and includes a target that all homes will be within 30 minutes' access to jobs, schools, and health care (GSC, 2018a). Two core directions address sustainability:

- A cool and green parkland city in the Wianamatta (South Creek) corridor (Objective 26)
- Biodiversity is protected, urban bushland and remnant vegetation is enhanced (Objective 27)

The Region Plan is supported by a series of five 20-year District Plans. These District Plans provide greater detail regarding planning, development and conservation objectives for each district of Sydney.

By supporting the delivery of the Western Parkland City, this Plan will contribute to the wider objective to develop Sydney as a 'polycentric city' and therefore help address many key planning challenges outlined in Section 6.2. Monocentric cities that experience growth can suffer from increasing business costs, increased housing and living costs, increased labour costs and reduced labour supply, and social segregation, congestion, air quality problems, heat island effects and spatial polarisation (GSC, 2018a). Major cities are responding to planning challenges associated with city growth through promoting the development of polycentric city structures (GSC, 2018a).

6.3.3 WESTERN SYDNEY DISTRICT PLAN

The relevant District Plan for the area covered by this Plan is the Western City District Plan. The Western City District Plan aligns with the Greater Sydney Region Plan, and provides more details regarding targeted planning objectives for the District, with associated actions to be undertaken to achieve the outlined objectives.

This Plan supports the implementation of Western City District Plan's planning priorities for:

- Creating a Parkland City urban structure and identity, with Wianamatta (South Creek) as a defining spatial element (Priority W13)
- Protecting and enhancing bushland and biodiversity (Priority W14)
- Protecting and enhancing scenic and cultural landscapes (Priority W16)

6.3.4 FUTURE TRANSPORT STRATEGY 2056

The Future Transport Strategy 2056 is an overarching strategy to achieve a series of objectives for the NSW transport network (Transport for NSW, 2018). The Transport Strategy will be implemented by a suite of plans, including the Greater Sydney Services and Infrastructure Plan (Transport for NSW, 2018).

The Future Transport Strategy 2056 supports the development of Sydney as a polycentric city by developing an integrated network of transport corridors to support connectivity and liveability within Sydney.

The Transport Strategy identifies a range of transport initiatives for investigation, including the Outer Sydney Orbital identified under this Plan (Transport for NSW, 2018).

This Plan supports the delivery of these transport initiatives in Western Sydney.

6.3.5 NSW KOALA STRATEGY

The NSW Koala Strategy aims to stabilise and then increase Koala numbers, ensuring genetically diverse and viable populations of Koalas in NSW in the longer term (OEH, 2018).

The Koala Strategy identifies a series of actions to be implemented from 2018 to 2021. Actions fall under the following categories: Koala habitat conservation, conservation through community action, safety and health of Koala populations and building knowledge and education (OEH, 2018). The NSW Government has committed approximately $45 million to implementing the Koala Strategy (OEH, 2018).

This Plan supports the delivery of the Koala Strategy in Western Sydney.

Koala habitat has been significantly impacted by the 2019/20 bushfires in NSW. This is further discussed in Supporting Document G.

6.4 NEED AND JUSTIFICATION FOR THE PLAN

This Section addresses section 2.1(3) of the ToR, which requires the report to '…describe the need and justification for the Plan including the environmental, social and economic drivers for its development'.

The Plan is needed for the following four key reasons:

- Supports the delivery of the nominated areas program and transport corridors
- Supports the delivery of key planning strategies and plans
- Provides a mechanism to address conservation challenges for the Cumberland subregion
- Supports NSW Government priorities

6.4.1 SUPPORTS THE DELIVERY OF THE NOMINATED AREAS PROGRAM AND TRANSPORT CORRIDORS

This Plan supports the delivery of the NSW Government nominated areas program and the development of major transport infrastructure to meet the long-term transport needs of Western Sydney.

The nominated areas program represents the strategic prioritisation and delivery of new development as part of the long-term growth of Greater Sydney and to meet key social and economic objectives identified under the Greater Sydney Region Plan. The program will consolidate future development needs across Western Sydney by establishing four new nominated areas. The nominated areas are the key focus for urban development over the coming decades and will be the centres of economic and social activity in Western Sydney.

Future Transport 2056 identifies a series of major infrastructure corridors for the coming decades. For Western Sydney, major transport infrastructure is planned to be delivered to respond to the economic and social needs of Western Sydney over the next 40 years. This Plan includes key Western Sydney transport corridors to facilitate infrastructure projects that will generate economic activity and support employment opportunities in the region.

6.4.2 SUPPORTS DELIVERY OF KEY PLANNING STRATEGIES AND PLANS

The Plan supports the delivery of key planning strategies and plans for Western Sydney, as well as the Western City Deal. By supporting the delivery of these, the Plan is directly helping to address key environmental, social and economic planning challenges facing Greater Sydney outlined in Section 6.2.

The key plans and strategies that this Plan is supporting, and how the Plan supports their delivery, are outlined in Section 6.3. In summary, the Plan is needed to support implementation of:

- Western Sydney City Deal – by providing the mechanism to conduct a strategic assessment under the EPBC Act to protect the environment and streamline environmental approvals for development in Western Sydney
- Greater Sydney Region Plan, by supporting the delivery of:
  - Western Parkland City
  - Key objectives of the Region Plan, including:
    1. A cool and green parkland city in the Wianamatta (South Creek) corridor (Objective 26)
    2. Biodiversity is protected, urban bushland and remnant vegetation is enhanced (Objective 27)
- Western City District Plan, by supporting the delivery of planning priorities:
  - Creating a Parkland City urban structure and identity (Priority W13)
  - Protecting and enhancing bushland and biodiversity (Priority W14)
  - Protecting and enhancing scenic and cultural landscapes (Priority W16)
- NSW Koala Strategy in Western Sydney

6.4.3 PROVIDES A MECHANISM TO ADDRESS CONSERVATION CHALLENGES FOR CUMBERLAND SUBREGION

Conservation planning in the Cumberland subregion is challenging and complex. Biodiversity in the subregion has suffered significant disturbance, and the subregion is one of the most threatened regions in NSW (DEC, 2005). Many ecological communities and species are listed as threatened under both NSW and Commonwealth legislation. Areas of remaining native vegetation are often of high conservation value. At the same time, the population of Sydney is growing, housing affordability is a priority and the cost of land across the region is very high.

These issues make it challenging to identify options that satisfy regulatory and community expectations around biodiversity conservation while also addressing the need for cost effective development.

Strategic assessment processes provide significant opportunities to address the key conservation challenges in the Cumberland subregion while facilitating cost effective development.

Strategic assessments can have the following benefits:

- Streamline the assessment and approval process and reduce duplication between regulatory requirements
- Enable effort to be focused on the highest biodiversity value areas of the landscape
- Address ecological function and landscape-scale ecological processes, such as habitat connectivity
- Manage threats at a landscape scale that can maximise benefits to multiple species
- Be designed and implemented strategically, such as by consolidating offsets into large and more viable patches
- Be implemented ahead of impacts occurring from development, to help reverse any trend of decline

6.4.4 SUPPORTS NSW GOVERNMENT PRIORITIES

The Plan supports NSW Government priorities and in particular, the Premier's Priorities. The Premier has prioritised making housing more affordable, delivering infrastructure and creating jobs for the people of NSW.

The Plan supports these priorities by:

- Supporting the delivery of key planning strategies and plans that help address these priorities
- Providing a mechanism to deliver development through a streamlined assessment and approval process and by reducing duplication between NSW and Commonwealth regulatory requirements.

6.5 ALTERNATIVES TO THE PLAN

This section addresses section 2.1(4) of the ToR, which requires the report to '…describe the decision-making framework used in considering alternatives and developing conservation outcomes of the Plan. It should identify where alternative options that have been evaluated to reach the final Plan have been published'.

Alternatives can be discussed in terms of different:

- Approaches to urban development
- Conservation outcomes
- Locations of the urban capable lands and transport corridors

6.5.1 ALTERNATIVE APPROACHES TO URBAN DEVELOPMENT

The nominated areas program involves the identification of large areas for greenfield development in high-level strategic planning documents. The nominated areas represent a planned approach to land release for which the NSW Government takes a lead role in setting objectives, planning, and co-ordinating the delivery of development.

Developing nominated areas provides the most effective approach to address the key planning challenges facing Sydney as it provides for a considered and strategic approach to the location of urban and transport infrastructure. A planned approach to land release through nominated areas also allows for:

- Co-ordinated precinct structure planning and better integration of land use and transport to maximise social and economic benefits, including employment areas, schools, hospitals, transport precincts, and open space
- More effective investment by infrastructure agencies when planning for services
- Better co-ordination and alignment between the objectives of different government agencies
- Better direction for the development industry about where future development will occur and greater certainty for landowners about the future use of their land
- A co-ordinated approach to development contributions to help fund the delivery of key infrastructure
- A more efficient use of government resources in responding to development proposals

The alternative to developing nominated areas is a larger number of smaller urban precincts that are separately identified and planned by different planning authorities across a broader region. This approach does not provide the benefits that come with the co-ordinated planning and consolidated development within nominated areas.

6.5.2 ALTERNATIVE CONSERVATION OUTCOMES

The Department applied a structured decision-making process during early development of the Plan to define a high-level biodiversity outcome for the Cumberland subregion that set the context and direction for the development of the Plan. The structured decision-making was one of the first steps in a comprehensive conservation planning process for the Plan. Other planning processes included a process to avoid impacts to biodiversity values (see Chapter 14) and a method to identify high value conservation lands within the Cumberland subregion for offsets that best support an ecologically-functioning, connected landscape (called the Conservation Priorities Method – see Sub-Plan A).

The structured decision-making process provides a systematic method to identify and compare a range of conservation options available to the NSW Government, taking into account social, economic and environmental considerations.

The structured decision-making process involves five steps:

1. Understanding the decision/s that need to be made
2. Identifying what is important when making those decision/s
3. Developing a range of alternatives to compare
4. Understanding the performance of different alternatives
5. Comparing options and selecting a preferred alternative

The key decision relevant to the structured decision-making work was:

> *"What is the optimal biodiversity outcome for Western Sydney that will enable planned and existing development (including both in and beyond the nominated areas in the Cumberland Plain) to proceed in an affordable and sustainable way?"*

The structured decision-making process was based around four decision making criteria and six performance measures across environmental, social and economic themes. The criteria were:

- Maximise conservation of biodiversity
- Minimise the costs of delivering the biodiversity outcome
- Ensure the biodiversity outcome is feasible
- Maximise public amenity

The process looked at four different models to provide funding for the biodiversity outcome, examined twenty alternative biodiversity outcomes, modelled the performance of each alternative and compared the twenty alternatives under various scenarios to reach conclusions about the optimal approach.

The process found that the best approach to achieving the optimal biodiversity outcome with the available funding is to apply a broad mix of commitments and actions to maximise the biodiversity values that are protected, maximise certainty of delivery and alleviate the pressure on offset supply and demand.

The best mix of approaches includes:

- Securing one or more new national parks in the Plan Area
- Investing in biodiversity stewardship in the best remaining vegetation in the Plan Area
- Restoring key parts of the landscape within the Plan Area
- Providing dedicated funding for a set of actions to protect Koalas
- Investing a smaller proportion of the funding on biodiversity stewardship outside the Plan Area, within the allowable variation rules under the BC Regulation

This mix of approaches is reflected in the conservation program for the Plan (see Chapter 8).

6.5.3 ALTERNATIVE LOCATIONS OF URBAN CAPABLE LANDS AND TRANSPORT CORRIDORS

PROCESSES TO LOCATE THE URBAN CAPABLE LAND

The urban capable land was identified in three phases:

- Strategic planning to locate the nominated areas
- Initial development of footprints through Land Use and Infrastructure Implementation Plans
- Iterative refinement of the footprints through development of the Plan and assessment of impacts

The initial development and refinement of the urban capable land footprints is described in Chapter 14.

Strategic planning to locate the nominated areas

The broad location of the nominated areas was determined through various strategic planning strategies and investigations over many years. Two key planning strategies that informed the location of the nominated areas were:

- *A Plan for Growing Sydney* (DPE, 2014) – this identified the general location of Wilton Growth Area (Wilton) and Greater Macarthur Growth Area (GMAC) and the Badgerys Creek Airport precinct, which was subsequently refined further by the Department to become WSA
- *A Metropolis of Three Cities* (GSC, 2017) – this identified the general location of Greater Penrith to Eastern Creek Investigation Area (GPEC) and establishes a 40-year vision for Sydney as a global metropolis of three cities, including the Western Parkland City covering the nominated areas

The nominated areas were located based on a broad range of strategic planning considerations, including:

- Proximity to current and planned locations of employment
- The cost of infrastructure provision including roads, water, sewerage, public transport, schools and health facilities
- The economic and social cost to communities of having poor access to employment and services, including transport
- Environmental constraints, including biodiversity values

Action 2.4.2 of *A Plan for Growing Sydney* (DPE, 2014) aimed to develop a long-term framework for the identification of new nominated areas to improve the management of future land release in Sydney. In preparing a framework for the identification of nominated areas, Action 2.4.2 indicates that a range of issues should be considered, including:

- The value of land for drinking water supply, agriculture, environmental management and other purposes
- Constraints to development, including environmental constraints and natural hazards

The Department undertook investigations into the location of the nominated areas in accordance with Action 2.4.2.

PROCESSES TO LOCATE THE TRANSPORT CORRIDORS

The process for identifying, selecting and designing future corridors and transport projects involves a detailed set of steps and processes to ensure optimum infrastructure, environmental, social and economic outcomes are achieved. The *Planning guideline for Major Infrastructure Corridors* (DPE, 2016) sets out the recommended processes for infrastructure agencies to follow through the different phases of corridor planning.

The guideline provides advice in relation to the three broad phases:

- Strategic planning – identification
- Corridor planning and selection
- Infrastructure delivery

The first two phases lead to the identification and protection of transport corridors. As part of this process, a Strategic Environmental Assessment (SEA) is prepared which provides an assessment of the environmental, economic and social impacts of reserving the corridor. SEAs are non-statutory documents that assist in the planning and decision-making process for the community and Government. They are subject to public consultation and include justification for a preferred corridor alignment and provide information on the assessment of alternative corridor alignments.

In making decisions on corridor selection, infrastructure agencies undertake a constraints analysis and multi-criteria comparison of options. These include consideration of a wide range of factors including:

- Aboriginal heritage
- Biodiversity
- Costs
- Engineering and construction limitations
- Land use and property impacts
- Landscape character and visual amenity
- Noise and vibration
- Non-Aboriginal heritage
- Socio-economic considerations
- Soils, geology and contamination
- Transport planning
- Water quality and hydrology

Box 1 provides an example of the process used to locate the Outer Sydney Orbital (OSO) (AECOM, 2018).

BOX 1: PROCESS USED TO LOCATE THE OUTER SYDNEY ORBITAL

The Draft SEA for the OSO (AECOM, 2018) sets out the process that was followed to locate that transport corridor. Transport for NSW commissioned the OSO study "to identify the most appropriate location for the corridor and to protect land within that corridor for the future provision of critical road and freight rail infrastructure". The method for identifying the corridor involved (AECOM, 2018):

- *Identifying a study area – investigations commenced with a broad OSO study area to identify high-level constraints and opportunities*
- *Understanding constraints and opportunities – an analysis of constraints and opportunities within the study area included prioritisation of constraints as well as identification of key areas and values to avoid during corridor design development*
- *Developing guiding principles – a list of guiding principles was developed to inform the selection of a long list of corridor options. These principles followed the hierarchy of 'avoid, minimise, and mitigate impacts', to allow for the creation of a series of options*
- *Identifying corridor options – a range of tools, including computer software and specialist advice, was used to identify a long list of corridor options*
- *Evaluating corridor options – this included specialist investigations of identified options, comparative assessment and multi-criteria analyses*
- *Selecting a recommended OSO corridor – a continuation of the evaluation process where selection and refinement of a recommended corridor involved multi-criteria assessment, targeted stakeholder consultation and design development*
- *Consulting with the public on the recommended corridor – to obtain feedback on the recommended OSO corridor*

Potential impacts to biodiversity were a key consideration (amongst a range of considerations) in the SEA and the ultimate selection of the corridor. A similar process was followed for the other transport corridors.

7 Development under the Plan

7.1 INTRODUCTION

This Chapter describes each of the development elements of the Plan in detail.

An overview of the development under the Plan is provided in Part 1. Part 1 also describes the scope and boundaries of the approvals being sought by the Department for the development under the BC Act and EPBC Act.

7.1.1 DEVELOPMENT UNDER THE PLAN

The Plan provides for the following development:

- Urban and industrial development within urban capable land in nominated areas
- Infrastructure within urban capable land in nominated areas, as well as 'essential' infrastructure in limited cases within avoided lands in the nominated areas
- Agribusiness within agribusiness lands in the Western Sydney Aerotropolis
- Western Sydney Major Infrastructure Corridors (transport corridors) within and outside the nominated areas

Each type of development is described in detail in sections 7.2 to 7.5. The development is described in terms of actions that are to be included in an approval of a class of actions pursuant to section 146 of the EPBC Act.

7.1.2 MAJOR DEVELOPMENT NOT PART OF THE PLAN

The following major urban and transport development occur within the Plan Area but are not part of this strategic biodiversity certification and strategic assessment process as they have been previously assessed and approved, or are currently being assessed and considered for approval, under NSW and Commonwealth laws:

- Existing North West and South West Growth Areas (previously assessed and approved)
- Western Sydney Airport (previously assessed and approved)
- Sydney Metro Stage 1 (currently being assessed and approved)

The location of these developments is shown in Part 1.

7.2 URBAN AND INDUSTRIAL DEVELOPMENT

The Plan provides for urban and industrial development in four nominated areas:

- Wilton Growth Area (Wilton)
- Greater Macarthur Growth Area (GMAC)
- Western Sydney Aerotropolis (WSA) (excluding where there is overlap with the existing South West Growth Area)
- Greater Penrith to Eastern Creek Investigation Area (GPEC)

The nominated areas are shown in Figure 7-1 to Figure 7-4.

Not all parts of the nominated areas are proposed for development. The proposed development will occur within specified urban capable lands within each nominated area. Other areas of land within the nominated areas include:

- Land covered by the transport corridors
- Land avoided for development because of its biodiversity value (see Chapter 14)
- Land avoided for development for other reasons (e.g. because it is unsuitable for development)
- Land that is already protected or developed, or otherwise not included in the Plan (excluded land)

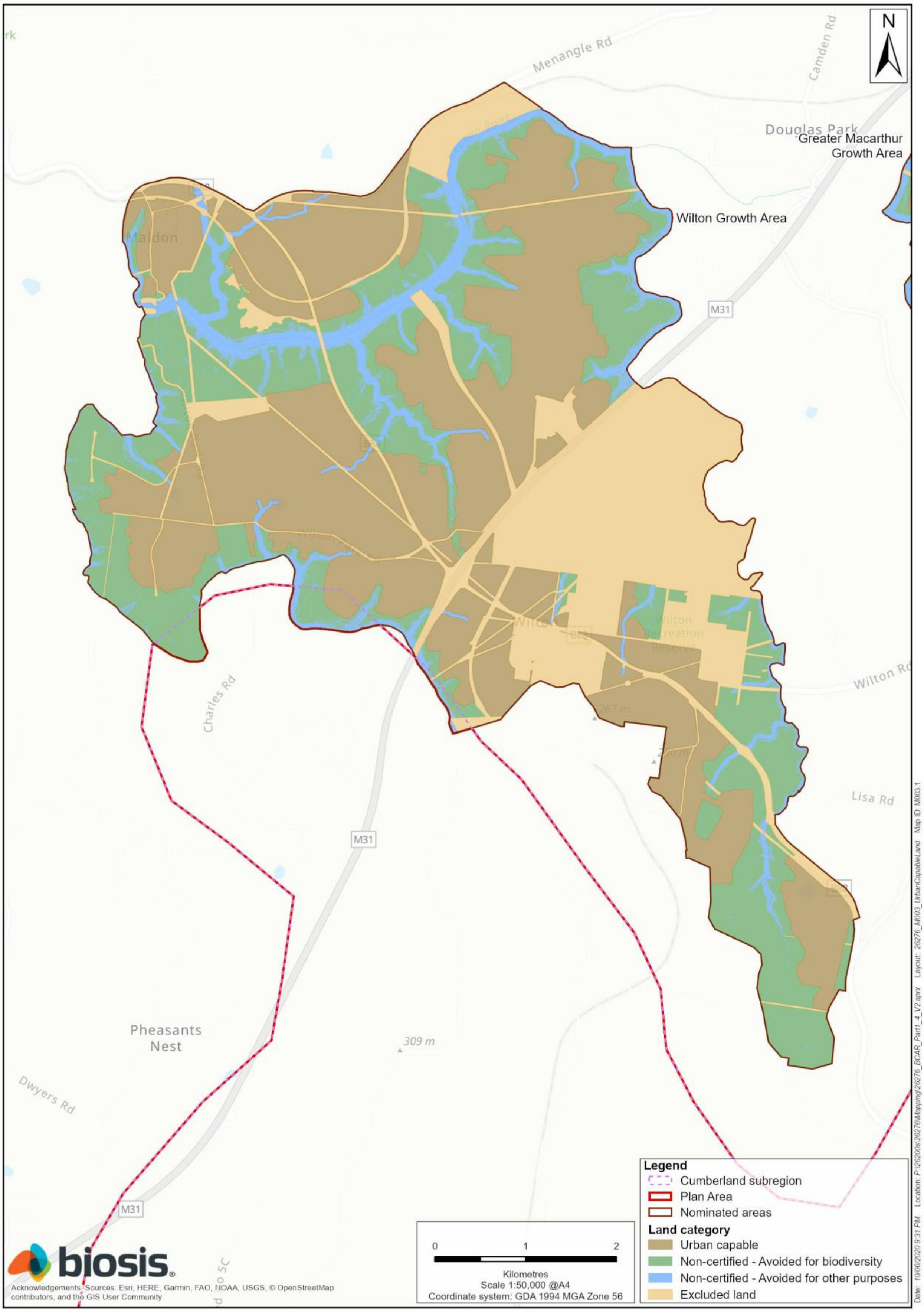

Figure 7-1: Wilton Growth Area and urban capable land

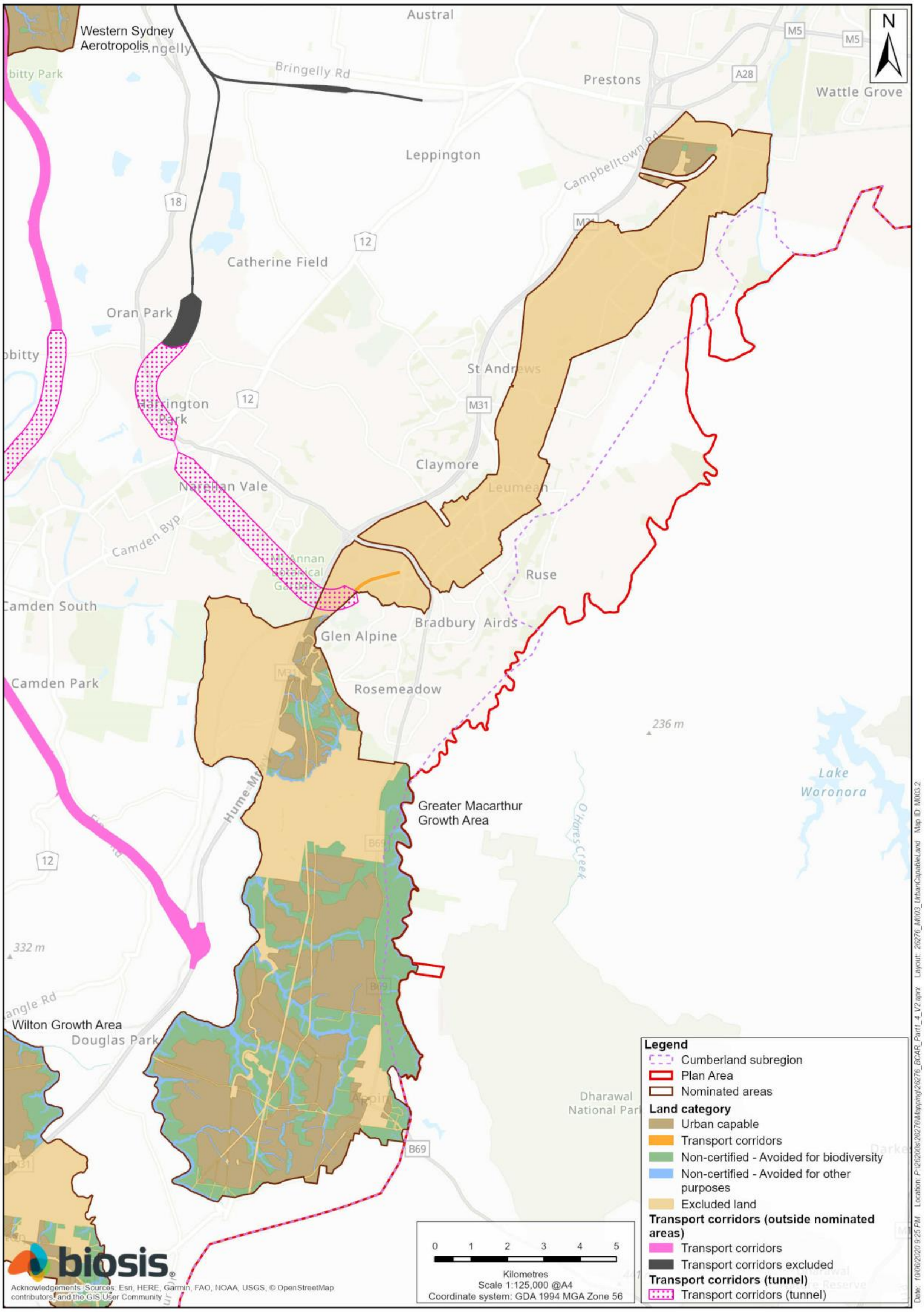

Figure 7-2: GMAC and urban capable land

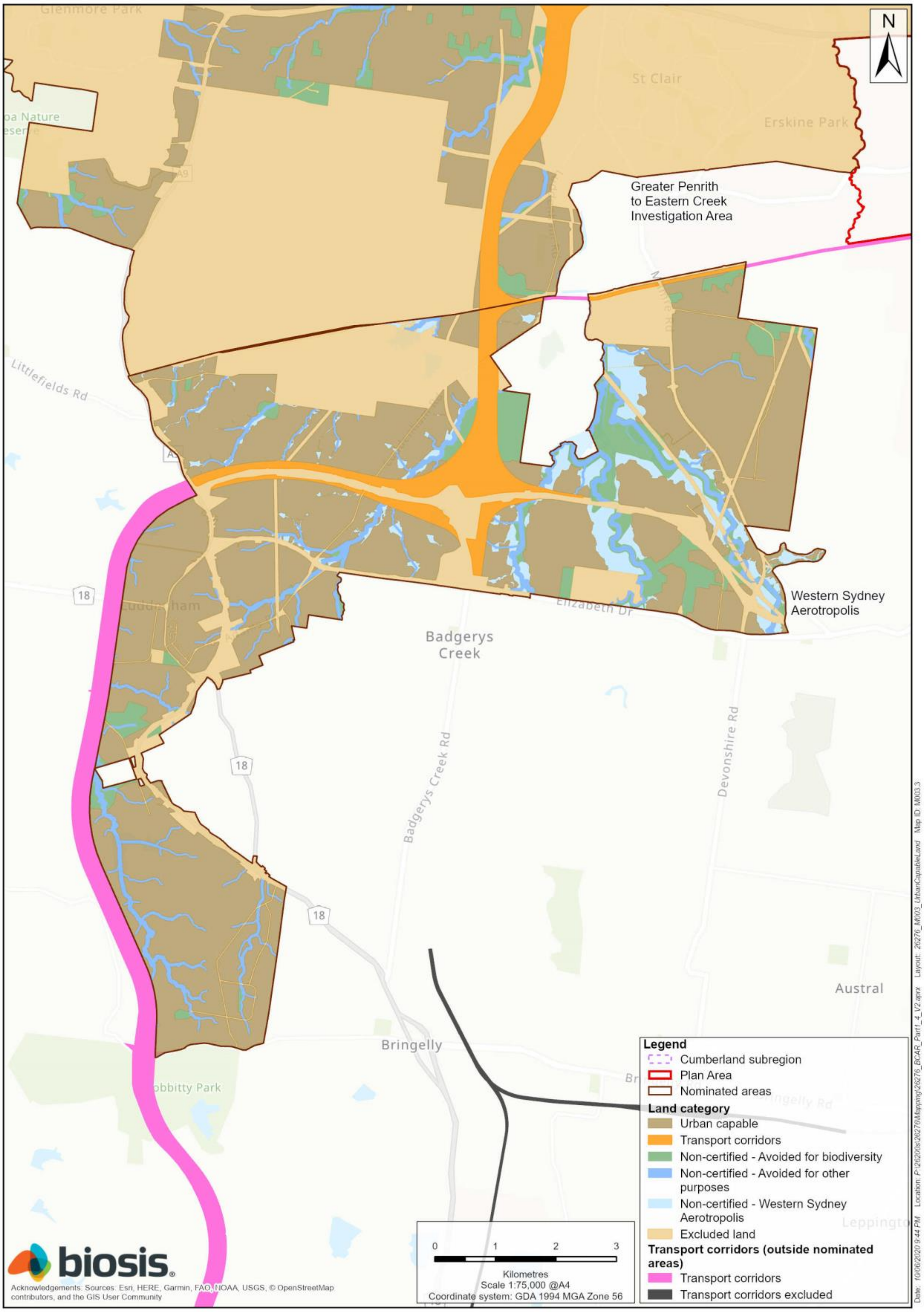

Figure 7-3: WSA and urban capable land

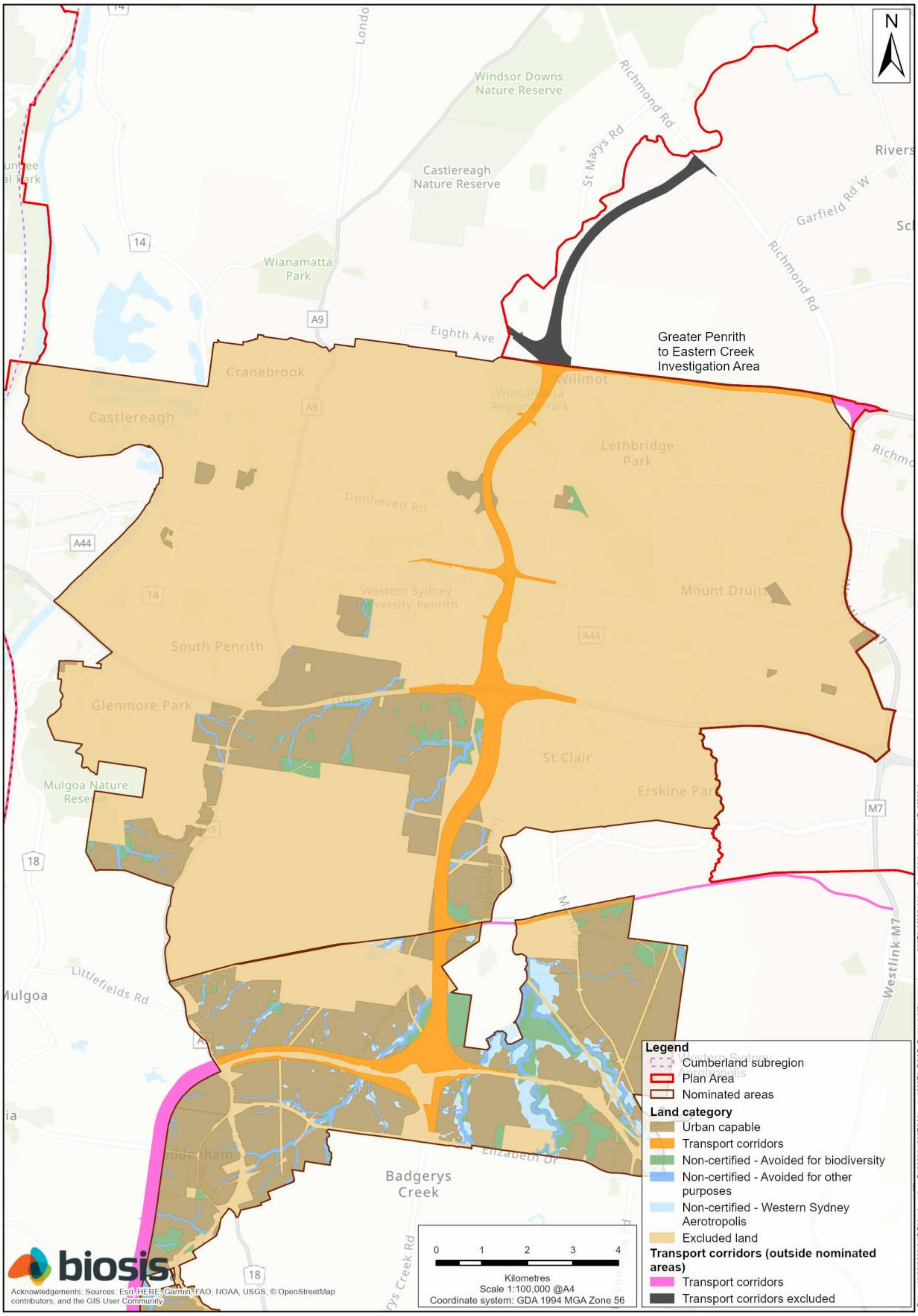

Figure 7-4: GPEC and urban capable land

Urban and industrial development will be confined to the urban capable lands within the nominated areas and includes any development permitted through residential, business, or industrial zones, consistent with the structure plan and precinct plans for each nominated area. Urban and industrial development includes:

- Mixed residential, commercial and industrial development
- Major town centres
- Social infrastructure, such as education facilities and child care services
- Essential services, such as health and emergency services facilities
- General industrial facilities, such as retail outlets and manufacturing industries
- Warehouse, freight and logistics including distribution centres
- Airport and ancillary uses to support the delivery and operation of the Western Sydney Airport
- Related, supporting development, provided they do not produce unforeseen impacts on MNES

Structure plans and precinct plans will be prepared for each nominated area and map the boundaries of the urban capable land and the intended land use zones. Structure plans and precinct plans will be made by the relevant planning authority under the *Environmental Planning and Assessment Act 1979* (EP&A Act). The NSW Government will amend the relevant State Environmental Planning Policy to attach the structure plans and precinct plans before development under the Plan commences.

Relevant planning authorities will rezone the land over time. A Ministerial Direction under section 9.1 of the EP&A Act will be made to require that any planning proposals to rezone the land must be consistent with the intended land use zones structure plan and precinct plans attached to the State Environmental Planning Policies (SEPPs).

7.3 INFRASTRUCTURE

Infrastructure development will generally be limited to urban capable land within the nominated areas and includes:

- Electricity transmission or distribution networks
- Gas pipelines
- Road or road infrastructure facilities, including public transport facilities (this is limited to local roads)
- Water reticulation systems, water storage facilities, water treatment facilities, or water supply systems
- Telecommunications facilities or telecommunication networks
- Stormwater management systems
- Resource recovery facility, waste disposal facility, waste or resource management facility and transfer stations
- Organic waste and composting facilities
- Supporting infrastructure for parks and public reserves (environmental facility, information and education facility, kiosk, recreation area, recreation facilities (outdoor), water recreation structure, road)

Certain essential infrastructure may be carried out by or on behalf of a public authority on land outside the urban capable land (not including excluded land) within the nominated areas (i.e. on avoided land) provided the 'guidelines for development' in the Plan are followed. The guidelines limit the scope of infrastructure development within these areas and aim to ensure development avoids and mitigates and offsets any impacts to biodiversity values.

The guidelines specify a range of requirements to achieve this outcome, including that:

- The environmental impacts of the projects are considered under the EP&A Act
- An 'avoid and mitigate' process is applied as part of this assessment process
- Any relevant MNES-specific requirements of the Plan are applied

The guidelines for development are described and evaluated in Chapter 37.

7.4 AGRIBUSINESS

The Western Sydney airport presents an opportunity to invest in agriculture and agribusiness industries. The Agribusiness Precinct within WSA occurs on the northern and western edges of the airport and supports the long-term retention and growth of agriculture and agribusiness in the Western Parkland City.

Agribusiness will be confined to within the Agribusiness Precinct within WSA (see Figure 7-5) and includes existing, new and proposed agricultural areas to support the nominated areas program. Agricultural production will be confined within the agriculture or agribusiness lands within WSA. However, it is possible that associated development related to agribusiness, wholesale markets, manufacturing and logistics may occur in other precincts.

Agriculture development may include:

- Intensive plant agriculture, including protective structures used for production of fruit, vegetables or flowers
- Agribusiness – businesses associated with the production, processing, marketing and distribution of agricultural products, such as biotechnology research and development, food processing and export enabling infrastructure
- Advanced food manufacturing and logistics
- Wholesale markets, such as retail, distribution centres, cold stores, ripening rooms, and treatment facilities

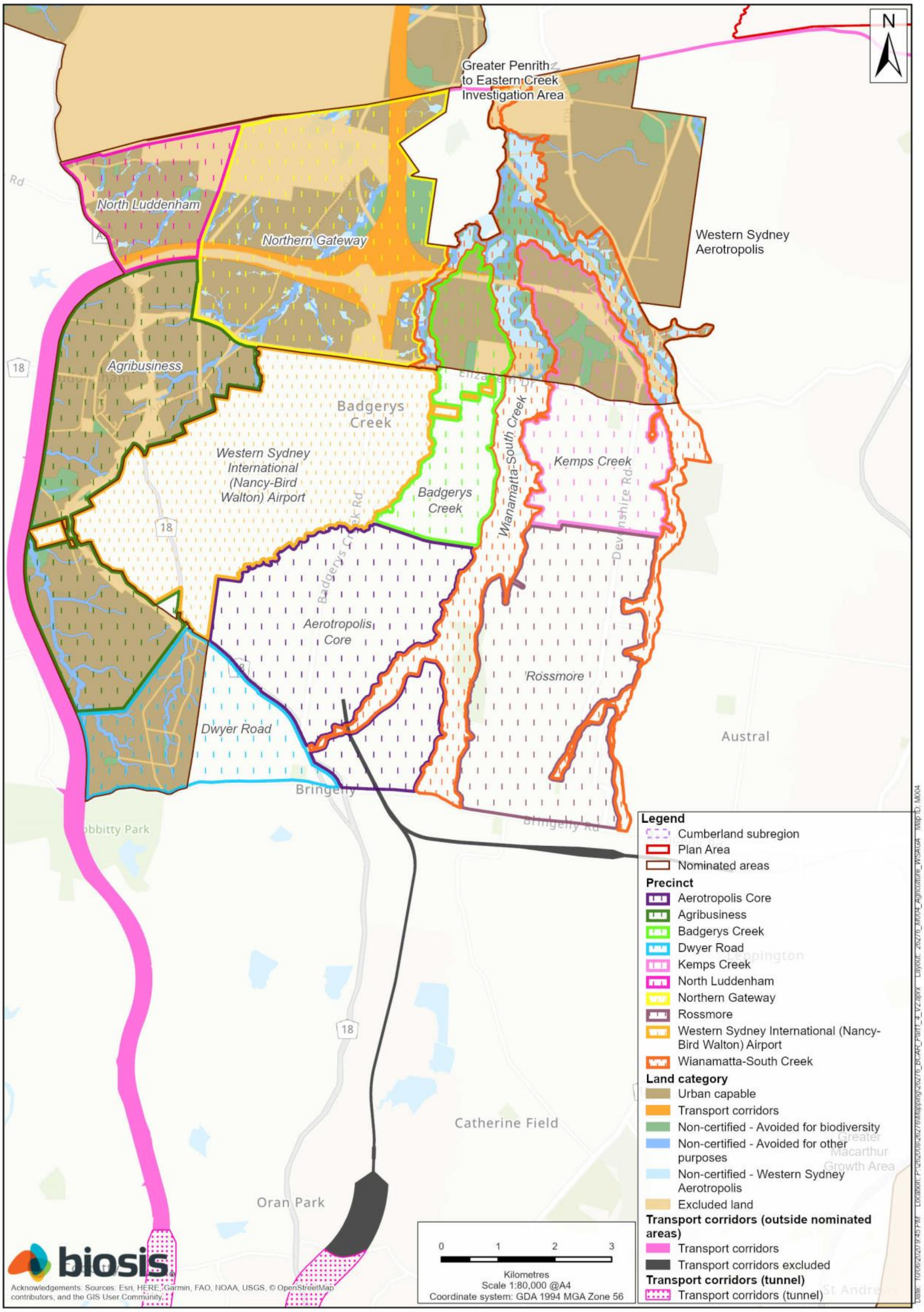

Figure 7-5: Agriculture and Agribusiness Precinct of WSA

7.5 TRANSPORT CORRIDORS

The NSW Government is finalising long term major infrastructure corridors for Western Sydney by identifying and protecting corridors that can be used to deliver the major components of the future transport network. These corridors will facilitate the delivery of major transport infrastructure to meet the long-term needs of Western Sydney, as outlined in the Future Transport Strategy 2056 (Transport NSW, 2017) and the Greater Sydney Region Plan.

For Western Sydney, the transport corridors are planned to be delivered over the next 40 years. The delivery and timing of the major transport infrastructure within the corridors is subject to future NSW Government decisions. The responsibility for delivery of the transport infrastructure rests with Transport for NSW.

The transport corridors and the indicative timing for investigating the delivery of these corridors are identified in Table 7-1. The indicative locations of the transport corridors are shown in Figure 7-6. Parts of the transport corridors are located within GPEC, WSA and GMAC. There are no transport corridors identified within Wilton.

Table 7-1: Transport corridors for investigation

<table>
<tr><th>Project</th><th>Description</th><th>Timing for investigation</th></tr>
<tr><td>Sydney Metro Greater West south from Western Sydney Aerotropolis to Macarthur (except for those areas within the existing South West Growth Area)</td><td>Provides for a commuter railway line</td><td>0 to 10 years</td></tr>
<tr><td>Western Sydney Freight Line corridor</td><td>Provides for a future freight rail line to connect Port Botany and Western Sydney</td><td rowspan="2">10 to 20 years</td></tr>
<tr><td>Outer Sydney Orbital (Stage 1) from Palmyra Avenue to the Hume Motorway</td><td rowspan="2">Provides for a future north south motorway and freight rail line</td></tr>
<tr><td>Remaining Outer Sydney Orbital 1</td><td rowspan="2">20 or more years</td></tr>
<tr><td>M7/Ropes Crossing Link Road</td><td>Provides for a future east-west motorway linking the M7 to the future Outer Sydney Orbital at Ropes Crossing</td></tr>
</table>

Development under the transport class of action includes all activities associated with the design, construction, and operation of the major road or rail projects. This includes any development on land within the transport corridors shown in the Plan (see Figure 7-6) or on any other land required for the transport project along these general alignments, as identified under the NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process).

The transport activities included under the Plan include, but are not limited to:

- Vegetation clearing
- Earthworks
- Utility works
- Landscaping
- Erosion and sediment control
- Laydown areas
- Road and rail construction
- Tunnel construction
- Construction of supporting infrastructure such as stations, car parks and pedestrian access
- Electricity infrastructure
- Site offices and access roads
- Dust and noise suppression

- Stormwater management (including detention basins, ponds and dams)
- Vehicle and train movements
- Maintenance and upgrade activities
- Installation and maintenance of traffic control and safety infrastructure

As each transport project is brought forward for investigation, the project will be subject to:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor
- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process).

The transport projects included in the Plan have not finalised implementing a process to avoid biodiversity values as the alignment for the corridors are not currently certain. Additional areas will be avoided as designs for the transport projects are determined. The Plan includes commitments for further avoidance and minimisation of impacts to biodiversity values related to the transport corridors (see Chapter 36).

It is important to note that sections of a number of the transport corridors occur within the existing North West and South West Growth Areas. These sections already have EPBC Act approval under the previous Part 10 strategic assessment for the growth areas and are therefore not further considered in this Assessment Report.

TUNNELS

Development under the transport class of action includes tunnel construction and operation. Sections of two of the transport corridors are proposed to include tunnels. These are:

- Outer Sydney Orbital – Cobbitty to Cawdor
- Metro Rail Future Extension tunnel – Oran Park to Narellan, and Narellan to Macarthur

The location of the tunnels are shown in Figure 7-6.

The activities associated with tunnelling may include but are not limited to the matters shown in Table 7-2.

Table 7-2: Construction activities and operational infrastructure associated with transport corridor tunnels

Project phase	Activities
Construction activities	• Site establishment and enabling work, including but not limited to utility work, fencing and hoarding, construction ancillary facilities and access, demolition of buildings and structures and clearance of vegetation where required • Erection of acoustic sheds (where relevant) over the temporary access tunnels and to contain noise and dust from tunnelling operations • Construction of temporary access tunnels • Construction of main tunnels, including but not limited to entry and exit ramps and associated tunnelled infrastructure • Spoil management and haulage • Finishing work in tunnel and provision of permanent tunnel services, including but not limited to mechanical and electrical fit out • Drainage work, including permanent water treatment facilities
Operational infrastructure	• Utilities infrastructure (including adjustments to, or relocation of, existing utilities infrastructure), electronic tolling facilities, signage, ventilation systems, emergency systems, systems for the control and management of roads, and tunnel control centre facilities • Entry and exit ramps (tunnel portals) • Connection to power, including construction of or connection to electrical substations • Connection and tie in with existing surface roads and infrastructure

Project phase	Activities
	• Pedestrian and cyclist facilities • Drainage work, pavement and finishing work (including landscaping and urban design treatments)

As for the other parts of the transport corridors, development for the tunnels will generally occur within the footprints of the tunnels shown in Figure 7-6. In some circumstances development activities may be necessary adjacent to the footprint.

The impacts of tunnels are assessed separately (see Chapter 36) to the rest of the transport corridors as only small areas of the footprints will be disturbed and impacts have not been included in the impact statistics for transport corridors in the assessments for Commonwealth-listed species and Threatened Ecological Communities (TECs) (see Chapters 29 to 31).

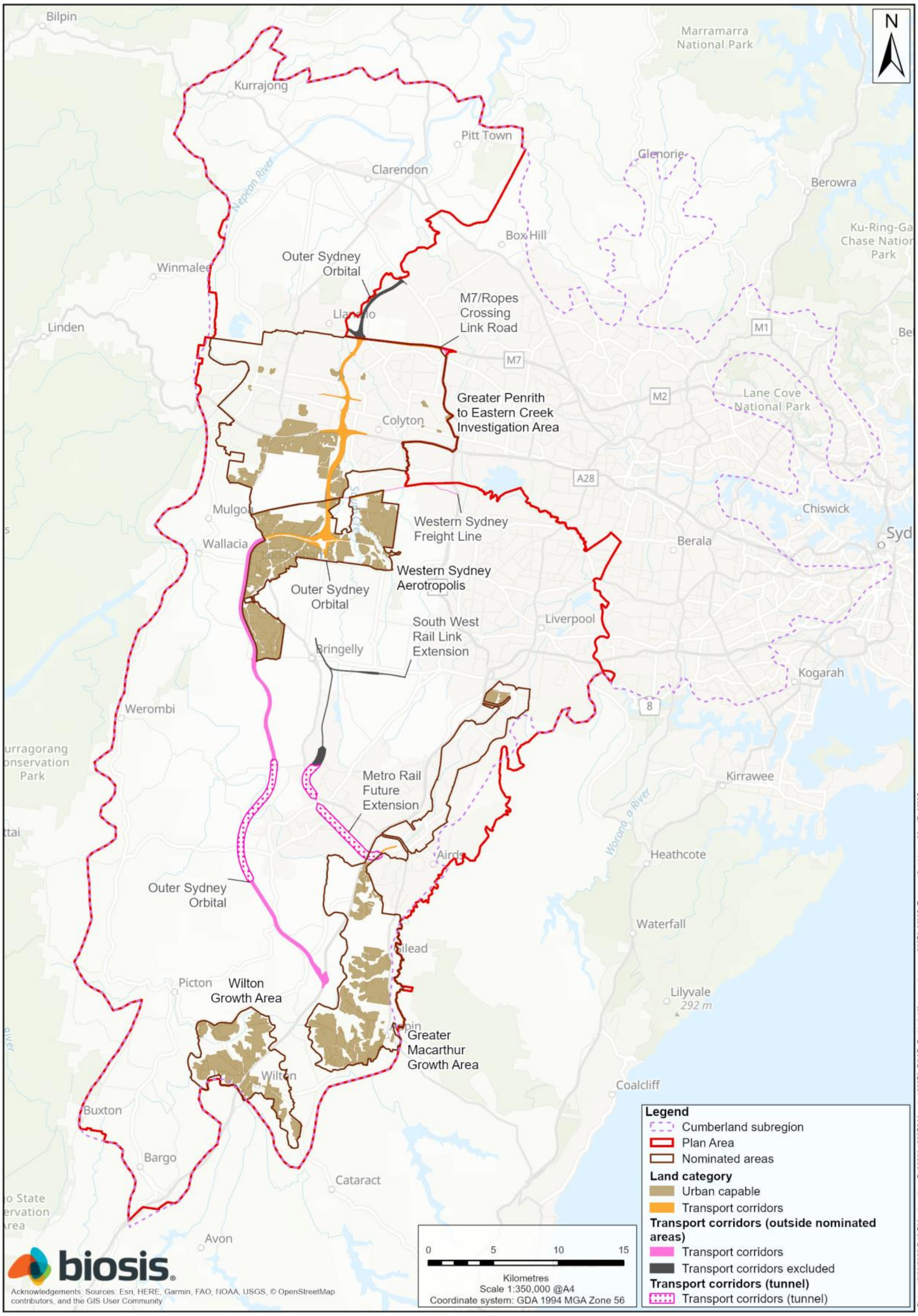

Figure 7-6: Indicative locations of transport corridors

8 Conservation program of the Plan

8.1 INTRODUCTION

The Plan includes a conservation program to achieve the Plan's objective to "deliver biodiversity outcomes and support the ecological function of the Cumberland Plain…" and offset the impacts of the development on biodiversity values.

This Chapter describes the conservation program under the Plan, including:

- Overview of the conservation program
- Commitments and actions to deliver the conservation program
- Koala conservation program
- Development of the conservation program

The conservation program is supported by an implementation framework which sets out how the Plan will be delivered. Chapter 9 provides an overview of the implementation framework.

Part 7 provides a detailed evaluation of the adequacy of conservation program.

8.2 OVERVIEW OF THE CONSERVATION PROGRAM

8.2.1 PURPOSE OF THE CONSERVATION PROGRAM

The purpose of the conservation program is to achieve the Plan's objective and conservation outcomes and offset the impacts of the development on biodiversity values. The conservation program has been designed to maximise ecological function and resilience at the landscape scale in the Cumberland subregion (see Section 8.5).

8.2.2 ELEMENTS OF THE CONSERVATION PROGRAM

The conservation program has five key elements:

1. Avoiding and minimising impacts
2. Mitigating indirect and prescribed impacts
3. Conserving flora and fauna and habitat
4. Managing landscape threats
5. Building knowledge and capacity

The key focus of the conservation program is conserving flora and fauna and habitat by securing priority conservation areas in the Cumberland subregion to offset the impacts of the development on biodiversity values and maximise ecological function and resilience at the landscape scale.

The elements of the conservation program are shown in Figure 8-1.

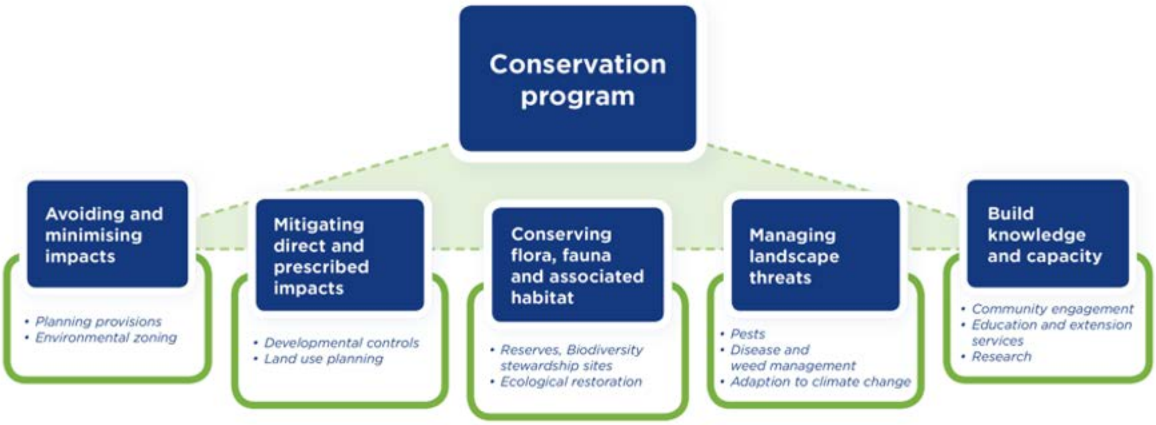

Figure 8-1: Key elements of the conservation program

8.2.3 OUTCOMES

The outcomes of the Plan deliver the Plan's vision and objective. The outcomes of the Plan include economic, social and environmental outcomes. The environmental outcomes of the Plan are:

- Extent and condition of native vegetation increases and improves within areas in the Cumberland subregion most likely to support long-term viability and ecological connectivity
- TECs persist and their condition improves within areas in the Cumberland subregion most likely to support long-term viability
- Populations of targeted threatened species persist and the condition of suitable habitat improves within areas in the Cumberland subregion most likely to support long-term viability
- Condition of riparian corridors within the nominated areas improves

8.2.4 COMMITMENTS

Commitments are what will be done to deliver the Plan's outcomes. The Plan includes commitments relating to each element of the conservation program. The commitments will be implemented over the life of the Plan.

8.2.5 ACTIONS

Actions are what will be done to deliver the commitments. Each commitment has a set of actions associated with it. Actions are set out in the Sub-Plans and may be subject to change following approval of the Plan.

8.3 COMMITMENTS AND ACTIONS TO DELIVER THE CONSERVATION PROGRAM

This Section provides a summary of the key commitments and actions to deliver the conservation program. Further details of the commitments and actions to deliver the conservation program are provided in the Plan.

8.3.1 AVOIDING AND MINIMISING IMPACTS

The Plan includes a commitment (Commitment 2) to avoid and minimise impacts from urban and industrial, and infrastructure development, to at least 4,315 hectares[1] of land within the nominated areas. This includes

- Avoiding 3,670 hectares of native vegetation comprising:
    - 2,735 hectares of native vegetation because of its biodiversity value
    - 935 hectares of riparian corridors and steep land
- Avoiding specific amounts of habitat for Commonwealth and NSW listed TECs
- Limiting cumulative direct impacts from essential infrastructure within non-certified land to the Commonwealth listed Shale Sandstone Transition Forest TEC and prioritising the avoidance of impacts from this infrastructure to specific known populations of flora species and important Koala corridors (see Chapter 37)

This commitment will be delivered through several actions, including:

- Introducing a planning provision to require that the urban capable lands in the precinct plans are consistent with the areas of certified land and avoided lands identified in the Plan
- Applying environmental protection zoning to avoided lands
- Applying further planning controls through the NSW planning system if the avoidance targets are not being met

The Plan includes commitments (Commitment 3 and Commitment 4) for further avoidance and minimisation in relation to the transport corridors, including the tunnel sections of the transport corridors.

Further avoidance in relation to the transport corridors will be undertaken through:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor
- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process)

8.3.2 MITIGATING INDIRECT AND PRESCRIBED IMPACTS

The Plan includes several commitments (Commitment 5, Commitment 6, and Commitment 7) related to mitigating indirect and prescribed impacts. The commitments are to mitigate indirect and prescribed impacts:

- On species and TECs from development, to best practice standards
- On species from transport corridors
- On Koala to best practice standards and in line with the Chief Scientist Koala Report

Sub-plan A identifies actions to deliver these commitments, including:

- Preparing Development Control Plans for each nominated area setting out the development controls to be addressed by neighbourhood plans and development applications to mitigate indirect and prescribed impacts
- Applying the environmental assessment and approval process for each transport project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process)
- A range of mitigation measures for Koala, including:
    - Constructing exclusion fencing between important Koala habitat and urban capable land in Wilton and GMAC
    - Applying development controls within 60 m of Koala habitat in accordance with the *Koala Habitat Protection Guideline* (DPIE, 2020) (made under State Environmental Planning Policy (Koala Habitat Protection) 2019)

[1] Note that the total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target has reduced this figure by 10 per cent to allow for potential future development of essential infrastructure in non-certified land

8.3.3 CONSERVING FLORA AND FAUNA HABITAT

This category of commitments is the key focus of the conservation program (see Figure 8-1). The key commitment of the Plan to offset the impacts of the development on biodiversity values is to protect a minimum of 5,475 ha of impacted native vegetation communities in the Cumberland subregion to conserve biodiversity values in perpetuity.

As part of this commitment, the Plan has committed to:

- Securing specific minimum amounts of Commonwealth and NSW-listed TECs
- Securing populations of species considered at risk of notable impacts
- Undertaking ecological restoration of priority areas
- Securing priority habitat corridors to support connectivity for TECs and species
- Establishing a Georges River Koala Reserve to secure a Koala movement corridor along the Georges River
- Establish at least two new reserves in addition to the Georges River Koala Reserve to protect TECs and species habitat that are targeted for protection under the Plan

PRIORITY AREAS FOR CONSERVATION

The Department has identified Strategic Conservation Areas (SCAs) within the Cumberland subregion within which the commitment to secure 5,475 ha of native vegetation will be prioritised. The SCAs are shown in Figure 8-2.

SCAs represent the areas in the Cumberland subregion containing habitat for biodiversity values impacted by the development that are considered most likely to be viable in the long-term and maximise ecological function and connectivity across the landscape. The process to identify the SCAs is described in Section 8.5.

The Department has developed several approaches to oversee, track and establish conservation lands as offsets over the life of the Plan. These are:

- A series of principles and steps to guide the selection of conservation lands
- A reconciliation accounting process to reconcile offsets acquired through the Plan (including conservation lands) with development impacts throughout the life of the Plan to 2056

The Department will also develop a Conservation Lands Implementation Strategy that will include:

- Priorities for establishing conservation lands
- Targets and timeframes for establishing conservation lands
- Proposed mechanisms for securing each area of priority conservation land
- Suitable land managers for each area of priority conservation land

Other key actions to deliver the offset targets in the Plan include:

- Undertaking surveys prior to securing land for conservation to confirm biodiversity values
- Entering into written agreements with delivery partners to set out the arrangements to secure land for conservation
- Establishing an engagement program to inform landholders about conservation opportunities under the Plan

MECHANISMS TO SECURE CONSERVATION LAND

Land will be secured for conservation in perpetuity through two programs:

- A reserve program to create reserves through acquisition of land
- A Biodiversity Stewardship Agreement (BSA) program to establish BSAs with landholders

The Department may also seek to purchase biodiversity credits from landholders who have already established BSAs to help deliver the offset targets, particularly the species offset targets.

Reserves

Reserves provide the highest level of in-perpetuity biodiversity protection and a range of social benefits not provided by the other commitments, such as public access to natural areas and open space.

There are a range of reserve types proposed under the Plan, including: National Park, Nature Reserve, State Conservation Area, Regional park, Council reserve and community-based reserves. Reserve managers will depend on the type of reserve, and will be determined during implementation of the Plan.

Office of Strategic Lands (OSL) will be responsible for securing land for reserves. Land may be secured through:

- Market purchase (a voluntary negotiated sale with the landholder)
- Owner-initiated acquisition of privately-owned land (where OSL has the right to purchase the land first)
- Active acquisition (where OSL actively engage with the landowner to purchase their land)
- Compulsory acquisition in limited circumstances

Within the first five years of the Plan's implementation, the NSW Government will prioritise the establishment of new public reserves to deliver upfront strategic offsets to protect TECs and species habitat. These are:

- The Georges River Koala Reserve – This is the most important north–south Koala movement corridor along the Georges River between Appin and Kentlyn. In addition to protecting important Koala habitat, the proposed reserve contains around 1,500 hectares of native vegetation, including approximately 375 hectares of Shale Sandstone Transition Forest and 60 hectares of Cumberland Plain Woodland
- The Gulguer Reserve Investigation Area – This investigation area covers about 1,800 hectares and is located in the Warragamba area in the Wollondilly LGA. A reserve in this area will support the east-west connection between Burragorang State Conservation Area and Gulguer Nature Reserve. TECs include approximately 600 hectares of Shale Sandstone Transition Forest and 200 hectares of Cumberland Plain Woodland
- The Confluence Reserve Investigation area – This investigation area lies in the Hawkesbury LGA in the north of the Plan Area, to the east of Londonderry and covers about 600 hectares. It has been identified as a potential area for conservation and ecological restoration efforts due to its proximity to several existing nature reserves

These reserve locations are not final and are likely to be refined. Other areas within the SCAs have also been identified for further investigation as future reserves to provide greater landscape connectivity, such as the Bargo area.

Biodiversity Stewardship Agreements

BSAs are voluntary cooperative agreements between a private landholder and the NSW Government. BSAs are registered on the title of a property to provide in-perpetuity protection of biodiversity values. Landholders are responsible to ongoing management of the land using funding provided via developers.

The Biodiversity Conservation Trust (BCT) will be responsible for overseeing the delivery of the BSA program under the Plan and ensuring compliance with BSAs.

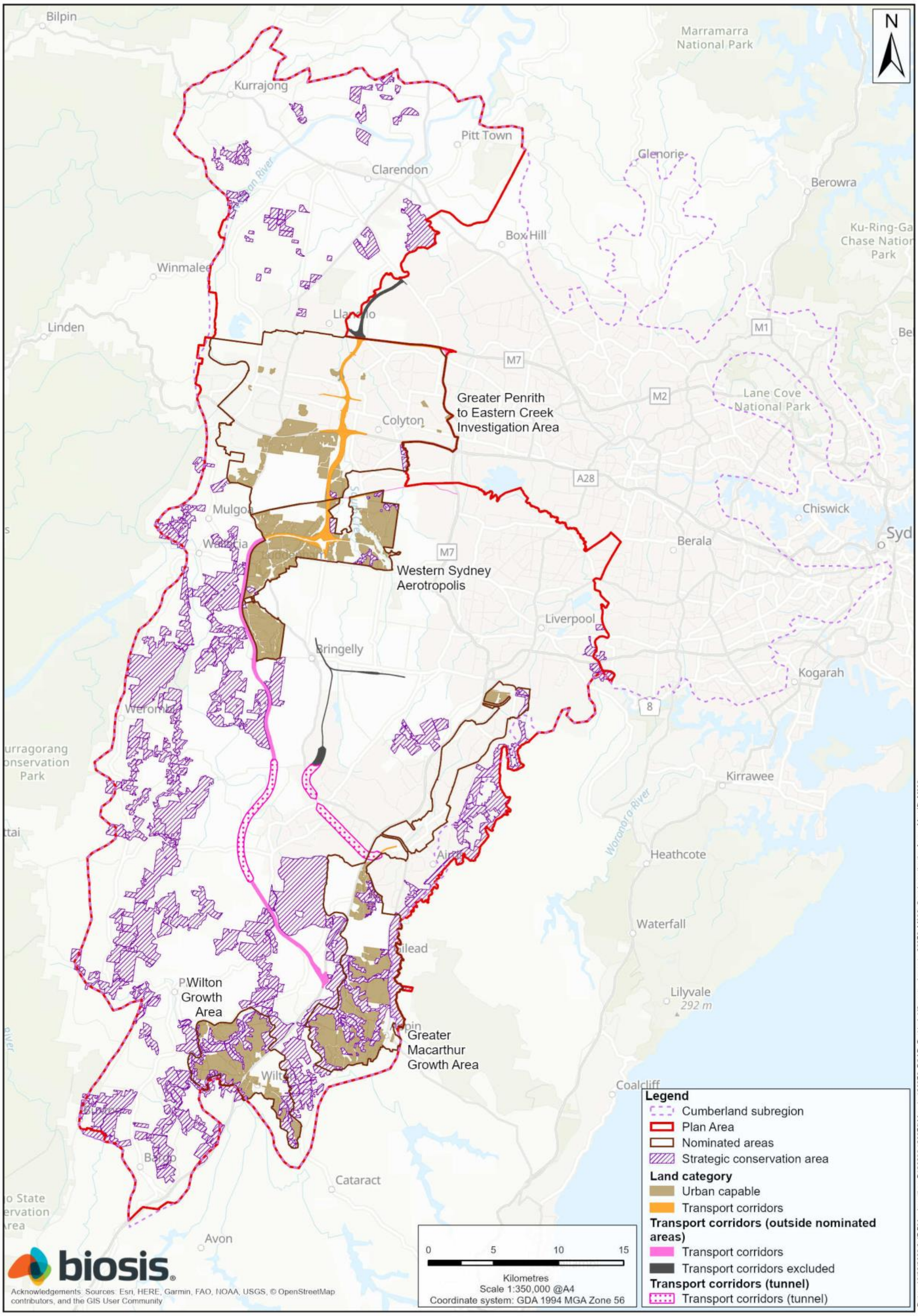

Figure 8-2: Location of Strategic Conservation Areas

RESTORATION OF LAND

As part of the commitments to secure 5,475 ha of native vegetation (Commitment 8) and undertake ecological restoration of priority areas (Commitment 13), there is a target to restore up to 25 per cent of the native vegetation through the ecological restoration of land. A key action to deliver this target includes developing a Restoration Implementation Strategy in consultation with key delivery partners to guide restoration priorities.

Ecological restoration works are intended to be carried out early in the life of the Plan to maximise conservation benefits. Restoration on BSA sites will be overseen by the BCT and undertaken in accordance with BCT guidelines.

INTERIM PROTECTION OF CONSERVATION LAND

The Plan includes a commitment to minimise impacts to biodiversity values on land within SCAs prior to securing land for conservation (Commitment 14). Several actions will be implemented as part of this commitment, including implementing planning controls and preparing a Ministerial Direction to strengthen consideration of biodiversity impacts when planning authorities consider development applications and rezoning applications in these areas.

Planning controls will be applied across the SCAs except for land owned by Local Aboriginal Land Councils (LALCs) or under claim by LALCs. Deerubbin owned land has been excluded from the SCAs at their request. Other LALC owned land and land under claim represents 1,700 ha of the 28,300 ha in the SCAs.

8.3.4 MANAGING LANDSCAPE THREATS

The Plan includes a range of commitments to manage threats to biodiversity in strategic locations in the Cumberland subregion to reduce threats to land secured within SCAs, including:

- Deliver weed and pest control programs (Commitment 16 and Commitment 17) to manage weeds and pests in strategic locations in the Cumberland subregion to reduce threats to conservation lands under the Plan
- Support disease control programs (Commitment 19) to better manage disease affecting fauna within the Cumberland subregion
- Fire management in strategic locations (Commitment 18) to support the maintenance of biodiversity values in conservation lands under the Plan
- Funding for research on biodiversity and climate adaptation in the Cumberland subregion

Actions under these commitments include to:

- Establish working groups for weeds and pest animals to advise on threat management
- Develop more detailed implementation strategies for weeds and pests and in consultation with the working groups and other key stakeholders, including delivery partners, to set out:
  - Priorities for management of the threat
  - Guidance on management approaches
  - Any research needs
  - Delivery arrangements, including the provision of funding under the Plan

The Plan identifies a range of delivery partners to support implementation of these commitments and actions.

8.3.5 BUILDING KNOWLEDGE AND CAPACITY

The Plan includes a range of commitments and actions to build capacity and support stakeholders in relation to biodiversity conservation in the Cumberland subregion, including:

- Providing opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation, including Koala conservation (Commitment 21)
- Providing opportunities for Aboriginal communities in Western Sydney to participate in biodiversity conservation and related economic opportunities arising from the Plan (Commitment 22)
- Providing extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land (Commitment 23)

- Investing in research that will help to secure threatened species and increase understanding of threats and land management issues (Commitment 24)
- Supporting rehabilitation measures to help maintain Koala health and welfare (Commitment 25)

The Plan identifies a range of delivery partners to support implementation of these commitments and actions.

8.4 KOALA CONSERVATION PROGRAM

The Koala is one of Australia's most iconic species and the Plan includes a specific set of commitments and actions to ensure the long-term protection of Koala in the Cumberland subregion.

The key commitment for Koala is to establish a reserve to secure a Koala movement corridor along the Georges River (Commitment 10) between Appin and Kentlyn. Key actions associated with this commitment include to:

- Protect up to 700 hectares of land between Appin and Kentlyn that is currently in ownership of NSW Government as the first stage in establishing the Georges River Koala Reserve
- Protect an additional 430 hectares of land between Appin and Kentlyn through the acquisition of land for the Georges River Koala Reserve
- Protect up to 755 hectares of land between Kentlyn and Long Point as future additions to the Georges River Koala reserve
- Restore up to 200 hectares of cleared land within the Georges River Koala reserve to strengthen the north-south Koala movement corridor

The Plan also includes a commitment relating to supporting habitat connectivity for TECs and species, including Koala (Commitment 12). Actions under this commitment relevant to Koala include:

- Protecting avoided Koala habitat through environmental conservation zoning in potential east-west Koala movement corridors between the Georges River and the Nepean River
- Through restoration, ensuring at least one north-south corridor (the Georges River Koala Reserve) and one east-west corridor are each at least 390m wide, for Koala viability and movement
- Facilitating Koala movement for at least one east-west corridor by constructing a Koala crossing at Appin Road
- Constructing a Koala passage under Kings Fall Bridge to support north-south Koala movement from the Georges River Koala Reserve to the southern Koala habitat

The Plan also includes commitments or actions to:

- Mitigate indirect and prescribed impacts from the development on the Southern Sydney Koala population to best practice standards and in line with the Chief Scientist Koala Report (Commitment 7)
- Investing in the NSW Koala Strategy (OEH, 2018) (under Commitments 21 and 25) to:
  - To implement the Koala health and welfare program in South Western Sydney
  - Raise awareness of the Southern Sydney Koala population

Koala movement corridors are shown in Figure 8-3.

Further details on the Koala conservation program are provided in Sub-Plan B.

8.5 DEVELOPMENT OF THE CONSERVATION PROGRAM

The conservation program was informed by two key processes to identify priority areas for conservation and establish offset targets that will adequately offset the impacts of the development on biodiversity values.

- A method to identify SCAs (called the Conservation Priorities Method)
- Establishment of offset targets

8.5.1 CONSERVATION PRIORITIES METHOD

The SCAs were identified through a Conservation Priorities Method. The method combines detailed spatial information about biodiversity values with an analysis of constraints and opportunities to identify an optimal mix of potential conservation sites to offset the impacts of the development on biodiversity values.

The method builds on the significant amount of strategic conservation planning that has occurred in the Cumberland subregion over the last decade, including the Cumberland Plain Recovery Plan (DECCW, 2011) and Biodiversity Investment Opportunities Map (OEH, 2015).

The method is summarised in Box 2 (taken from Sub-Plan A).

Box 2: Summary of Conservation Priorities Method

The Method uses multi-criteria analysis to achieve a ranking of conservation priorities, using three stages:

Stage 1 – Ecological assessment

The first stage identifies the areas of highest biodiversity value based on an ecological assessment of remaining vegetation patches and their proximity to key features and applying a set of criteria that would either constrain or permit that area to be used as an offset

Thresholds for the minimum area of offset required for each target Plant Community Type (PCT) were identified based on impact, predicted offset required and the amount of each PCT remaining in the landscape after the application of phase '0' constraints

Offset requirements were determined by applying a matrix that applies an offset ratio to all impacted entities based on their conservation status and condition. In accordance with the matrix, the offset ratio increases both as conservation significance increases and as the condition of vegetation improves

Phase 2 – Constraints Assessment

The remaining vegetation and species habitat available for potential offset is assessed for further constraints that could challenge the implementation of commitments

Stage 3 - Conservation priorities assessment & offset selection method

The final stage identifies suitable conservation areas based on Stages 1 and 2 using vegetation and species offset selection methods (noting that the selection of suitable offset areas is done from the ground up', i.e. from PCT and threatened species habitat to the landscape scale)

The SCAs will be updated over the life of the Plan using up to date information on biodiversity values, constraints and opportunities. A program of ground-truthing will be undertaken to confirm the biodiversity values of the SCAs consisting of desktop and aerial assessment (using satellite imagery) and on-ground surveys.

The Conservation Priorities Method will be reviewed in line with the Plan's 5-yearly review process.

8.5.2 DEVELOPMENT OF OFFSET TARGETS

The conservation program includes commitments to secure 5,475 ha of native vegetation in conservation lands. As part of this commitment, the Plan establishes offset targets for specific biodiversity values to ensure that the commitment addresses the biodiversity values being impacted. Offset targets have been developed for:

- Each impacted Commonwealth-listed TEC
- Each impacted NSW-listed TEC
- Commonwealth and NSW-listed species likely to be at risk of residual adverse direct impacts

An analysis of how the conservation program and offset targets meets the principles of the EPBC offsets policy (DSEWPC, 2012) is provided in Part 7.

Threatened ecological community offset targets

The Department developed an approach for defining offset targets to ensure that the commitments address the biodiversity values being impacted. The offset target method determined offset targets on the basis of the amount (ha) of each impacted matter, the conservation status of the impacted matter and the condition of the impacted matter.

This approach is explained in detail in the Conservation Priorities Method that supports the Plan.

Table 8-1 identifies the offset targets for each impact TEC.

Table 8-1: Offset targets for threatened ecological communities

Matter	Offset target
Commonwealth-listed TECs	
Shale Sandstone Transition Forest	715 ha
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	575 ha
Coastal floodplain eucalypt forest of eastern Australia (subject to listing)	575 ha
Cooks River Castlereagh Ironbark Forest	105 ha
Coastal Swamp Oak Forest	5 ha
NSW-listed TECs/PCTs	
Cumberland Plain Woodland	3,170 ha
Shale Sandstone Transition Forest	1,540 ha
River-flat Eucalypt Forest	450 ha
Shale Gravel Transition Forest	150 ha
Cooks River Castlereagh Ironbark Forest	110 ha
Swamp Oak Floodplain Forest	50 ha
Freshwater Wetlands on Coastal Floodplains	5 ha
Moist Shale Woodland	0.2 ha

Species offset targets

Species offset targets were developed for each Commonwealth and NSW-listed species likely to be at risk of residual adverse impacts from the direct impacts of development under the Plan.

The determination of what species need offsets was based on:

- Commonwealth-listed species – assessments of the level of risk of residual adverse impacts as a result of the direct impacts of development under the Plan undertaken for each species in Chapter 29 and 30
- NSW-listed species – a set of criteria that aims to address the risk of residual adverse direct impacts

This risk-based approach was undertaken because the spatial and temporal scale of the Plan means that there is an inherent level of uncertainty in the baseline data (both for species habitat and records). In particular, the potential habitat mapping for the majority of species is highly precautionary and does not necessarily indicate with great certainty if a species will occur in an area impacted by the development. It is critical therefore to understand the level of risk to each species rather than take a simplistic view of direct impacts to potential habitat as presented in the impact numbers.

The approach to determining risk for Commonwealth and NSW-listed species was different because of the different methods used to assess impacts on these species used in the Assessment Report.

Species offset targets for Commonwealth and NSW-listed species are identified in Table 8-2.

Table 8-2: Offset targets for species

Species	Cth status	NSW status	Offset target
Cynanchum elegans	E	E	2 offset locations
Dillwynia tenuifolia	-	V	3 offset locations
Epacris purpurascens var. *purpurascens*	-	V	1 offset location
Grevillea juniperina subsp. *juniperina*	-	V	3 offset locations
Hibbertia fumana	-	CE	1 offset location
Hibbertia puberula	-	E	1 offset location
Koala	V	V	610 ha of important habitat
Marsdenia viridiflora subsp. *viridiflora*	-	E	1 offset location
Meridolum corneovirens	-	E	3 offset locations
Persoonia nutans	E	E	2 offset locations
Pimelea spicata	E	E	3 offset locations
Pultenaea parviflora	V	E	2 offset locations
Pultenaea pedunculata	-	E	1 offset location
Southern Myotis	-	V	2 offset locations
Swift Parrot	CE	E	4,470 ha of potential foraging habitat

Commonwealth-listed species

The determination of what Commonwealth-listed species need offsets was based on assessments of the level of risk of residual adverse direct impacts undertaken for each species in Chapter 29 and 30. A detailed description of the risk framework applied to assess each Commonwealth-listed species is provided in Chapter 29 and 30.

Risk is generally considered to be the combination of the likelihood and consequence of an event occurring. In summary, the risk framework involved consideration of:

- Likelihood that a species will be directly impacted due to impacts to populations and/or potential habitat, taking into account records and potential habitat mapping, as well as level of confidence in these
- Consequence of the direct impacts, taking into account conservation status, SAII entities, endemicity, and thresholds that were specified for the amount of direct impact on populations and potential habitat due to the development

The risk framework also included an assessment of the likelihood and consequence of impacts due to fragmentation, as well as an amended approach to determining risk for wide-ranging fauna (such as Swift Parrot).

The species considered to require offsets were those with a high or medium risk of residual adverse impacts. These were:

- *Cynanchum elegans*
- Koala
- *Persoonia nutans*
- *Pimelea spicata*
- *Pultenaea parviflora*
- Swift Parrot

Offsets were not considered necessary for species which are considered to be at low or very low risk.

Species offset targets are specified under the Plan in terms of:

- Number of ‘offset locations’

- Hectares of foraging habitat for Swift Parrot
- Hectares of important habitat for Koala

An 'offset location' is a site where one or more populations and habitat of the species has been confirmed through surveys or an expert report as being present. Offset location sites may be reserves or BSA sites (see Section 8.3.3).

Specifying offset targets in terms of number of 'offset locations' rather than amounts of potential habitat was considered the most robust approach. This is because it ensures known habitat and populations will be secured and managed in perpetuity, rather than merely potential habitat with no certainty that the species will benefit from the offset.

For Swift Parrot, 'potential foraging habitat' was used as the offset target. This species is a species credit species for 'important habitat' under the BAM, however, only potential foraging habitat will be impacted by the development.

For Koala, 'important habitat' (defined as primary and secondary corridors – see Part 3) was used as the offset target as this has been mapped in the Plan Area and will be impacted by the development.

The method to determine the 'offset location' targets for each species was based on a combination of the identified level of risk of residual adverse direct impacts (high or medium) and conservation status. Consistent with the approach for determining offset targets for TECs, Swift Parrot, and Koala, species with a higher conservation status (as well as a higher risk of residual adverse direct impacts) required larger offset targets. This is shown in Table 8-3.

Table 8-3: Method to determine offset targets for species with offset locations targets

Risk of residual adverse direct impacts	Conservation status		
	V	E	CE
High	2 offset locations	3 offset locations	4 offset locations
Medium	1 offset locations	2 offset locations	3 offset locations

Offset targets for Swift Parrot and Koala were determined by applying an approach developed by the Department consistent with the approach for determining TEC targets. As for TECs, targets were determined on the basis of the amount (ha) of habitat of each matter impacted by the development, and were driven by two key principles:

- Impacts to higher conservation status matters require more offsets that lower status matters
- Impacts to higher condition habitat require more offsets than lower condition habitat

This approach is explained in detail in the Conservation Priorities Method that supports the Plan.

NSW-listed species

As the method to assess impacts to NSW-listed species is different to Commonwealth-listed species and does not involve an assessment of risk around residual direct impacts, NSW-listed species needing offset targets were considered to be candidate species credit species directly impacted by the development in relation to:

- Species populations, or
- Habitat for highly restricted species (endemic or largely endemic to the Cumberland Plain) that was considered likely to contain the species (records not present), based on advice of the ecological consultants, or
- Priority management sites for site-managed species under the SOS program

Consistent with the BAM, offsets for ecosystem credit species are addressed through NSW TEC/PCT offsets.

Note that where a NSW-listed species met these criteria but was assessed under the Commonwealth approach (as it was also a Commonwealth-listed species), the determination of whether the species needed an offset target, and the offset target required, was based on the approach to Commonwealth-listed species. For example, there are direct impacts to records of Green and Golden Bell Frog, Grey-headed Flying Fox, and *Grevillea parviflora* subsp. *parviflora*, however, these species were not determined to have a high or medium risk rating under the risk framework.

There were also direct impacts to habitat for Little Eagle and White-bellied Sea Eagle where prior records exist. These species are Serious and Irreversible Impact entities and have been assessed in detail in Chapter 25. Impacts to breeding habitat for these species was not considered to be significant and no specific offsets for these species were considered to be needed.

Table 8-4 identifies the NSW only-listed species (not Commonwealth-listed) that meet the above criteria.

Table 8-4: NSW only-listed species (not Commonwealth-listed) considered to need offset targets

Species	Status	Rationale
Dillwynia tenuifolia	V	Direct impacts to records
Epacris purpurascens var. *purpurascens*	V	Priority management site under the SOS program occurs within urban capable land in the southern part of Wilton
Grevillea juniperina subsp. *juniperina*	V	Direct impacts to records
Hibbertia fumana	CE	Direct impacts to habitat considered likely to contain the species (records not present), based on advice of the ecological consultants
Hibbertia puberula	E	Direct impacts to habitat considered likely to contain the species (records not present), based on advice of the ecological consultants
Marsdenia viridiflora subsp. *viridiflora*	E	Direct impacts to habitat considered likely to contain the species (records not present), based on advice of the ecological consultants
Meridolum corneovirens	E	Direct impacts to records
Pultenaea pedunculata	E	Direct impacts to records
Southern Myotis	V	Direct impacts to records

Because the potential habitat mapping for the majority of species is highly precautionary and is not an appropriate basis for determining offset targets, a method was developed to refine the habitat mapping for each species in Table 8-4. The purpose of this was to determine the area of habitat for each species where there is a higher level of certainty that impacts will occur to the species from the development under the Plan. This refined mapping was done using records and the native vegetation mapping prepared for this Assessment Report and by:

- Collating species records from the NSW BioNet and project surveys
- Identifying all vegetation zones that intersected with the collated species records or a 30 m buffer surrounding the records (the entire vegetation zone was selected where an intersect occurred)
- Combining the habitat model for the species with the vegetation zones selected above, leaving only areas common between the two data sets

Consistent with the approach for TECs, offset targets were derived based on the refined area of habitat for each species impacted by the development under the Plan and the conservation status of the species.

The number of offset locations was then calculated as follows:

- Area of refined habitat impacted of 0 – 50 ha – 1 offset location
- Area of refined habitat impacted of 50 – 100 ha – 2 offset locations
- Area of refined habitat impacted of 100 + ha – 3 offset locations

For the *Hibbertia* and *Epacris* species where no habitat areas containing prior records are impacted, a refined area of habitat was not able to be determined. The target for these species was determined to be one offset location on the basis that impacts are not certain and few populations of *Hibbertia* species are known to occur (particularly *Hibbertia fumana*).

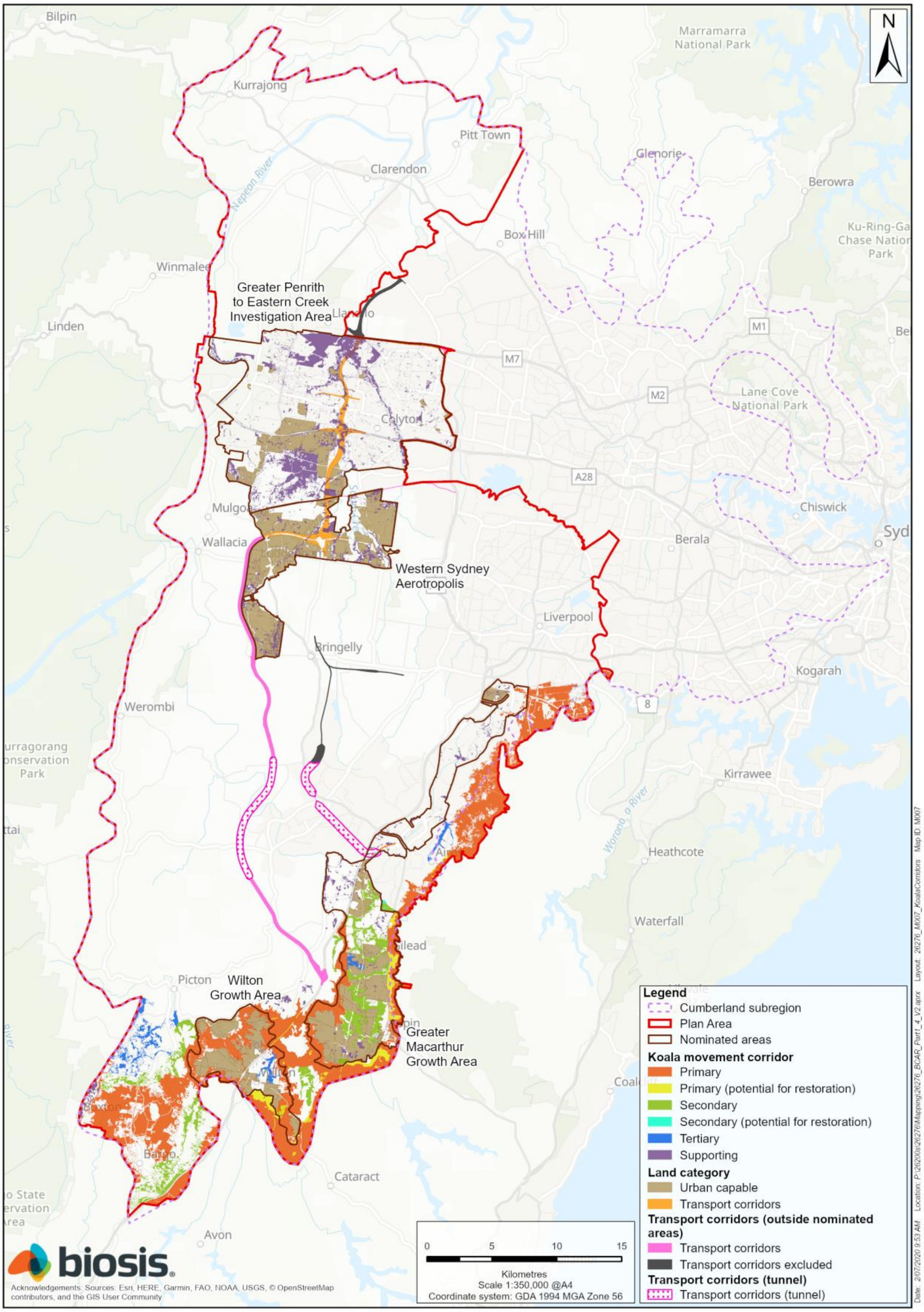

Figure 8-3: Key Koala movement corridors within the Plan Area

9 Implementation framework for the Plan

9.1 INTRODUCTION

The Plan includes an implementation framework to ensure successful delivery of the Plan and provide assurance to approval bodies that the Plan is being delivered in accordance with conditions of approval.

This Chapter describes the implementation framework for the Plan, including:

- Delivery mechanisms
- Roles and responsibilities
- Funding
- Monitoring, evaluation and reporting and adaptive management
- Compliance

This chapter provides an overview of each element of the implementation framework.

9.2 DELIVERY MECHANISMS

9.2.1 NSW PLANNING SYSTEM

Implementation of the Plan will be supported by the NSW planning system.

The Department has committed under the Plan to undertake urban and industrial, infrastructure, agribusiness and transport development in accordance with the Plan and any conditions of approval. Sub-Plan A includes an action to integrate the Plan into the planning delivery framework for the nominated areas through planning mechanisms including zoning, development controls, ministerial directions and development guidelines.

PROPOSED STATE ENVIRONMENTAL PLANNING POLICY

The Department is proposing a new State Environmental Planning Policy (SEPP) for strategic conservation planning to implement the Plan's strategic conservation planning requirements. The objectives of the proposed SEPP include to:

- Ensure development in the nominated areas is consistent with NSW Government and Australian Government biodiversity approvals
- Facilitate appropriate development on biodiversity certified areas
- Identify and protect areas of high value biodiversity in the nominated areas
- Identify areas across the Plan Area that have high-value biodiversity and/or strategic biodiversity values that can support the ecological function of the Cumberland subregion, including threatened ecological communities and species, and areas with important connectivity or ecological restoration potential
- Minimise impacts from future development on biodiversity values in areas of high-value biodiversity
- Support the acquisition of priority areas of high-value biodiversity in the Cumberland subregion as conservation lands in perpetuity
- Minimise impacts to biodiversity values on land secured for conservation from adjoining land uses

The proposed SEPP will include:

- Environmental conservation (E2) zoning that will be applied to areas that are identified in the Plan as non-certified because they are avoided for biodiversity purposes, or other purposes (riparian corridors, steep land). Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land[2]

- Planning controls for the SCAs to minimise impacts from development on areas of high biodiversity value, improve the management of biodiversity and help protect TECs and species in these areas. Note that planning controls will be applied across the SCAs except for land owned by LALCs or under claim by LALCs. Deerubbin owned land has been excluded from the SCAs at their request. Other LALC owned land and land under claim represents 1,700 ha of the 28,300 ha of the SCAs
- Consistency clause for urban development to ensure consistency between the urban capable land identified in precinct plans and areas of urban capable land identified by the Plan, to contain urban development to the urban capable lands and ensure avoided lands remain outside the development areas
- Acquisition clauses that allow the relevant acquisition authority to secure lands suitable for public reserves, such as national parks and council reserves

OTHER PARTS OF THE PLANNING SYSTEM

The other key parts of the planning system that will be used to implement the Plan are shown in Table 9-1.

Table 9-1: Key parts of the planning system and relationship with the Plan

Planning mechanism	Description and relationship to Plan
Strategic plans, such as Land Use and Infrastructure Implementation Plans (LUIIPs)	LUIIPs are high-level strategic plans that set the vision and strategic direction of each nominated area, consistent with the Greater Sydney Region Plan and District Plans LUIIPs will include the boundaries of urban capable lands identified for development through this Plan, and identify as potential environmental or conservation areas high biodiversity land avoided by the Plan
Precinct plans	Precinct plans identify land uses, development and infrastructure for each precinct and are prepared consistent with the relevant strategic plan/LUIIP Precinct Plans will be required to be consistent with the biodiversity approvals under the Plan, and specifically to identify the urban capable land as the certified land mapped by the Plan
Neighbourhood plans	Neighbourhood plans show the detailed structure of a future neighbourhood, including lot yields, residential densities, movement networks, open space, and environmentally sensitive land Neighbourhood plans must be generally consistent with a Precinct Plan and address the controls in the Development Control Plan, and are approved prior to the approval of Development Applications Neighbourhood plans include development requirements that apply at a neighbourhood level, and must include plans for: • Water management, including stormwater drainage and riparian corridors. • Open space, including retention of trees and native vegetation • Protection of environmentally sensitive areas

[2] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10% to allow for potential future development of essential infrastructure in non-certified land

Planning mechanism	Description and relationship to Plan
Development Control Plans (DCPs)	DCPs include detailed planning and design requirements, objectives and additional development controls that apply at a neighbourhood and lot level to be considered by consent authorities in assessing and determining development applications A DCP is a planning policy that supplements development standards and provisions within environmental planning instruments. DCPs support the implementation of planning controls in the SEPP, Local Environmental Plans (LEPs), or precinct or neighbourhood plan DCPs may include planning principles, as well as objectives, requirements and development standards that address biodiversity and mitigate indirect and prescribed impacts
Development applications	Subdivision and development in the nominated areas will require development consent, as well as appropriate approvals covering any further environmental assessment required under other legislation (not biodiversity) Development applications in nominated areas will need to be consistent with the biodiversity approvals under the Plan, and will need to occur within the certified land mapped by the Plan
Environmental protection zoning	Environmental conservation (E2) zoning will be applied to areas that are identified in the Plan as non-certified because they are avoided for biodiversity purposes, or other purposes (riparian corridors, steep land) Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land
Ministerial Directions	The Department proposes to introduce a Ministerial Direction under section 9.1 of the EP&A Act. The direction will apply to avoided land and the SCAs as mapped in the proposed SEPP. It will restrict the ability to rezone avoided land, increase development or intensify land uses in the SCAs, and require a relevant planning authority to ensure any planning proposals consider the land use objectives that apply to avoided land and, for the SCAs, the matters for consideration in the planning controls that apply to the area Note that planning controls will be applied across the SCAs except for land owned by LALCs or under claim by LALCs. Deerubbin owned land has been excluded from the SCAs at their request. Other LALC owned land and land under claim represents 1,700 ha of the 28,300 ha of the SCAs

9.2.2 IMPLEMENTATION DOCUMENTS

The Plan includes several actions that provide for the preparation of detailed implementation documents that will support the implementation of the Plan. Key implementation documents include:

- Conservation Lands Implementation Strategy to guide the securing of land for conservation (see Chapter 8)
- Restoration Implementation Strategy (see Chapter 8)
- Weed and pest animal control implementation strategies to guide delivery of the weed and pest programs
- Reconciliation accounting process to track progress in meeting offset targets
- Written agreements with delivery partners to set out delivery arrangements
- Compliance strategy

9.3 ROLES AND RESPONSIBILITIES

The Department is the responsible agency for implementing the Plan and meeting regulatory requirements as the party to strategic biodiversity certification under section 8.9 of the BC Act, and is the approval holder under section 146B of the

EPBC Act. The NSW Minister for Planning is the applicant for strategic biodiversity certification and strategic assessment approval. The transport corridors program is administered by Transport for NSW.

The governance framework for the Plan is shown in Figure 9-1.

Roles and responsibilities for implementing the Plan fall under the following categories:

- Oversight bodies
- Co-ordinating bodies
- Delivery partners
- Agency partners

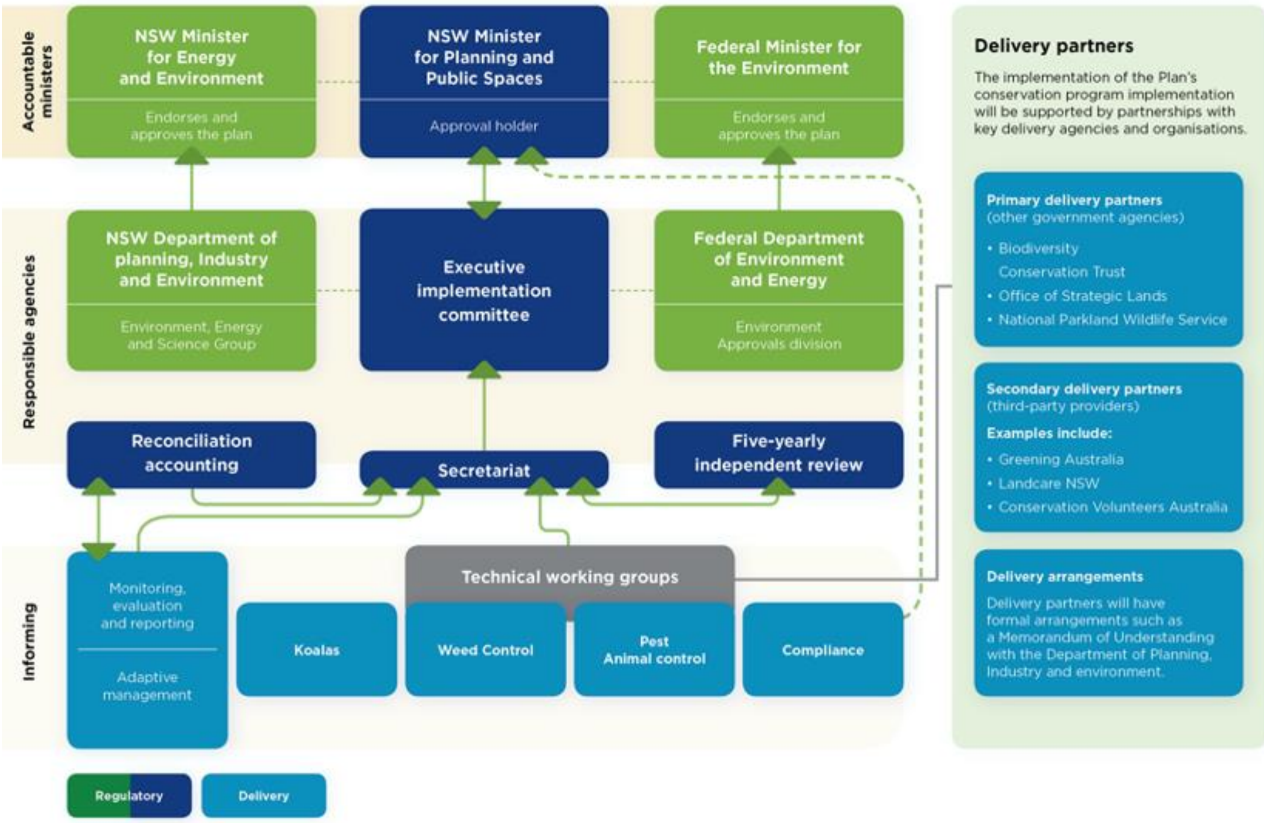

Figure 9-1: Governance framework for the Plan

9.3.1 OVERSIGHT BODIES

An executive implementation committee will be established under the Plan that includes executive level representatives from the Department, approval bodies and partner agencies to act as a steering committee for the Plan.

The executive committee will be the key decision-making authority to determine the appropriate course of action on matters raised, or whether issues need to be escalated for ministerial attention.

9.3.2 CO-ORDINATING BODIES

The Department is the responsible agency for implementing the Plan and meeting regulatory requirements as the party to strategic biodiversity certification under the BC Act, and is the approval holder under the EPBC Act.

The Department's roles will include:

- Reporting to the Minister and preparing progress reports on the implementation and performance of the Plan

- Central coordination of the Plan, through:
  - Steering committees and associated sub-groups and committees
  - Coordinating delivery partners including setting delivery/reporting requirements
  - Contract/grant management
  - Ensuring reports from delivery partners/other relevant agencies feed into Plan's reporting framework
- Overseeing compliance with the Plan

9.3.3 DELIVERY PARTNERS

A range of delivery partners will be responsible for delivering programs under the Plan, including:

- NSW Government bodies, such as:
  - Office of Strategic Lands – key responsibilities include acquisition of reserves under the reserve program
  - National Parks and Wildlife Service – key responsibilities include long-term management of reserves established under the *National Parks and Wildlife Act 1974*
  - Biodiversity Conservation Trust – key responsibilities include delivering the BSA program
- Councils – key responsibilities include administering planning controls and management of council reserves
- Community organisations – key responsibilities include management of smaller community reserves

Service level agreements or memorandums of understanding will be prepared as part of the process of engaging delivery partners to clarify the roles and responsibilities of each delivery partner and to ensure accountability.

9.3.4 AGENCY PARTNERS

Agency partners are involved with planning, delivery and oversight of transport infrastructure, in addition to avoiding, mitigating and offsetting transport environmental impacts. The key agency partner is Transport for NSW.

9.4 FUNDING

The NSW Government will establish a conservation fund to implement the conservation program under the Plan, including the securing of reserves and BSA sites for conservation in perpetuity.

The final Plan will include a commitment for upfront funding to deliver conservation priorities in the first five years of the Plan, including the three new priority reserves (see Chapter 8).

Funding is proposed to be secured using a public-private funding model. The model involves upfront investment from the government and partial cost-recovery from industry through the biodiversity component of a Special Infrastructure Contribution (SIC) levy imposed on housing development in the nominated areas.

Cost recovery from industry will ensure developers contribute to the cost of infrastructure, including the offsetting of biodiversity impacts. Developer contributions will increase annually in line with the medium-term average of the Producer Price Index to ensure industry contributions broadly align with the costs of production.

To establish the funding arrangements, the NSW Government will:

- Establish a biodiversity component of the SIC levy to be applied to developers within the nominated areas
- Establish a Trust to administer funds on behalf of the Department
- Prepare a funding framework in consultation with the Trust to set out details of the cost recovery model and how funding decisions will be made and administered

9.5 MONITORING, EVALUATION, REPORTING AND ADAPTIVE MANAGEMENT

The Plan commits to implementing a monitoring, evaluation and reporting (MER) program over the life of the Plan. Details of the MER framework are provided in Sub-Plan A. The MER framework provides for:

- Monitoring of the delivery of actions and commitments and achievement of outcomes
- Evaluation of the Plan to inform adaptive management responses

- Public reporting on progress in delivering the Plan

The MER framework has been developed on the basis of the program logic underpinning the Plan (see Chapter 5). The key elements of the MER framework are outlined in Figure 9-2.

An MER plan will be prepared during implementation to support the MER framework, including to:

- Identify key performance indicators for biodiversity conservation and report on actions and commitments
- Set out monitoring and data collection procedures
- Identify the scope and frequency of evaluations and key evaluation questions
- Describe how monitoring and evaluation will be used to adaptively manage implementation of the Plan, including defining the scope of potential changes

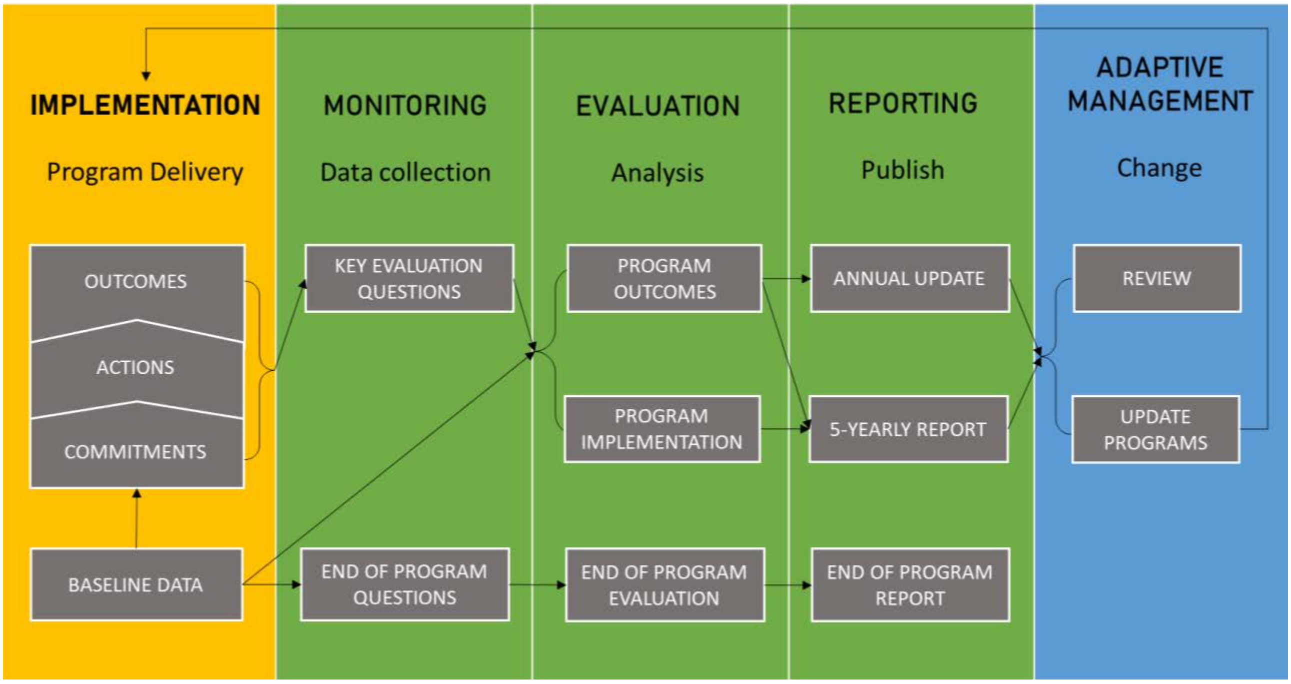

Figure 9-2: Key elements of the MER framework

MONITORING

Monitoring will be designed to inform the evaluations and Key Evaluation Questions and will include:

- Monitoring of the delivery of commitments and actions
- Monitoring of the achievement of the Plan's outcomes

The Department will establish a process to identify what monitoring data is already collected and what further data needs to be collected to establish baselines and support monitoring needs.

Formal agreements will be established with delivery partners and include detailed data collection, management and sharing arrangements and reporting templates. This will streamline data collation and reporting processes for the Plan and feed directly into the adaptive management process.

EVALUATION

Evaluations will be undertaken regularly throughout the implementation of the Plan.

The evaluations will aim to:

- Determine the effectiveness of actions, targets and commitments to deliver outcomes

- Reconsider assumptions made as part of the program logic
- Determine the influence of external factors outside the control of the Plan
- Inform any necessary adaptive management decisions to the implementation of the Plan

Two types of evaluations will be done:

- Evaluation of deliverables – this will evaluate the delivery of commitments and actions
- Evaluation of program – this will evaluate the efficiency and effectiveness of delivery and achieving the outcomes of the Plan, including evaluation of the Plan's success in terms of impact, appropriateness of design and logic, resource efficiency and any external factors that may have contributed to results

The evaluations will be done on the basis of Key Evaluation Questions. The evaluation questions will be designed to measure the Plan's progress and the effectiveness of delivering its commitments and outcomes by asking questions that will reveal the cause of any shortfall or prompt adaptive management for a more effective result.

PUBLIC REPORTING

The Department will prepare an annual update on the delivery of the Plan's commitments and actions. The annual updates will include information from the Key Evaluation Questions and include reporting on program revenue and expenditure. The NSW Government will also collate finer scale program and project reporting from the relevant delivery partners more frequently to support adaptive management over the life of the Plan.

The Department will prepare a fire-yearly report on the status of the Plan, its delivery and interim outcomes. The report will be approved by the NSW Minister for Planning and provided to the NSW and Australian Government Environment Ministers.

The annual update and the five-yearly report as well as other relevant data and information will be made publicly available via the Department's website and published in accordance with the NSW Government's accessibility requirements. They will remain available throughout the life of the Plan.

ADAPTIVE MANAGEMENT

The Plan will be implemented adaptively to ensure the commitments and actions are delivered and the outcomes are achieved efficiently and effectively. Adaptive management will be triggered on the basis of the findings of the evaluations and will be informed by the monitoring data collected as part of the MER framework.

The approach to adaptive management under the Plan is further described in Chapter 16.

9.6 COMPLIANCE

The Plan will be implemented under several existing mechanisms, particularly the NSW planning system.

As the primary mechanism to implement the Plan is the NSW planning system, most mechanisms that will be used to ensure compliance with the Plan and conditions of approval sit under the planning system.

A compliance strategy will be prepared under the Plan to ensure that the development occurs in accordance with the Plan and conditions of approval. The development of the compliance strategy will be informed by a compliance task force that will be established early during Plan implementation. The compliance strategy will:

- Identify relevant compliance mechanisms
- Set out compliance monitoring and auditing priorities and processes
- Set out a framework to make decisions on appropriate actions for non-compliance
- Set out procedures and protocols for taking compliance action
- Identify roles and responsibilities for compliance monitoring and action

The Plan will provide funding for at least three Council-based surveillance officers to ensure compliance with the Plan.

Part 2 References

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 3: ASSESSMENT APPROACH AND METHODS

CHAPTER 10 – OVERVIEW

CHAPTER 11 – APPROACH TO UNDERSTANDING BIODIVERSITY VALUES

CHAPTER 12 – APPROACH TO THE IMPACT ASSESSMENT

CHAPTER 13 – DATA AND LIMITATIONS

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

DOCUMENT TRACKING

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Part 3 Contents

Part 3 List of Tables

This Part sets out the approach and methods used to prepare the Assessment Report:

- Chapter 10: Provides an overview of the assessment approach
- Chapter 11: Describes the approach and methods for understanding the biodiversity values and other matters that require assessment within the Plan Area
- Chapter 12: Describes the approach to analysing the impacts of the development under the Plan
- Chapter 13: Provides an overview of the data used in the Assessment Report and the limitations with the data

10 Overview

This Chapter sets out:

- Overview of the scope of the assessment
- Summary of the Biodiversity Assessment Method (BAM) that applies to the Biodiversity Certification Assessment Report (BCAR) and the Terms of Reference that applies to the Strategic Assessment Report (SAR)
- Discussion of the key steps in the assessment process
- Overview of the peer review processes for key methods

10.1 SCOPE

The scope of the assessments under the BC Act and EPBC Act are different (see Part 1). This relates to both:

- The development that is being assessed for approval
- The impact assessment requirements under each piece of legislation

The assessment approach was designed to meet the requirements of the assessment processes under both the BC Act and EPBC Act (see Table 10-1), as well as address the various overlaps and differences.

Table 10-1: Impact assessment requirements of the BC Act and the EPBC Act*

Legislation	Impact assessment requirements	Comments
BC Act	Relevant provisions of the legislation and regulations	The Cumberland Plain Conservation Plan (the Plan) is being assessed as a strategic application for biodiversity certification under Part 8 of the BC Act. The relevant regulatory provisions need to be met
	BAM	The BAM specifies the requirements for the BCAR
	Draft guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification (Draft Version 6)(EES, 2019)	The EES Guidelines "*provide guiding principles for demonstrating that the conservation measures proposed for a strategic application for biodiversity certification adequately address impacts on biodiversity values under section 8.7 of the BC Act*". The Guidelines need to be addressed
EPBC Act	Relevant provisions of the legislation and regulations	The Plan is undergoing strategic assessment under Part 10 of the EPBC Act. The relevant regulatory provisions need to be addressed
	Terms of Reference (ToR) for the SAR	The ToR specify the requirements for the SAR
	Relevant statutory documents	The EPBC Act requires that certain statutory documents be considered in the impact assessment process. For example, these include recovery plans, threat abatement plans, and conservation advices
	EPBC Act policies and guidelines	The Australian Government has published a range of EPBC Act policies and guidelines which need to be considered in the impact assessment process

*See Part 1 for detail on the regulatory context of this project

10.2 BIODIVERSITY ASSESSMENT METHOD

The BAM was established under the BC Act to assess impacts on NSW listed threatened species and ecological communities and their habitats. As outlined on the Environment Energy and Science (EES) website:

> "[The BAM] *is a scientific document that provides:*
>
> - *a consistent method for the assessment of biodiversity on a proposed development or major project, or clearing site,*
> - *guidance on how a proponent can avoid and minimise potential biodiversity impacts, and*
> - *the number and class of biodiversity credits that need to be offset to achieve a standard of 'no net loss' of biodiversity."*

The BAM specifies the assessment requirements for the BCAR and was applied within the nominated areas.

The BAM also provides a strong starting point for meeting the EPBC Act ToR. For example, the detailed requirements around data gathering within the nominated areas are also largely appropriate for protected matters.

The BAM is structured around three stages:

- **Stage 1 – Biodiversity assessment**. This stage establishes a consistent approach to identifying and assessing the biodiversity values on land (including the land to be biodiversity certified). It sets out the data gathering requirements for the landscape context, native vegetation, and threatened species
- **Stage 2 – Impact assessment**. This stage provides the method for assessing impacts to biodiversity values. It specifies requirements around:
  - Avoiding and minimising impacts
  - Assessing both direct and indirect impacts
  - Dealing with issues such as prescribed impacts, and serious and irreversible impacts
  - Determining the credits required for meeting the no net loss standard
- **Stage 3 – Improving biodiversity values**. This stage is used to determine the credits that can be created at stewardship sites. This stage does not need to be applied at the time of application for strategic biodiversity certification and has therefore not been applied in this Assessment Report (see Chapter 2)

The outputs of the BAM for this project need to be presented in a BCAR. The components of this Assessment Report that comprise the BCAR are set out in Part 1.

10.3 EPBC ACT TERMS OF REFERENCE

The ToR for the SAR are part of the Strategic Assessment Agreement between the NSW Government and Australian Government. The ToR set out the information requirements that this Assessment Report needs to address for matters protected under the EPBC Act.

Clause 4.2 of the ToR outlines how the Assessment Report should describe the methods used in the assessment:

> *"The Report must describe the method used to understand likely impacts on all protected matters of actions taken under the Plan. The level of the assessment will be proportionate to the level of likely risk to each protected matter. The method must:*
>
> 1. *Be appropriate for assessment at a strategic scale*
> 2. *Rely on the best available information*
> 3. *Discuss uncertainty, including reference to the technical data and information relied upon*
>
> *The Report must identify the data used in the assessment, any limitations it may have, where (or if) the data is available and where it can be accessed, including publicly accessed."*

The ToR specifies the assessment requirements for the SAR and was applied within the Plan Area. The ToR are provided in Supporting Document A.

10.4 PEER REVIEW OF KEY METHODS

Section 4.8 of the ToR for the SAR specifies:

> *"The Report must include justification for key methods used in the assessment, including summaries of independent peer review processes and where the review/s are available to the public."*

The term 'key methods' refers to technical methods for describing the protected matters impacted by the Plan, such as methods used to collect data on protected matters and map the location of protected matters.

The term does not include approaches to understand the likely impacts on protected matters of actions taken under the Plan, such as the approach to assessing direct, indirect and cumulative impacts.

In accordance with section 4.2 of the ToR, the SAR has described these impact assessment approaches in detail and any uncertainties or limitations with them (see Chapter 12 and Chapter 13).

The NSW Department of Planning, Industry, and Environment (the Department) commissioned an independent peer reviewer, Dr Rhidian Harrington, from Niche Environment and Heritage, to review the key methods. The key methods reviewed were:

- The approach to determining the relevant EPBC matters for assessment (see Section 11.1.2)
- The methodology for mapping EPBC listed TECs (see Section 11.4.3)
- The method for identifying important populations of flora and fauna (see Section 11.5.3)
- The approach and criteria for mapping habitat across the Cumberland subregion for approximately 30 threatened species using an expert knowledge-based process (see Section 11.5)
- An evaluation method for determining the viability of the Southern Sydney koala population (see Chapter 30)

The peer review process involved:

- Initial review of key methods by peer-reviewer
- One day workshop with ecological consulting team, technical staff from the Department and peer reviewer to discuss key methods
- Preparation of report that:
  - Sets out the context of the peer review (including expertise of the peer reviewer)
  - Analyses each method against the following questions:
    - Is the general approach to the method appropriate?
    - Are the details of the method appropriate?
    - Are there critical components of the method that need improvement?

The peer review report is provided in Supporting Document B.

The peer review report concluded that in general:

- The datasets, methods for data collection and assumptions associated with the methods are appropriate for a large-scale strategic assessment process such as this project
- The methods used are generally conservative and are unlikely to under-represent the presence or distribution of any TEC or species, and are more likely to over-predict presence and distributions

The report recommended that further details associated with the input data and assumptions be provided in the Assessment Report to provide the regulators and the public more complete understanding of limitations.

The limitations associated with the methods are set out in Chapter 13.

Several other methods were used to prepare the SAR. These methods and a rationale for not undertaking a peer review of them is provided in Table 10-2.

Table 10-2: Rationale for not undertaking peer review of other methods

Method	Rationale
Data collection and surveys for EPBC listed TECs and species	Data collection within the nominated areas was undertaken in accordance with the BAM. The BAM was independently peer reviewed in 2015. The previous formalised biodiversity assessment method – the BioBanking Assessment Method – was also independently reviewed
Species Distribution Modelling for Commonwealth-listed species mapping	The Species Distribution Modelling work was undertaken by a Senior Research Fellow at RMIT University. The modelling process is a well-recognised and peer reviewed method for mapping species habitat at a landscape scale. References to published literature establishing the validity of the method are provided in the Species Distribution Modelling Report (see Supporting Document F) Species experts at EES reviewed several example outputs of the model and provided input into the modelling method
Migratory shorebird mapping	Mapping was undertaken in accordance with EPBC Policy Statement 3.21 (DEWHA, 2009b)
Trend analysis	The trend analysis was undertaken by a Senior Research Fellow at RMIT University. The work involved an expert elicitation process involving eight people considered to be experts on the native vegetation of the Cumberland subregion, including representation from academia. As part of this process, several experts reviewed or provided input into the trend analysis method

11 Approach to understanding biodiversity values

This Chapter describes the approach and methods for understanding the biodiversity values and other matters that require assessment within the Plan Area. It includes information about:

- The approach to identifying NSW and Commonwealth matters needing assessment
- The approach to understanding the landscape context
- The surveying and mapping methods for native vegetation communities
- The mapping methods for threatened ecological communities (TECs)
- The surveying and mapping methods for threatened species and their habitats
- The approach to understanding the other matters protected by the EPBC Act

It should be noted that an initial assessment of the implications of the 2019/2020 NSW bushfires on species impacted by the Plan was also undertaken based on available information. This assessment is set out in Part 1 and Supporting Document G.

11.1 IDENTIFICATION OF MATTERS FOR ASSESSMENT

The BAM and ToR require the Assessment Report to identify the NSW and Commonwealth matters that may occur in the Plan Area and that may be impacted by the development.

Section 6.4 of the BAM provides a process to predict all NSW-listed species that may occur in the nominated areas and consider whether any of these species can be excluded from the assessment based on likelihood of occurrence.

The ToR requires all Commonwealth matters relevant to the Strategic Assessment Area to be identified. Clause 4.2 provides that the level of assessment be proportionate to the level of likely risk of impacts to each matter.

Separate processes were undertaken to identify the NSW and Commonwealth matters needing assessment.

11.1.1 NSW MATTERS NEEDING ASSESSMENT UNDER THE BCAR

PURPOSE

Section 6.4 of the BAM requires several steps be applied to determine the NSW-listed threatened species that require assessment under the BCAR. This process was applied to the nominated areas.

The BAM categorises species into two groups:

- Ecosystem credit species (ECS) – these species can be reasonably predicted to occur at a location based on habitat type and condition
- Species credit species (SCS) – these species cannot be reasonably predicted to occur at a location based on habitat

In some cases, SCS can be both listed as an ECS as well as a SCS, based on species life cycle and breeding requirements.

The process for determining what species require assessment is different for ecosystem and species credit species.

METHOD

NSW-listed species

Relevant NSW-listed species were identified by:

Step 1: Identification of an initial list of species using the BAM credit calculator in accordance with Step 1, Section 6.4 of the BAM. The calculator uses data contained in the NSW Threatened Biodiversity Data Collection and on Plant Community Types (PCTs) in the nominated areas to predict the initial list of species on the basis of the following:

- Distribution of the species includes relevant subregion where the nominated areas are mostly located
- Nominated areas are within any geographic constraints of the distribution of the species within the subregion

- Species associated with any of the PCTs identified as occurring within the nominated areas
- Native vegetation cover within an assessment area including a 1,500 m wide buffer surrounding the boundary of the nominated areas is equal to or greater than the minimum native vegetation cover required for the species
- Patch size of which the vegetation zone is part is equal to or greater than minimum value specified for the species

Step 1 was completed separately for each nominated area.

ECS identified in Step 1 were identified for assessment in the BCAR based on the associated PCTs. SCS identified in Step 1 were considered further under Step 2.

Step 2: A SCS may be excluded from needing further assessment because:

- Ecological information about a species provided in BioNet or published, peer reviewed literature, suggests that the SCS is unlikely to occur, or habitat is unlikely to be suitable (BAM section 6.1.1.2)
- Habitat constraints (defined in Threatened Biodiversity Data Collection) are not present (BAM section 6.4, step 2)
- Habitat is not suitable because it is substantially degraded (BAM section 6.4, step 3)
- An expert report determines that habitat for the species is unlikely to be present (BAM section 6.4, step 3)

Step 2 involved a series of workshops with accredited assessors and ecologists from Biosis and Ecoplanning to consider each SCS identified in Step 1. The workshops involved:

- Consolidating information on habitat types present within the urban capable land for each nominated area based on field surveys and the most up to date native vegetation mapping
- Reviewing each species' habitat preferences, and known distributions based on BioNet and published peer reviewed literature, including habitat constraints identified in the NSW Threatened Biodiversity Data Collection
- Interrogation of records data, including BioNet records
- Application of knowledge and expertise of accredied assessors and ecologists who had surveyed the nominated areas, as well as ecologists with detailed knowledge of the flora and fauna of Cumberland subregion
- Determining whether any species is likely to occur outside the urban capable lands of the nominated areas and would not be impacted by clearing of native vegetation or habitat
- Determining which species should be subject to an expert report

SCS considered likely to have suitable habitat in the nominated areas after Step 2 and requiring assessment under the BCAR are called 'candidate SCS'. Step 4, Section 6.4 of the BAM requires the accredited assessor to determine whether each candidate SCS is present or is likely to use suitable habitat on the basis of:

- Undertaking threatened species surveys
- Assuming the species is present
- Obtaining an expert report

Attachment A provides a justification for each SCS removed from needing further assessment and identifies the relevant section of the BAM under which a SCS was removed.

The removal of SCS from needing further assessment was based primarily on distribution (the natural distribution of the species is not within the assessment area, or a species' distribution is restricted and it would not occur within one or more of the nominated areas) (see Attachment A). This is consistent within section 6.1.1.2 of the BAM, which states that 'an assessor may use additional information about a threatened species, in BioNet (e.g. the profile of a threatened species) or published, peer reviewed literature, when assessing the habitat suitability of a site'.

Several SCS were dismissed based on a lack of suitable habitat within the nominated areas. Where this has occurred, reference is made to published sources. A small number of SCS have been dismissed due to a lack of known records over the past 30 - 50 years within the nominated areas. It can reasonably be expected that the presence of these species would have been recorded across this well surveyed part of NSW if the species was still present.

A total of 84 SCS were predicted to occur within the nominated areas. Of these, 40 SCS were determined to be candidate SCS needing further assessment, and 44 were removed.

The methods used to determine the presence of each candidate SCS are described in section 11.5.

Justification for excluding koala in GPEC and WSA

Koala was excluded as a candidate SCS in Greater Penrith to Eastern Creek Investigation Area (GPEC) and Western Sydney Aerotropolis (WSA) (see Attachment A). This was determined on the basis of:

- Habitat mapping
- Consideration of threatening processes
- Consideration of distribution of koala records

Habitat mapping within GPEC and WSA: While koala was excluded as a candidate species in GPEC and WSA, mapping was undertaken for koala within these nominated areas. This mapping informed the decision to exclude koala as a candidate species from these areas. Three methods of mapping were conducted to determine the availability and importance of koala habitat within GPEC and WSA (see section 11.5.4). The first method, known as a Species Distribution Model (SDM), did not find any areas of potential koala habitat within either GPEC or WSA. The second method, known as corridor mapping, found only scattered areas of supporting koala habitat within GPEC or WSA. The NSW Threatened Biodiversity Data Collection requires the assessment of impacts on koala to be determined on the basis of 'important habitat'. The koala corridor habitat mapping undertaken within all the nominated areas was used to identify important habitat that comprises the species polygons for koala as required by the BAM. No areas of important habitat (defined as primary or secondary corridors – see section 11.5.4) were identified. The third method, known as habitat critical to the survival mapping, did not map any habitat critical in GPEC or WSA.

Consideration of threatening processes: GPEC already contains large areas of existing urban development. Urban environments pose significant threats to koalas, through factors including high road and traffic densities, high densities of predators such as domestic dogs, landscape hazards such as swimming pools and barriers to movement such as fences. Whilst koalas may occasionally occur within areas of vegetation within GPEC, it is considered unlikely that a breeding and persisting population of koalas would be able to permanently reside in habitat within GPEC, as it is likely that the mortality rates of koalas due to the high threat pressures would be greater than the breeding rate. Therefore, it is probable that habitat currently available within GPEC constitutes 'sink' habitat. WSA does not currently have such a high density of urban development, and therefore is less likely to have threat densities which are as significant as those in GPEC. However, the scarcity of native vegetation within the nominated area would require koalas to cross large areas of open habitat whilst traversing between vegetation, which would increase the vulnerability of koalas to threats such as predation by dogs. Overall, it is considered that significant threats would be present within both GPEC and WSA.

Consideration of koala record distribution: The BioNet record database was examined to determine the likelihood that koalas are present within GPEC and WSA. It is noted that there are high human population densities in both areas, particularly within GPEC, and therefore an absence of records would be likely to accurately reflect an absence of koalas (as opposed to an absence of surveys). There are no records of koalas within WSA, and only one koala record within GPEC dated from 1990 in Blackett. A small number of records also occur in semi-rural areas north of GPEC, as follows:

- One record is dated from 1984 in the Londonderry locality
- One record is dated from 2006 and located in a biodiversity offset site near Colebee
- Two records are dated from 2018 and located to the west of Shanes Park

Further koala records are located to the west of the GPEC and WSA, within and in proximity to areas of remnant vegetation associated with the eastern boundary of the Blue Mountains.

Whilst a small number of koala records occur within and in the vicinity of the GPEC and WSA, the scarcity of these records, and the length of time between sightings, suggests that koalas are extremely rare within the locality, and that it is very unlikely that there is a persistent population in the locality. Instead, it is more likely that koala sightings within these localities are of dispersing individuals travelling between areas of more suitable habitat.

Koala habitat mapping, consideration of threatening processes and koala BioNet records all suggest that:

- It is very unlikely that suitable koala habitat is present within either GPEC or WSA
- It is likely that any koalas present within GPEC or WSA are dispersing between areas of more suitable habitat

It is therefore considered that any koalas within the GPEC or WSA would likely constitute individuals which have dispersed from the Blue Mountains koala population, as this is the closest habitat area which is known to support a self-sustaining and expanding population from which koalas are known to disperse.

NSW-listed TECs

Relevant NSW-listed TECs were identified by:

- Identifying the relationship between PCTs and NSW-listed TECs. In accordance with the BAM, this relationship was identified in the NSW BioNet Vegetation Classification System
- Reviewing updated native vegetation maps that identify the PCTs within the nominated areas
- Conformance with NSW listed TEC profile information (structure, floristics, landscape position, soil association etc.)

RESULTS

The results of the process to identify the matters requiring assessment under the BCAR are presented in Section 11.5 and Attachment A. This includes the list of NSW-listed candidate SCS requiring assessment under the BCAR, along with justification for the inclusion or exclusion of species from further assessment.

11.1.2 EPBC ACT MATTERS NEEDING ASSESSMENT UNDER THE SAR

PURPOSE

As required by Section 3.2 of the ToR, the SAR must identify the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan.

METHOD

This was undertaken by:

- Identifying the full list of protected matters that may potentially be relevant to the Plan and require assessment under the SAR (both within and outside of the Strategic Assessment Area)
- Categorising those matters to identify the subset that have the potential to be impacted and require assessment

A precautionary approach was applied to both steps to ensure that all matters requiring assessment were identified. In accordance with Section 4.8 of the ToR, the approach was supported by peer review of both the method and results.

It is important to note that this process did not relate to how protected matters were assessed. Rather, this step merely identified the matters requiring assessment under the SAR.

Identification of protected matters

The full list of protected matters potentially relevant to the Plan was identified through searches of:

- The Australian Government's online Protected Matters Search Tool
- NSW BioNet
- Atlas of Living Australia
- The Australian Government's Finalised Priority Assessment List (FPAL)

These searches were done using the Strategic Assessment Area boundary plus a 10 km buffer around the boundary. This was considered an appropriate area to identify matters that may be impacted directly, indirectly or cumulatively by the Plan. This work identified the following groups of protected matters as being relevant to the assessment:

- Listed threatened species and ecological communities
- Listed migratory species
- Wetlands of international importance (Ramsar wetlands)
- World and National Heritage
- Commonwealth land

The full list of protected matters was then assigned to one of two categories:

- Category 1: matter needs detailed assessment. These matters are reliant on the Strategic Assessment Area, have some potential to be impacted (directly, indirectly or cumulatively), and are addressed in detail

- Category 2: matter does not need further assessment. These matters are not reliant on the Strategic Assessment Area, are subject to very low risk of impacts (directly, indirectly or cumulatively), and are not addressed further

Commonwealth-listed TECs

Commonwealth-listed TECs present in the Strategic Assessment Area that have some potential to be impacted (directly, indirectly or cumulatively), were identified and assigned to Category 1 based on:

- The Australian Government's Protected Matters Search Tool
- Existing native vegetation mapping for the Cumberland Plain (OEH, 2013b, 2016b)
- Detailed native vegetation mapping undertaken within the nominated areas for this project
- Assignment of a PCT in the BioNet Vegetation Classification (formerly known as Vegetation Information System Classification (VIS-C))
- Conformance with Commonwealth-listed TEC profile information (structure, floristics, landscape position, soil association, patch size etc.)

Commonwealth-listed threatened species

Two steps were applied to categorise threatened species for assessment:

- Application of criteria
- Expert review

Application of criteria

Criteria were applied to initially identify the threatened species that may be impacted by actions under the Plan (see Table 11-1). A species was allocated to Category 1 (meaning it required detailed assessment) if it met any of the criteria. Species that did not meet one or more of the criteria were assigned to Category 2 (no further assessment required).

Two senior ecologists with extensive expertise in species within Western Sydney reviewed the criteria and overall approach to ensure that all matters that may be directly, indirectly or cumulatively impacted by the Plan were identified. The ecologists recommended taking a precautionary approach and simplifying some of the criteria.

Table 11-1: Criteria and process for categorising threatened species

Category 1 criteria*	Rationale for the criteria	Process to apply the criteria
1. The species was identified as a species requiring assessment as part of the BAM process for the nominated areas	The BAM process identifies the NSW-listed species that may be impacted within the nominated areas. The process is based on a range of detailed on ground surveys and analysis Where these species are also listed as a Commonwealth-listed species they should be assigned to Category 1	See Section 11.5 for a description of the relevant part of the BAM process
2. The species was subject to a commitment in the Sydney Growth Centres Strategic Assessment Program Report (DECCW, 2010)	A range of species are subject to commitments associated with the previous Growth Centres strategic assessment. Given the close association in areas that may be affected by the Plan it is appropriate that these species be assigned to Category 1	This criterion was applied through a review of the Growth Centres Program Report to identify relevant species

Category 1 criteria*	Rationale for the criteria	Process to apply the criteria
3. The Strategic Assessment Area contains a known important population	Important populations of threatened species require particular consideration under the EPBC Act (DoE, 2013). Where they are present in the Strategic Assessment Area the species should be assigned to Category 1	Important populations within the Strategic Assessment Area were identified through: • Review of recovery plans, conservation advices, species profiles, EPBC policies, and other published literature • Application of the process for mapping important populations in the Strategic Assessment Area It is important to note that any record of an endangered or critically endangered species is considered to form part of an important population (DoE, 2013)
4. The Strategic Assessment Area contains >5 per cent of all known records in NSW of a species since 1990 on the Atlas of NSW Wildlife	Known records provide an indication of the importance of the Strategic Assessment Area to a species. Using a precautionary approach, greater than 5 per cent of records in NSW was chosen as a threshold for assigning species to Category 1	This criterion was applied using post 1990 species records from the NSW BioNet Atlas database. Records within the Strategic Assessment Area were compared to the total number of records across NSW
5. The Strategic Assessment Area comprises >5 per cent or more of the mapped distribution of the species according to the Department of Agriculture, Water and the Environment's (DAWE) current distribution mapping	DAWE's distribution mapping of habitat showing where a species is 'known to occur', 'likely to occur' and 'may occur' also provides an indication of the importance of the Strategic Assessment Area to a species. Using a precautionary approach, greater than 5 per cent of a species distribution was chosen as a threshold for assigning species to Category 1	This criterion was applied using distribution statistics provided by DAWE about the percentage of each species distribution within the Strategic Assessment Area
6. It is an FPAL species, and available information suggests it occurs in the Strategic Assessment Area	The FPAL includes species nominated for listing as threatened or for up-listing. Any FPAL species likely to occur in the Strategic Assessment Area warrants assessment and should be assigned to Category 1	Where DAWE's distribution and records information for an FPAL species was available, this was used to determine occurrence in the Strategic Assessment Area Where this information was not available, information from the NSW Threatened Biodiversity Data Collection in BioNet or DAWE's listing documentation was used

* A species was allocated to Category 1 if it met <u>any</u> of the criteria

Review of the initial list

The initial list was reviewed by two expert senior ecologists to confirm the categorisation or to move species between categories based on specific expert knowledge. This step was important as it provided the opportunity to consider specific information to ensure that all species that may be impacted were identified.

The findings of this review are incorporated into the results in Chapter 28.

Migratory species

Migratory species were addressed in three groups:

- Migratory shorebirds
- Migratory birds addressed in the *Draft referral guideline for 14 birds listed as migratory species under the EPBC Act* (DoE, 2015)
- Other migratory species

Migratory shorebirds

Thirty-seven migratory shorebirds visit Australia each year. They are addressed as a group in EPBC Act Policy Statement 3.21 (DoE, 2017). Given the overlap in habitat used by many of these species and the similar way they are treated under the EPBC Act, any migratory shorebirds that were known to occur in the Strategic Assessment Area were assigned to Category 1. This was based on post 1990 records within the area from NSW BioNet and Birdlife Australia.

Any species without records were assigned to Category 2.

Other migratory birds

Fourteen migratory bird species are addressed in another EPBC guideline (DoE, 2015). A similar approach to shorebirds was applied. Any species with records in the Strategic Assessment Area was assigned to Category 1.

Any species without records were assigned to Category 2.

Remaining migratory species

For the remaining migratory species, two steps were applied to categorise them:

1. **Application of criteria:** Criteria were applied to initially identify the other migratory species that may be impacted by actions under the Plan (see Table 11-2). A species was allocated to Category 1 if it met any of the criteria. Species that did not meet one or more of the criteria were assigned to Category 2
2. **Expert review:** The list was reviewed by two senior ecologists to confirm the categorisation or to move species between categories based on specific expert knowledge

Table 11-2: Criteria and process for categorising the remaining migratory species

Category 1 criteria*	Rationale for the criteria	Process to apply the criteria
1. **The Strategic Assessment Area supports important habitat or an ecologically significant proportion of a species**	"Important habitat" and "ecologically significant proportion" are key concepts for migratory species (DoE, 2013). Where these are present within the Strategic Assessment Area it is appropriate to assign a species to Category 1	Important habitat and ecologically significant proportion need to be determined on a species-by-species basis. The guidance around these concepts from the EPBC Act significant guidelines (DoE, 2013) were applied Information from recovery plans, conservation advices, species profiles, EPBC policies, and other published literature were used to identify if the Strategic Assessment Area supported important habitat or an ecologically significant proportion of a species
2. **The Strategic Assessment Area contains >5 per cent of all known records in NSW of a species since 1990 on the Atlas of NSW Wildlife**	Known records provide an indication of the importance of the Strategic Assessment Area to a species. Using a precautionary approach, greater than 5 per cent of records in NSW was chosen as a threshold for assigning species to Category 1	This criterion was applied using post-1990 species records from the NSW BioNet Atlas database. Records within the Strategic Assessment Area were compared to the total number of records across NSW

* A species was allocated to Category 1 if it met any of the criteria

<u>Wetlands of international importance (Ramsar)</u>

There are no Ramsar Wetlands within the Plan Area. However, Towra Point Nature Reserve occurs downstream of the Plan Area and was assigned to Category 1.

<u>World and national heritage</u>

Any World or National Heritage places within or within the vicinity of the Plan Area were assigned to Category 1.

<u>Commonwealth land</u>

Any Commonwealth land within the Plan Area was assigned to Category 1.

<u>Finalised Priority Assessment List (FPAL) matters</u>

Any matters on FPAL that were known to occur in the Strategic Assessment Area were put into Category 1.

Results

The results of the process to identify the matters requiring assessment under the SAR are presented in Chapter 28.

11.2 LANDSCAPE CONTEXT

11.2.1 LANDSCAPE CONTEXT WITHIN THE NOMINATED AREAS

Purpose

Section 4 of the BAM requires the BCAR to describe:

- Landscape context, including landscape features such as waterways, wetlands and habitat connectivity
- Site context, including native vegetation cover and patch size

Method

<u>Native vegetation cover</u>

Native vegetation cover was assessed within a 1500 m buffer from the urban capable footprint of each of the nominated area separately, and entered into the BAM Calculator.

This approach was undertaken in accordance with Section 6.4.1.3 of the BAM and to ensure that all ECS and SCS with a native vegetation cover class requirement lower than, or equal to that of each nominated area, were considered. This ensured accurate and area specific information was used, and that no species were excluded based on a higher overall value for native vegetation cover resulting from averaging across all nominated areas.

<u>Rivers and streams</u>

Rivers and streams were identified in accordance with Appendix 3 of the BAM.

<u>Wetlands</u>

Wetlands were identified through aerial photographic interpretation (API), as well as data in the Digital Topographic Database hydro area layer (LPI, 2016) and the Directory of Important Wetlands (DoEE, 2018).

<u>Habitat connectivity</u>

Habitat connectivity was assessed by senior ecologists through API and maps of existing native vegetation. Habitats of similar types (e.g. riparian corridors, dry forests, grasslands) were identified, and connectivity between these areas was then determined and mapped using GIS.

Areas of geological significance and soil hazard features

The likely locations of areas of geological significance, including cliffs, caves and escarpments, were identified on the basis of existing knowledge of senior ecologists, field investigation results, topographic and geological maps, and the following datasets:

- Geological sites of NSW (Cartoscope, 2019)
- Karst Environments of NSW (OEH, 2018d)

Soil hazard features including dryland salinity, acidification, compaction, structural breakdown, sodicity and contamination were identified on the basis of the following datasets:

- NSW soils datasets at 1:100,000 from the EES data portal
- NSW geology datasets at 1:250,000 from the Department data portal
- eSpade (OEH, 2018c)
- NSW (Mitchell) Landscapes (OEH, 2018e)
- Western Sydney Hydrogeological Landscapes (OEH, 2011)

RESULTS

The results of the landscape context analysis within the nominated areas is provided in Chapter 18.

11.2.2 LANDSCAPE CONTEXT WITHIN THE STRATEGIC ASSESSMENT AREA

PURPOSE

Clause 3 of the ToR requires the SAR to describe the nature of the environment within the Strategic Assessment Area, and other areas outside this area that may be impacted by actions taken under the Plan. This includes:

- A description of historical and current land use
- The extent and quality of native vegetation
- The nature of the environment (including ecosystem processes and threatening processes)
- A description of landscape context for key matters (including connectivity, fragmentation, ecological processes)
- A map of areas that are already protected

METHOD

The nature of the environment was described through a review of relevant literature. Key source documents are referenced in Chapter 28 and included:

- The Cumberland Plain Recovery Plan (DECCW, 2011)
- Cumberland subregion BIO Map report (OEH, 2015)
- A range of technical papers on the ecology and ecological processes of the Cumberland subregion
- Relevant government policies and guidelines

RESULTS

The results of the landscape context analysis within the Strategic Assessment Area is provided in Chapter 28.

11.3 NATIVE VEGETATION

11.3.1 OVERALL APPROACH TO NATIVE VEGETATION MAPPING

Native vegetation maps were prepared:

- Within the nominated areas to meet the requirements of the BAM. Detailed mapping of the nominated areas was undertaken based on field surveys and API

- Within the Strategic Assessment Area outside the nominated areas to meet the requirements of the ToR. Mapping of the Strategic Assessment Area was based on existing native vegetation maps (OEH, 2013b, 2016b)

11.3.2 NATIVE VEGETATION MAPPING WITHIN THE NOMINATED AREAS

PURPOSE

Section 5 of the BAM requires the BCAR to identify and map for the nominated areas:

- Extent of native vegetation
- PCTs and TECs
- Vegetation integrity

METHOD

The extent of native vegetation and PCT allocation, as well as the determination of vegetation integrity scores within the nominated areas, was assessed in accordance with Section 5 and Appendix 6 of the BAM using:

- API
- Interrogation of LiDAR data
- Existing desktop mapping
- Previous surveys and studies
- Rapid assessment ground-truthing
- Field surveys

Given the scale of the assessment area, the native vegetation mapping method was developed in consultation with EES to ensure consistency with BAM requirements. Use of existing vegetation mapping as a basis to determine the type and extent of native vegetation in the assessment area is consistent with section 5.1.1.2 of the BAM.

<u>Native vegetation community extent</u>

Native vegetation community extent within the nominated areas was determined using API, existing vegetation mapping (OEH, 2013b, 2016b) and GIS analysis. All native vegetation, including native ground cover and the canopy area of trees was mapped.

<u>Identification of Plant Community Types</u>

PCTs present within the nominated areas were determined using the BioNet PCT identification tool and the Tozer-types PCT identification tool for vegetation communities of the Cumberland subregion.

All data collected in the field was analysed to provide the 'best fit' PCT for each community.

Draft PCT map based on desktop analysis

A draft PCT map for each nominated area was prepared based on desktop analysis. This involved:

Step 1: Collating relevant datasets and GIS layers, including:

- Recent Nearmap imagery at 15 cm resolution
- NSW landuse polygons (OEH, 2013a)
- NSW soils datasets at 1:100,000 from the NSW Government data portal
- NSW geology datasets at 1:250,000 from the NSW Government data portal

Step 2: Processing multispectral aerial imagery into Normalised Difference Vegetation Index (NDVI) imagery

Step 3: Amalgamating previous native vegetation mapping across the nominated areas

Step 4: Combining two existing EES maps of native vegetation within the Cumberland subregion (OEH, 2013b, 2016b) into a single layer and clipping the layer to the nominated area boundaries

Step 5: Creating a Canopy Height Model (CHM) using 1 m LiDAR data

Step 6: Processing the CHM into amalgamated canopy polygons for vegetation over 1 m in height

Step 7: Compiling the data into a single GIS map for the nominated areas with 500 m by 500 m grid squares

Interpretation of Nearmap imagery, desktop analysis and refinement of existing native vegetation mapping (OEH, 2013b, 2016b) using the BioNet Vegetation Classification database (OEH, 2018a) and the ArcGIS mapping application was undertaken by botanists experienced in the survey and identification of the PCTs of the subregion. The botanists moved cell by cell through the grid within each nominated area. All vegetation polygons shown within the existing native vegetation mapping and any unmapped vegetation was assessed and assigned a likely PCT.

A condition type for each vegetation polygon was assigned through analysis of canopy structure using LiDAR, the CHM, and API of the Nearmap imagery. In most instances, subject to land access restrictions, this was verified in the field by collection of data in accordance with the BAM.

The condition states used for each vegetation polygon were:

- **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present. This condition state was assigned during the desktop mapping to areas where the Nearmap imagery indicated significant patches of continuous canopy and the CHM indicated vegetation in both the upper and middle storeys
- **Thinned:** This condition state was assigned to native vegetation in various states of modification, including:
  - Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT
  - Wooded vegetation that has been under scrubbed. This condition state was assigned during desktop mapping to areas where the Nearmap imagery indicated patches of notably reduced canopy density, which was typically where the CHM indicated canopy and visible ground only, with no discernible shrub layer or structural complexity
- **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed. This condition state was assigned during the desktop mapping to areas where the Nearmap imagery and LiDAR canopy polygons indicated one or a few likely native trees surrounded by cleared land
- **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands. Areas of potential derived native grassland (DNG) were identified from the Nearmap imagery and later verified or reclassified in the field. Grasslands were considered to be DNG where they had a vegetation integrity score of greater than or equal to 15 (based on data collected in the field). Where grasslands were dominated by exotic species and the vegetation integrity score was less than 15, these were considered to be 'non-offsettable grasslands' (NOG)
- **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species. This condition type was also used to map areas of exotic vegetation

Final draft PCT maps

Draft PCT maps were made available online to the ecological consultants in the field to allow an ongoing process of field verification and refinement. Ecological consultants undertook rapid assessment ground-truthing and validation or amendment of the PCTs and/or condition states assigned during the desktop analysis. Amendments were usually recorded in the field using Collector for ArcGIS and later cross checked with field data.

Final draft maps were used to determine the number of plot-based survey sites required to be surveyed to meet BAM requirements. As plots were surveyed, the number of plots required for each PCT and condition state (in section 5.3.4 of the BAM) was reviewed and the vegetation mapping was updated to develop a final PCT map for each nominated area.

Floristic plot surveys

A stratified field survey was designed to verify and identify PCTs within the nominated areas, including:

- PCT and condition state
- Environmental variation

- Gaps in existing mapping and site data

A total of 258 plots were surveyed across the nominated areas (see Table 11-4). Of these plots, 123 were located within urban capable lands or transport corridors within the nominated areas, and 12 plots were located either in PCTs not impacted by the final urban capable lands or within Urban Native / Exotic vegetation. Plot surveys were undertaken in accordance with the requirements of the BAM by BAM accredited assessors and ecological consultants. Plot surveys were undertaken during the period February 2018 to March 2019.

Plot data was collected from a 20 m x 20 m plot to capture:

- Species presence (by scientific name and any relevant common name)
- Stratum and layer in which each species occurs
- Growth form of each species (as per the BAM)
- Percent foliage cover
- Abundance count (as per the BAM)

The PCT at each plot location was assigned in the field and later verified using assessment of a number of attributes including soil type, landscape position, diagnostic species and community structure. Floristic data collected from the plot surveys was analysed to identify PCT to the best match using the BioNet PCT identification tool.

The PCT results obtained from the identification tool were then checked by a senior ecologist for any discrepancies and a final PCT was allocated to the plot and to the broader vegetation community polygon.

The vegetation maps were continually updated throughout this process.

Plot data collected during previous surveys in accordance with the previous BioBanking Assessment Method (BBAM) was also used to supplement plot data collected in accordance with the BAM. Additional data was collected to supplement the BBAM data in order to meet BAM requirements, including:

- Tree stem count
- 1 x 1 metre plots (litter, bare ground, cryptogram and rock cover)
- High threat weed cover
- Updated growth forms

Vegetation integrity assessment

Vegetation zones

Areas of each PCT in different broad condition states were stratified into separate vegetation zones. Derived grasslands were assessed against the benchmark data for the original, or likely original PCT, and included as a separate vegetation zone. Non-offsettable Grasslands were also included as a separately vegetation zone. A map of vegetation zones was prepared by GIS consultants using the final PCT map.

To ensure consistency of data across the assessment area and to prevent over-complicating the assessment approach and data collection requirements, vegetation zones were not broken down by nominated area. For example, vegetation zone 849 (thinned) occurs across all four nominated areas, and all data collected from within that zone has been pooled to determine the vegetation integrity score, independent of where each plot was collected.

This approach ensured that an accurate and consistent landscape scale vegetation integrity assessment for each vegetation zone was undertaken, which is considered the most suitable approach for an assessment of this scale.

Patch size

The patch size of each vegetation zone was assigned using GIS on the basis of the final PCT map as follows:

- Vegetation zones were assigned to the same patch where they were located within 100 m of each other for intact native woody vegetation and within 30 m of each other for intact native non-woody vegetation
- Any intact native vegetation that adjoined vegetation zones beyond the nominated areas was included
- Each patch was digitised, and separate polygons were mapped where multiple patches existed

- The area of each patch in hectares was calculated

Site condition

For each vegetation zone identified within the urban capable land or transport corridors, a quantitative measure of composition, structure and function was determined through plot and transect surveys in accordance with the BAM.

Table 11-3 shows the attribute data collected.

Table 11-3: Site condition attributes

Growth form groups to assess composition and structure	Attributes to assess function
Tree	Number of large trees
Shrub	Tree regeneration
Grass and grass like	Tree stem size class
Forb	Total length of fallen logs
Fern	Litter cover
Other	High threat exotic vegetation cover
	Hollow-bearing trees

Vegetation integrity plot surveys

For this Assessment Report, the plots used for floristic survey were also used to assess vegetation integrity, consistent with the BAM. Plots and transects were established to provide a representative assessment of the vegetation integrity of the vegetation zone. Plots were undertaken on properties where access was available, which resulted in a number of plots being collected in patches of vegetation outside the urban capable lands or transport corridors of the nominated areas. All plots were collected within vegetation contiguous with urban capable lands or transport corridors within nominated areas, and within vegetation mapped specifically for this assessment.

Plots were randomly located within each vegetation patch using the following method:

- PCT vegetation polygons identified based on the desktop native vegetation mapping were verified in the field to confirm or revise PCT and/or extent
- Locations of BAM plots were determined with the aim of capturing the representative condition of the PCT within the zone, avoiding bias wherever possible
- Ecotones, vehicle tracks and their edges, or other disturbed areas that are readily distinguishable from the broad condition state of the vegetation zone were avoided
- In large patches, the orientation of transects were randomly assigned by throwing an object flagged with tape into the patch of vegetation – the direction that the tape pointed following landing was assigned the plot orientation
- In smaller patches of vegetation, particularly narrow, linear strips, the location of plots was determined based on capturing a representative sample of the patch, avoiding edge areas where possible

The floristic survey plots were 10 m either side of the first 20 m of the transect (nested within the larger 0.1 ha quadrat).

The following data were collected from the plots and transects:

- 20 m x 20 m plot: floristic data (composition and structure) attributes listed in Table 11-3
- 20 m x 50 m plot: function attributes listed in Table 11-3 (except litter cover)
- Five 1 m x 1m sub-plots: average litter cover

Table 11-4 shows the number of plots/transects required to be surveyed to meet BAM requirements for each vegetation zone, and the number of plots and/transects completed for this Assessment Report.

Table 11-4: Number of plots surveyed for each PCT and vegetation zone within the nominated areas

PCT	State	Total impact area (ha)	Minimum plots required	Total plots completed
724	Intact	8.0	3	4
	Scattered Trees	0.2	1	1
	Thinned	44.0	4	4
725	Intact	15.6	3	3
	Scattered Trees	3.0	2	2
	Thinned	18.3	3	7
781	Thinned	2.1	2	4
830	Thinned	0.1	1	2
835	Intact	12.2	3	3
	Non-offsettable Grassland	941.6	7	9
	Scattered Trees	17.8	3	6
	Thinned	135.1	6	7
849	DNG	239.2	6	16
	Intact	29.7	4	9
	Non-offsettable Grassland	5135.1	8	16
	Scattered Trees	125.3	6	12
	Thinned	335.6	7	18
850	DNG	188.5	6	6
	Intact	8.1	3	9
	Non-offsettable Grassland	682.8	7	9
	Scattered Trees	22.2	4	4
	Thinned	66.1	5	6
1395	DNG	237.3	6	15
	Intact	44.9	4	16
	Non-offsettable Grassland	778.4	7	9
	Scattered Trees	50.5	4	5
	Thinned	155.0	6	30
1800	Intact	0.2	1	4
	Scattered Trees	0.4	1	2
	Thinned	18.6	3	8
		Total	**126**	**246**

RESULTS

The native vegetation maps of the nominated areas, including plot locations relative to vegetation zones, are provided in Chapter 19.

11.3.3 NATIVE VEGETATION MAPPING ACROSS THE BROADER STRATEGIC ASSESSMENT AREA

Purpose

Clause 3 of the ToR requires the SAR to describe the nature of the environment within the Strategic Assessment Area. This includes the extent and quality of native vegetation.

Method

The approach to identify and map native vegetation across the broader Strategic Assessment Area involved

Step 1: Collating the most recent and highest resolution existing native vegetation mapping data relevant to the Cumberland subregion. This data included:

- Native Vegetation of the Sydney Metropolitan Area Version 3.0 (OEH, 2016b)
- Remnant Vegetation of the Western Cumberland subregion, 2013 Update (OEH, 2013b)
- Native Vegetation of Southeast NSW (Tozer, Turner et al., 2010)
- Biometric Vegetation Compilation for the South East Local Land Services Region (Eco Logical Australia, 2015)

Step 2: Merging the data into a single native vegetation data layer for the Cumberland subregion using GIS and clipping the data to the Cumberland subregion boundary

Step 3: Incorporating the updated the native vegetation maps for the nominated areas into the single native vegetation data layer for the parts of the Cumberland subregion within the nominated areas

Step 4: Reviewing vegetation condition or disturbance data held within the attributes the existing mapping data (Step 1) and updating this data to align with the condition types used for the nominated areas (see section 11.3.2)

Step 5: Where condition data was unavailable in the existing mapping data, undertaking a desktop assessment of the vegetation polygons and determining condition based on patch size, connectivity and edge impacts. This was only required for the Tozer et al (2010) and Eco Logical Australia (2015) data layers

Results

The native vegetation maps of the nominated areas are provided in Chapter 19.

11.4 THREATENED ECOLOGICAL COMMUNITIES

11.4.1 OVERALL APPROACH TO TEC MAPPING

To meet the requirements of the BAM and the ToR, TEC maps have been prepared for all:

- NSW-listed TECs (see Section 11.1.1) within the nominated areas
- Commonwealth-listed Category 1 TECs (see Section 11.1.2) within the Strategic Assessment Area

TECs were mapped based on associations between PCTs and TECs and rule-sets applied to these associations to refine the maps based on TEC definitions. Separate rule-sets were applied to NSW-listed TECs and Commonwealth-listed Category 1 TECs because of the typically different definitions of each TEC under the BC Act and EPBC Act.

Table 11-5 summarises the mapping approaches within and outside the nominated areas for NSW-listed TECs and Commonwealth-listed Category 1 TECs.

Table 11-5: Summary of mapping approaches for NSW- and Commonwealth-listed TECs

TECs	Mapping area	Mapping method
NSW-listed TECs	Nominated areas	Rule set specific to NSW-listed TECs applied to updated native vegetation maps of the nominated areas (see Section 11.3)

TECs	Mapping area	Mapping method
Commonwealth-listed Category 1 TECs	Strategic Assessment Area	Rule set specific to Commonwealth-listed TECs applied to: • Within the nominated areas – updated native vegetation maps of the nominated areas (see Section 11.3) • Outside the nominated areas – existing native vegetation maps of the Cumberland subregion (see Section 11.3)

11.4.2 NSW-LISTED TECS

PURPOSE

Section 5 of the BAM requires the BCAR to:

- Identify any TECs that are associated with PCTs, or the most likely PCT
- Map the extent of TECs

METHOD

The method to identify and map NSW-listed TECs within the nominated areas was:

Step 1: The updated native vegetation map (see Section 11.3) was used to identify areas of potential TECs on the basis of associations between PCTs and TECs and the rule set in Table 11-6.

Step 2: A draft map showing candidate TECs was created by GIS consultants on the basis of Step 1.

Step 3: Plots were surveyed in the field within and outside potential TEC areas. The plot data were cross checked by ecologists with the definition of TECs using the BioNet PCT identification tool and against final determinations, to confirm that the specific criteria as shown in Table 11-6 were met for the TEC at that location. Where no field survey of a potential TEC was possible, the TEC was assumed to be present at that location.

Step 4: Draft TEC maps for the nominated areas were developed and a report on the method and field verification was prepared for consultation and review by EES.

Step 5: The method and rule set were amended based on comments from EES. Final TEC maps for the nominated areas were prepared based on the updated method and rule-set and final native vegetation maps. Table 11-6 shows the rule set developed for mapping NSW TECs.

GRASSLAND TECS

Where derived native grasslands form part of a TEC listing all such vegetation zones were mapped as the relevant TECs. Where grasslands were assessed as potentially supporting a native component, but were not determined as derived native grasslands, they were not considered to form part of the relevant TEC. These vegetation zones were deemed 'non-offsettable grasslands' and floristic plot data was collected in accordance with the BAM to determine the associated vegetation integrity score. In each case, the vegetation integrity score was found to be less than 15, which is lower than the minimum score required to offset a TEC in accordance with BAM section 10.3. Non-offsettable grasslands with a vegetation integrity score of less than 15 were not considered to form part of a TEC as the vegetation is considered so degraded it no longer meets the minimum requirements for the TEC or requires any offsetting.

Table 11-6: Rule set for mapping NSW listed TECs within the nominated areas

PCT	NSW TEC	Condition state	Specific criteria – field verification
724 Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	*Shale Gravel Transition Forest in the Sydney Basin Bioregion*	All	Species composition, elevation, soils and landscape position met based on listing advice
725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	All	
781 Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	*Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions*	All	
830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	*Moist Shale Woodland in the Sydney Basin Bioregion*	All	
835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	*River-flat Eucalypt Forest in the Sydney Basin Bioregion*	All except non-offsettable grasslands	
849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	All except non-offsettable grasslands	
850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	All except non-offsettable grasslands	
877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	*Western Sydney Dry Rainforest in the Sydney Basin Bioregion*	All	
883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	*Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion*	All	
1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	All except non-offsettable grasslands	

PCT	NSW TEC	Condition state	Specific criteria – field verification
1800 Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	*Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	All	

11.4.3 COMMONWEALTH-LISTED TECS

PURPOSE

Section 3.1 and 3.2 of the Terms of Reference requires the SAR to:

- Describe the nature of the environment within the Strategic Assessment Area, and other areas outside the Strategic Assessment Area that may be impacted by actions taken under the Plan. This must include the extent and quality of native vegetation, including mapping of Commonwealth-listed TECs
- Identify and describe each protected matter that may be impacted directly, indirectly and cumulatively by actions taken under the Plan, including:
  - Key sites
  - Condition, including seasonal and annual variability, and likelihood to alter over time

IDENTIFYING POTENTIALLY RELEVANT COMMONWEALTH TECS

Commonwealth TECs potentially present in the Strategic Assessment Area (see Table 11-7) were identified based on:

- The Australian Government's Protected Matters Search Tool
- Existing native vegetation mapping for the Cumberland Plain (OEH, 2013b, 2016b)
- Detailed native vegetation mapping undertaken within the nominated areas for this project

Table 11-7: EPBC Act TECs potentially relevant to the Plan

Commonwealth TEC	Commonwealth status
Blue Gum High Forest of the Sydney Basin Bioregion	CE
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	E
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	E
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	CE
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE
Coastal floodplain eucalypt forest of eastern Australia*	FPAL
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	CE
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	CE
Western Sydney Dry Rainforest and Moist Woodland on Shale	CE

* Currently being considered for listing under the EPBC Act

The general relationship between these TECs and PCTs is set out in Table 11-8.

Table 11-8: General relationship between Commonwealth TECs and PCTs

EPBC TECs	Associated PCTs	General relationship
Blue Gum High Forest in the Sydney Basin Bioregion	1237 Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin Bioregion	PCT equivalent to (wholly subset of) Commonwealth TEC (VIS database)
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	PCT is equivalent to (partial subset of) Commonwealth TEC (VIS database)

EPBC TECs	Associated PCTs	General relationship
	958 Narrow-leaved Apple – Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion	PCT equivalent to (wholly subset of) Commonwealth TEC (VIS database)
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland	1800 Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	PCT is equivalent to Commonwealth TEC (VIS database; OEH 2016)
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	725 Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	PCT equivalent to (wholly subset of) Commonwealth TEC (VIS database)
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	724 Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	PCT is equivalent to (wholly subset of) Commonwealth TEC (VIS database)
	849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	PCT is equivalent to (wholly subset of) Commonwealth TEC (VIS database)
	850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	PCT is equivalent to (partial subset of) Commonwealth TEC (VIS database)
*Coastal floodplain eucalypt forest of eastern Australia**	835 Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	PCT is assumed to be equivalent to potential listing of Commonwealth TEC (FPAL)
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	774 Coast Banksia scrub on sand in the Elderslie area, Sydney Basin Bioregion	PCT is equivalent to (wholly subset of) Commonwealth TEC (VIS database)
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	PCT is equivalent to (wholly subset of) Commonwealth TEC (VIS database)
	1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	PCT is equivalent to (wholly subset of) Commonwealth TEC (VIS database)
Turpentine–Ironbark Forest of the Sydney Basin Bioregion	1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	PCT is partial subset of Commonwealth TEC (VIS database)
	1284 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion	PCT partially contains TEC (VIS database)
Western Sydney Dry Rainforest and Moist Woodland on Shale	830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	PCT is largely equivalent to Commonwealth TEC (VIS database; OEH 2016)

EPBC TECs	Associated PCTs	General relationship
	877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion	PCT is a partial subset/component of Commonwealth TEC (VIS database; OEH 2016)

* Currently being considered for listing under the EPBC Act

COMMONWEALTH TEC MAPPING METHOD

Within the nominated areas

The approach to identify and map Commonwealth-listed TECs within the nominated areas was broadly similar to the approach used to map NSW-listed TECs, but involved a number of additional steps which reflected the listing definitions of the TECs. The approach involved:

Step 1: The updated native vegetation map (see Section 11.3) was used to identify areas of potential TECs on the basis of associations between PCTs and TECs (see Table 11-8).

Step 2: Rapid assessment ground truthing was undertaken to contribute to the reliability of the desktop process. GIS consultants used this data to assist with assigning condition classes to the PCTs within the nominated areas.

Step 3: PCTs were correlated with potential TEC types. Once the vegetation maps were updated, the PCTs were selected for further assessment against the EPBC TEC criteria.

Step 4: To account for potential occurrence of DNG around treed patches of PCTs, polygons were buffered by 30 m and overlapping buffers were merged into single polygons.

Step 5: A patch size was attributed to each polygon and distribution criteria for each potential TEC were applied to the polygons. Table 11-9 shows the distribution criteria and patch size criteria for each TEC with potential to occur within the nominated areas. Where a polygon did not meet the criteria, it was not considered further as an area of TEC.

Step 6: Projected Foliage Cover (PFC) as assessed (where relevant to the TEC threshold criteria (see Table 11-9)) and polygons not meeting the criteria were removed. This was done by:

- Reclassifying the canopy height model raster (derived from 1 metre LiDAR point cloud) to select vegetation pixels over 15 m tall to represent canopy trees
- Calculating the number of 1 m x 1 m tree pixels in each contiguous patch of vegetation
- Calculating the per cent canopy coverage by dividing the area covered by tree pixels by the total area of the polygons and multiplying by 100
- Calculating PFC by multiplying the per cent canopy coverage by 0.5
- Removing polygons that fell below the criteria for the TEC

Step 7: Where a TEC included elevation criteria, this was applied and polygons not meeting the criteria were removed. This was done by calculating the maximum elevation for each vegetation polygon (derived from 1 m LiDAR point cloud) and removing areas that fell outside the elevation threshold criteria.

Step 8: Candidate TEC polygons were mapped. If a vegetation polygon satisfied the conditions in Steps 3-7, it was mapped as a 'candidate' TEC polygon, and Step 9 or Step 10 were undertaken to further classify the PCT.

Step 9: Where plot data was available in a candidate TEC polygon, condition class criteria were applied to determine if the polygon met the definition of the TEC. The following steps were undertaken in this step:

- BAM plot data points were joined to TEC candidate polygons
- Condition class criteria for respective TECs were applied
- For polygons achieving all criteria, they were assigned to the respective TEC as 'known'
- For all other candidate polygons that did not meet the condition class criteria, they were removed from being considered a TEC

Step 10: Where plot data was not available in a candidate TEC polygon, they were categorised into 'high', 'moderate' or 'low' potential EPBC TEC based on the following parameters:

- High potential TEC – Intact veg with a patch size > 10 ha
- Moderate potential TEC – All veg conditions with a patch size > 1 ha
- Low potential TEC – All veg conditions with a patch size between 0.5-1 ha

Table 11-9 shows the rule set developed for identifying Commonwealth TECs.

<u>Outside the nominated areas</u>

The approach for TEC mapping outside the nominated areas within the Strategic Assessment Area used additional mapping sources and did not apply detailed criteria to the mapping models.

The approach involved:

Step 1: Potential areas of the TEC were identified from existing native vegetation maps. This involved:

- Combining the Cumberland Plain West vegetation mapping with SMCMA vegetation mapping into a single layer and clipping it to the Cumberland subregion
- Correlating PCTs with potential TEC types

Step 2: Distribution and patch size class criteria were applied. A patch size was attributed to each potential TEC polygon and polygons were filtered for distribution criteria. Where a polygon did not meet the criteria, it was not considered further as an area of TEC

Step 3: Condition class criteria were applied. This involved selecting potential TEC polygons for further consideration by sorting for the following condition classes in the vegetation mapping (OEH, 2013b, 2016b): A and B, and Low and Moderate condition classes respectively. These condition classes are the only ones considered likely to meet EPBC condition class criteria. This step was undertaken by GIS consultants

Step 4: Candidate TEC polygons were mapped. If a vegetation polygon satisfied the conditions in Step 3, it was mapped as a candidate TEC polygon. The candidates were based on the following parameters:

- High potential TEC – Intact veg with a patch size > 10 ha
- Moderate potential TEC – All veg conditions with a patch size > 1 ha
- Low potential TEC – All veg conditions with a patch size between 0.5-1 ha
- Not TEC

<u>Justification of method</u>

The mapping of Commonwealth-listed TECs is particularly challenging at the scale of the Strategic Assessment Area. It poses greater challenges to the mapping of NSW-listed TECs as Commonwealth-listed TECs are subject to additional key diagnostic characteristics and condition thresholds identified in conservation or listing advices that determine whether a patch of vegetation comprises the TEC. These criteria aim to focus protection on the most valuable patches, and generally exclude highly degraded patches of less value (DEWHA, 2009a). The method for mapping Commonwealth-listed TECs aimed to ensure these criteria were considered to the greatest extent possible with the data available.

Several criteria in the conservation or listing advices can be assessed through desktop methods using data such as high definition aerial imagery and LiDAR, as well as GIS tools. However, this process is limited by the accuracy of the input data, including the underlying vegetation mapping. The limitations of the vegetation mapping that underpins the Commonwealth-listed TEC mapping within the nominated areas is summarised in Chapter 13.

Within the nominated areas the vegetation mapping is considered to be reasonably accurate, as mapping was undertaken based on detailed desktop analysis and on-ground validation (see section 11.3).

Outside the nominated areas, the mapping is based on vegetation modelling and has not undergone the same degree of validation. In these areas, the process to determine candidate TEC polygons was subject to several assumptions and limitations relating to the accuracy of the vegetation mapping, the age of the LiDAR data, and the angle and aspect of the aerial imagery used. These limitations were addressed where possible by testing the models that generated the TEC mapping based on desktop validation and making iterative updates to the models.

Other criteria in the conservation or listing advices relating to the condition or floristic composition and structure of the patch, can only be accurately determined from on-ground surveys. Where surveys were undertaken, this data was used to provide an accurate determination about whether a patch comprised a TEC. However, due to the large size of the Strategic Assessment Area and limited land access, many candidate TEC patches could not be validated on-ground. To address this limitation, assumptions about the condition of a patch were made at a desktop level based on the size of the patch, its likely resilience to degradation, and its likelihood of being edge effected.

To address the lack of certainty around patches of candidate TEC that could not be validated through on-ground surveys, all non-validated candidate TEC patches were assigned to a category reflecting the potential of the patch to comprise the TEC. This was based on the assumption that larger and better condition patches of vegetation that have satisfied the criteria for Steps 3 to 7 are more likely to meet the listing criteria for the TEC. This step was undertaken to provide transparency around the level of certainty in the TEC mapping and to provide the highest level of assurance possible around the potential impacts of the project on Commonwealth-listed TECs.

It is important to note that the peer review (see section 10.4) concluded that the Commonwealth-listed TEC mapping method is generally conservative and likely to over-predict the distribution of TECs in the Strategic Assessment Area.

RESULTS

Nine of the ten potentially relevant TECs were determined to be present in the Strategic Assessment Area. *Blue Gum High Forest in the Sydney Basin Bioregion* was found not to be present.

The results of the mapping for Commonwealth-listed TECs is provided in Chapter 31.

Table 11-9: Rule set for mapping Commonwealth-listed TECs within the nominated areas

PCT no.	Commonwealth TEC	Distribution/ size class criteria	Specific criteria
883 958	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion*	Patch size ≥0.5 ha AND greater than 30 per cent (and less than 50 per cent) of the perennial understorey vegetation cover is made up of native species (field verification) AND the patch is contiguous with a native vegetation remnant >1 ha in area AND Growing on tertiary sands and gravels of the Hawkesbury-Nepean river system	Greater than (or equal to) 50 per cent of the perennial understorey vegetation cover is made up of native species A low woodland, with canopy species reaching an average 15 m in height, but with some trees growing to around 20 m
		Patch size ≥ 0.5 ha AND Greater than (or equal to) 50 per cent of the perennial understorey vegetation cover is made up of native species (field verification) AND Patch is contiguous with a native vegetation remnant >1 ha in area AND Elevations below 80 m AND Growing on tertiary sands and gravels of the Hawkesbury-Nepean river system AND greater than 30 per cent (and less than 50 per cent) of the perennial understorey vegetation cover is made up of native species	A low woodland, with canopy species reaching an average 15 m in height, but with some trees growing to around 20 m
1800	*Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community*	Patch size ≥ 5 ha OR Patch size at least 2 ha and < 5 ha OR Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha AND Non-native species comprise less than 20 per cent of total understorey vegetation cover	Non-native species comprise less than 50 per cent of total understorey vegetation cover
		Patch size ≥ 5 ha OR Patch size at least 2 ha and < 5 ha OR Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha	Non-native species comprise less than 50 per cent of total understorey vegetation cover AND transformer species* comprise less than 30 per cent of total understorey vegetation cover

PCT no.	Commonwealth TEC	Distribution/ size class criteria	Specific criteria
		AND Non-native species comprise less than 50 per cent of total understorey vegetation cover	
725	*Cooks River / Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	Patch size greater than or equal to 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone 150◎ 51′ 38″E) AND Greater than or equal to 30 per cent of the perennial understorey vegetation cover is made up of native species (field verification) AND Below 100 m elevation AND Rainfall 800-1000 mm pa AND Growing on Clay rich soils derived from tertiary alluvium and on Wianamatta derived shale soils found next to tertiary alluvium AND the patch is contiguous with a native vegetation remnant > 1ha OR the patch has at least one tree with hollows or at least one large locally indigenous tree (>80 cm diameter at breast height) (field verification)	Greater than or equal to 50 per cent of the perennial understorey vegetation cover is made up of native species
		Patch size ≥ 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone 150 51′ 38″E) AND Greater than or equal to 50 per cent of the perennial understorey vegetation cover is made up of native species (field verification) AND Below 100 m elevation AND Rainfall 800-1000 mm pa AND Growing on clay rich soils derived from tertiary alluvium and on Wianamatta derived shale soils found next to tertiary alluvium	Consistent canopy, mid and ground strata layers in accordance with the listing advice species composition Greater than or equal to 30 per cent of the perennial understorey vegetation cover is made up of native species Where patch is not contiguous with a native vegetation remnant >1 ha, patch must have one tree with hollows or at least one large locally indigenous tree (>80 cm diameter at breast height)
724 849 850	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	Patch size ≥ 0.5 ha AND > 50 per cent perennial understorey vegetation made up of natives (field verification) OR patch size ≥ 5 ha AND >30 per cent perennial understorey made up of natives (field verification) AND Below 350 m elevation	Canopy cover greater than 10 per cent For patches greater than 0.5 ha native understorey cover is greater than 50 per cent OR for patches greater than 5 ha, native understorey cover is greater than 30 per cent

PCT no.	Commonwealth TEC	Distribution/ size class criteria	Specific criteria
		AND Growing on clay soils derived from Wianamatta	
		Patch size ≥ 0.5 ha AND > 30 per cent native understorey (field verification) AND is contiguous with a native vegetation remnant ≥ 5 ha OR patch size ≥ 0.5 ha AND > 30 per cent perennial understorey vegetation made up of natives AND the patch has at least one tree with hollows per ha or at least one large tree (≥ 80 centimetre diameter at breast height) per ha (field verification). AND Below 350 m elevation AND Growing on clay soils derived from Wianamatta	Native understorey cover is greater than 30 per cent AND/OR at least one tree with at least one tree with hollow per ha or at least one large tree (≥80 centimetre diameter at breast height) per ha Consistent canopy, and either mid and/or ground strata layers in accordance with the listing advice species composition
1395 1281	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	Patch size ≥ 0.5 ha AND > 50 per cent of the perennial understorey vegetation cover is made up of native species (field verification) OR patch size ≥ 2 ha AND > 50 per cent of the perennial understorey vegetation cover is made up of native species (field verification) AND Rainfall 800-1100 mm pa AND Growing on Shale or sandstone soil substrates	Consistent canopy, mid and ground strata layers in accordance with the listing advice species composition Where patch size is 0.5–2 ha, native understorey cover is greater than 70 per cent OR where patch size is greater than 2 ha, native understorey cover is greater than 50 per cent
		Patch size ≥ 0.5 ha AND > 30 per cent perennial understorey vegetation made up of natives AND the patch has at least one tree with hollows per ha or at least one large tree (≥ 80 centimetre diameter at breast height) per ha OR the patch is contiguous with a native vegetation remnant ≥ 1 ha (field verification) OR patch size ≥ 0.5 ha and > 50 per cent perennial understorey vegetation made up of natives (field verification) AND Rainfall 800-1100 mm pa AND Growing on Shale or sandstone soil substrates	Where patch size is greater than 0.5 ha, native understorey cover is greater than 50 per cent OR where patch size is greater than 0.5 ha, native understorey cover is greater than 30 per cent and patch is not contiguous with another remnant greater than 1ha, at least one tree with hollows per ha or at least one large tree (≥ 80 cm diameter at breast height) per ha

PCT no.	Commonwealth TEC	Distribution/ size class criteria	Specific criteria
		Some areas of regrowth intact woodland	
830 877	*Western Sydney Dry Rainforest and Moist Woodland on Shale*	Patch size ≥ 0.1 ha AND at least 20 native species present in sample 0.04 ha plot AND non-native perennial plants no more than 50 per cent of total vegetation cover (field verification) AND Below 300 m elevation AND Growing on clay soils derived from Wianamatta	At least 20 native species present in sample 0.04 ha plot AND non-native perennial plants no more than 50 per cent of total vegetation cover

Table 11-10: Rule set for mapping Commonwealth-listed TECs outside the nominated areas

PCT no.	Commonwealth TEC	Condition Class	Distribution criteria – GIS	Specific criteria – assumed
1237	*Blue Gum High Forest in the Sydney Basin Bioregion*	A or B	Patch size > 1 ha	Canopy cover greater than 10 per cent
		Low and moderate	Patch size > 1 ha AND occurs in areas of native vegetation in excess of 5 ha	Canopy cover less than 10 per cent Diagnostic species present
883 958	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion*	A or B	Patch size ≥ 0.5 ha AND Patch is contiguous with a native vegetation remnant > 1 ha in area	Diagnostic species present Greater than (or equal to) 50 per cent of the perennial understorey vegetation cover is made up of native species
		Low and moderate	Patch size ≥ 0.5 ha AND the patch is contiguous with a native vegetation remnant > 1 ha in area	Greater than 30 per cent (and less than 50 per cent) of the perennial understorey vegetation cover is made up of native species Diagnostic species present
1800	*Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community*	A or B Low and moderate	Patch size ≥ 5 ha OR Patch size at least 2 ha and < 5 ha OR Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha	Non-native species comprise less than 50 per cent of total understorey vegetation cover AND transformer species* comprise less than 30 per cent of total understorey vegetation cover
725	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	A or B	Patch size ≥ 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone (150° 51′ 38″E))	Greater than or equal to 50 per cent of the perennial understorey vegetation cover is made up of native species Diagnostic species present
		Low and moderate	Patch size greater than or equal to 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone (150° 51′ 38″E)) AND the patch is contiguous with a native vegetation remnant > 1ha OR the patch has at least one tree with hollows or at least one large locally indigenous tree (> 80 cm diameter at breast height) (field verification)	Diagnostic species present Greater than or equal to 30 per cent of the perennial understorey vegetation cover is made up of native species Where patch is not contiguous with a native vegetation remnant greater than 1 ha, patch must have one tree with hollows or at least one large locally indigenous tree (>80 cm diameter at breast height)

PCT no.	Commonwealth TEC	Condition Class	Distribution criteria – GIS	Specific criteria – assumed
724 849 850	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	A or B Low and moderate	Patch size ≥ 0.5 ha AND > 50 per cent perennial understorey vegetation made up of natives (field verification) OR patch size ≥ 5 ha AND > 30 per cent perennial understorey made up of natives (field verification)	For patches greater than 0.5 ha native understorey cover is greater than 50 per cent OR for patches greater than 5 ha, native understorey cover is greater than 30 per cent Diagnostic species present
			Patch size ≥ 0.5 ha AND > 30 per cent native understorey (field verification) AND is contiguous with a native vegetation remnant ≥ 5 ha OR patch size ≥ 0.5 ha AND > 30 per cent perennial understorey vegetation made up of natives AND the patch has at least one tree with hollows per ha or at least one large tree (≥ 80 cm diameter at breast height) per ha (field verification)	Native understorey cover is greater than 30 per cent AND / OR at least one tree with hollow per ha or at least one large tree (≥ 80 cm diameter at breast height) per ha Diagnostic species present
1395 1281	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	A or B Low and moderate	Patch size ≥ 0.5 ha AND > 70 per cent of the perennial understorey vegetation cover is made up of native species (field verification) OR patch size ≥ 2 ha AND > 50 per cent of the perennial understorey vegetation cover is made up of native species (field verification)	Consistent canopy, mid and ground strata layers in accordance with the listing advice species composition Where patch size is 0.5 – 2 ha, native understorey cover is greater than 70 per cent OR where patch size is greater than 2 ha, native understorey cover is greater than 50 per cent Tree density and diversity present, including mature trees Regrowth is acceptable for intact vegetation assuming the justification criteria are met
			Patch size ≥ 0.5 ha AND > 30 per cent perennial understorey vegetation made up of natives AND the patch has at least one tree with hollows per ha or at least one large tree (≥80 centimetre diameter at breast height) per ha OR the patch is contiguous with a native vegetation remnant ≥1 ha (field verification) OR patch size ≥ 0.5 ha and > 50 per cent perennial understorey	Diagnostic species present Where patch size is greater than 0.5 ha native understorey cover is greater than 50 per cent OR where patch size is greater than 0.5 ha, native understorey cover is greater than 30 per cent and patch is not contiguous with another remnant greater than 1ha, at least one tree with hollows per ha or at least one large tree (≥80 centimetre diameter at breast height) per ha

PCT no.	Commonwealth TEC	Condition Class	Distribution criteria – GIS	Specific criteria – assumed
			vegetation made up of natives (field verification)	
1281 1284	*Turpentine–Ironbark Forest of the Sydney Basin Bioregion*	A or B Low and moderate	Patch > 1 ha AND tree canopy cover > 10 per cent (field verification)	Tree canopy cover > 10 per cent Consistent canopy, mid and ground strata layers in accordance with the listing advice species composition Diagnostic species present
			Patch > 1 ha AND tree canopy cover < 10 per cent (field verification) AND part of a remnant of native vegetation > 5 ha	Tree canopy cover less than 10 per cent Diagnostic species present
830 877	*Western Sydney Dry Rainforest and Moist Woodland on Shale*	A or B Low and moderate	Patch size ≥ 0.1 ha	At least 20 native species present in sample 0.04 ha plot AND non-native perennial plants no more than 50 per cent of total vegetation cover Extent accuracy of updated native vegetation map Diagnostic species present

*Transformer species (e.g. *Chrysanthemoides monilifera, Asparagus* spp, *Pennisetum* spp, *Ipomoea* spp. etc.) are non-native plant species with the potential to permanently change the character, condition, form or nature of patches of the ecological community.

11.5 THREATENED SPECIES

11.5.1 OVERALL APPROACH TO SPECIES MAPPING

To meet the requirements of the BAM and the ToR, species habitat maps have been prepared for all:

- NSW-listed candidate SCS within the nominated areas
- Commonwealth-listed Category 1 species within the Strategic Assessment Area

The BAM does not require mapping of NSW-listed ECS, as these species are associated with specific PCTs and their presence in these PCTs is assumed for the purposes of the BAM.

Different mapping methods were applied within the nominated areas and outside the nominated areas within the Strategic Assessment Area, as well as to NSW-listed candidate SCS and Commonwealth-listed Category 1 species because of the different requirements of the BAM and ToR.

In general:

- Within the nominated areas – detailed species habitat mapping was undertaken based on field surveys (where landholders granted access to land) in accordance with the BAM, or an expert report was generated to complement the survey work to ensure compliance with BAM
- Outside the nominated areas – broader species habitat mapping was undertaken based on the best available existing information on species (including species records) in accordance with the ToR

In some cases, a habitat map was prepared for a Commonwealth-listed Category 1 species within the nominated areas in accordance with the BAM because the Commonwealth species is also a NSW-listed species. In these cases, that nominated areas species map was integrated into the species map of the Strategic Assessment Area and formed the basis of the assessment of impacts on that species within the nominated areas.

Table 11-11 summarises the mapping methods within and outside the nominated areas for NSW-listed candidate SCS and Commonwealth-listed Category 1 species.

Table 11-11: Summary of mapping approaches for NSW and Commonwealth-listed species

Species	Mapping area	Mapping method
NSW-listed candidate SCS	Nominated areas	Species polygon mapping, either based on: • Expert reports (section 6.5.2 of BAM), or • Assumed presence using a knowledge-based method (section 6.4.1.30 of BAM)
Commonwealth-listed Category 1 species	Strategic Assessment Area	• Species Distribution Modelling, where species records are adequate, or • Assumed presence using a knowledge-based method as for NSW-listed candidate SCS, where species records are not adequate
		For Commonwealth-listed species that have habitat maps prepared within the nominated areas (because they are also NSW-listed candidate SCS), the maps incorporate the nominated area mapping (e.g. including any expert report polygons)

11.5.2 NSW-LISTED SPECIES

Purpose

Section 6 of the BAM requires the BCAR to map 'species polygons' (area of occupied habitat with buffer, or suitable habitat, or likely suitable habitat) for each NSW-listed candidate SCS within the nominated areas, where either:

- A survey or expert report confirms a SCS is present or likely to use suitable habitat, or
- A SCS is assumed to be present

A species polygon must be used to identify:

- The location of suitable habitat for each species
- The area of suitable habitat, or number of individuals within suitable habitat, for each species
- The condition of the suitable habitat (for species assessed on the basis of area of suitable habitat)

METHOD

Consistent with the BAM, NSW-listed candidate SCS were mapped using either:

- Expert reports (section 6.5.2 of BAM), or
- Assumed presence using a knowledge-based method (section 6.4.1.30 of BAM)

It is important to note that both methods resulted in maps of potential habitat for each species within the nominated areas. Potential habitat represents areas where a species may occur, but it not necessarily known to occur. These habitat maps are conservative and are very likely to greatly overestimate the area of actual habitat for these species.

Table 11-12 summarises the mapping method used for each NSW-listed candidate SCS.

Table 11-12: Summary of mapping method used for NSW-listed candidate SCS

Species	Expert report	KBM
Acacia bynoeana	Yes	
Acacia pubescens	Yes	
Allocasuarina glareicola		Yes
Callocephalon fimbriatum		Yes
Calyptorhynchus lathami		Yes
Cercartetus nanus		Yes
Chalinolobus dwyeri		Yes
Dillwynia tenuifolia	Yes	
Epacris purpurascens var. *purpurascens*		Yes
Eucalyptus benthamii		Yes
Grevillea juniperina subsp. *juniperina*	Yes	
Grevillea parviflora subsp. *parviflora*		Yes
Haliaeetus leucogaster		Yes
Heleioporus australiacus		Yes
Hibbertia fumana	Yes	
Hibbertia puberula	Yes	
Hieraaetus morphnoides	Yes	Yes
Litoria aurea	Yes	
Lophoictinia isura	Yes	Yes
Marsdenia viridiflora subsp. *viridiflora* - endangered population		Yes
Maundia triglochinoides		Yes
Melaleuca deanei	Yes	
Meridolum corneovirens	Yes	
Micromyrtus minutiflora		Yes

Species	Expert report	KBM
Myotis macropus		Yes
Ninox connivens		Yes
Ninox strenua		Yes
Persicaria elatior		Yes
Persoonia bargoensis		Yes
Persoonia nutans	Yes	
Petaurus norfolcensis		Yes
Phascolarctos cinereus		Yes
Pimelea curviflora var. *curviflora*		Yes
Pimelea spicata	Yes	
Pomaderris brunnea		Yes
Pseudophryne australis		Yes
Pterostylis saxicola	Yes	
Pultenaea parviflora		Yes
Pultenaea pedunculata		Yes
Tyto novaehollandiae		Yes

Expert reports

This method was used to define species polygons for species where expert reports were prepared. The expert reports were prepared in accordance with Section 6.5.2 of the BAM and are provided in Supporting Document C.

Expert reports were prepared for species that:

- Could not be sufficiently surveyed for due to either access restrictions, seasonality or their cryptic nature
- Had highly specific habitat requirements and restrictions for which expert advice was required

Table 11-12 shows the NSW-listed candidate SCS for which expert reports were prepared.

The methods and assumptions used to map species habitat for each species, and the credentials of the expert who prepared the report, is provided in each expert report. The experts conducted field surveys where access was granted.

Habitat polygons in expert reports were further refined by undertaking seasonal surveys within potential habitat and excluding areas from the habitat polygons where either the specific habitat components required by the species were found not to be present (in accordance with BAM section 6.4), or the species were not detected (in accordance with BAM section 6.5). Where adequate surveys were undertaken within potential habitat and the species was not found to be present, the areas surveyed were removed from the habitat map for that species.

For flora species, this was done by classifying habitat into high, moderate or low quality for each species based on native vegetation condition, and applying the following buffers to GPS survey tracks depending on the classification:

- Trees:
  - High (Intact): 40 m either side of the transect line
  - Moderate or Low (Thinned, Scattered Trees, DNG): 40 m either side of the transect line
- Shrubs, herbs, forbs, grasses, other:
  - High (Intact): 20 m either side of the transect line
  - Moderate or Low (Thinned, Scattered Trees, DNG): 40 m either side of the transect line

It is acknowledged that these buffers were generally greater than those prescribed for transect separation distances in the *NSW Guide to Surveying Threatened Plants* (OEH 2016). Increased transect separation widths were undertaken to ensure a greater coverage of potential habitat during surveys. Transect separation distances were generally doubled from the recommended separation detailed in the guidelines. This is considered appropriate given the very large size of the study area. Based on experience in the field for this project and nature of the habitats being surveyed, it is considered likely that any larger populations of threatened plants would be (and were) recorded in undertaking surveys in this manner.

For fauna species, habitat assessment polygons and habitat confirmation polygons were used to refine the habitat polygons based on the ground-truthed habitat data collected (these were captured in the field using handheld tablet devices running Collector for ArcGIS software). Where field data confirmed a specific habitat component was missing from a patch of vegetation (i.e. leaf litter and woody debris), the habitat polygons for the species dependant on those components (i.e. Cumberland Plain Land Snail) was refined.

Assumed presence using a knowledge-based method

Assumed presence using a knowledge-based method was used to define species polygons for species where expert reports were not prepared. For some species, habitat polygons were mapped by assuming presence over all vegetation zones that the species is predicted to occur within (following steps 1-4, BAM section 6.4), in accordance with BAM section 6.4.1.30 (note that no vegetation zones were excluded on the basis of an assessment of habitat constraints under BAM section 6.4.1.10). For other species, vegetation zones were refined based on additional information about the species in BioNet or other published literature (e.g. known habitat or geographic constraints). This is consistent with section 6.1.1.2 of the BAM, which states that 'an assessor may use additional information about a threatened species, in BioNet (e.g. the profile of a threatened species) or published, peer reviewed literature, when assessing the habitat suitability of a site'. The rule sets applied to refine the vegetation zones for these species is provided in Attachment B.

The key steps in the method were:

Step 1: Collate information on records and potential habitat into species profiles for each species. The following information and datasets were used to collate species profiles:

- DAWE Protected Matters Search Tool and Species Profile and Threats Database
- EES BioNet Atlas and Threatened Biodiversity Data Collection
- PlantNET
- BirdLife Australia, the New Atlas of Australian Birds 1998-2015
- BioNet Vegetation Classification database (OEH, 2018a)
- Remnant Vegetation of the Western Cumberland Subregion 2013 Update VIS_ID 4207 (OEH, 2013b)
- Native Vegetation of the Sydney Metropolitan Area VIS_ID 4489 (OEH, 2016b)
- Catchment Boundaries of New South Wales dataset
- NSW (Mitchell) Landscapes Version 3.0
- State Environmental Planning Policy (SEPP) Coastal Management
- NSW Soil and Land Information System (SALIS)
- Soil Landscapes of the Sydney, Penrith and Wollongong-Port Hacking 1:100 000 map sheets (Chapman & Murphy, 1989; Hazelton & Tille, 1990; Bannerman & Hazelton, 1990)
- Handbook of Australian, New Zealand and Antarctic Birds (Higgins, 1999)
- Conserving Koalas in Wollondilly and Campbelltown LGAs (OEH, 2018b)
- Terrestrial Vertebrate Fauna of the Greater Southern Sydney Region Volume 2 (DECC, 2007)
- Cumberland Plain Recovery Plan (DECCW, 2011)
- Threatened ecological community determinations, conservation advices and listings
- BirdLife Australia shorebird data
- Topographic information

Step 2: Map areas of potential habitat. Potential habitat was initially mapped for each species on the basis of habitat associations with PCTs using the relevant PCT and condition class for the species identified in BioNet and the updated native vegetation maps. These maps were then refined for each species using the information within species profiles collated in step 1, including data on species records. The rule-sets built from the species profiles that were used to map potential habitat for each species are provided in Attachment B.

Step 3: Undertake targeted field surveys. Surveys were undertaken within urban capable lands or transport corridors on land where access was provided by landholders. Details of species surveys and survey effort is provided below.

Step 4: Integrate results from targeted surveys. The results of species surveys were used to refine the potential habitat maps for each species. Where adequate surveys were undertaken within potential habitat in Step 3, and the species was not found to be present, the areas surveyed were removed from the habitat map for that species. This was done by classifying habitat into high, moderate or low quality for each species based on native vegetation condition, and applying the following buffers depending on the classification:

- Trees:
  - High (Intact): 40 m either side of the transect line
  - Moderate or Low (Thinned, Scattered Trees, DNG): 40 m either side of the transect line
- Shrubs, herbs, forbs, grasses, other:
  - High (Intact): 20 m either side of the transect line
  - Moderate or Low (Thinned, Scattered Trees, DNG): 40 m either side of the transect line

Step 5: Define species polygons by assuming presence in potential habitat. Species polygons were created for each species based on the:

- Area of potential habitat, including species records (Step 1 and Step 2)
- Results of targeted surveys (Step 4)

Targeted surveys

The BAM requires surveys to be undertaken for candidate SCS in accordance with EES survey guidelines, including the *'Species credit' threatened bats and their habitats NSW survey guide for the Biodiversity Assessment Method* (OEH, 2018f), *Threatened species survey guidelines for Amphibians* (DECC, 2009) and *NSW Guide to surveying threatened plants* (OEH, 2016a). Where no survey guidelines exist, surveys must be undertaken using best practice methods.

Targeted surveys were focused within areas of potential habitat for species within the urban capable lands and transport corridors of the nominated areas. A total of approximately 2,190 hectares of combined threatened species habitat was surveyed. The candidate SCS recorded during the surveys are identified in Part 5.

Surveys were undertaken on all land where access was granted by landholders, in accordance with relevant EES survey guidelines where possible. Not all surveys were able to be undertaken in accordance with survey guidelines due to lack of access to land or seasonal constraints. In accordance with the BAM, this was addressed by:

- Preparing expert reports
- Assuming species presence within areas of potential habitat

Initial surveys – 2017 to 2018

Initial surveys for flora and fauna were undertaken across all nominated areas between November 2017 and November 2018, by Biosis and Ecoplanning ecologists. Each survey team comprised of a minimum of two people, including one Accredited BAM Assessor.

The knowledge-based method and expert report species polygons were reviewed following initial field surveys and further refined by excluding areas of habitat where the species, or suitable habitat, was not recorded. Habitat polygons that were not surveyed (or survey data was deficient), were retained for each species credit species, and presence was assumed for the purpose of impact calculations in accordance with the BAM.

Winter and spring surveys – 2019

Following analysis by the ecological consulting team, it was decided that further surveys were required. These surveys were undertaken to ground-truth the KBM and expert report habitat maps with the purpose of confirming the presence or absence of species habitat in locations where access had been limited in the past.

Habitat maps were then updated based on the results of the surveys.

Pre-survey workshops were held between the ecological consulting team and the Department in June 2019 to determine an approach to the survey work, prioritise species for survey, determine which species could be surveyed for immediately, and the locations where targeted surveys should be undertaken.

The approach to gaining land access included targeted letter correspondence, phone calls (where available) and door knocking. It was determined that two additional survey periods would be undertaken, a winter 2019 survey and a spring 2019 survey in order to cover the defined survey periods of the included targeted species under the BAM. These surveys included targeted flora searches as well as targeted fauna habitat assessments.

The survey locations of the winter and spring surveys were determined and prioritised based on a combination of:

- Land access availability
- Total area of target species potential habitat mapped on a property
- Total number of species with potential habitat mapped on a property
- Distribution of properties across the nominated areas, to gain a broader coverage

Broad priority locations were determined based on the above criteria, and the Department contacted landowners to arrange access for targeted surveys. Once permission was obtained, each survey day was planned to ensure maximum coverage of the Plan Area by grouping sites supported by multiple survey teams across the nominated areas. In addition to the Department contacting landowners to arrange access, Biosis also undertook a number of doorknocking surveys in an attempt to gain access to additional private properties located within the Plan Area.

The winter 2019 targeted surveys were undertaken between 29 June and 02 August 2019 by both Biosis and Ecoplanning ecologists. The spring 2019 targeted surveys were undertaken between 17 October and 17 December 2019 by Biosis ecologists. Each survey team comprised of a minimum of two people, including one Accredited BAM Assessor.

Fauna surveys

Survey effort for the initial targeted fauna surveys undertaken within the nominated areas is summarised in Table 11-13. Survey effort for the targeted fauna habitat assessments undertaken during the winter 2019 and spring 2019 surveys is included in Table 11-14 (winter 2019), and Table 11-15 (spring 2019).

The weather conditions during the initial targeted fauna survey period are summarised in Table 11-16.

Map 8 shows the locations of targeted fauna surveys within the nominated areas.

Table 11-13: Initial targeted fauna survey effort

Nominated area	Date	Survey type	Person Hours/trap nights	Target species	Weather
Wilton	15/08/2018	2 ha bird transect	1.25	Regent Honeyeater and Little Lorikeet	Fine
	15/08/2018	2 ha spotlight transect	2	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	15/08/2018	Anabat - targeted survey	1	Southern Myotis	Fine
	15/08/2018	Anabat - targeted survey	1	Large-eared Pied Bat	Fine
	5/09/2018	2 ha bird transect	1.2	Regent Honeyeater and Little Lorikeet	Fine
	5/09/2018	Songmeter	8	Koala	Fine
	5/09/2018	2 ha spotlight transect	2.5	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine

Nominated area	Date	Survey type	Person Hours/trap nights	Target species	Weather
	3/10/2018	2 ha bird transect	2	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Overcast and rainy
GMAC	13/09/2018	Songmeter	5	Green and Golden Bell Frog	Fine
	2/08/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	2/08/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	13/09/2018	2 ha spotlight transect	2	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	13/09/2018	2 ha spotlight transect	1	Greater Glider, Squirrel Glider, Koala, Masked Owl, Powerful Owl and Barking Owl	Fine
	13/09/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	18/09/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine with slight cloud cover
	18/09/2018	2 ha spotlight transect	2	Masked Owl and Barking Owl	Fine with slight cloud cover
	18/09/2018	2 ha bird transect	0.75	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine with slight cloud cover
	3/10/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Overcast and rainy
	3/10/2018	2 ha spotlight transect	0.5	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Overcast and rainy
	3/10/2018	Drive-by spotlight survey	0.75	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Overcast and rainy
GPEC	12/09/2018	Drive-by spotlight survey	1	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	12/09/2018	Drive-by spotlight survey	1	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	12/09/2018	2 ha bird transect	2	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	11/09/2018	2 ha spotlight transect	2.5	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine

Nominated area	**Date**	**Survey type**	**Person Hours/trap nights**	**Target species**	**Weather**
	11/09/2018	Songmeter	2	Koala	Fine
	19/09/2018	Camera trapping	6	Squirrel Glider and Greater Glider	Fine
	12/09/2018	Anabat - targeted survey	7	Southern Myotis	Fine
	20/09/2018	2 ha bird transect	3	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	20/09/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	20/09/2018	2 ha bird transect	1	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	25/09/2018	2 ha spotlight transect	2	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
WSA	15/08/2018	2 ha spotlight transect	7	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	15/08/2018	Anabat - targeted survey	7	Southern Myotis	Fine
	4/09/2018	2 ha spotlight transect	1	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	6/09/2018	Songmeter	4	Koala and GGBF	Fine
	4/09/2018	Anabat - targeted survey	2	Southern Myotis	Fine
	4/09/2018	2 ha spotlight transect	1	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	6/09/2018	Songmeter	4	Koala and GGBF	Fine
	4/09/2018	Anabat - targeted survey	2	Southern Myotis	Fine
	4/09/2018	2 ha spotlight transect	1	Masked Owl and Barking Owl	Fine
	17/08/2018	2 ha bird transect	1	Regent Honeyeater, Glossy Black-Cockatoo and Little Lorikeet	Fine
	6/09/2018	2 ha bird transect	1	Regent Honeyeater, Glossy Black-Cockatoo and Little Lorikeet	Fine
	6/09/2018	2 ha spotlight transect	3	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine
	19/09/2018	2 ha bird transect	1.5	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	19/09/2018	Anabat - targeted survey	6	Southern Myotis	Fine

Nominated area	Date	Survey type	Person Hours/trap nights	Target species	Weather
	26/09/2018	2 ha bird transect	2.5	Regent Honeyeater, Swift Parrot, Glossy Black-Cockatoo and Little Lorikeet	Fine
	26/09/2018	2 ha spotlight transect	4	Greater Glider, Squirrel Glider, Masked Owl, Powerful Owl and Barking Owl	Fine

Table 11-14: Winter 2019 targeted fauna habitat assessment

Nominated area	Date	Survey type	Person hours	Target species	Weather
Wilton	29 June – 22 July 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	24	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	Fine
GMAC	29 June – 22 July 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	24	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	Fine
GPEC	8 July - 02 August 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	32	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	Fine
WSA	19 July – 24 July 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	32	Eastern Pygmy-possum, White-bellied Sea-Eagle, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Powerful Owl, and Koala	Fine

Table 11-15: Spring 2019 targeted fauna habitat assessment

Nominated area	Date	Survey type	Person hours	Target species	Weather
Wilton	27 November 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	8	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail,	Fine

Nominated area	Date	Survey type	Person hours	Target species	Weather
				Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	
GMAC	13 November – 17 December 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	43.25	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	Fine
GPEC	17 October – 12 December 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	20	Gang-gang Cockatoo, Glossy Black-Cockatoo, Eastern Pygmy-possum, White-bellied Sea-Eagle, Giant Burrowing Frog, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Barking Owl, Powerful Owl, Masked Owl, Squirrel Glider, Koala and Red-crowned Toadlet	Fine
WSA	11 December 2019	Habitat assessment Stick nest surveys, and survey for breeding birds	5.5	Eastern Pygmy-possum, White-bellied Sea-Eagle, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Powerful Owl and Koala	Fine

Table 11-16: Weather during initial targeted fauna survey period

Station	Date	Temps		Rain	9:00 AM				3:00 PM			
		Min.	Max.	Rain.	Temp.	Humidity	Wind	Speed	Temp.	Humidity	Wind	Speed
		°C	°C	mm	°C	%		km/h	°C	%		km/h
Penrith (067113)	11-Sep 2018	10.7	26.8	0	17.1	71	NNE	11	26.5	32	NE	20
	12-Sep 2018	8.6	32.1	0	17.3	66	N	4	31	21	NNW	19
	19-Sep 2018	7.7	29.7	0	18.7	46	ESE	2	27.7	14	WNW	33
	20-Sep 2018	6.1	20.3	0	12.9	51	ESE	6	18.4	39	E	13
	25-Sep 2018	10.5	20.6	0	14.6	63	WSW	4	19.7	40	ESE	15
	19-Jul 2019	0.4	20.4	0	7.2	77	N	4	19.8	36	ESE	6
	20-Jul 2019	2.0	20.4	0	6.8	98	calm	-	19.4	44	WSW	6

Station	Date	Temps		Rain	9:00 AM				3:00 PM			
		Min.	Max.	Rain.	Temp.	Humidity	Wind	Speed	Temp.	Humidity	Wind	Speed
		°C	°C	mm	°C	%		km/h	°C	%		km/h
	23-Jul 2019	3.2	23.6	0	8.3	98	SW	2	23.6	26	WNW	11
	24-Jul 2019	8.4	21.6	0	16.6	47	S	9	20.8	27	WSW	9
Badgerys Creek (067108)	2-Aug 2018	5.1	19	0	11.7	60	WSW	2	18.2	44	NNE	17
	15-Aug 2018	1.8	25.3	0	18.1	25	WSW	22	24.4	14	WNW	31
	17-Aug 2018	0.2	18.9	0	11.4	48	NW	2	17.2	25	W	22
	4-Sep 2018	7.9	18.4	4	12.9	85	S	9	16.9	53	SE	24
	6-Sep 2018	5.9	20.8	2	11.5	100	Calm	1021.9	53		N	9
	19-Sep 2018	5.6	29.1	0	18.3	53	SE	9	25.9	15	WNW	41
	26-Sep 2018	10.2	16.3	8.2	12.2	91	NNW	13	11.4	88	SSW	15
	8-Jul 2019	8.7	19.5	0.4	11.3	100	N	4	18.1	68	NNW	6
	10-Jul 2019	2.5	17.1	0	8.4	80	NW	4	16.9	46	NNW	7
	19-Jul 2019	0.7	19.1	0	7.6	70	NNE	7	18.8	38	SW	7
	2-Aug 2019	5.3	19.3	0	11.6	73	SW	11	18.0	48	NNE	17
Campbelltown (Mt Annan 068257)	2-Aug 2018	3.9	18.9	0	11	61	WSW	7	18.6	35	NNE	9
	15-Aug 2018	2	25.1	0	16.3	25	NW	13	24.6	5	WNW	22
	5-Sep 2018	4.7	17.3	1.4	13.7	77	SSW	6	17.1	63	NNE	4
	13-Sep 2018	8.5	23.7	0	16.8	63	SSW	9	20.3	45	E	13
	29-June 2019	3.3	20.8	0.2	8.9	99	Calm	-	20.1	47	NNE	15

Station	Date	Temps		Rain	9:00 AM				3:00 PM			
		Min.	Max.	Rain.	Temp.	Humidity	Wind	Speed	Temp.	Humidity	Wind	Speed
		°C	°C	mm	°C	%		km/h	°C	%		km/h
	1-Jul 2019	0.7	17.2	0	5.9	81	SSW	6	16	44	N	7
	3-Jul 2019	1.7	19.1	0	11.1	76	Calm	-	16.7	62.	S	11
	9-Jul 2019	4	17.6	0.2	11.6	78	Calm	-	16.6	43	WSW	15
	18-Jul 2019	9.9	20	0	14	54	WSW	7	19.2	21	SSW	13
	22-Jul 2019	6.8	23.4	0.2	12.3	62	S	2	22.2	30	NNE	15

Flora surveys

Targeted flora survey effort is summarised in Table 11-17 (initial targeted flora survey effort), Table 11-18 (winter 2019 targeted flora survey effort) and Table 11-19 (spring 2019 targeted flora survey effort). Flora surveys were undertaken within each PCT and vegetation zone and extended up to 50 m into habitat adjacent to the edge of urban capable lands or transport corridors. Flora species included in winter and spring targeted surveys are detailed in Table 11-20.

Map 8 shows the locations of the targeted flora surveys within the nominated areas.

Table 11-17: Initial targeted flora survey effort

Nominated area	Date	Method	Combined area (ha) of habitat surveyed	Surveyor
Wilton	34 days, Nov 2017 - Sept 2018	Targeted meanders/transects in suitable habitat	445.76	Ecoplanning and Biosis
GMAC	51 days, Nov 2017 - Nov 2018	Targeted meanders/transects in suitable habitat	351.05	Ecoplanning and Biosis
GPEC	26 days, Apr - Nov 2018	Targeted meanders/transects in suitable habitat	43.08	Ecoplanning and Biosis
WSA	56 days, Feb - Nov 2018	Targeted meanders/transects in suitable habitat	94.08	Ecoplanning and Biosis

Table 11-18: Winter 2019 targeted flora survey effort

Nominated area	Date	Method	Combined area (ha) of habitat surveyed	Surveyor
Wilton	8 days, 29 June - 02 August 2019	Targeted meanders/transects in suitable habitat	442.1	Ecoplanning and Biosis
GMAC	8 days, 29 June - 02 August 2019	Targeted meanders/transects in suitable habitat	199.5	Ecoplanning and Biosis

GPEC	10 days, 29 June - 02 August 2019	Targeted meanders/transects in suitable habitat	178.1	Ecoplanning and Biosis
WSA	10 days, 29 June - 02 August 2019	Targeted meanders/transects in suitable habitat	181.4	Ecoplanning and Biosis

Table 11-19: Spring 2019 targeted flora survey effort

Nominated area	Date	Method	Combined area (ha) of habitat surveyed	Surveyor
Wilton	2 days, 27 November – 13 December 2019	Targeted meanders/transects in suitable habitat	101.8	Biosis
GMAC	7 days, 4 November – 17 December 2019	Targeted meanders/transects in suitable habitat	97.1	Biosis
GPEC	4 days, 17 October – 12 December 2019	Targeted meanders/transects in suitable habitat	47.0	Biosis
WSA	1 day, 11 December 2019	Targeted meanders/transects in suitable habitat	9.6	Biosis

Table 11-20: Flora species targeted during winter and spring surveys

Scientific name	Common name	Initial surveys*	Winter 2019 survey	Spring 2019 survey	Nominated area
Acacia bynoeana	Bynoe's Wattle	Yes	Yes	Yes	Wilton GMAC GPEC WSA
Acacia pubescens	Downy Wattle	Yes	Yes	Yes	Wilton GMAC GPEC WSA
Allocasuarina glareicola	-	Yes	Yes	Yes	GPEC
Dillwynia tenuifolia	-	Yes	Yes	Yes	WSA GPEC
Epacris purpurascens var. *purpurascens*	-		Yes	Yes	Wilton GMAC
Eucalyptus benthamii	Camden White Gum		Yes	Yes	Wilton GMAC
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea		Yes	Yes	WSA GMAC
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea		Yes	Yes	Wilton GMAC GPEC WSA

Scientific name	**Common name**	**Initial surveys***	**Winter 2019 survey**	**Spring 2019 survey**	**Nominated area**
Hibbertia fumana	-	No	No	Yes	Wilton GMAC GPEC WSA
Hibbertia puberula	-	No	No	Yes	Wilton GMAC GPEC WSA
Marsdenia viridiflora subsp. *viridiflora* – endangered population	-	Yes	Yes	Yes	GMAC GPEC WSA
Maundia triglochinoides	-	No	Yes	Yes	GPEC WSA
Melaleuca deanei	Deane's Paperbark		Yes	Yes	Wilton GMAC
Micromyrtus minutiflora	-		Yes	Yes	GPEC WSA
Persicaria elatior	Tall Knotweed	No	Yes	Yes	GMAC GPEC WSA
Persoonia bargoensis	Bargo Geebung		Yes	Yes	Wilton GMAC
Persoonia nutans	Nodding Geebung		Yes	Yes	GPEC WSA
Pimelea curviflora var. *curviflora*	-		Yes	Yes	GPEC
Pimelea spicata	Spiked Rice-flower	No	Yes	Yes	Wilton GMAC GPEC WSA
Pomaderris brunnea	Brown Pomaderris		Yes	Yes	Wilton GMAC
Pterostylis saxicola	Sydney Plains Greenhood	No	No	Yes	Wilton GMAC GPEC WSA
Pultenaea parviflora	-		Yes	Yes	GPEC WSA

Scientific name	Common name	Initial surveys*	Winter 2019 survey	Spring 2019 survey	Nominated area
Pultenaea pedunculata	Matted Bush-pea		No	Yes	Wilton GMAC GPEC WSA

*The initial survey period occurred from November 2017 to November 2018 with targeted species surveys within this period occurring according to applicable species survey timeframes.

RESULTS

The habitat maps of each NSW-listed candidate SCS are provided in Chapter 21.

As for the expert report habitat polygons, polygons based on KBMs were further refined by undertaking seasonal surveys within potential habitat and excluding areas from the polygons where either the specific habitat components required by the species were found not to be present (in accordance with BAM section 6.4), or the species were not detected (in accordance with BAM section 6.5). Where adequate surveys were undertaken within potential habitat and the species was not found to be present, the areas surveyed were removed from the habitat map for that species. The process used to refine the KBM habitat polygons is outlined above under 'expert reports'.

11.5.3 COMMONWEALTH-LISTED SPECIES

PURPOSE

Section 3.2 of the ToR requires the SAR to describe for the Strategic Assessment Area the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan. This includes:

- Identification of key sites and habitats
- Identification of important populations

METHOD

Habitat for Commonwealth-listed Category 1 species was mapped within the Strategic Assessment Area using either:

- Species Distribution Modelling where species data is adequate, or
- Assumed presence using a knowledge-based method

In some cases, a map has been prepared for a Commonwealth-listed Category 1 species within the nominated areas in accordance with the BAM because the Commonwealth species is also a NSW-listed candidate SCS. In these cases, that nominated areas species map was integrated into the Strategic Assessment Area species map and formed the basis of the assessment of impacts on that species within the nominated areas.

Table 11-21 summarises the mapping method used for each Commonwealth-listed Category 1 species, and shows where any nominated area mapping has been integrated into the Strategic Assessment Area map for a Commonwealth species.

Table 11-21: Summary of mapping method used for Commonwealth-listed Category 1 species

Scientific Name	Nominated areas		Strategic Assessment Area	
	Expert report	KBM	SDM	KBM
Acacia bynoeana	Yes		Yes	
Acacia pubescens	Yes		Yes	
Allocasuarina glareicola		Yes		Yes
Anthochaera phrygia				Yes

Scientific Name	Nominated areas		Strategic Assessment Area	
	Expert report	KBM	SDM	KBM
Botaurus poiciloptilus				Yes
Chalinolobus dwyeri		Yes		Yes
Commersonia prostrata				Yes
Cynanchum elegans				Yes
Dasyurus maculatus maculatus (SE mainland population)				Yes
Deyeuxia appressa				Yes
Eucalyptus benthamii		Yes	Yes	
Genoplesium baueri				Yes
Grevillea parviflora subsp. *parviflora*		Yes	Yes	
Heleioporus australiacus		Yes		Yes
Hibbertia puberula subsp. *glabrescens (Hibbertia* sp. Bankstown)				Yes
Hoplocephalus bungaroides				Yes
Lathamus discolor				Yes
Leucopogon exolasius				Yes
Litoria aurea	Yes		Yes	
Macquaria australasica				Yes
Melaleuca deanei	Yes			Yes
Micromyrtus minutiflora		Yes	Yes	
Persicaria elatior		Yes		Yes
Persoonia bargoensis		Yes	Yes	
Persoonia glaucescens				Yes
Persoonia hirsuta			Yes	
Persoonia nutans	Yes		Yes	
Petauroides volans				Yes
Phascolarctos cinereus		Yes	Yes	
Pimelea curviflora var. *curviflora*		Yes		Yes
Pimelea spicata	Yes		Yes	
Pomaderris brunnea		Yes	Yes	
Pommerhelix duralensis			Yes	
Pteropus poliocephalus			Yes	
Pterostylis saxicola	Yes			Yes
Pultenaea parviflora		Yes	Yes	
Rostratula australis				Yes

Species Distribution Modelling

SDM was undertaken for Commonwealth-listed Category 1 species within the Strategic Assessment Area where adequate species records were available to develop a model. SDMs were developed for 19 Commonwealth-listed Category 1 species (6 fauna species and 13 flora species).

SDMs are statistical models used to estimate the relationship between species records at sites and the environmental and/or spatial characteristics of those sites. Once this relationship has been estimated, the SDM can be used to predict other locations in the landscape where the species is likely to occur.

SDMs were developed using the software package 'Maxent'. Data required for the modelling included:

- Species records obtained from BioNet. During a review of the records, various errors were identified. Ecologists were engaged to review the records and amend or exclude those with errors.
- Twenty-one environmental predictors that were used to establish the relationships between species records at sites and the environmental and/or spatial characteristics of those sites. These included:
    - Native vegetation community (PCTs)
    - Soil type
    - Mean annual temperature
    - Mean annual radiation
    - Number of days per year with minimum temperature less than 2 degrees
    - Latitude
    - Distance to streams
    - Topographic position

An approach was developed to account for the different levels of bias likely to be present in the species records. This resulted in the development of three maps for each species with different assumptions regarding bias in the records, depicting the likelihood of occurrence for each species. These three maps were then combined to produce a single SDM for each species with three classes of occurrence for each species:

- Unlikely to occur – none of the three models predicted the species to occur
- Potential to occur – at least one of the three models predicted the species to occur
- Likely to occur – all three of the models predicted the species to occur

Details of the SDM method and the results of the mapping is provided in Supporting Document F.

Assumed presence using a knowledge-based method

Where adequate species records were not available, Commonwealth-listed Category 1 species within the Cumberland subregion were mapped on the basis of assumed presence using a knowledge-based method. This method is the same method applied to NSW-listed candidate SCS within the nominated areas (see Section 11.5.2). The species profiles for each species, including habitat associations with PCTs, are provided in Attachment B.

Important populations

The term 'important populations' refers to a concept applied under the EPBC Act to inform the assessment of impacts of actions, such as urban development, on matters of national environmental significance. Important populations are defined in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) (DoE, 2013) as:

> *Any population of a vulnerable species which meets the definition of an important population in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) as follows:*
>
> *'A population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:*
>
> - *key source populations either for breeding or dispersal*
> - *populations that are necessary for maintaining genetic diversity, and/or*
> - *populations that are near the limit of the species range'*

For the purposes of the SAR, important populations are also defined as including any population of an endangered or critically endangered species. Under the EPBC Act, all populations of an endangered or critically endangered species are considered to be important for the survival and recovery of the species.

The following steps were undertaken to identify and map important populations for critically endangered, endangered and vulnerable Commonwealth-listed Category 1 matters:

Step 1: Development criteria for defining important populations for vulnerable Commonwealth-listed Category 1 matters. The criteria and rationale for each criterion is provided in Table 11-22.

Step 2: For each species, BioNet records were analysed to define biological populations of the species. This analysis was undertaken by senior ecologists with knowledge and expertise in the ecology of each species. Where gene flow between two records is considered likely, the records were assigned to the one population. The ecologists took the following factors into account in determining whether gene flow is likely between records:

- Distance between individual flora records
- The presence of features or barriers that might limit demographic or genetic exchange
- Pollinator type and seed dispersal mechanism (where known)
- The continuity of patches of vegetation

Attachment C sets out the assumptions made in defining biological populations for each species.

Step 3: For critically endangered and endangered Category 1 matters:

- Describe and map each population (including identifying population sizes)

Step 4: For vulnerable Category 1 species:

- Collate the required data on each species as per the data sources in Table 11-22
- Apply the criteria in Table 11-22 to each species, using GIS analysis where necessary
- Describe and map each population (including identifying population sizes)

RESULTS

The habitat and important population maps for each Commonwealth-listed Category 1 species are provided in Chapters 29 and 30.

Table 11-22: Criteria for identifying and mapping important populations of vulnerable Commonwealth-listed Category 1 species

	Criteria	Rationale	Data sources
1	Any population of a species identified as a Serious and Irreversible Impacts (SAII) entity under the NSW BC Act	SAII entities have been identified under the NSW BC Act and meet one or more of the following principles: • Species in rapid rate of decline • Very small population size • Very limited geographic distribution • Unlikely to respond to management and therefore irreplaceable Populations of SAII entities therefore make a significant contribution to the conservation of the species	• Threatened Biodiversity Data Collection
2	A population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important	Consistent with the EPBC Act Policy Statement 1.1 (DoE, 2013)	• Recovery plans • Conservation advices • Final determinations
3	A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program	Species targeted by the Saving our Species program have been prioritised for conservation effort under a program that aims to maximise the chance of securing the greatest number of species in the wild. Therefore populations targeted under the NSW Saving our Species program could comply with the following EPBC important population criteria: • Key source populations either for breeding or dispersal • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species' range	• Saving our Species program conservation projects database
4	A population associated with a commitment made under the Sydney growth centres conservation program	These populations have been previously identified for conservation, have had significant resources attributed to their conservation and are subject to existing commitments under the Sydney growth centres conservation program and should therefore be considered important	• Sydney Growth Centres Strategic Assessment: Program Report (DECCW & DOP, 2010) • NSW *Threatened Species Conservation Act 1995* Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006

	Criteria	Rationale	Data sources
5	Any population of a species that contains more than 20 per cent of the total population (total number of mature individuals in the species) or 20 per cent of the Area of Occupancy (AOO)* of that species	Significant contribution to the conservation of the species. Loss of any population that contains 20 per cent or more of the total population or AOO is justification for change in status from Vulnerable to Endangered under IUCN and EPBC Act criteria (IUCN, 2012)	• BioNet, site specific surveys
6	Any population of a species where the species has less than 10 known subpopulations	These are species that have very few populations. All known populations therefore make a significant contribution to the conservation of the species. Loss of any population of such a species would be significant	• BioNet, site specific surveys
7	Any population of a species that is a large population in the context of the ecology of that species, in the opinion of senior ecologists	Large populations are important from a genetic perspective. They typically will have sufficient genetic diversity, increased evolutionary potential, reduced inbreeding effects and increased probability of long-term viability and persistence	• BioNet, site specific surveys
8	Any population of a species within a conservation reserve (regardless of the number of plants or size, etc)	These populations are important because they are more likely to be effectively managed and have a greater chance of persistence due to their occurrence in a conservation reserve, and therefore make a significant contribution to the conservation and recovery of the species. Conservation reserve refers to those that meet IUCN protected area categories I-IV	• BioNet, site specific surveys • National parks estate data • BioBank and stewardship site data
9	Any population of a species that is important for maintaining the Extent of Occurrence (EOO)^ of that species	Maintaining the full range of a species has a greater chance of retaining the variation within the species (a primary aim of biodiversity conservation). Populations at the extent of occurrence or that are outliers to the more general distribution are likely to contain genetic difference or capacity to persist in different environmental conditions that will provide the species ability to cope and respond to changes in the environment, such as climate change	• BioNet, site specific survey • Commonwealth database profiles/distribution mapping

*AOO is defined as the area within a species 'extent of occurrence' which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats

^EOO is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy

11.5.4 KOALA

Specific habitat mapping was undertaken for the koala. Three forms of habitat mapping were undertaken. They include:

- An SDM for the species across the Cumberland subregion
- Corridor habitat mapping to identify the species polygons for koala as required by the BAM
- Mapping of habitat critical to the survival of the species

In addition, a connectivity analysis was undertaken for part of the Southern Sydney population.

SPECIES DISTRIBUTION MODEL FOR THE CUMBERLAND SUBREGION

RMIT University was engaged to prepare SDMs for a total of nineteen EPBC listed species found within the Cumberland subregion (see Supporting Document F). As part of this assessment, an SDM was prepared for koalas.

The SDM for koalas was prepared through the following process (Gordon & Koshkina, 2018):

1. Species records for koalas within the Cumberland subregion were sourced from BioNet and examined. The following records were removed:
    - Erroneous/inaccurate records
    - Records which were *not* associated with native vegetation were also removed, as records outside of native vegetation were taken to represent dispersing male koalas outside of regular habitat areas following the breeding season, or of records of areas that previously supported vegetation that is no longer there
2. A range of environmental parameters associated with koala records were tested for their capacity to predict koala occurrence across the subregion. The parameters which were selected for use in the SDM were those which:
    - Performed well in predicting koala occurrence
    - Did not increase the risk of introducing bias into the model
3. The selected environmental parameters, in addition to koala records, were used as inputs to generate three different SDMs. Each SDM adopted a different modelling methodology which accounted for different types of bias which were likely to be present within the input data
4. The outputs of each SDM were correlated, and a final SDM map was produced with the following categories:
    - 'Unlikely to occur' – Locations where none of the SDM models showed the species occurring
    - 'Potential to occur' – Locations where at least one of the SDM models showed the species occurring. These areas are the most appropriate for assessing potential impacts on the target species
    - 'Likely to occur' – Locations where all three of the SDM models showed the species occurring. These areas are the most appropriate for targeting conservation actions such as offsetting

The results of the SDM mapping are provided in Part 6. Results show the presence of higher quality ('likely to occur') koala habitat in the south of the Cumberland Plain, with small areas of lower quality habitat ('potential to occur') occurring elsewhere in the subregion (predominantly to the north-west and west). Overall, results indicate that there is likely to be very little koala habitat available within the Cumberland subregion.

Despite there being few koala records within the Cumberland subregion, it is recognised that there is an abundance of koala records in close proximity to the boundaries of the Cumberland subregion. For instance, Gordon & Koshkina (2018) recognise that there are over 2,700 records of koalas within a 10 km buffer distance of the subregion boundary.

It is important to recognise that the SDM mapping only shows areas where koalas are likely to be present based on environmental predictors. It does not take into account other key considerations, such as connectivity, habitat quality, minimum habitat patch sizes for population viability or presence of threats. The mapping is therefore indicative, showing the extent and distribution of potential habitat available within the subregion; it does not necessarily indicate which areas of habitat are the most important locations to conserve a species (Gordon & Koshkina, 2018).

CORRIDOR HABITAT MAPPING

Corridor habitat mapping was undertaken using slightly different approaches for:

- Wilton Growth Area (Wilton) and Greater Macarthur Growth Area (GMAC)
- GPEC and WSA

Important habitat

The NSW Threatened Biodiversity Data Collection requires the assessment of impacts on koala to be determined on the basis of 'important habitat'. The koala corridor habitat mapping undertaken within all the nominated areas was used to identify important habitat that comprises the species polygons for koala as required by the BAM.

Koala corridor habitat was mapped using an approach that was consistent with the mapping undertaken by EES (OEH, 2018b) as part of the *Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas* project.

As described in more detail below, the following four types of habitat were mapped:

- Primary corridors: Defined as connected areas of principal habitat (and associated supporting habitat) that provide for ecological function of a population. EES (OEH, 2018b) characterise primary corridors as, "the most important koala habitat in which the bulk of koalas in the area live and breed. The breaking or weakening of primary corridors would have serious ramifications on the long-term viability of koalas in the area, and thereby, the regional koala population"
- Secondary corridors: Defined as corridor areas that become narrow to less than 50 metres wide, or that are not connected at both ends. EES (OEH, 2018b) suggest that, "the retention of secondary corridors is not critical to the long-term viability of the regional koala population; however, enhancement of these corridors would support primary corridors and [principal] koala habitat"
- Tertiary corridors: Defined as smaller corridor areas that are not connected at the landscape level. EES (OEH, 2018b) suggest that, "…[tertiary corridors] are the least valuable connectivity asset to retain for koalas and the regional koala population"
- Supporting habitat: Defined by EES (OEH, 2018b) as "Scattered trees peripheral to and outside of identified koala movement corridors"

Consistent with the categorisation of koala habitat and the focus on protecting key linkages for koala in the landscape (OEH, 2018b), 'important habitat' was defined as primary and secondary corridors. This was considered appropriate as it identifies the areas that are critical to the long-term viability of koalas (primary corridors) as well as the areas (if enhanced) that would support the population (secondary corridors).

Mapping method for Wilton and GMAC

The mapping method for Wilton and GMAC is driven by the "long-established relationship between the presence of koalas and vegetation that grow on higher fertility soils such as shale or shale-transition soils" (OEH, 2018b).

There are five steps in the mapping method:

1. Map koala habitat
2. Identify principal and supporting habitat
3. Identify movement corridors
4. Categorise corridors into primary, secondary and tertiary
5. Define important habitat

Spatial scope of the mapping

The spatial scope of the mapping for Wilton and GMAC was identified as:

- The two nominated areas
- Connected habitat between them
- Habitat to the east to the edge of the Strategic Assessment Area
- West to Bargo

Step 1: Map koala habitat

Using PCTs (see Table 11-23), koala habitat was mapped into three categories (Table 1):

- High quality habitat (HQH) = all shale and shale-enriched vegetation types with a dominant eucalypt canopy

- Moderate quality habitat (MQH) = Eucalypt-dominated riparian sandstone communities, rainforest communities on shale with some eucalypts present, and regenerating *Acacia* scrubs on shale. **NB:** based on the vegetation within Wilton and GMAC and the surrounding land in the Plan Area there are no PCTs that meet this definition of moderate quality
- Low quality habitat (LQH) = Low-fertility sandstone vegetation communities including heaths, heathy woodlands, swamps, and rocky woodlands

Table 11-23: PCTs and koala habitat in Wilton and GMAC

PCT	HQH	MQH	LQH
724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Y		
725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Y		
830 - Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Y		
835 - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Y		
849 - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Y		
850 - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Y		
1081 - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion.	Y		
1181 - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Y		
1395 - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.	Y		
1292 - Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion			Y
883 - Hard- leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion			Y
1800 - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley			Y

Step 2: Identify principal and supporting koala habitat

Principal habitat is defined as HQH patches greater than 100 ha that contain Koala records.

The remainder of habitat is defined as “supporting”.

Step 3: Identify movement corridors

Movement corridors include:

- All principal habitat except for those patches of principal habitat that are separated by more than 1 km
- Smaller patches of HQH within 100 m of patches of principal habitat in corridors
- Patches of MQH or LQH that connect patches of principal habitat within corridors or are entirely within principal habitat in corridors
- Scattered trees where they are completely or largely contained within corridors

Movement corridors exclude:

- Patches of principal habitat that are separated by more than 1 km
- Patches of MQH or LQH peripheral to corridors
- Scattered trees peripheral to corridors

Step 4: Categorise corridors into primary, secondary and tertiary

Primary corridors are identified as:

- Movement corridors that include patches of principal habitat which are contiguous (gaps between trees <100 m) and together contain greater than 380 ha

Secondary corridors are identified as:

- Movement corridors that include patches of principal habitat separated by more than 100 m from scattered trees or other principal habitat
- Are narrow or have pinch points of less than 50 m wide
- Together contain between 100 ha and 380 ha of principal habitat
- Otherwise, if containing greater than 380 ha of habitat or are not narrow, secondary corridors are those that do not connect to primary corridors on both ends

Tertiary corridors are identified as:

- Patches of principal habitat not linked to primary corridors
- Together contain between 30 ha and 100 ha of principal habitat
- Do not connect to other corridors on both ends
- Otherwise, if containing greater than 100 ha of habitat, tertiary corridors are those that lead away from other corridors

Step 5: Define important habitat

As described above, important habitat comprises the species polygons for koala as required under the BAM and is defined for this assessment as comprising primary and secondary corridors.

Mapping method for GPEC and WSA

The koala habitat mapping method for GPEC and WSA is based on the same concepts used for Wilton and GMAC. However, the same quantitative thresholds used for Wilton and GMAC are not transferrable to other areas. For this reason, habitat quality, and area thresholds for Koala habitat and corridors are not defined, nor any buffer areas.

This method of mapping is only indicative in identifying areas that could potentially be utilised by koalas.

There are four steps:

1. Map koala habitat
2. Identify principal and supporting habitat
3. Identify potential movement corridors
4. Categorise potential corridors into primary, secondary and tertiary
5. Define important habitat

Spatial scope of the mapping

The spatial scope of the mapping for this method included the GPEC and WSA boundaries.

Step 1: Map koala habitat

Koala habitat is identified as PCTs (excluding derived grasslands and urban native condition classes) that contain preferred koala feed trees (see Table 11-24) (DECC 2008; Environment Protection Authority 2016).

Table 11-24: PCTs - Potential koala habitat GPEC, WSA and buffer area

PCT No.	PCT Name	Type of feed tree (DECC 2008)
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Primary
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Primary
830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Primary
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Primary
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Primary
850	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Primary
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	Primary
941	Mountain Blue Gum - Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion	Supplementary
1067	Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	Primary
1081	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Secondary
1083	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Supplementary
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Secondary
1281	Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Secondary
1319	White Stringybark - Grey Gum grassy forest on shale caps of the Woronora Plateau, Sydney Basin Bioregion	Secondary
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Secondary
1787	Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus	Secondary
1789	Smooth-barked Apple - Blackbutt - Red Bloodwood open forest in enriched sandstone gullies of the western Woronora plateau	Secondary
1790	Red Bloodwood - Grey Gum - Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	Secondary
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Primary
1841	Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region	Primary

Step 2: Identify principal and supporting koala habitat

Principal habitat is defined as potential habitat (above) that contains Koala records.

The remainder of habitat is defined as "supporting". PCTs representative of supporting habitat are not listed in this document.

Step 3: Identify potential movement corridors

Potential movement corridors include all identified koala habitat, except for those patches that are separated by more than 1 km.

Step 4: Categorise corridors into primary, secondary and tertiary

Primary corridors are identified as:

- Patches of principal habitat which are contiguous (gaps between trees <100 m).

Secondary corridors are identified as:

- Patches of principal habitat separated by more than 100 m from other habitat.
- Are narrow or have pinch points of less than 50 m wide.
- Patches of principal habitat that do not connect to primary corridors on both ends.

Tertiary corridors are identified as:

- Patches of principal habitat not linked to primary corridors.
- Do not connect to other corridors on both ends.

Step 5: Define important habitat

As described above, important habitat comprises the species polygons for koala as required under the BAM and is defined for this assessment as comprising primary and secondary corridors.

HABITAT CONNECTIVITY MAPPING – GAPCLOSR

Mapping of habitat connectivity was undertaken using a GIS-based spatial analytical framework known as the Generalised Approach to Planning Connectivity at Local and Regional Scales (GAPCLoSR) (Biolink, 2018). The text below provides a high level summary of that work, and the full report should be read to understand the project.

GAPCLoSR enables examination of issues associated with landscape connectivity and fragmentation. However, it is noted that the model only considers the length and arrangement of dispersal pathways; it does not consider other important factors which impact corridor usage (such as corridor width). The model is therefore useful as a support tool which enables more detailed analysis.

GAPCLoSR takes into account two key factors:

- The ecological needs and movement characteristics of the target species (e.g. the key characteristics of preferred habitat, the distribution and extent of preferred habitat, the greatest distance of open ground which can be crossed by the target species and the total distance which can be moved across the landscape by the species)
- The extent to which the existing landscape enables, influences and/or impedes movement of the target species

The program was used to investigate three different scenarios:

- **Baseline (*status quo*):** This constituted an analysis of the distribution of current habitat patches and connectivity through the Plan Area
- **Scenario 1:** This constituted analysis in which clearing occurred within the urban capable footprint, and where Appin Road was upgraded to a multi-lane dual carriageway with wildlife fencing on the eastern side of the road
- **Scenario 2:** This constituted analysis in which clearing occurred within the urban capable footprint, and where Appin Road was upgraded to a multi-lane dual carriageway with wildlife fencing on the eastern side of the road, with a wildlife crossing in place at the Ousedale-Mallaty corridor

Methodology

The basic model process involves inputting of key landscape features, determining the capacity for koala movement across each landscape feature, and then analysing the spatial distribution of the overall landscape to determine the degree of connectivity and fragmentation across the Plan Area.

Mapping landscape features

Key landscape features within the model included:

- Transport infrastructure (e.g. roads and railway lines)
- Hydrology (drainage lines, canals, etc.)
- Vegetation cover (including Preferred Koala Habitat)
- Mining and quarrying
- Agricultural areas (grazing and horticulture)
- Urban, commercial and industrial areas

Preferred Koala Habitat (PKH) was determined through the following process:

1. Vegetation mapping data was sourced from EES and from publicly available NSW Government databases
2. Vegetation maps were analysed, and the following areas were removed from analysis as being non-suitable for koala habitat:
    - Cleared areas
    - Highly-disturbed areas
    - Areas of scattered trees
    - Areas where satellite imagery did not match the vegetation type
3. Remaining vegetation layers are all considered to be Preferred Koala Habitat (PKH)
4. Areas of PKH were then classified into different sub-categories based on the availability of Preferred Koala Food Trees[1] (PKFTs). The following classes were made:
    - Primary Koala Habitat – where primary PKFTs comprise the dominant or co-dominant overstorey species
    - Secondary Koala Habitat (Class A) – where primary PKFTs are a sub-dominant component of the overstorey species
    - Secondary Koala Habitat (Class B) – primary PKFTs are absent, but the vegetation type is dominated by one or more 'secondary' PKFT
    - Secondary Koala Habitat (Class C) – primary PKFTs are absent, but one or more 'secondary' PKFTs are present as a sub-dominant component of the overstorey species
    - Other – does not contain PKFT
5. Each vegetation class was then assigned a different movement cost as follows:
    - Where PKH (of any class) is within a 'habitat patch' (i.e. area of habitat >10ha, an area defined by the authors), there are no movement costs
    - When PKH is present as a corridor, Primary Koala Habitat has no movement cost, and Secondary Class Habitat has an increasing scale of movement cost (with the least movement cost for Class A, and the highest movement cost for Class C)

Allocating resistance values to landscape features

Each landscape feature was then assigned a Percentage Resistance Value (PRV). This value refers to the effort or cost it takes for a koala to cross a particular land-use type or class.

[1] These include the following: *E. moluccana, E. longifolia, E. punctata, E. viminalis, E. tereticornis*

The resistance of the Plan Area to koala movement was then calculated as follows:

1. A rasterised surface was produced from land use layers of the Plan Area
2. Each pixel was then assigned a dispersal cost for koalas to cross at each point. Dispersal costs were calculated through considering each of the land use layers present for each pixel
3. In instances where multiple land use layers intersected at a particular point, it was important to define which data layer took precedence over the other. The following outlines the precedence in terms of their cost value:
    a) Connectivity structures spanning roads, train lines and aqueducts
    b) Train lines and aqueducts
    c) Roads
    d) Hydrology
    e) Vegetation cover (including PKH and non-PKH)
    f) Urban / commercial / industrial / agricultural land uses
4. A Gap Crossing Layer of 220 m was applied as a buffer around all vegetation, which was taken to be the maximum distance that a koala would travel across an open area (based on Euclidian distance of all koala records within the region from the nearest patch of mapped vegetation)

Mapping habitat connectivity

The locations and importance of connectivity corridors through the Plan Area were then modelled as follows:

a) The PRV of each pixel was examined
b) The cumulative PRV cost of any potential pathway between habitat patches was calculated
c) If the cumulative PRV cost of any potential pathway between habitat patches exceeded a threshold value, then a pathway would not be formed

It is noted that this method for identifying connectivity corridors does not rely on the Euclidian distance between habitat patches, but instead considers how hostile the landscape is to movement.

HABITAT CRITICAL TO THE SURVIVAL OF THE SPECIES MAPPING

In order to address the requirements of the EPBC Act referral guidelines for the vulnerable Koala (DoE, 2014) a map was prepared to identify habitat critical to the survival of the Koala. This mapping was prepared by adapting the method proposed in Koala Habitat Assessment Tool (KHAT) (Table 4, (DoE, 2014)) for use with the data available within the nominated areas and broader Strategic Assessment Area.

The KHAT scores five attributes related to the quality and extent of Koala habitat, with each attribute scored out of 2. A total score of 10 is possible, and habitat a score of five or greater is habitat critical to the survival of the Koala. The five attributes considered in the KHAT are:

- Koala occurrence
- Vegetation composition
- Habitat connectivity
- Key existing threats
- Recovery value

A number of data sets were compiled for use in the mapping of habitat critical to the survival of the Koala within the Strategic Assessment Area. A method was then prepared based on the KHAT for use in the Strategic Assessment Area.

As a first step the habitat units to be assessed were defined by combining a compilation vegetation data set (Biosis 2019) with the mapping of Koala corridors for this project. These units were then interrogated against a number of different data sets (Step 2 – Step 6) to identify habitat critical to the survival of the Koala. Data sets used to define habitat critical to the survival of the Koala include Koala sighting records (OEH, 2019), Koala corridor mapping, an assessment of connectivity and key existing threats (road kill records (OEH, 2019) and adjacency to urban areas).

The method applied is described in Table 11-25.

Table 11-25: Method used to map habitat critical to the survival of the Koala within the Strategic Assessment Area

Step	KHAT attribute	Approach	Score allocated	Data used
Step 1	N/A	Habitat units were defined by combining a compilation vegetation data set (Biosis 2019) with the mapping of Koala corridors. Koala corridors were assigned to individual habitat units by Plant Community Type (PCT) and broad vegetation condition (intact, scattered etc.) All internal linework between habitat units was dissolved where PCT, condition and corridor rank were identical. In the case of a Koala corridor not being allocated a PCT or condition state due to the land not being identified as native vegetation: Polygons smaller than 0.5 ha were removed from the habitat units layer Polygons >0.5 ha were allocated a PCT of 9999 and a condition of Unknown The habitat units were used as the based layer for the assessment	N/A	Biosis 2019 - Compilation vegetation data set (100 km buffer from Cumberland subregion). Layer includes Biosis nominated area vegetation mapping, and where this isn't available a compilation of the best available data sets, including: Remnant Vegetation of the western Cumberland subregion, 2013 Update. VIS_ID 4207 The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 (OEH, 2016b) VIS_ID 4489 South East Local Land Services Biometric vegetation map, 2014. VIS_ID 4211 Southeast NSW Native Vegetation Classification and Mapping - SCIVI. VIS_ID 2230 Koala corridor mapping
Step 2	Koala occurrence	Koala occurrence was scored based on Koala records recorded within, and adjacent to, the Strategic Assessment Area over a five year period (2014 – 2019). Distance buffers were applied to allocate appropriate scores	2 - Within 1 km of a record 1 - Within 1-2 km from a record 0 - Beyond 2 km from a record	Koala BioNet species records (OEH, 2019)
Step 3	Vegetation composition	Each habitat unit was allocated a vegetation composition score. The Koala corridors mapped for the Strategic Assessment Area were used as a surrogate for this score	2 - Primary and secondary corridors 1 - Tertiary corridors 0 - Supporting habitat	Koala corridor mapping

Step	KHAT attribute	Approach	Score allocated	Data used
Step 4	Habitat connectivity	A score for habitat connectivity was calculated for each habitat unit. This was done by, first, calculating the patch size of each habitat unit. Habitat units were considered to be part of the same patch where adjacent or within 100 m of another patch. Patches were then separated where intersected by a major road or rail line as these features are likely to create barriers to the movement of corridors. The roads identified for this analysis include those classified as Arterial, Motorway or Primary Road	2 - >500 ha of contiguous habitat 1 - 300-500 ha of contiguous habitat 0 - <300ha of contiguous habitat	NSW Spatial Data Services (Six Clip and Ship) (2019) – Railway and Road Segment (where road = Arterial, Motorway or Primary Road)
Step 5	Key existing threats	Key existing threats were assessed, with the lower score taken for each habitat unit. Threat from road kill was determined by calculating the distance from each road kill record to each habitat unit. The threat from existing urban development was determined by calculating the distance from existing urban areas to each habitat unit	The lowest of: Threat from road kill (road kill records from 2014 - 2018). 2 - >2 km from road kill record 1 - 1-2 km from road kill record 0 - 0-1 km from road kill record Threat from urban land use (adjacency to urban land): 2 - >2 km from existing urban area 1 - 1-2 km from existing urban area 0 - 0-1 km from existing urban area	Koala BioNet species records (observation type = roadkill) (OEH, 2019) NSW Spatial Data Services (SiX Clip and Ship) (2019) – General cultural area (where area = Builtup)
Step 6	Recovery value	Each habitat unit was allocated a score based on whether the habitat is likely to be important for achieving the interim recovery objectives for the species. The Koala corridors mapped for the Strategic Assessment Area were used as a surrogate for this score	2 - Primary and secondary corridors 1 - Tertiary corridors 0 - Supporting habitat	Koala corridor mapping

11.6 OTHER MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The assessment considered all protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan and identified the following groups of protected matters as being relevant to the assessment in addition to listed threatened species and ecological communities:

- Commonwealth land
- Migratory species
- Wetlands of international importance (Ramsar wetlands)
- World and National Heritage

11.6.1 COMMONWEALTH LAND

PURPOSE

The Commonwealth land assessment considered the whole of the environment that might be affected over the life of the Plan. As required by Section 4.3 of the ToR, the assessment was undertaken to "describe and assess separately the likely impacts (if any) of actions taken under the Plan on the environment on Commonwealth land (as defined in section 528 of the EPBC Act)".

METHOD

All known areas of Commonwealth land within the Strategic Assessment Area were assessed. The location of these areas was identified with the help of DAWE and relevant NSW Government agencies. Consideration was also given to areas of Commonwealth land outside of the Strategic Assessment Area that may be affected indirectly by the classes of action.

Desktop information was used to understand the environment on Commonwealth land. Environmental values are presented in relation to soils, waterways and topography, vegetation, fauna, rare or sensitive values, heritage and information on the biodiversity landscape context of the site.

The assessment has been framed around the Commonwealth's 'Significant Impact Guidelines 1.2 – Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies'.

RESULTS

A profile of the environment on each of the Commonwealth land sites is provided in Chapter 35.

11.6.2 MIGRATORY SPECIES

PURPOSE

Section 3.2 of the ToR requires the SAR to describe for the Strategic Assessment Area the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan. This includes:

- Identification of key sites and habitats
- Identification of important populations

METHOD

The migratory species relevant to the assessment include:

- Nine species addressed in the *Referral guideline for 14 migratory birds listed under the EPBC Act* (migratory bird referral guidelines), released in September 2015 (DoE, 2015)
- 21 species addressed in the *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (migratory shorebird referral guidelines), released in 2017 (DoEE, 2017)

The approach to understanding the values within the Strategic Assessment Area for each of these migratory species was framed around the key elements of these guidelines.

Migratory bird species

For the nine migratory bird species, the assessment drew on the concepts of important habitat and ecologically significant proportions of a population. Important habitat for each species was identified based on the PCTs that correspond to the important habitat descriptions set out in the passerine bird referral guidelines.

Ecologically significant proportions of a population of each of the species was determined using observation records from Birdlife Australia, the Atlas of Living Australia, and BioNet Atlas. The analysis used a conservative estimate of individuals based on the total recorded sightings of each species per year across the Cumberland subregion.

Migratory shorebird species

Habitat mapping was undertaken broadly in accordance with the approach outlined in the EPBC guidelines (DoEE, 2017). However, the method applied was more precautionary than required under the EPBC guidelines to ensure that no important habitat sites were missed.

The process involved the following steps:

Step 1: Analysis of records across the Cumberland subregion

Records were compiled and examined across the whole of the Cumberland subregion. The initial step considered the subregion as a single habitat unit to determine which species exceeded the thresholds for important habitat across the whole area (i.e. which species occur in numbers greater than the threshold when records in the subregion are summed).

Step 2: Identification of important migratory shorebird habitat sites

The spatial distribution of records was then assessed to identify the individual wetland and waterbody (or wetland mosaic) where the thresholds were exceeded at a site level. Each wetland that was identified as important for migratory shorebirds had its boundary marked and a 250 m buffer applied. This buffer distance is consistent with the guidelines which suggest buffer distances ranging from 165 to 255 m to mitigate against disturbance (DoEE, 2017).

For ephemeral wetlands the threshold was considered across every year where records were held.

For permanent wetlands, the guidelines suggest considering the last five years. The approach taken for this assessment was to look at records for the last 20 years (since 2000) for sites that were thought to be permanent. This acknowledges the uncertainty in determining if habitat sites are permanent or ephemeral across the Strategic Assessment Area.

Step 3: Identification of potential migratory shorebird habitat

The remaining potential migratory shorebird habitat in the subregion was determined based on the presence of suitable wetlands throughout the landscape that exceed 1.5 ha in area. This 1.5 ha threshold was used as a proxy for the minimum disturbance distance for shorebirds of 150 m.

Wetland mapping layers were interrogated from the Directory of Important Wetlands (DoEE, 2018) and the LPI topographical data Hydro_Area layer (LPI, 2016) to identify areas of potential habitat.

RESULTS

The results of the migratory bird and migratory shorebird habitat assessment is provided in Chapter 32.

11.6.3 WETLANDS OF INTERNATIONAL IMPORTANCE (RAMSAR WETLANDS)

PURPOSE

Section 3.2 of the ToR requires the SAR to describe for the Strategic Assessment Area the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan. This includes:

- Identification of key sites and habitats
- Condition of protected matters, including where relevant, seasonal and annual variability, and their likelihood to alter over time
- Key threatening processes

METHOD

Towra Point Nature Reserve Wetland is the only Ramsar wetland relevant to the assessment. It is located outside of the Strategic Assessment Area. Available desktop information was used to understand the environmental values at Towra Point Nature Reserve. The assessment focused on the ecological character of the wetland, which is a key concept under the Ramsar Convention and the main element for the consideration of significant impacts under the EPBC Act.

RESULTS

The description of the environmental values at Towra Point Nature Reserve is provided in Chapter 33.

11.6.4 WORLD AND NATIONAL HERITAGE

PURPOSE

Section 3.2 of the ToR requires the SAR to describe for the Strategic Assessment Area the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan.

METHOD

A description of the World and National Heritage properties relevant to the assessment was developed based on available desktop information. For World Heritage, the assessment focused on the Outstanding Universal Value of the property, including an understanding of the attributes that meet the relevant listing criteria, how the property meets the conditions of integrity and the way in which the property is protected and managed.

For National Heritage, a description of each site focused on the heritage values that meet the criteria for listing.

RESULTS

A description of the World and National Heritage properties relevant to the assessment is provided in Chapter 34.

12 Approach to the impact assessment

The approach to analysing and assessing the impacts of the development under the Plan is set out in detail in each of the relevant Chapters of the Assessment Report, as follows:

- Avoiding and minimising impacts – see Chapter 14
- Addressing serious and irreversible impacts – see Chapter 25
- Assessing:
  - Direct impacts:
    - see Chapter 23 for the approach to NSW-listed matters
    - see Chapters 27-35 for the approach to Commonwealth-listed matters
  - Indirect impacts – see Chapter 15 for the approach to NSW and Commonwealth-listed matters
  - Prescribed impacts – see Chapter 24
  - Cumulative impacts – see Chapter 38
- Evaluation of the overall acceptability of the Plan – see Chapter 41

13 Data and limitations

This Chapter:

- Summarises the key types of information used in the Assessment Report
- Describes the key data sets on biodiversity values and how they were used
- Identifies the key limitations associated with:
  - Field surveys
  - Vegetation and species mapping
  - BAM credit calculations

The data and limitations associated with the preparation of specific reports that informed this Assessment Report, such as expert reports and the trend analysis, are described in these documents (see Supporting Documents C and D).

As described in Chapter 10, the technical methods for describing the EPBC protected matters impacted by the Plan were independently peer-reviewed to meet a requirement of the ToR. The peer review report concluded that in general:

- The data sets, methods for data collection and assumptions associated with the methods are appropriate for a large-scale strategic assessment process such as this project
- The methods used are generally conservative and are unlikely to under-represent the presence or distribution of any TEC or species (and are more likely to over-predict presence and distributions)

The report recommended that further details associated with the input data and assumptions be provided in the Assessment Report to provide regulators and the public more complete understanding of limitations, including:

- Categorisation of EPBC species – further explain limitations associated with information sources used in the categorisation process, including whether they incorporate up to date information and their relevant scale
- TEC mapping method – provide further details associated with the input data, including details of the extent and dates of field validation undertaken for the source mapping
- SDM mapping method – provide further details associated with the assumptions of the model to provide a more complete understanding of the factors affecting the outcomes of the model
- KBM mapping method – the exclusion of habitat based on patch size needs to be explained and justified
- Important populations – for the species that have been determined not to have important populations within the subregion and have had records excluded based on the lifespan of the species, discuss implications of this approach

These limitations are discussed in Section 13.3.

13.1 TYPES OF INFORMATION SOURCES

A wide variety of information sources and processes were used to prepare the Assessment Report, including:

- Data sets on biodiversity values
- Surveys and field verification
- Scientific literature
- Government strategies, plans, policies and guidelines
- Use of expert reports under the BAM
- Existing knowledge of ecological consultants
- Expert workshops , including technical representatives from EES
- Expert elicitation for the trend analysis (see Supporting Document D)

The information used in this Assessment Report is consistent with the requirements of the BAM and the ToR.

The data sets used across the nominated areas and broader Strategic Assessment Area represent the best available information on biodiversity and other values, and were drawn from a wide variety of sources. Where land access was granted, field surveys and verification were undertaken to improve the data.

13.2 KEY DATA SETS

A large number of data sets were collated and generated for use in the Assessment Report. These are summarised in Table 13-1. The data sets cover a range of themes, including:

- Vegetation mapping
- Mapping of species distribution and habitat
- Mapping of protected lands and other conservation planning information
- Soil, geology and landscape mapping
- Mapping of topographic features such as water bodies and drainage lines

Table 13-1: Sources of data used in the Assessment Report

Data set theme	Data set name	Custodian	Date	Details	Use on project
Drainage and water bodies	Directory of Important Wetlands	DAWE	2018	Data set containing boundaries for wetlands listed on the Directory of Important Wetlands	Used in determining the landscape context components of the BAM plus mapping for water dependant species
	NSW Digital Topgraphic Database - Hydro Areas Dataset	LPI	2019	Data set containing boundaries of hydrography feature types - water body areas and water courses	Used to inform the assessment of prescribed impacts for hydrology and water bodies
Land use	NSW land use polygons	EES	2013	NSW land use information including food production, forestry, nature conservation, infrastructure and urban development	Layer used in preparing native vegetation mapping for the nominated areas
Protected lands and conservation planning	Biobank sites	EES	2019	Data layer containing boundaries of Biobank sites	Layer used in determining the amount of protected land within the Plan Area
	Conservation agreements	EES	2018	Data layer containing boundaries of conservation agreements	Layer used in determining the amount of protected land within the Plan Area
	Cumberland subregion BIO Map	EES	2015	A map of core areas and corridors identified in western Sydney	Used to calculate impacts to, and protection of, important landscape features and as a surrogate for connectivity
	Metro Region biodiversity offsets	EES	2018	Data layer containing boundaries of known biodiversity offsets protected under relevant covenants governed by the relevant local Council, in the Sydney Metropolitan Region	Layer used in determining the amount of protected land within the Plan Area
	NCT Agreements	EES	2018	Data layer containing boundaries of Nature Conservation Trust Agreements	Layer used in determining the amount of protected land within the Plan Area
	NSW National Parks Estate	EES	2020	Data layer containing boundaries of National Parks, Nature Reserves and other NPWS estate	Layer used in determining the amount of protected land within the Plan Area
	Perpetual Lease Covenant	EES	2018	Data layer containing boundaries of Perpetual Lease Covenants	Layer used in determining the amount of protected land within the Plan Area

Data set theme	Data set name	Custodian	Date	Details	Use on project
	Registered Property Agreements	EES	2018	Data layer containing boundaries of Registered Property Agreements	Layer used in determining the amount of protected land within the Plan Area
Soils, geology and landscapes	NSW (Mitchell) Landscapes Version 3.1	EES	2002	Mapping of landscapes in NSW defined by landform, topography, geology, soil, climate and vegetation	Soil landscape assessment as part of the BAM assessment
	LiDAR data	New South Wales Spatial Services	2018	Layer containing LiDAR point cloud for nominated areas. LiDAR data used of varying currency, and is generally captured in 2011 across the nominated areas	Preparation of a Canopy Height Model (CHM) to assist vegetation mapping preparation within the nominated areas and identification of topographic features such as cliff lines etc.
	NSW Soil Landscapes	EES	2017	Mapping provides an inventory of soil and landscape properties and identifies major soil and landscape qualities and constraints	Soil hazard assessment as part of the BAM assessment, informed vegetation mapping
	Topographic data (Digital Topographic Database)	New South Wales Spatial Services	2019	A range of data sets which display topographic features, such as contours, drainage features and water bodies	Used for a number of project tasks including species habitat and distribution mapping, shorebird mapping and vegetation mapping
	Western Sydney Hydrogeological Landscapes	EES	2011	Spatial layer defining the areas of similar salt stores and pathways for salt mobilisation	Soil landscape assessment as part of the BAM assessment
Species sightings and habitat	BioNet (Wildlife Atlas) records of species sightings in western Sydney and surrounds – download of records provided by the Department	EES	2019	Fauna and flora sightings records stored in the NSW BioNet database	Used for a number of project tasks including important habitat mapping, one input for species distribution models, an input into determining whether a species requires needs consideration under the EPBC Act and an input into determining whether a species is a candidate species for the BAM assessment
	Conserving Koalas in Wollondilly and Campbelltown LGAs	EES	2019	Koala habitat and corridor mapping of the Appin, Wilton and Picton areas of Sydney	Data layer used to inform updated koala corridor mapping within the nominated areas. Layer accepted without modification outside nominated areas

Data set theme	Data set name	Custodian	Date	Details	Use on project
	New Atlas of Australian Birds	BirdLife Australia	1998-2015	Bird sightings database administered by BirdLife Australia	Used in the preparation of species maps for bird species
Vegetation mapping	Remnant Vegetation of the western Cumberland subregion, 2013 Update. VIS_ID 4207	EES	2013	Vegetation data layer covering western Sydney. Update of the Remnant Vegetation Mapping of the Cumberland Plain (OEH, 2013b). Contains details on Plant Community Type (PCT), map unit and dated condition information	Used as part of a compilation vegetation data set outside the nominated areas. One of the inputs for species mapping outside the nominated areas
	South East Local Land Services Biometric vegetation map, 2014. VIS_ID 4211	EES	2015	A seamless standardised vegetation map, from a combination of existing available data, which covers the full extent of the South East Local Land Services (SE LLS) region. Compiled from best available data sets in the region. Contains information on PCTs and map units	Used as part of a compilation vegetation data set outside the nominated areas. One of the inputs for species mapping outside the nominated areas
	Southeast NSW Native Vegetation Classification and Mapping - SCIVI. VIS_ID 2230	EES	2010	Classification, descriptions and mapping of native vegetation types of southeast NSW (including the South Coast and parts of the eastern tablelands)	Used as part of a compilation vegetation data set outside the nominated areas. One of the inputs for species mapping outside the nominated areas
	The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 VIS_ID 4489	EES	2016	Vegetation data layer covering the Sydney metropolitan area. Extends west to cover all of Georges and Parramatta River catchments. Contains details on PCT, map unit, TEC, and disturbance	Used as part of a compilation vegetation data set outside the nominated areas. One of the inputs for species mapping outside the nominated areas

13.3 LIMITATIONS

There are a number of limitations associated with the collection and use of data in this Assessment Report.

The limitations can be categorised into three main themes:

- Field survey limitations (i.e. land access, project scale, data and drought)
- Vegetation and species mapping limitations
- BAM credit calculation limitations

13.3.1 FIELD SURVEYS

Table 13-2 identifies limitations with field surveys and provides comment on the implications of these limitations or any precautionary measures that were taken to address these.

Table 13-2: Limitations of field surveys

Limitation	Comment
BAM native vegetation plots and threatened species surveys were only undertaken within the nominated areas, and were not undertaken within the transport corridors outside the nominated areas	While the best available data was used to assess impacts of the transport corridors outside the nominated areas, the assessment may be less accurate as it is based on existing data that has not been recently confirmed
Within the nominated areas, BAM native vegetation plots and threatened species surveys were restricted to sites where access was granted by landholders. While the number and distribution of BAM plots met BAM requirements, limited land access meant surveys were not possible across the entire urban capable land	The Department undertook an extensive program to seek approval from landholders for land access, involving: • Letter mailouts to landholders in the nominated areas • Follow-up emails or phone calls to public landholders and businesses such as developers where phone numbers were publicly available • Door knocking (Biosis) in high priority areas for surveys where no responses were received
Targeted species surveys were not always undertaken in accordance with EES survey guidelines due to the very large scale of the Plan Area	Species were assumed to be present across all areas mapped as potential habitat in accordance with the BAM, except where targeted species surveys confirmed the species was unlikely to be present
For some BAM plots, some BAM data components were based on existing BBAM plot data	In these cases, sites were re-visited and the additional BAM data components were captured to ensure the plot data was consistent with BAM
The survey period was exceptionally dry. Significant rainfall deficiencies occurred across eastern Australia and the eighth-lowest January to November rainfall since 1900 was recorded for NSW for 2018 Rainfall was in the lowest 10 per cent of all years for Western Sydney. NSW had its warmest January–November period on record for 2018, compounding the impact of low rainfall (BOM, 2019)	These conditions are likely to have affected the results of the field surveys – likely reducing vegetation integrity scores and the ability to detect some flora species

13.3.2 MAPPING AND OTHER METHODS

Table 13-3 identifies limitations with vegetation and species mapping and provides comment on the implications of these limitations or any precautionary measures that were taken to address these.

Table 13-3: Limitations of mapping and other methods

Limitation	Comment
The criteria used to categorise EPBC matters needing assessment was applied based largely on existing data	There may be limitations associated with the quality and accuracy of the existing data, such as DAWE's species distribution maps. However, the best available information was used in applying the criteria The criteria used to categorise EPBC matters is generally objective and does not involve subjective judgement. Where applying the criteria involved judgement (criteria 3), expert ecologists from Biosis were used
Mapping - general Native vegetation, TEC and species mapping was undertaken based largely on existing data	The final outputs from the mapping and modelling will be limited by the input data. Poor quality (i.e. inaccurate species data, soil mapping or vegetation mapping) or missing data may result in the identification of conservation priorities or potential development impacts that do not align with the on-ground environment
On-ground validation of native vegetation, TEC and species mapping was only undertaken within the nominated areas where land access was granted. No validation of mapping was undertaken within the transport corridors outside the nominated areas	While the best available data was used to assess impacts of the transport corridors outside the nominated areas, the assessment may be less accurate as it is based on existing data that has not been recently confirmed
Assumptions were made about PCT types and condition for areas not surveyed. The type of PCT was assumed to be correct where native vegetation extent aligns with PCTs as mapped by EES (2013, 2016) and soil/landscape mapping aligned with the PCT description	Over the fence verification was undertaken where possible (where sufficient visibility was available) within all nominated areas to validate PCTs and condition, where access was not available
The vegetation mapping within the 1500 m buffer for the assessment under the BAM was undertaken using existing vegetation mapping only and therefore the native vegetation extent for derived grasslands is likely to be under-represented	
TEC mapping TEC mapping is based on the native vegetation mapping and is subject to the same limitations (discussed above) Due to data limitations, some assumptions were made to establish the rule-sets used to map Commonwealth and NSW-listed TECs	Details of the rule-sets used to map EPBC TECs and the field validation undertaken for the TEC mapping within the nominated areas are provided in Chapter 11 The peer review concluded that the TEC mapping method used is generally conservative and is more likely to over-predict distribution of TECs
Species mapping Some candidate SCS were considered to be too cryptic for detection or difficult to map and model	These species were assigned to recognised experts for assessment (BAM expert reports)

Limitation	Comment
Species mapping - KBM Only potential habitat for species was able to be mapped due to the very large scale of the Plan Area. The species maps are therefore likely to be precautionary and greatly overpredict actual habitat Due to data limitations, some assumptions were made to establish the rule-sets used to map species habitat For species with known patch size thresholds identified in scientific literature, the rule-set included exclusion of small patches of native vegetation from the species map to provide a more accurate prediction of potential habitat	The rule-sets used to map species were based on the best available information sourced from SPRAT and BioNet profiles, NSW Threatened Biodiversity Data Collection, conservation advices, recovery plans and scientific literature. Where judgement was needed to make a decision, expert ecologists from Biosis were used Details of the rule-sets used to map species and the field validation undertaken for the KBM mapping within the nominated areas are provided in Chapter 11 The peer review concluded that KBM species mapping method used is generally conservative and is more likely to overpredict species habitat
Species mapping - SDM modelling All data used for species distribution models was based on presence-only data, meaning it is data without any 'absence' records of species (i.e. where observers have not noted the absence of a species at surveyed sites)	Undertaking SDM modelling with presence-only data results in relative measures of habitat suitability. A location with a predicted high habitat suitability score is only high relative to other locations in the Plan Area, and not necessarily high-quality habitat in absolute terms
The study area for the SDM modelling was limited to a 10 km buffer around the Cumberland subregion. For some species, this comprises only a small part of their range, which may reduce the accuracy of the modelling	
SDM modelling does not account for factors such as historical accidents and competition with other species that may significantly drive species distributions	
SDM modelling may overpredict actual habitat in highly-modified landscapes such as the Cumberland subregion due to the standard assumptions regarding a species occupying its niche not applying in such landscapes	
There may be large amounts of bias in the species records	Species data used in the SDM modelling was cleaned (likely inaccurate records removed) and multiple bias layers were used in the modelling to address this bias
For some of the species, there may be false associations between records and PCTs due to spatial errors in the point locations and and/or the PCT maps	
Important populations The criteria used to identify important populations was applied based largely on existing data Due to data limitations, some assumptions were made in applying the criteria to identify important populations. For some species, this included excluding records that were older than the lifespan of the species in some cases	There may be limitations associated with the quality and accuracy of the existing data, such as information on species' Area of Occurrence. However, the best available information was used in applying the criteria Information was sourced from SPRAT/BioNet profiles, Threatened Biodiversity Data Collection, conservation advices, recovery plans and scientific literature Where applying the criteria involved judgement (particularly criteria 7 and 9), expert ecologists from Biosis were used to inform decisions Excluding old records based on the lifespan of the species was undertaken for five fauna species. This was only done where few records existed and there were no recent records in the Cumberland subregion

Limitation	Comment
Shorebird mapping Where count data has not been provided with a BioNet or Birds Australia record, each point has been assumed to represent one individual within the shorebird mapping	

13.3.3 BAM CREDIT CALCULATIONS

Table 13-4 identifies limitations with the BAM credit calculations and provides comment on the implications of these limitations or any precautionary measures that were taken to address these.

Table 13-4: Limitations of BAM credit calculations

Limitation	Comment
Some plot data collected in vegetation mapped as NOG has returned a Vegetation Integrity (VI) of >15 (the cut-off score for the requirement to offset endangered or critically endangered TECs)	This has occurred across a low proportion of the plots and is largely explained through either a high cover of a single native grass species in the ground layer (most often Common Couch *Cynodon dactylon*) or a high cover of "litter" as defined under the BAM (most often a result of dead and/or detached grass on the ground as a result of the unusually dry survey seasons). Furthermore, the majority of the BAM plot data shows the areas sampled to be of very low ecological condition
Where impacts to species credit species were less than 0.005 ha (i.e. 0.00 when rounded to 2 decimal places), the impact was completely discounted and not entered into the BAM calculator	Such impacts typically relate to 'slivers' of slight mismatch between various spatial layers used to prepare the impact assessments
Impacts to candidate SCS were generally either allocated to a vegetation zone or NOG polygon for entry into the credit calculator. Where the habitat for the threatened species fell outside of these areas the impact was not entered into the BAM calculator and was identified as a prescribed impact	

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 3: ATTACHMENT

ATTACHMENT A - JUSTIFICATION FOR REMOVAL OF SPECIES CREDIT SPECIES FROM REQUIRING FURTHER ASSESSMENT

ATTACHMENT B - KNOWLEDGE-BASED METHOD PARAMETERS

ATTACHMENT C - BIOLOGICAL AND IMPORTANT POPULATION DEFINITIONS

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 3 Attachment Contents

Part 3 Attachment List of Tables

A. Justification for removal of SCS

Table A-1: Justification for removal of species credit species from requiring further assessment

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Acacia bynoeana	Bynoe's Wattle	✓	✓	✓	✓	Yes	*Acacia bynoeana* is a shrub that occurs in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains. Habitat comprises heath or dry sclerophyll forest on sandy soils. It prefers open, sometimes slightly disturbed sites. Records occur in about 30 locations within the distribution of the species (OEH, 2019f). The closest records to the nominated areas occur immediately to the North East of Glenfield on sandy soils, outside the nominated areas The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.	N/A	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Acacia gordonii	Gordon's wattle	R	X	X	X	No	*Acacia gordonii* is a shrub that is restricted to the north-west of Sydney. It has a disjunct distribution in the lower Blue Mountains and the Maroota/Glenorie area. Habitat comprises dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops. Records occur in only a few locations in the lower Blue Mountains and Maroota/Glenorie area(OEH, 2019a). The species was removed as a candidate species in Wilton because urban capable land is outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Acacia prominens - endangered population	Gosford Wattle	R	X	R	R	No	*Acacia prominens* is a tree. The endangered population occurs outside the nominated areas in the Kogarah – Hurstville local government areas. This occurrence is disjunct from other occurrences of the population of the species and at the southern limit of the species range (NSW Scientific Committee, 1998a). The population was removed as a candidate species in Wilton, WSA, and GPEC due to the listed extent occurring outside urban capable land.	N/A	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Acacia pubescens	Downy Wattle	✓	✓	✓	✓	Yes	*Acacia pubescens* is a shrub that occurs around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. Habitat comprises gravely soils, often with ironstone, within open woodland and forest in a variety of vegetation communities, including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland (OEH, 2019i). There are recent records of this species outside the nominated areas, and the species has the potential to occur within WSA. The other nominated areas contain mostly old records (from 1910 and 1960) with low spatial accuracy in areas that are now highly urbanised. This species is easily recognisable so is unlikely to be missed during surveys. The species was retained as a candidate species in all nominated areas due to suitable habitat that has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.	N/A	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Allocasuarina glareicola		X	X	R	✓	Yes	*Allocasuarina glareicola* is a shrub largely found in the vicinity of Castlereagh and Londonderry within an area of 27 km2 (Fairley, 2004). An outlier population occurs on Commonwealth land at the Holsworthy Military Area, south-west of Sydney (French, Pellow et al., 2001). Habitat comprises open Castlereagh woodland, growing on tertiary alluvial gravels, with yellow clayey subsoil and lateritic soil (DEWHA, 2008a). Preferred soils for the species are found in GPEC around the Penrith Lakes area. The species was retained as a candidate species in GPEC because suitable habitat has the potential to occur in urban capable land. The species was removed in WSA because of a lack of records and suitable habitat within urban capable land.	Section 6.1.1.2 (lack of BioNet records)	Yes	No	N/A
*Anthochaera Phrygia**	Regent honeyeater	R	R	R	R	No	*Anthochaera Phrygia* is a medium sized bird mainly confined to its two main breeding areas in NSW – at Capertee Valley and the Bundarra-Barraba region –and surrounding fragmented woodlands. Minor and sporadic breeding occurs in other areas such as Warrumbungle National Park, Pilliga forests, Mudgee-Wollar region, and the Hunter and Clarence Valleys (NSW Scientific Committee, 2010). Habitat comprises dry open forest and woodland, particularly Box-Ironbark woodland,	EES confirmed no important habitat mapped	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							and riparian forests of River Sheoak. No breeding habitat for the species occurs in the Cumberland subregion. The species was removed as a candidate species from all nominated areas because EES confirmed mapped important habitat for the species does not occur within urban capable lands.				
Burhinus grallarius	Bush Stone-curlew	R	R	R	R	No	*Burhinus grallarius* is a large bird that occurs throughout much of Australia, although in the south-east it is rare or extinct throughout its former range. Habitat comprises open woodlands with few shrubs, and short, sparse grasses of less than 15 cm, with scattered fallen timber, leaf litter and bare ground present (NSW DEC, 2006). Habitat is associated with broad ground and understorey structural features and is not necessarily associated with any particular vegetation communities. Removal of fallen timber affects the suitability of habitat as this comprises foraging habitat and the species relies on it for camouflage when roosting (NSW DEC, 2006). Records occur across the Cumberland subregion, but there are few recent records and no records within WSA or Wilton. Records only occur within GPEC and GMAC, a total of four within GPEC, and five within GMAC. GPEC records are prior to 1996 from within the	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							RAAF base at Orchard Hills. As no new BioNet records of the species exist in that location for over the last 23 years, more than a generation's length for this species, the birds are considered no longer to be present, based on lack of sightings/records. The remaining records from GPEC are specimen records form the Australian Museum, dated as 1884 and 1895. GMAC records are prior to 1981, with a very low level of accuracy (10,000m), with limited location descriptions. Records from 1981 are noted as 'Appin', with the remainder being specimen records form the Australian Museum, dated as 1860/1861. A single record occurs from within the Cumberland subregion since 1996, noted as being from 2012 in Greystanes and associated with WIRES. No more information is provided in BioNet. Due to the isolated nature of this record, both temporally and spatially, it is considered a vagrant record, and not evidence of the species persistence in the subregion. The species was removed as a candidate species in all nominated areas because suitable micro-habitats have undergone a long history of degradation and are now considered scarce in urban capable land, and the substantial lack of recent records within				

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							the subregion. Considerable survey effort has been undertaken for the species across the Cumberland subregion since 1996 and if present, it is considered likely that the species would have been positively recorded in that time.				
Caladenia tessellata	Thick Lip Spider Orchid	R	R	R	R	No	*Caladenia tessellata* is an orchid that is known within NSW from two disjunct areas; one population near Braidwood on the Southern Tablelands and three populations in the Wyong area on the Central Coast (NSW Scientific Committee, 2002a). Habitat comprises grassy sclerophyll woodland in clay loam or quartz-rich sandier soil (OEH, 2019af). The total population size is estimated to be less than 50 individuals. Old records occur in the Penshurst (recorded 1901) and Como (recorded 1930) areas. The species was removed as a candidate species in all nominated areas because of a lack of records and suitable habitat within urban capable lands.	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
*Calidris ferruginea**	Curlew sandpiper	X	X	R	X	No	*Calidris ferruginea* is a small bird that breeds in Siberia and migrates to Australia (as well as Africa and Asia) for the non-breeding period (NSW Scientific Committee, 2011). In NSW, the species occurs along the coast, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. Foraging habitat in NSW mainly comprises intertidal mudflats. The species was removed as a candidate species in WSA because of a lack of suitable habitat within urban capable land.	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A
Callistemon linearifolius	Netted Bottle Brush	R	R	R	R	No	*Callistemon linearifolius* is a shrub that occurs from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW. Habitat comprises dry sclerophyll forest. For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River. There are currently only five or six known populations of the species remaining in the Sydney area, of the 22 populations recorded in the past. Three of these are reserved in Ku-ring-gai Chase National Park, Lion Island Nature Reserve, and Spectacle Island Nature Reserve. Further north it has been recorded from Yengo National Park (NSW Scientific Committee, 1999a). The species was removed as a candidate species in	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							all nominated areas because urban capable lands are outside the geographic extent of the species.				
*Callocephalon fimbriatum**	Gang-gang cockatoo	✓	✓	R	✓	Yes	*Callocephalon fimbriatum* is a bird restricted to the south-eastern coast and highlands, from the lower Hunter and northern Blue Mountains to the Southwestern Slopes, south to and contiguous with the Victorian population (e.g. (Barrett, 2003)). Habitat comprises eucalypt open forests and woodlands with an acacia understorey (NSW Scientific Committee, 2008a). Breeding habitat includes remnant tall moist forest and riparian corridors along major streams (3rd and higher order). Nests are located in hollows that are 10 cm in diameter or larger and at least 9 m above the ground in eucalypts (OEH, 2019l). The species has been recorded within the vicinity of the nominated areas nesting in tall eucalypts within sandstone gullies (e.g. The Oaks area). The species was retained as a candidate species in Wilton, GMAC and GPEC because records occur in the vicinity of urban capable lands. The species was removed in WSA because of a lack of records within the nominated area and a lack of suitable breeding habitat within urban capable lands. Targeted surveys during breeding season and habitat assessment surveys have been undertaken	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							across the nominated areas for this species. The species was not recorded, however potential breeding habitat was found to be present.				
*Calyptorhynchus lathami**	Glossy black cockatoo	✓	✓	R	✓	Yes	*Calyptorhynchus lathami* is a bird that occurs mainly in the eastern part of NSW from the coast to the tablelands, with populations on the western slopes and plains tenuously connected to those on the tablelands. Habitat comprises eucalypt open forest and woodland with hollow-bearing trees and a midstorey of sheoaks. It nests in tree hollows, and forages exclusively in sheoak species (NSW Scientific Committee, 2008b). Favoured habitat occurs on richer soils and within gentle terrain, and where *Allocasuarina* species are present. Records occur in the vicinity of the nominated areas, mainly where there is better tree cover and *Allocasuarina* species. Hollow-bearing trees within these areas are potential breeding habitat. The species was retained as a candidate species in Wilton, GMAC and GPEC because records occur in the vicinity of urban capable lands. The species was removed in WSA because of a lack of records within the nominated area and a lack of suitable breeding habitat within urban capable lands. Targeted surveys during breeding season and habitat assessment surveys have been undertaken	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							across the nominated areas for this species. The species was not recorded, however potential breeding habitat was found to be present.				
Cercartetus nanus	Eastern Pygmy-possum	✓	✓	✓	✓	Yes	*Cercartetus nanus* is a small marsupial that in NSW occurs from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. The species occurs within a broad range of habitats from rainforest through to sclerophyll forest (including Box-Ironbark) and woodland to heath (OEH, 2019k), generally in more intact forms of vegetation. Records occur to the south-east of Wilton and are all in intact vegetation on a different substrate generally to that of urban capable lands (sandstone rather than shale). Most records within the Cumberland subregion are either inaccurately located or are located in the Bargo River and not within urban capable lands. The record near Campbelltown is located to the north east and is outside the Cumberland subregion. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.	N/A	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							Targeted habitat assessment surveys have been undertaken across the Growth Ares for this species and potential habitat was found to be present.				
Chalinolobus dwyeri	Large-eared Pied Bat	✓	✓	R	✓	Yes	*Chalinolobus dwyeri* is a small to medium sized bat that is found from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. Habitat comprises areas with extensive cliffs and caves (OEH, 2019s). Potential habitat for the species within the nominated areas is likely to occur only in areas outside urban capable lands. The species was retained as a candidate species in Wilton, GMAC and GPEC because foraging habitat within 2 km of sandstone cliffs and caves (potential roosting/breeding habitat) occurs within the nominated areas. The species was removed as a candidate in WSA as no potential roosting / breeding habitat occurs within 2 km of the nominated areas.	N/A	Yes	No	N/A
Cynanchum elegans	White-flowered Wax Plant	R	R	R	R	No	*Cynanchum elegans* is a climbing vine that is restricted to eastern NSW and is found from Brunswick Heads in the north to Gerroa in the South. Habitat usually occurs on the edge of dry rainforest vegetation (OEH, 2019ah). Within the nominated areas, the species is most likely to occur along streamlines and steeper shale lands. No	Section 6.1.1.2 (lack of records, lack of suitable habitat)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							records of the species occur in the nominated areas. The species was removed as a candidate species in all nominated areas because of a lack of records and suitable habitat within urban capable lands. The urban capable lands are generally avoiding streamlines and steeper shale lands containing native vegetation where this species is most likely to occur. No dry rainforest vegetation occurs within urban capable land.				
Darwinia biflora		R	X	X	X	No	*Darwinia biflora* is an erect spreading shrub that is restricted to NSW and found in Ku-ring-gai, Hornsby, Baulkham Hills and Ryde Local Government Areas (OEH, 2017d). This species occurs on the edges of weathered shale-capped ridges and the transition area with Hawkesbury Sandstone. Most sites occur on the Lucas Heights Soil Landscape and the transition with Gymea or the Hawkesbury Soil Landscapes (NPWS, 2003). These habitat characteristics tend to occur in the lower-slope areas where the Shale Sandstone Transition Forest intersects with the sandstone enriched gully forests (PCT 1081, PCT 1181). The species may also occur in coastal upland swamp communities, but these do not occur within the nominated areas. The species has been removed as a candidate	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							species in Wilton because urban capable land is outside the geographic extent of the species.				
Darwinia peduncularis		R	X	X	X	No	*Darwinia peduncularis* is a broad spreading shrub that has been recorded from Brooklyn, Berowra, Galston Gorge, Hornsby, Bargo River, Glen Davis, Mount Boonbourwa and Kings Tableland in NSW. The species occurs as local disjunct populations in coastal NSW with isolated populations in the Blue Mountains. Populations also occur within the Marramarra National Park, Wollemi National Park, Blue Mountains National Park and Berowra Valley Regional Park (NSW Scientific Committee, 1999a). Habitat comprises sandstone soils on either ridge crests or upper slopes and dry sclerophyll forest on sandstone hillsides and ridges. Potential habitat for the species within the nominated areas is likely to occur only in areas outside urban capable lands. The species has been removed as a candidate species in Wilton because of a lack of suitable habitat in urban capable land.	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A
Deyeuxia appressa		R	X	R	X	No	*Deyeuxia appressa* an erect perennial grass that is a highly restricted in NSW. Habitat comprises wet ground in the Hornsby area (Royal Botanic Gardens & Domain Trust, 2019). The species is primarily found east of the Plan Area with records	Section 6.1.1.2 (outside geographic extent,	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							from Salt Pan Creek and Killara, and questionable records from Kellyville. The species is considered to be extinct in the wild as the areas confirmed to be formerly occupied are now well developed and the species has not been otherwise reliably recorded since 1942. The species favours wetter areas that will be excluded from urban capable land as major streams will be avoided. It is not known from the Wianamatta (South Creek) area in GPEC that may be potentially impacted by transport corridors. The species has been removed as a candidate species in WSA and Wilton because urban capable lands are outside the geographic extent of the species and a there is a lack of suitable habitat within urban capable lands.	lack of BioNet records)			
Dillwynia tenuifolia		R	R	✓	✓	Yes	*Dillwynia tenuifolia* is a low spreading shrub that primarily occurs in the Cumberland Plain from Windsor and Penrith in the north to Dean Park and near Colebee in the east. Habitat comprises scrubby and dry heath areas that occur in Castlereagh Ironbark Forest and Shale Gravel Transition Forest. It can also be found in the transition areas between these communities and Castlereagh Scribbly Gum Woodland. Outside of its primary distribution, the species has been recorded from Voyager Point and Kemps Creek, Luddenham, and South Maroota	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	Yes	Yes	WSA, GPEC

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		Wilton	GMAC	WSA	GPEC						
							(OEH, 2017c). The species is likely to occur in all areas of PCT 724 and most areas of PCT 725. The species was retained as a candidate species in WSA and GPEC because suitable habitat is likely to occur in urban capable lands. The species was removed in GMAC and Wilton because of a lack of records within the nominated areas and a lack of suitable micro-habitat in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.				
Dillwynia tenuifolia - endangered population	Dillwynia tenuifolia	X	X	R	X	No	*Dillwynia tenuifolia* is a low spreading shrub. The endangered population occurs at Kemps Creek south of WSA (the population occurs within the existing South West Sydney Growth Area) (NSW Scientific Committee, 1997). The population was removed as a candidate species in WSA because it does not occur within urban capable land.	Section 6.1.1.2 (outside geographic extent)	No	Yes	WSA
Epacris purpurascens var. *purpurascens*		✓	✓	R	R	Yes	*Epacris purpurascens* var. *purpurascens* is a shrub that is found in NSW from Gosford in the north, Narrabeen in the east, Silverdale in the west, and Avon Dam in the south (OEH, 2017e). Habitat comprises areas in the vicinity of creeks and swamps on sandstone in dry sclerophyll forest and scrub (Royal Botanic Gardens & Domain Trust,	Section 6.1.1.2 (lack of BioNet records, lack of suitable	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							2019). Surveys have been undertaken for this species within urban capable lands. The species was not recorded during surveys. Though common in the Bingara Gorge and St Marys Towers areas, the species appears to be absent from other areas. This includes adjacent properties that were assessed. The species was retained as a candidate species in Wilton and GMAC because suitable habitat is likely to occur in urban capable lands. The species was removed in WSA and GPEC because of a lack of records and no suitable micro-habitat within urban capable lands.	habitat)			
Eucalyptus benthamii	Camden White Gum	✓	✓	R	R	Yes	*Eucalyptus benthamii* is a tree that is restricted to the alluvial flats of the Nepean River and its tributaries (DoE, 2014; OEH, 2017b). Habitat comprises wet forest on sandy alluvial soils along valley floors (Royal Botanic Gardens & Domain Trust, 2019). The distribution of the species includes Wilton and GMAC and south of GPEC and WSA, including west of WSA in the Bents Basin/Wallacia area. The species was retained as a candidate species in Wilton and GMAC because suitable habitat may occur in urban capable lands, although habitat is most likely to occur only in areas outside urban capable lands. The species was removed in WSA	Section 6.1.1.2 (lack of BioNet records)	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							and GPEC because of a lack of records within urban capable lands.				
Eucalyptus sp. Cattai		R	X	X	X	No	*Eucalyptus sp. Cattai* is a small tree that occurs between Colo Heights and Castle Hill. It is generally found outside the subregion and considered restricted to the Cattai - Glenhaven region. Historic records occur near the Royal Botanic Gardens, Sydney (NSW Scientific Committee, 1998b). Habitat comprises scrub, heath, and low woodland on sandy soils generally in flat areas and on ridge tops (OEH, 2018e). This species was removed as a candidate species in Wilton as urban capable land occurs outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Grammitis stenophylla	Narrow-leaf Finger Fern	R	X	X	X	No	*Grammitis stenophylla* is a small fern that occurs in eastern Queensland and NSW as far west as Narrabri. Habitat comprises moist places in rainforest and moist eucalypt forests near streams on rocks or in trees (OEH, 2018k). A single record occurs in the Cumberland subregion at Parramatta. The location of the record is close to the subregion boundary (but occurs in much wetter habitats than occur in the nominated areas). This record is old, and its location is unreliable (Royal Botanic Gardens & Domain Trust, 2019). This species was removed as a candidate species in	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							Wilton as urban capable land occurs outside the geographic extent of the species.				
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	R	R	✓	✓	Yes	*Grevillea juniperina* subsp. *juniperina* is a shrub endemic to Western Sydney. It has a restricted range, occurring on red sandy to clay soils on Wianamatta Shale and Tertiary alluvium in Cumberland Plain Woodland and Castlereagh Woodland (NSW Scientific Committee, 2000). The species is likely to occur within WSA and GPEC. The species was retained as a candidate species in WSA and GPEC because suitable habitat is likely to occur in urban capable lands. The species was removed in Wilton and GMAC because the expert report confirmed a lack of suitable habitat within urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.	Section 6.4.1.17 (expert report concluded species unlikely to be present)	Yes	Yes	GPEC
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	✓	✓	✓	✓	Yes	*Grevillea parviflora* subsp. *parviflora* is a shrub that has a sporadic distribution throughout the Sydney Basin IBRA region (OEH, 2018l). Habitat comprises damper sandy or light clay soils, often with lateritic ironstone gravels and nodules, in a range of vegetation types from heath and shrubby woodland to open forest (OEH, 2018l). The species has been recorded during surveys undertaken for	N/A	Yes	No	Wilton

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		Wilton	GMAC	WSA	GPEC						
							this project The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within inaccessible parts of urban capable lands.				
Grevillea parviflora subsp. *supplicans*		R	R	X	R	No	*Grevillea parviflora* subsp. *supplicans* is a shrub with a highly restricted distribution confined to approximately 8 x 10 km to the north-west of Sydney in the area near Arcadia and Maroota-Marramarra Creek. Habitat comprises heathy woodland associations on skeletal sandy soils over massive sandstones (OEH, 2017f, 2018b). Most records occur in the Yengo and Pittwater subregions. The species was removed as a candidate species in all nominated areas as urban capable lands occur outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Gyrostemon thesioides		R	R	R	R	No	*Gyrostemon thesioides* is a shrub with a highly restricted distribution in NSW. Habitat comprises hillsides and riverbanks in riparian zones on sandy soils. It has only been recorded at three sites near the Colo, Georges, and Nepean Rivers (OEH, 2018g). Existing records are poorly geolocated, but all records of the species are located in riparian	Section 6.1.1.2 (lack of suitable habitat and BioNet	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							corridors of high order streams. As such all habitats have been avoided within urban capable lands in the Wilton, GMAC and WSA. No records of the species occur within the GPEC, and the closest records, more recent than 1967, are over 30kms away in the Wollemi and Blue Mountains NPs. Potential habitat for the species (riparian corridors) within the nominated areas is likely to occur only in areas outside urban capable lands This species was removed as a candidate species in all nominated areas because of a lack of suitable habitat within urban capable lands	records)			
*Haliaeetus leucogaster**	White-bellied Sea-Eagle	✓	✓	✓	✓	Yes	*Haliaeetus leucogaster* is a large bird that is widespread along the east coast of NSW and occurs along all major inland rivers and waterways. The species forages over large areas of open water, including swamps, lakes, larger rivers and the sea. It breeds in tall, open forest and woodland, and swamp sclerophyll forest close to foraging areas. Nest trees typically comprise the tallest trees, often with emergent dead branches or large dead trees nearby which are used as 'guard roosts' (OEH, 2019ag). The species was retained as a candidate species in all nominated areas because suitable habitat has	N/A	Yes	Yes	GMAC, WSA, Wilton

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		Wilton	GMAC	WSA	GPEC						
							the potential to occur in urban capable lands. Targeted surveys for breeding habitat were undertaken within the nominated areas and potential habitat was recorded.				
Haloragis exalata subsp. *exalata*	Square Raspwort	X	X	R	X	No	*Haloragis exalata* subsp. *exalata* is a shrub that occurs in four scattered localities in eastern NSW within the Central Coast, South Coast and North Western Slopes regions. Habitat comprises wet and shaded parts of riparian corridors (Miles & Cameron, 2007). It is not known the Cumberland subregion. Populations recorded historically from Western Sydney are thought to no longer exist (NSW Scientific Committee, 2009). The closest records occur at Marramarra Creek and in the Kiama area. Surveys have not been undertaken for this species within urban capable lands. The species was removed as a candidate species in WSA as urban capable land occurs outside the geographic extent of the species. Wet riparian habitats have been excluded from urban capable lands through stream buffers, and as such habitat for the species is not considered likely to occur.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Haloragodendron lucasii		R	X	X	X	No	*Haloragodendron lucasii* is a shrub found in a very narrow distribution spanning a 10 km range in the northern suburbs of Sydney (OEH, 2019o). Habitat comprises moist sandy loam soils in sheltered	Section 6.1.1.2 (outside geographic	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							aspects, and on gentle slopes below cliff-lines near creeks in low open woodland (OEH, 2019). Records occur in nine sites in the Hornsby-Gordon area (DEWHA, 2008b; Hogbin, Peakall et al., 2000). The species has been removed as a candidate species in Wilton and WSA as urban capable land occurs outside the geographic extent of the species.	extent, lack of BioNet records)			
Heleioporus australiacus	Giant Burrowing Frog	✓	✓	X	✓	Yes	*Heleioporus australiacus* is a large frog found in south eastern NSW and Victoria. In NSW. It appears to be largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla (OEH, 2019m). Habitat comprises heath, woodland and open dry sclerophyll forest on a variety of soil types except clay soils. Breeding habitat comprises soaks or pools within first or second order streams. The species has been added as a candidate species in GPEC as it has the potential to occur within urban capable land in the Penrith Lakes area. Targeted habitat assessments were undertaken for this species, the species was not recorded however suitable habitat was found to occur.	N/A	No	No	N/A
Hibbertia fumana		✓	✓	✓	✓	Yes	*Hibbertia fumana* is a shrub found only in the Sydney basin (OEH, 2020a). Habitat comprises intergrade sand-clay soils primarily in areas with a scribbly gum-dominated overstorey which may	N/A	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							also have some ironbarks. The species is only known from the Moorebank and Bankstown areas. The species is recently described and if present, could have been recorded under a different name in previous studies. Within urban capable lands, habitat may occur in the Kemps Creek area. The species was retained as a candidate species in WSA and GPEC because suitable habitat may occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.				
Hibbertia puberula		✓	✓	✓	✓	Yes	*Hibbertia puberula* is a shrub found from Wollemi National Park south to Morton National Park and the south coast near Nowra. Habitat comprises sandy soil often associated with sandstone, or on clay within dry sclerophyll woodland communities (OEH, 2019p). One of the recently (2012) described subspecies also favours upland swamps. Within urban capable lands, habitat may occur in the Kemps Creek and Glenfield areas and the margins of Wilton. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm	N/A	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							whether suitable habitat exists for this species within urban capable lands.				
Hibbertia sp. *Bankstown*		X	R	R	R	No	*Hibbertia* sp. *Bankstown* is a shrub known to occur in only one population at Bankstown Airport in Sydney. Habitat comprises tertiary alluvial soil along Airport Creek within an area likely to have comprised Cooks River/Castlereagh Ironbark Forest. The species does not occur in areas where fill has been deposited (OEH, 2019q). The species is not known to occur in the Plan Area (although it occurs in the Cumberland subregion). Surveys for *H. fumana* and *H. puberula* have not identified this species within urban capable lands. The species has been removed as a candidate species in GMAC, WSA and GPEC because of a lack of suitable habitat within urban capable lands. Potential habitat within the nominated areas is only likely to occur outside urban capable lands. Species is also known to be highly restricted in distribution to a single known population.	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A
Hibbertia spanantha	Julian's Hibbertia	R	R	X	R	No	*Hibbertia spanantha* is a shrub restricted to the Turramurra - Beecroft - Macquarie Park region. Habitat comprises forest with canopy species including *Eucalyptus pilularis, E. resinifera, Corymbia gummifera* and *Angophora costata* (OEH, 2019r). The species is known from three populations (in three	Section 6.1.1.2 (outside geographic extent, lack of	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							proximate Sydney suburbs within the Lane Cove River catchment (DoE, 2016a; Toelken & Robinson, 2015). The species was removed as a candidate species in Wilton, GMAC, and GPEC as urban capable lands occur outside the geographic extent of the species.	BioNet records)			
Hibbertia superans		R	R	X	R	No	*Hibbertia superans* is a shrub in the north west Sydney region between Baulkham Hills and Wisemans Ferry and near Blaxland in the lower Blue Mountains. It is also known from a disjunct occurrence near Mt Boss (inland from Kempsey) (Royal Botanic Gardens & Domain Trust, 2019). Habitat comprises dry sclerophyll forest on sandstone ridgetops (Royal Botanic Gardens & Domain Trust, 2019). All records of the species are to the north and east of the Plan Area. The species was removed as a candidate species in Wilton, GMAC, and GPEC as urban capable lands occur outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
*Hieraaetus morphnoides**	Little Eagle	✓	✓	✓	✓	Yes	*Hieraaetus morphnoides* is a bird found throughout the Australian mainland except the most densely forested parts of the Dividing Range escarpment. Habitat comprises open eucalypt forest, woodland or open woodland (OEH, 2019v). The species requires tall trees within a remnant patch in which to build a large stick nest. Stick nests have been	N/A	No	Yes	GPEC, GMAC, WSA

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		Wilton	GMAC	WSA	GPEC						
							recorded during surveys undertaken for this project. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within Wilton and GMAC. Targeted surveys for breeding habitat were undertaken within the nominated areas, however no potential habitat was recorded.				
*Hoplocephalus bungaroides**	Broad-headed Snake	R	R	X	X	No	*Hoplocephalus bungaroides* is largely confined to sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, in an area within approximately 250 km of Sydney. Habitat comprises rock crevices and sandstone rock areas on exposed cliff edges. The species moves from sandstone rocks to shelters in crevices or hollows in large trees within 500m of escarpments in summer (OEH, 2019e). There is a single record from Appin in the Plan Area (1970), and a few other records in other parts of the Cumberland subregion. The records are poorly geolocated. The species was removed as a candidate species in Wilton and GMAC because of a lack of suitable habitat within urban capable lands. Potential	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							habitat for the species within the nominated areas is likely to occur only outside urban capable lands.				
Lasiopetalum joyceae		R	X	X	X	No	*Lasiopetalum joyceae* is a shrub with a restricted range. It is found on lateritic to shaley ridgetops on the Hornsby Plateau south of the Hawkesbury River. Habitat comprises heath areas on sandstone (OEH, 2019t). It is known from 34 sites between Berrilee and Duffys Forest (NSW Scientific Committee, 1999b). The species was removed as a candidate species in Wilton as urban capable lands occur outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
*Lathamus discolor**	Swift parrot*	R	R	R	R	No	*Lathamus discolor* is a small bird that breeds in Tasmania during the summer and migrates north to mainland Australia for the winter (TSSC, 2016). The species was removed as a candidate species in all nominated areas based on EES advice that no areas critical for the persistence of the species occur in urban capable lands.	EES confirmed no important habitat mapped	No	Yes	Wilton

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		Wilton	GMAC	WSA	GPEC						
Leucopogon exolasius		R	X	R	R	No	*Leucopogon exolasius* is a shrub restricted to the Woronora and Grose Rivers and Stokes Creek, Royal National Park. Habitat comprises sandy alluvium and rocky sandstone hillsides near creeks, on low nutrient soils (Royal Botanic Gardens & Domain Trust, 2019).The descriptive text for many of the records within the Cumberland subregion suggest the records are inaccurately geolocated and unlikely to occur within the subregion (apart from the few records near Jordan Pass, south of Appin). Potential habitat for the species within the nominated areas is likely to occur only in areas outside urban capable lands. The species was removed as a candidate species in Wilton, WSA and GPEC because of a lack of suitable habitat within urban capable lands.	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A
Leucopogon fletcheri subsp. *fletcheri*		R	R	X	R	No	*Leucopogon fletcheri* subsp. *fletcheri* is a shrub endemic to north-western Sydney, and is found between St Albans in the north and Annangrove in the south (OEH, 2017h). Habitat comprises dry eucalypt woodland or shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs (OEH, 2017h). There are four records from the area east and north-east from Kentlyn in the sandstone ridge terrain and the	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							species is found elsewhere in similar terrain. Despite the potential to occur in Wilton and southern part of GMAC, the habitat has been well surveyed previously and no additional records were located. The species was removed as a candidate species in Wilton, GMAC and GPEC because of a lack of suitable habitat within urban capable lands.				
Limicola falcinellus	Broad-billed Sandpiper	X	X	R	X	No	*Limicola falcinellus* is a small migratory bird that breeds in northern Siberia and overwinters in Australia (OEH, 2017b). The species does not breed in Australia and there is no breeding habitat or important habitat within the Plan Area. Foraging habitat significant to the species primarily comprises coastal wetlands and mudflats. The species was removed as a candidate species in WSA as breeding habitat and significant foraging habitat does not occur within urban capable land.	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A
*Limosa limosa**	Black-tailed Godwit*	X	X	R	X	No	*Limosa limosa* is a migratory wading bird that breeds in Mongolia and eastern Siberia, and spends the southern summer in Australia. In NSW, it has been recorded at Kooragang Island. The species does not breed in Australia and there is no breeding habitat within the Plan Area. Non-breeding habitat is predominantly coastal areas including sheltered bays, estuaries and lagoons. It	Section 6.1.1.2 (lack of suitable habitat)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							can also be found further inland on mudflats and around muddy lakes and swamps (OEH, 2019d). There are 10 records in the Cumberland subregion mostly from between 1980 and 1992. Sighting locations include lagoons in the northern parts of the Plan Area (e.g. Bakers Lagoon) outside urban capable lands. The species was removed as a candidate species in WSA as breeding and significant foraging habitat does not occur within urban capable land.				
Litoria aurea	Green and Golden Bell Frog	✓	✓	✓	✓	Yes	*Litoria aurea* is a large frog formerly distributed from the NSW north coast near Brunswick Heads, southwards along the NSW coast to Victoria (OEH, 2019n). Habitat comprises marshes, dams and stream-sides, particularly those containing bulrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.). Primary habitat includes water-bodies that are unshaded, free of predatory fish, and have a grassy area nearby. Records of the species within the nominated areas are scattered and generally old or poorly geolocated. Two recent records (2013, 2015) in the Blair Athol area near Campbelltown suggest that the species is able to persist in heavily impacted environments. The species was retained as a candidate species in all nominated areas because suitable habitat has	N/A	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands. Targeted habitat assessments have not been undertaken for this species.				
*Lophoictinia isura**	Square-tailed kite	✓	✓	✓	✓	Yes	*Lophoictinia isura* is a medium-sized bird found in coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. It is known to occur in the Cumberland subregion. Habitat comprises dry woodlands and open forests, in particular timbered watercourses (OEH, 2017m) Stick nests that may be associated with this species have been recorded during field surveys for this project The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within Wilton and GMAC. Targeted surveys for breeding habitat were undertaken within the nominated areas and potential habitat was recorded.	N/A	Yes	Yes	GMAC, GPEC

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		Wilton	GMAC	WSA	GPEC						
Marsdenia viridiflora subsp. *viridiflora* - endangered population		X	✓	✓	✓	Yes	*Marsdenia viridiflora* subsp. *viridiflora* is a climbing plant. The distribution of the population within the relevant local government areas described in the final determination is not clearly defined. Habitat comprises vine thickets and open shale woodland (OEH, 2019w). Recent records occur in Narellan, Mt Annan Botanic Gardens and the Western Sydney Airport. Recent survey in the Menangle area did not record the species. The species may occur in the Gilead area of GMAC. Habitat for the species will be modelled to determine impacts. The species was retained as a candidate species in all GMAC, WSA and GPEC because suitable habitat has the potential to occur in urban capable lands.	N/A	Yes	No	N/A
Maundia triglochinoides		X	X	✓	✓	Yes	*Maundia triglochinoides* is a water plant restricted to coastal NSW and extending into southern Queensland. Habitat comprises swamps, lagoons, dams, channels, creeks or shallow freshwater 30 to 60 cm deep on heavy clay with low nutrients (OEH, 2019y).There is a single record in the Cumberland subregion that is highly questionable as it occurs in very weedy habitat. Other records in the Sydney area are from coastal sites and wetlands that occur outside urban capable lands. Detailed habitat assessments have been	N/A	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							undertaken. The species was retained as a candidate species in WSA and GPEC due to the presence of high Strahler order streams (e.g. Wianamatta (South Creek)) in suitable PCTs.				
Melaleuca deanei	Deane's Paperbark	✓	✓	X	R	Yes	*Melaleuca deanei* is a shrub found in two distinct areas – in the north (Ku-ring-gai/Berowra area) and south (Holsworthy/Wedderburn area) of Sydney. There are also more isolated occurrences in the Blue Mountains, Nowra and Central Coast areas" (NSW Scientific Committee, 1999c). Habitat mostly comprises ridgetop woodland, with about 5 per cent of sites located in heath on sandstone (OEH, 2019h). The species was retained as a candidate species in Wilton and GMAC because suitable habitat has the potential to occur in urban capable lands. The species was removed in GPEC as suitable habitat does not occur within urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.	Section 6.1.1.2 (lack of BioNet records)	Yes	No	N/A
Meridolum corneovirens	Cumberland Plain Land Snail	✓	✓	✓	✓	Yes	*Meridolum corneovirens* is a snail that is found on the Cumberland Plain from Richmond and Windsor south to Picton, and from Liverpool west to the Hawkesbury and Nepean Rivers. Habitat	N/A	Yes	Yes	GPEC, GMAC

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		Wilton	GMAC	WSA	GPEC						
							comprises the litter of bark, leaves and logs, or shelters in loose soil around grass clumps within Cumberland Plain Woodland and Shale Gravel Transition Forest, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest (OEH, 2019g). The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.				
Micromyrtus minutiflora		X	X	✓	✓	Yes	*Micromyrtus minutiflora* is a shrub restricted to the area between Richmond and Penrith. Habitat comprises Castlereagh Scribbly Gum Woodland, Ironbark Forest, Shale/Gravel Transition Forest and open forest on tertiary alluvium and consolidated river sediments (OEH, 2019z). Records to the south-east of Wilton and Appin are likely to be misidentifications of the very similar species *M. blakelyi* and *M. ciliata.* The species was retained as a candidate species in WSA and GPEC because suitable habitat has the potential to occur in urban capable lands.	N/A	Yes	No	N/A
Miniopterus	Little Bentwing-	R	R	R	R	No	*Miniopterus australis* is a micro-bat found along the east coast and ranges of Australia from Cape York	Section 6.1.1.2	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
*australis**	bat						in Queensland to Wollongong in NSW. Habitat comprises moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and Banksia scrub. Roosting habitat includes caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and buildings (OEH, 2019u). Breeding habitat occurs within steep and rocky areas. The species was removed as a candidate species in all nominated areas as breeding habitat is unlikely to occur within urban capable lands. Potential breeding habitat within the nominated areas occurs only outside urban capable lands.	(outside geographic extent)			
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	R	R	R	R	No	*Miniopterus orianae oceanensis* is a micro-bat found along the east and north-west coasts of Australia. Roosting habitat comprises caves, but also derelict mines, storm-water tunnels, buildings and other man-made structures (OEH, 2019j). Potential breeding habitat for the species (caves) within the nominated areas is likely to only occur outside urban capable lands. There are no records of any significant human-made breeding habitat within urban capable lands. The species was removed as a candidate species in all nominated areas as breeding habitat is unlikely	Section 6.1.1.2 (outside geographic extent)	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							to occur within urban capable lands.				
Myotis macropus	Southern Myotis	✓	✓	✓	✓	Yes	*Myotis Macropus* is a micro-bat in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. Habitat comprises caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage (OEH, 2019ad). Records occur throughout the Cumberland subregion. There have been 72 sightings of the species in the subregion since 2012. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands.	N/A	Yes	Yes	GMAC, WSA
*Ninox connivens**	Barking owl	✓	✓	R	✓	Yes	*Ninox connivens* is a medium-sized owl that occurs in a wide but sparse distribution in NSW. Core populations exist on the western slopes and plains and in some northeast coastal and escarpment forests (OEH, 2019b). Habitat comprises woodland and open forest, including fragmented remnants and partly cleared farmland. Breeding habitat comprises hollows of large eucalypts or paperbarks, usually near watercourses or wetlands (NSW NPWS, 2003b). The species was retained as a candidate species in Wilton, GMAC and GPEC because suitable habitat	Section 6.1.1.2 (lack of suitable habitat)	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							has the potential to occur in urban capable lands. The species was removed in WSA because of a lack of suitable breeding habitat within urban capable land (as urban capable land has been largely cleared). Habitat assessment surveys have been undertaken across the Growth Ares for this species. Potential breeding habitat was found to be present.				
*Ninox strenua**	Powerful owl	✓	✓	✓	✓	Yes	*Ninox strenua* is a large owl that is occurs in eastern and south-eastern Australia, from Mackay down to Victoria (OEH, 2017k). Habitat comprises a range of vegetation types, including woodland, open sclerophyll forest, tall wet open forest and rainforest (OEH, 2017k). While this species typically requires large tracts of intact woodland, it is also known to occur in fragmented landscapes (OEH, 2017k). The species nests in large tree hollows (OEH, 2017k). The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. Habitat assessment surveys have been undertaken across the nominated areas for this species. Potential breeding habitat was found to be present.	N/A	Yes	Yes	GMAC
Pandion	Eastern	X	R	R	R	No	*Pandion cristatus* is a bird of prey (OEH, 2018d) that is found around the Australian coastline, except for	Section 6.1.1.2	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
*cristatus**	Osprey						Victoria and Tasmania, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia (OEH, 2018d). Habitat comprises coastal areas, particularly large coastal river mouths, lakes and lagoons (OEH, 2018d). The species nests in tall trees in coastal woodland to forest habitat (NSW Scientific Committee, 2009). The breeding population of this species in NSW spans from the Queensland border to Ulladulla in south-eastern NSW (NSW Scientific Committee, 2009). Vagrants have been recorded as far south as Victoria (NSW Scientific Committee, 2009). There are four records in the Cumberland subregion. Three occur in Milperra in 2014 (two have the same coordinates), while the last record is from North Ryde. The species was removed as a candidate species in GMAC, WSA and GPEC because of a lack of suitable breeding habitat within urban capable lands.	(outside geographic extent, lack of BioNet records, lack of suitable habitat)			
Persicaria elatior	Tall Knotweed	X	✓	✓	✓	Yes	*Persicaria elatior* is a herb found in south-eastern and northern NSW and Queensland (OEH, 2018n). It is known from the Cumberland subregion. Habitat comprises damp places, particularly beside streams and lakes. The species is occasionally found in swamp forest or associated with	N/A	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							disturbance (OEH, 2018n). There are a few records within and nearby the Plan Area. The 1949 record from 'Picton Lakes' refers to Thirlmere Lakes (at that time being called Picton Lakes), and more recent (2010) records occur there. There is an unverified record from 2018. The species has been retained as a candidate in GMAC, WSA and GPEC because it may be subject to prescribed impacts (hydrology) and the transport corridors may have a direct impact on the species in WSA and GPEC. Targeted surveys have not been undertaken for this species within urban capable lands. However, habitat assessments have been completed.				
Persoonia bargoensis	Bargo Geebung	✓	✓	R	R	Yes	*Persoonia bargoensis* is a shrub that is restricted to a small area south-west of Sydney bounded by Picton, Douglas Park, Yanderra and Cataract River (NSW Scientific Committee, 2000). Habitat comprises woodland or dry sclerophyll forest on sandstone and shale soils (OEH, 2017a). The species can be found adjacent to disturbed areas such as roadsides (OEH, 2017a). Many of the records in Wilton and GMAC have very low reliability and are not recent records. The species was retained as a candidate species in Wilton and GMAC because records occur within	Section 6.1.1.2 (lack of suitable habitat)	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							urban capable lands and suitable habitat has the potential to occur. The species was removed in WSA and GPEC because of a lack of suitable habitat within urban capable lands and no records occur north of Wilton.				
Persoonia glaucescens	Mittagong Geebung	R	X	X	X	No	*Persoonia glaucescens* is a shrub that is found in the Southern Highlands area, roughly between Picton and Berrima (NSW Scientific Committee, 2002b). Recent surveys have indicted this distribution has contracted (OEH, 2018j). Habitat includes woodland to dry sclerophyll forest, mostly on ridge tops, plateaux and upper slopes (OEH, 2018j). Records occur to the south of the Plan Area, with the northernmost records at Tahmoor. Surveys have been undertaken for this species within urban capable lands. The species was not recorded during surveys. The species was removed as a candidate species in Wilton as urban capable land is outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Persoonia hirsuta	Hairy Geebung	R	R	R	R	No	*Persoonia hirsuta* is a shrub that has a scattered distribution around Sydney, and is found in the area bounded by Bargo to the south, Singleton to the north and the Blue Mountains to the west (OEH, 2017g). Habitat comprises sandstone and sandstone-derived soils in dry sclerophyll open	Section 6.1.1.2 (outside geographic extent, lack of	No	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							forest, woodland and heath (OEH, 2017g). There are no records of the species within the Plan Area. The sole record within the Plan Area is a specimen that is misplaced and should correctly be located in 'Long Point, Macquarie Fields', approx. 3 km south-east of the mapped location. The species was removed as a candidate species in all nominated areas as urban capable land is outside the geographic extent of the species.	BioNet records)			
Persoonia mollis subsp. *maxima*	Soft Geebung	R	X	X	X	No	*Persoonia mollis* subsp. *maxima* is a tall shrub with a restricted distribution, and is known from the Hornsby Heights - Mt Colah area north of Sydney (OEH, 2017i). Habitat comprises sheltered, deep Hawkesbury sandstone gullies and upper steep hillsides (OEH, 2017i). These habitats often support relatively moist, tall forest vegetation communities, often with warm temperate rainforest influences (OEH, 2017i). There 11 records within the Cumberland subregion. All records occur outside the nominated areas. The most recent record is 2005. The species was removed as a candidate species in Wilton as urban capable land is outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A
Persoonia nutans	Nodding Geebung	R	R	✓	✓	Yes	*Persoonia nutans* is a shrub that is found on the Cumberland Plain, between Richmond in the north	Section 6.4.1.17	Yes	Yes	GPEC

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		Wilton	GMAC	WSA	GPEC						
							and Macquarie Fields in the south (OEH, 2019aa). Core distribution occurs in Penrith, and to a lesser extent the Hawkesbury area (OEH, 2019aa). Northern populations are found on aeolian and alluvial sediments, while southern populations occur on alluvial sediments and shale/sandstone transition zones (OEH, 2019aa). Habitat comprises a range of sclerophyll forest and woodland vegetation communities (OEH, 2019aa). Records in the northern end of GMAC are poorly geolocated. More accurate records occur in the Simmos Beach and Moorebank area The species was retained as a candidate species in WSA and GPEC because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands. The species was removed as a candidate species in Wilton and GMAC because the expert report confirmed a lack of suitable habitat within urban capable lands.	(expert report concluded species unlikely to be present)			
Petaurus norfolcensis	Squirrel Glider	✓	✓	R	✓	Yes	*Petaurus norfolcensis* is a small possum that is found in eastern Australia from northern Queensland to western Victoria. Habitat comprises blackbutt-bloodwood forest with heath understorey in	Section 6.1.1.2 (lack of BioNet	Yes	No	N/A

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		Wilton	GMAC	WSA	GPEC						
							coastal areas, and box, box-ironbark and river red gum woodlands further inland (OEH, 2017n). The species prefers mature or old growth woodland and requires abundant tree hollows for refuge and nesting sites (OEH, 2017n). Records occur within Wilton in areas outside urban capable lands. The species was retained as a candidate species in Wilton, GMAC and GPEC because suitable habitat has the potential to occur in urban capable lands. The species was removed in WSA because of a lack of suitable habitat and recent records (<100 years old) within urban capable land Habitat assessment surveys have been undertaken across the Growth Ares for this species. Potential habitat was found to be present.	records, lack of suitable habitat)			
*Phascolarctos cinereus**	Koala	✓	✓	R	R	Yes	*Phascolarctos cinereus* is an arboreal marsupial that has a fragmented distribution throughout eastern Australia. In NSW, it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. Habitat comprises eucalypt woodlands and forests (OEH, 2018h). Koalas feed on over 70 species of Eucalyptus and over 30 non-Eucalyptus species (OEH, 2018h). There are a significant number of recent Koala records present within and adjacent to Wilton and GMAC. Breeding habitat occurs through the	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	Yes	Yes	GMAC, Wilton

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment: Wilton	GMAC	WSA	GPEC	Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
							eastern portion of GMAC and around Wilton (OEH, 2018c). Records further indicate the presence of Koalas within the Blue Mountains, particularly in the district of Kurrajong, with very few records occurring east of these areas within the urban matrix. Three forms of Koala habitat mapping were undertaken across the Plan Area, including within all the nominated areas (see Part 3). They include: • A species distribution model (SDM) for the species across the Cumberland subregion • Corridor habitat mapping • Mapping of habitat critical to the survival of the species The BAM requires the assessment of impacts on Koala to be determined on the basis of 'important habitat'. The Koala corridor habitat mapping undertaken within the nominated areas was used to identify important habitat that comprises the species polygons for Koala as required by the BAM. The corridor habitat mapping is built on the work of EES in mapping habitat around Wilton and GMAC (OEH, 2018h). The species was retained as a candidate species in Wilton and GMAC as the corridor mapping found 'important habitat' to be present in the form of				

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							primary and secondary corridors, as well as multiple recent records. The species was removed in WSA and GPEC because of a lack of important habitat within these nominated areas (as defined as primary and second habitat corridors). Part 3, section 11.1.1, provides a more detailed justification for the exclusion of Koala as a candidate species from GPEC and WSA, and Part 3, section 11.5.4 provides further detail on the corridor mapping method.				
Pilularia novae-hollandiae	Austral Pillwort	X	R	R	R	No	*Pilularia novae-hollandiae* is a semi-aquatic fern that has a scattered distribution in NSW. Habitat comprises shallow swamps and waterways, often amongst grasses and sedges (OEH, 2018a). The species is probably ephemeral, growing in moist soils following rain events, and is often recorded in drying mud (OEH, 2018a). Despite the high occurrence and coverage of botanical surveys across the Cumberland subregion the species has not been recorded since a single record from 1966 in Doonside. It is expected that more recent records would exist if the species natural range included the Cumberland subregion. Potential habitat for the species (high order Strahler streams) within the nominated areas is likely to only occur in areas outside urban capable	N/A	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							lands, with all mapped creek lines above Strahler order one, being excluded from the footprint. The species has been removed as a candidate in all nominated areas.				
Pimelea curviflora var. *curviflora*		R	R	R	✓	Yes	*Pimelea curviflora* var. *curviflora* is a shrub found in the coastal area of Sydney and the Illawarra regions (OEH, 2019ac).The species is known from approximately 20 locations in the Baulkham Hills, Blacktown, Hornsby, Parramatta and Warringah Local Government Areas (NSW NPWS, 1999) and the Shellharbour area. The species was formerly recorded around the Parramatta River and Port Jackson areas. Habitat comprises shale, sandstone, and lateritic soils, on ridgetops and upper slopes in woodlands (OEH, 2017j). Records (dated 2000) occur in only two locations in the vicinity of the nominated areas. Despite extensive surveys at Bingara Gorge in suitable habitat, the species was not recorded, suggesting that the two records in the vicinity of the nominated areas may be misapplications for *P. curviflora* var. *sericea* which is recorded in that area. The species was retained as a candidate species in GPEC because records or suitable habitat potentially occur in the vicinity of urban capable lands. The species was removed in Wilton, GMAC	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							and WSA because of limited habitat within nominated areas and a lack of trusted BioNet records within 10kms of the nominated area.				
Pimelea spicata	Spiked Rice-flower	✓	✓	✓	✓	Yes	*Pimelea spicata* is a shrub that occurs in two disjunct areas; the Cumberland Plain (Marayong and Prospect Reservoir south to Narellan and Douglas Park) and the Illawarra (Lansdowne to Shellharbour to northern Kiama) (OEH, 2017l). Habitat comprises Grey Box communities (particularly Cumberland Plain Woodland variants and Moist Shale Woodland) and in areas of ironbark on well-structured clay soils (OEH, 2017l). Nearest records to the nominated areas are around Douglas Park. It is likely that the species no longer occurs in the parts of the nominated areas due to a history of intensive grazing and other land uses. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands. While the species was not recorded during surveys for this project, suitable habitat was recorded.	N/A	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Pomaderris brunnea	Brown Pomaderris	✓	✓	R	R	Yes	*Pomaderris brunnea* is a shrub that is found in restricted areas near the Colo, Nepean and Hawkesbury rivers in NSW, in addition to areas near Bargo and Camden (OEH, 2017c). It is also known near Walcha in the New England Tablelands, and from Gippsland in Victoria (OEH, 2017c). Habitat comprises moist woodland or forest on clay and alluvial soils of flood plains and creek lines (OEH, 2017c). Records occur in several areas within the GMAC, particularly to the south of Menangle Creek in the Gilead area and on Beulah Biobank site. One of the records adjacent to Wilton appears to be poorly geolocated. The species was retained as a candidate species in Wilton and GMAC because records or suitable habitat occurs in the vicinity of urban capable lands. The species was removed in WSA and GPEC because of a lack of records and suitable clay and alluvial soils within urban capable lands.	Section 6.1.1.2 (lack of BioNet records)	Yes	Yes	GMAC
Pomaderris prunifolia - endangered population		R	X	R	R	No	*Pomaderris prunifolia* is a shrub that occurs uncommonly on the tablelands and slopes of NSW. A population of the species within the Parramatta, Auburn, Strathfield and Bankstown Local Government Areas is listed as endangered. The population is known from only three sites – at Rydalmere on a road reserve, within Rookwood	Section 6.1.1.2 (outside geographic extent, lack of BioNet	No	Yes	GMAC

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							Cemetery and at The Crest of Bankstown (OEH, 2019ab). The species was removed as a candidate species in Wilton, WSA and GPEC because the extent of the population does not occur within urban capable lands.	records)			
Pommerhelix duralensis	Dural Woodland Snail	R	R	R	R	No	*Pommerhelix duralensis* is a medium sized snail endemic to NSW where it occurs on the northwest fringes of the Cumberland subregion. Habitat comprises shale-sandstone transitional landscapes. Most of the records for the species occur around the towns of Wisemans Ferry, Maraylya, Glenorie and Dural (DoE, 2015). The species occurs primarily northwards from Lake Parramatta through Dural and Kentlyn towards the Hawkesbury River. Records from west and south of the GPEC are likely errors (S. Clark pers. comm.) or relate to different taxa (C. Allen pers. comm.). The species was removed as a candidate species in all nominated areas as urban capable lands are outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Pseudophryne australis	Red-crowned Toadlet	✓	✓	X	✓	Yes	*Pseudophryne australis* is small frog that occurs in the Sydney Basin. Habitat comprises periodically wet drainage lines in open forests on Hawkesbury and Narrabeen Sandstones. There are a number of records of the species within the vicinity of three of the nominated areas. The species was retained as a candidate species in Wilton, GMAC and GPEC because suitable habitat has the potential to occur in urban capable lands. Targeted habitat assessments were undertaken for this species, the species was not recorded however suitable habitat was found to occur.	N/A	No	No	N/A
*Pteropus poliocephalus**	Grey-headed flying fox	R	R	R	R	No	*Pteropus poliocephalus* is a large bat that is found along the eastern coast of Australia. Habitat comprises a range of forests, woodlands, heaths and swamps as well as urban gardens and fruit crops (OEH, 2018f). The location of breeding and roosting sites within the Cumberland subregion has been monitored since 2012 as part of a national program (Geoscience Australia, 2015). The species was removed as a candidate species in in all nominated areas because there are no known breeding sites in urban capable lands.	Section 6.1.1.2 (no known flying fox camps)	Yes	Yes	GMAC, GPEC
Pterostylis saxicola	Sydney Plains	✓	✓	✓	✓	Yes	*Pterostylis saxicola* is an orchid that is restricted to western Sydney between Freemans Reach in the	N/A	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
	Greenhood						north and Picton in the south. Habitat comprises sandstone outcrop areas in shale-sandstone transition forest, although it is occasionally found on clay-rich sites (OEH, 2018m). There are a number of records in the vicinity of the nominated areas. Some of these are thought to have low reliability in terms of their location. The species was retained as a candidate species in all nominated areas because suitable habitat has the potential to occur in urban capable lands. An expert report has been prepared to confirm whether suitable habitat exists for this species within urban capable lands.				
Pultenaea parviflora		X	X	✓	✓	Yes	*Pultenaea parviflora* is a small shrub that is endemic to the Cumberland Subregion. The species primarily occurs in areas of Shale Gravel Transition Forest and Cooks River/ Castlereagh Ironbark Forest, with some potential in Castlereagh Scribbly Gum Woodland and Castlereagh Swamp Forest (OEH, 2019a). The species was retained as a candidate species in WSA and GPEC because records occur in the vicinity of the nominated areas and suitable habitat has the potential to occur in urban capable lands.	N/A	Yes	Yes	WSA, GPEC
Pultenaea	Matted	✓	✓	✓	✓	Yes	*Pultenaea pedunculata* is a shrub that occurs in NSW, Victoria, and Tasmania. In NSW it occurs in three	N/A	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
pedunculata	Bush-pea						locations including the Cumberland Subregion. The species occurs in a range of habitats and in the Cumberland Subregion it favours clay or sandy-clay soils that have a lateritic influence with ironstone gravel (nodules) present (OEH, 2018i). The species has been recorded in several places in the vicinity of the nominated areas. The species was retained as a candidate species in all nominated areas because records occur in the vicinity of the nominated areas and suitable habitat has the potential to occur in urban capable lands.				
Tetratheca glandulosa		R	R	X	R	No	*Tetratheca glandulosa* is a small shrub that is restricted to the following Local Government Areas (LGAs): Baulkham Hills, Gosford, Hawkesbury, Hornsby, Ku-ring-gai, Pittwater, Ryde, Warringah, and Wyong (the nominated areas do not occur in these LGAs). The species has a strong association with shale-sandstone soils (OEH, 2017o). The nearest substantiated records to the nominated areas are to the west of Thirlmere lakes where they occur on sandstone communities outside urban capable lands. The species was removed as a candidate species in Wilton, GMAC and GPEC because urban capable lands are outside the geographic range of the species and no records of the species occur within	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
							the vicinity.				
Thesium australe	Austral Toadflax	R	R	R	R	No	*Thesium australe* is a small herb that is found in small populations along the coast of NSW. The species occurs in grasslands on the coast, and grassland or grassy woodland further inland (OEH, 2018a). The species is distinctive in survey (sprawling yellow-grey-green herb) and has only a single old record (1803) from the Cumberland subregion (which is also the type collection). It is currently considered to be extinct in the subregion (OEH, 2018a). The species was removed as a candidate species in all nominated areas because urban capable lands are outside the geographic range of the species and no reliable records of the species occur within the vicinity.	Section 6.1.1.2 (lack of BioNet records)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Tyto novaehollandiae (breeding)	Masked Owl	✓	✓	R	✓	Yes	*Tyto novaehollandiae* is a medium-sized owl which occurs over 90 per cent of NSW and is most abundant on the coast. Roosting and breeding habitat for the species comprises moist eucalypt forested gullies, and it uses large tree hollows or caves for nesting (OEH, 2019x). The large-scale breeding habitat and the fairly specific requirements of large hollowed trees (and especially hollowed stag trees) are scarce on the Cumberland subregion. The species was removed as a candidate species in WSA because of a lack of suitable habitat within urban capable land. The species was retained as a candidate species in Wilton, GMAC and GPEC because known sites occur within the vicinity of the nominated areas. Habitat assessment surveys have been undertaken across the Growth Ares for this species. Potential breeding habitat was found to be present.	Section 6.1.1.2 (lack of BioNet records, lack of suitable habitat)	Yes	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Wahlenbergia multicaulis - endangered population	Tadgell's Bluebell	R	R	R	R	No	*Wahlenbergia multicaulis* is a perennial herb that is found in 13 known sites in northern Sydney and Western Sydney (Rookwood, Chullora, Bass Hill, Bankstown, Georges Hall, Campsie, South Granville and Greenacre) (OEH, 2019ae). In Western Sydney, habitat is associated with the Villawood Soil Series, which is a poorly drained, yellow podsolic extensively permeated with fine, concretionary ironstone (laterite). The species was removed as a candidate species in all nominated areas because the population does not occur within urban capable lands.	Section 6.1.1.2 (outside geographic extent)	No	No	N/A
Zannichellia palustris	Horned Pondweed	X	X	R	X	No	*Zannichellia palustris* is a submerged aquatic plant. In NSW it is only known from the lower Hunter region and Sydney Olympic Park. It occurs in fresh or slightly saline stationary or slowly flowing water (OEH, 2017d). The species was removed as a candidate species in WSA because urban capable land is outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

Scientific name	Common name	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species	Justification for removal of species from further assessment	Basis for removal under BAM	Targeted for survey for this project (y/n)	Recorded during survey (y/n)	Location of record
		Wilton	GMAC	WSA	GPEC						
Zieria involucrata		R	X	X	X	No	*Zieria involucrata* is a small shrub that occurs to the north and west of Sydney in the Baulkham Hills, Hawkesbury, Hornsby and Blue Mountains Local Government Areas. The species is associated with Hawkesbury sandstone, as well as Narrabeen Group sandstone and Quaternary alluvium (OEH, 2017e). The Cumberland subregion occurs within the predicted distribution of the species (OEH, 2017e), and there is one old record from Kurrajong in 1959. The species was removed as a candidate species in Wilton because urban capable land is outside the geographic extent of the species.	Section 6.1.1.2 (outside geographic extent, lack of BioNet records)	No	No	N/A

* These species are SCS in relation to breeding habitat or mapped "important habitat" only

B. Knowledge-based Method parameters

Two tables are provided to describe the KBM parameters:

- Table B-1 – KBM parameters for species within the nominated areas
- Table B-2 – KBM parameters for species outside the nominated areas within the Cumberland subregion

Table B-1: Nominated area threatened species KBM parameters

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Allocasuarina glareicola	-	Intact, Thinned	BioNet PCT associations	-	-	SOILS: (Blacktown, Agnes Banks, Berkshire Park, Gymea) Justification: Existing records occur within these soils	-	-	-
Callocephalon fimbriatum	Gang-gang Cockatoo	Intact	BioNet PCT associations	> 25 ha Justification: Medium BAM patch size. Favours old growth forest and woodland attributes for nesting and roosting (OEH, 2019c)	-	-	-	-	Tree height >20 m (CHM) Justification: Breeding habitat information (Higgins, 1999)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Calyptorhynchus lathami	Glossy Black-Cockatoo	Intact	BioNet PCT associations	> 25 ha Justification: Medium BAM patch size. Breed in hollows, often near water, usually within tall mature sclerophyll forest with dense shrubby understorey, often in secluded valleys (Higgins, 1999)	-	-	-	-	Tree height >15 m (CHM) Justification: Breeding habitat information (Higgins, 1999)
Cercartetus nanus	Eastern Pygmy-possum	Intact	BioNet PCT associations	-	-	-	-	-	-
Chalinolobus dwyeri	Large-eared Pied Bat	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	-	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone')	-	-	Habitat restricted to within a 200 m buffer on "Cliffline" DEM layer. Justification: Species roost predominantly in caves and overhangs in sandstone cliffs and forage in nearby high-fertility forest or woodland near watercourses (DERM, 2011)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Epacris purpurascens var. *purpurascens*	Epacris purpurascens var. purpurascens	Intact, Thinned	BioNet PCT associations	-	-	-	-	-	-
Eucalyptus benthamii	Camden White Gum	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	Habitat restricted to within a 350 m buffer of the 'NEPEAN RIVER' Hydro Area Justification: Requires a combination of deep alluvial sands and a flooding regime to recruit seedlings (OEH, 2019c) and captures extent of species records	ROCK UNIT: ('Alluvium', 'Bringelly Shale', 'Hawkesbury Sandstone')	Between 25 to 300 m (OEH, 2019c)	-	-
Grevillea parviflora subsp. *Parviflora*	Small-flower Grevillea	Intact, Thinned	BioNet PCT associations	-	-	SOILS: ('Berkshire Park', 'Lucas Heights', ' Wianamatta (South Creek) ROCK UNIT: ('Alluvial channel deposits-in-channel bar', 'Alluvial floodplain deposits',	Between 25 to 300 m (OEH, 2019c)	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
						'Alluvium', 'Mittagong Formation', 'Alluvial terrace deposits') Justification: Sydney region occurrences are usually on Tertiary sands and alluvium, and soils derived from the Mittagong Formation. Soil landscapes include Lucas Heights or Berkshire Park (OEH 2018c) Habitat also present where PCTs occur on or w/in 200 m of Hawkesbury soils AND sandstone geology (Hawkesbury Sandstone) (i.e. must satisfy both criteria) Justification: at least 80 of the 97 records of the			

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
						species that occur outside Lucas Heights soils (around Wilton and GMAC) meet the above criteria			
Haliaeetus leucogaster	White-bellied Sea-Eagle	Intact	BioNet PCT associations	>5 ha Justification: Exclude small isolated patches of vegetation from habitat model	Habitat restricted to within 350 m around (Strahler order >3 or any waterbody include hydronametype IN ('BRANCH', 'DAM', 'LAKE', 'LAKES', 'RESERVOIR', 'RIVER', 'ARM')) Justification: Selection of nest site data (Dennis, McIntosh et al., 2011)	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Heleioporus australiacus	Giant Burrowing Frog	Intact	BioNet PCT associations	>5 ha Justification: Exclude small isolated patches of vegetation from habitat model	Habitat restricted to within 300 m of 1st , 2nd and 3rd order watercourses, excluding overlapping areas within 300 m from a 4th (or higher) order watercourse Justification: Burrows in the creek bank. Eggs are laid in burrows or under vegetation in small pools. Breeding habitat of this species is generally soaks or pools within first or second order streams. (up to 300 metres from breeding site (first and second order streams) (OEH, 2019c)	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone') and SOILS: NOT in ('Blacktown', 'Glenorie', 'Luddenham', 'Picton', 'West Pennant Hills') Justification: Found in vegetation on a variety of soil types except those that are clay based (OEH, 2019c)	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Hieraaetus morphnoides	Little Eagle	Intact, Thinned	BioNet PCT associations	>5 ha Justification: Exclude small isolated patches of vegetation from habitat model	-	-	-	Habitat excluded from within 215 m of a dwelling and 65 m from industrial building Justification: Little Eagle expert report for WGA and GMAC (Saunders and Debus, 2018)	Minimum tree height restricted to 20m Justification: Nest trees height determined in WSA and GMAC expert report (Saunders and Debus, 2018)
Lophoictinia isura	Square-tailed Kite	Intact	BioNet PCT associations	>5 ha Justification: Exclude small isolated patches of vegetation from habitat model	Habitat restricted to within 350 m around Strahler order 3+ watercourses or any waterbody include hydronametype IN ('BRANCH', 'DAM', 'LAKE', 'LAKES', 'RESERVOIR', 'RIVER', 'ARM')) Justification: Species shows a particular preference for timbered watercourses, with nest sites generally located along or near	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
					watercourses (OEH, 2019c)				
Marsdenia viridiflora subsp. *viridiflora* - endangered population	Marsdenia viridiflora subsp. viridiflora - endangered population	Intact, Thinned	BioNet PCT associations	-	-	-	-	LGAs IN ('BANKSTOWN', 'BLACKTOWN', 'CAMDEN', 'CAMPBELLTOWN', 'FAIRFIELD', 'HOLROYD', 'LIVERPOOL', 'PENRITH')	-
Maundia triglochinoides	-	Intact, Thinned	BioNet PCT associations	-		SOILS: (Berkshire Park, Birrong, Blacktown, Deep Creek, Freemans Reach, Glenorie, Lane Cove, Monkey Creek, Picton, Richmond, Wianamatta (South Creek), Teresa Park, Upper Castlereagh) Justification: Grows on heavy clay (OEH, 2019c)	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Micromyrtus minutiflora	-	Intact, Thinned	BioNet PCT associations	-	-	-	Up to 50 m (Doug & Lyn, 1998)	-	-
Myotis macropus	Southern Myotis	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	All waterbodies in the Plan Area with pools/reaches of water 3 m or wider and areas of habitat within 200 m of these waterbodies where they occur on the subject land and coincide with the relevant PCTs (OEH, 2019c)	-	-	-	-
Ninox connivens	Barking Owl	Intact	BioNet PCT associations	>25 ha Justification: Moderate BAM patch size, removes isolated patches	Restricted to within 100 m of a watercourse Justification: Breeding habitat known to be similar and more restrictive than Powerful Owl (DEC, 2006)	-	-	-	Vegetation within "Gullies" DEM layer. Justification: Breeding habitat known to be similar and more restrictive than Powerful Owl (DEC, 2006)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Ninox strenua	Powerful Owl	'Intact'	BioNet PCT associations	-	Restricted to within 100 m of a watercourse Justification: Nests in old hollow eucalypts in unlogged, unburnt gullies and lower slopes within 100 m of streams or minor drainage lines (DEC, 2006)	-	-	-	Vegetation within "Gullies" DEM layer. Justification: Nests in old hollow eucalypts in unlogged, unburnt gullies and lower slopes within 100 m of streams or minor drainage lines (DEC, 2006)
Persicaria elatior	-	Intact, Thinned, Scattered Trees, DNG	BioNet PCT associations	-	Habitat mapped within vegetation polygons occurring within 50m of the following Hydro Areas: Anabranch, Backwater, Billabong, Branch, Cowal, Creek, Pond, River, Stream, Swamp, Watercourse, Waterway Justification: Species grows in damp places, especially beside streams and	SOILS: ('Wianamatta (South Creek), 'Richmond', 'Freemans Reach', 'Berkshire Park', 'Upper Castlereagh) Justification: Species grows on sandy, alluvial soil (DEWHA, 2008c)	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
					lakes, occasionally in swamp forest (OEH, 2019c)				
Persoonia bargoensis	Bargo Geebung	Intact, Thinned	BioNet PCT associations	-	-	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member', 'Razorback Sandstone Member') AND Blacktown, Glenorie, Picton, Luddenham soil landscapes within 80 m of the edge of the sandstone geology. Justification: Species favours interface soil landscapes such as between the Blacktown Soil Landscape and the complex Mittagong Formation soils (Lucas Heights	0 - 450 m Justification: As detailed in Cunninghamia Vol. 6(4): 2000, increased based on records around Bargo (Doug & Lyn, 1998)	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
						Soil Landscape) with the underlying sandstone (OEH, 2019c)			
Petaurus norfolcensis	Squirrel Glider	Intact, Thinned, Scattered Trees	BioNet PCT associations	>4 ha Justification: Expected home range within the Plan Area (NSWSC, 2008)	-	-	-	-	Vegetation 10 m tall and higher, buffer all polygons by 12.5 m (to establish connected habitat within glide ratio of 1:2.5 for 10 m trees), clip the buffered polygons back to vegetation polygons, select patches that are 4 hectares and greater Justification: Connected habitats are those which the animals can reach by gliding, 10m tall trees are the minimum expected height for glide launch (Jackson, 2000; Vernes, 2001)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Pimelea curviflora var. *curviflora*	-	Intact, Thinned	BioNet PCT associations	-	-	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone') AND All Blacktown soil landscape within a 500m buffer on Wianamatta (South Creek), plus all Berkshire Park soil landscape Justification: Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils (OEH 2018g)	Less than 300 m (Doug & Lyn, 2001)	-	Sandstone units selected only within a 100 m buffer on "Ridge and Crest" DEM layer Justification: Occurs on shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands (OEH, 2019c)
Pomaderris brunnea	Rufous Pomaderris	Intact, Thinned	BioNet PCT associations	-	100 m around waterways Justification: Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines (OEH, 2019c)	SOILS: ('Blacktown', 'Lucas Heights') Justification: Grows in moist woodland or forest on clay and alluvial soils of flood plains and creek lines (OEH, 2019c)	Up to 450 m (BioNet records)	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
Pseudophryne australis	Red-crowned Toadlet	Intact	BioNet PCT associations	-	Restricted to 1st and 2nd order watercourses (OEH, 2019c)	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone') inside Ridge and Crest Justification: Occurs in open forests, mostly on Hawkesbury and Narrabeen Sandstones (OEH, 2019c)	-	-	Habitat buffered to 50m above and 100m below "Ridge and Crest" DEM layer Justification: Species usually restricted to within 100 m of a ridgetop (NPWS, 2001)
Pultenaea parviflora	-	Intact, Thinned	BioNet PCT associations	-	-	-	Less than 120 m (Doug & Lyn, 1996)	-	-
Pultenaea pedunculata	Matted Bush-pea	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	-	Occurs on Blacktown, Wianamatta (South Creek), Berkshire Park soil landscapes AND On, or within a 600 m buffer from, "Alluvium" in "GRPSUITE" field OR Within 500 m buffer from boundaries sandstone	Less than 150 m (Doug & Lyn, 1996)	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	LiDAR – EM / CHM
						derived soil landscapes Justification: Favours sites in clay or sandy-clay soils on Wianamatta Shale-derived soils, usually close to patches of Tertiary Alluvium, or at or near the Shale-Sandstone interface. All sites have a lateritic influence (OEH, 2019c)			
Tyto novaehollandiae	Masked Owl	Intact, Thinned	BioNet PCT associations	All "Intact" Vegetation or "Thinned" patches over 10 ha in area Justification: Removed scattered and isolated occurrences of "Thinned" vegetation not suitable for breeding habitat	-	-	-	-	Vegetation within "Gullies" DEM layer. Justification: Roosts and breeds in moist eucalypt forested gullies, using large tree hollows or sometimes caves for nesting (OEH, 2019c)

Table B-2: Cumberland subregion threatened species KBM parameters

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Allocasuarina glareicola	-	Intact, thinned	BioNet PCT associations	>40 ha Justification: Exclusion of small patches of vegetation not meeting the known geographic extent of the species	-	-	Below 50 metres (Doug & Lyn, 1995)	Primarily restricted to the Richmond (NW Cumberland Plain) district, but with an outlier population found at Voyager Point, Liverpool (DAWE, 2020)	>800 mm (Doug & Lyn, 1995)
Anthochaera phrygia	Regent Honeyeater	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	-	-	-	-	-
Botaurus poiciloptilus	Australasian Bittern	Intact, thinned	BioNet PCT associations	-	40 metre buffer applied to hydrolines. Justification: Preferred habitat is comprised of wetlands, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water (DAWE, 2020).	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Chalinolobus dwyeri	Large-eared Pied Bat	Intact, thinned	BioNet PCT associations	-	-	Habitat restricted to within 2 kms of Rock Units ('Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member', 'Razorback Sandstone Member') Justification: species primarily roosts in caves and overhangs in sandstone cliffs and forage in nearby high-fertility forest or woodland near watercourses (DECC, 2007; Pennay, 2008; Pennay & Gosper, 2002)	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Commersonia prostrata	Dwarf Kerrawang	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	-	SOILS: ('Berkshire Park', 'Freemans Reach', 'Hawkesbury', 'Monkey Creek', 'Richmond', ' Wianamatta (South Creek), 'Theresa Park', 'Upper Castlereagh', 'Bakers Lagoon', 'Ettalong') ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone') Justification: Sandy/peat soils (OEH, 2020b)	-	-	-
Cynanchum elegans	White-flowered Wax Plant	Intact, thinned	BioNet PCT associations	-	-	-	Below 600 metres (DAWE, 2020)	All occurrences of PCT 830, 835, 849 and 850 within 1km of PCT 877, and all PCT 877 patches. Justification: Species occurs in ecotonal areas of dry rainforest and surrounding drier forest / woodland	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Dasyurus maculatus maculatus	Spot-tailed Quoll	Intact, thinned	BioNet PCT associations	>1000 ha Justification: Restrict habitat to areas of very large intact bushland remnants around, and connected to, the edges of the Cumberland sub-region	-	-	-	-	>600 mm (DAWE, 2020)
Deyeuxia appressa	-	Intact, thinned	BioNet PCT associations	-	-	-	-	-	-
Genoplesium baueri	Yellow Gnat-orchid	Intact	BioNet PCT associations	-	-	-	Below 500 metres (Doug & Lyn, 2005)	-	-
Heleioporus australiacus	Giant Burrowing Frog	Intact	BioNet PCT associations	>5 ha Justification: Exclude small isolated patches of vegetation from habitat model	Habitat restricted to all PCTs within 300 m of 1st , 2nd and 3rd order watercourses, excluding overlapping areas within 300 m from a 4th (or higher) order watercourse. And wetland PCTs within 300m f watercourse irrespective of	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone') and SOILS not in ('Blacktown', 'Glenorie', 'Luddenham', 'Picton', 'West Pennant Hills') Justification: Found in vegetation on a variety of soil types except	-	Northern population largely confined to the sandstone geology of the Sydney Basin and extending as far south as Ulladulla (OEH, 2019c)	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
					Strahler order. Justification: Burrows in the creek bank. Eggs are laid in burrows or under vegetation in small pools. Breeding habitat of this species is generally soaks or pools within first or second order streams. (up to 300 metres from breeding site (first and second order streams) (OEH, 2019c)	those that are clay based (OEH, 2019c)			
Hibbertia puberula subsp. *glabrescens* (also known as *Hibbertia sp. Bankstown)*	-	-	BioNet PCT associations	-	-	-	-	1 km around records Justification: Restrict habitat to known geographic extent of the species	-
Hoplocephalus bungaroides	Broad-headed Snake	Intact	BioNet PCT associations	>5 ha Justification: Excluded small isolated patches of vegetation from habitat model	-	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Lathamus discolor	Swift Parrot	Intact, Thinned, Scattered Trees	BioNet PCT associations	-	-	-	-	-	-
Leucopogon exolasius	Woronora Beard-heath	Intact, thinned	BioNet PCT associations	-	200 metre buffer applied to Cataract River and Georges River: Justification: Restrict to known area of occurrence of the species, and the species' inhabits woodland on sandstone (and sandy alluvium) and prefers rocky hillsides along creek banks - prefers rocky hillsides along creek banks (DAWE, 2020).	SOILS: ('Berkshire Park', 'Freemans Reach', 'Hawkesbury', 'Monkey Creek', 'Richmond', Wianamatta (South Creek), 'Theresa Park', 'Upper Castlereagh') ROCK UNIT: ('Alluvial channel deposits-in-channel bar', 'Alluvial floodplain deposits', 'Alluvial terrace deposits', 'Alluvium', 'Hawkesbury Sandstone', 'Minchinbury Sandstone') Justification: Sandstone and sandy alluvium (DAWE, 2020).	Below 400 metres (DAWE, 2020)	-	1000-1400 mm (DAWE, 2020)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Macquaria australasica	Macquarie Perch	-	N/A	-	The waterways identified in the recovery plan (DoEE & DPI, 2018) that occur within and close to the Strategic Assessment Area that support self-sustaining native populations, or translocated and stocked populations Any additional waterways within the Strategic Assessment Area that support records of the species since 2000	-	-	-	-
Melaleuca deanei	Deane's Melaleuca	Intact, thinned	BioNet PCT associations	-	-	-	Below 400 metres (DAWE, 2020)	-	1000-1400 mm (DAWE, 2020)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Persicaria elatior	Tall Knotweed	All	BioNet PCT associations	-	Habitat mapped within vegetation polygons occurring within 50m of the following HydroAreas: Anabranch, Backwater, Billabong, Branch, Cowal, Creek, Pond, River, Stream, Swamp, Watercourse, Waterway Justification: Species grows in damp places, especially beside streams and lakes, occasionally in swamp forest (OEH, 2020b)	-	-	-	-
Persoonia glaucescens	Mittagong Geebung	Intact, thinned	BioNet PCT associations	-	-	-	250-650m (DAWE, 2020)	Restricted to within 7.5 kms of existing records	-
Petauroides volans	Greater Glider	Intact	BioNet PCT associations	>25 ha Justification: Restrict habitat to larger areas of vegetation. BioNet notes	-	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
				species can occur in medium patches of 5-24ha, however this was returning many unsuitable areas as habitat					
Pimelea curviflora var. *curviflora*	-	Intact, thinned	BioNet PCT associations	-	-	ROCK UNIT: ('Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member', 'Razorback Sandstone Member') AND All Blacktown soil landscape within a 500 m buffer on Wianamatta (South Creek) plus all Berkshire Park soil landscape Justification: Occurs on shaley/lateritic soils over sandstone and shale/sandstone	Below 300 metres (DAWE, 2020)	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
						transition soils (OEH, 2019c)			
Pterostylis saxicola	Sydney Plains Greenhood	Intact	BioNet PCT associations	-	-	Include 'Lucas Heights', 'Woodlands' with ROCK UNIT: ('Hawkesbury Sandstone', 'Ashfield Shale', 'Mittagong Formation'. Justification: Ashfield Shale, Mittagong Formation shales and sandstones, and Hawkesbury Sandstone and Devonian metasediments (DAWE, 2020)	-	-	<300 mm (DAWE, 2020)

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
Rostratula australis	Australian Painted Snipe	Intact	Vegetation classes derived from DAWE (2015)	-	All waterways (hydrolines) that have hydronames or group/sub-groups types as below with 40m buffer from that watercourse. (Includes 'Coastal lagoons and lakes', 'Estuarine Wetland', 'Floodplain Wetland', 'Freshwater Lake', 'Reservoir', 'Saline Wetland') And SUBGROUP Coastal vegetation', 'Named coastal lagoons and lakes', 'Unnamed coastal lagoons and lakes', 'Estuarine water body', 'Floodplain water body', 'Named freshwater lake', 'Unnamed	-	-	-	-

Scientific name	Common name	Veg. condition	Veg. associations	Patch size	Waterways	Soil/ Geology restrictions	Elevation	Geographic	Rainfall associations
					freshwater lake', 'Canal', 'Dam', 'Golf Course', 'Quarry', 'Reservoir', 'Sewage Treatment Pond', 'Saline Lake') Justification: Wetland habitats as detailed in SPRAT profile (DAWE, 2020)				

C. Biological and important populations definitions

Table C-1: Biological populations and important populations definitions

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
Acacia bynoeana	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Limited information is available on the dispersal distance of *A. bynoeana*. The recovery plan for *A. pubescens* notes that dispersal over a distance of 300 m is considered likely for *Acacia* spp. (NSW NPWS, 2003a). Therefore, plants within 300 m of each other have been defined as one population.	Populations of *A. bynoeana* were considered important because they met one or more of the following criteria: • A large population • A population within a conservation area • A population that is site-managed species or iconic species targeted for conservation under the NSW Saving our Species program
Acacia pubescens	Vulnerable	All available BioNet records were used to identify populations, with no date restrictions.	Plants within 300 m of each other have been defined as one population, as dispersal is considered likely to occur over this distance in *Acacia* spp. (NSW NPWS, 2003a)	Populations of *A. pubescens* were considered important because they met one or more of the following criteria: • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program • A large population • Is associated with a commitment made under the Sydney Growth Centres conservation program • A population within a conservation area
Allocasuarina glareicola	Endangered	All available BioNet records were used to identify populations, with no date restrictions.	Biological populations were defined based on clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollination	All populations of *A. glareicola* were considered important as the species is endangered.
Anthochaera phrygia	Critically Endangered	All available BioNet records were considered in the assessment.	The Regent Honeyeater comprises a single population (DoE, 2016b).	The population was considered to be important as the species is critically endangered.
Botaurus poiciloptilus	Endangered	Records restricted to post 2007 to account for estimated 11-year lifespan of the species.	The south-eastern Australian subpopulation of the species is considered as one population for this assessment. All records within the Strategic Assessment Area are therefore considered part of the same population.	All populations were considered to be important as the species is endangered.

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
Chalinolobus dwyeri	Vulnerable	All BioNet records for the Strategic Assessment Area were included in the assessment.	The species is known to breed in very few locations across NSW and the distance bats move from the maternity roost to over wintering roosts has not been established, but is likely to be less than 100 km (DoEE, 2018). As such all records within the Cumberland subregion are considered likely to be from the same breeding population	The population of Large-eared Pied Bats was considered important within the Strategic Assessment Area because it met the following criteria: • A population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important
Commersonia prostrata	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Populations were considered to constitute clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	All populations were considered to be important as the species is endangered.
Cynanchum elegans	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Little is known of the reproduction and dispersal ecology of *C. elegans* (DoEE, 2018). As part of this assessment, a population was considered to be clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	All populations were considered to be important as the species is endangered.
Dasyurus maculatus maculatus	Endangered	BioNet records from 1999 onwards were considered current for the assessment.	All records within an area covered by the average male home range (up to 5,512 ha) were considered a single population.	All populations were considered to be important as the species is endangered.
Deyeuxia appressa	Endangered	All available BioNet records were used to identify populations, with no date restrictions.	There are not thought to be any extant populations of this species, as there are no recent records of species, and it is considered possible that the species is now extinct.	All populations were considered to be important as the species is endangered.
Eucalyptus benthamii	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	There is limited information available regarding pollination and dispersal thresholds for *E. benthamii.* Therefore, a population was considered to constitute clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	Populations of *E. benthamii* were considered important because they met one or more of the following criteria: • A population identified or inferred in a Commonwealth conservation advice, plan, final determination, or other relevant policy document as being important • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
				• A large population • A population within a conservation reserve • A population that is important for maintaining the Extent of Occurrence of a species
Genoplesium baueri	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Records within 500 m of each other have been considered to be a single population.	All populations of *G. baueri* have been considered as important as the species is endangered.
Grevillea parviflora subsp. *parviflora*	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Little is known about the life cycle of *G. parviflora* subsp. *parviflora*. Flowers are insect pollinated, and it is likely that seeds have limited dispersal distances (probably <2 m) (DoEE, 2018). Populations were identified as clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	Populations of *G. parviflora* subsp. *parviflora* were considered important because they met one or more of the following criteria: • A population that is important for maintaining the Extent of Occurrence of a species • A population within a conservation reserve • A large population
Heleioporus australiacus	Vulnerable	BioNet records were used from 2008 onwards based on the approximate 10 year life-span of the species (noting that this only excluded two records from the assessment – both with limited accuracy from 1974 and 1913).	Records within 300 m were considered to be a population	The populations of Giant Burrowing Frog were considered important within the Strategic Assessment Area because they met the following criteria: • A population within a conservation reserve
Hibbertia puberula subsp. *glabrescens*	Critically Endangered	All available BioNet records were used to identify populations, with no date restrictions.	This species is known to occur in one location, as a single population. The translocation site has been planted with a number of individuals propagated from the Bankstown location.	All populations of *H. puberula* subsp. *glabrescens* have been considered as important as the species is critically endangered.
Hoplocephalus bungaroides	Vulnerable	Records of this species within the Strategic Assessment Area and Cumberland subregion were assessed to determine the age and accuracy of the record, the characteristics of the landscape in which the record is located, and the likelihood of persistence of the species in that locality due to subsequent	There is only one record of this species within the Strategic Assessment Area, which has been identified as a single population.	No important populations have been identified for this species (all non-important).

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
		removal of, or disturbance to, habitat.		
Lathamus discolor	Critically Endangered	All available BioNet records were considered in the assessment.	The species is considered to be a single migratory population. All records within the Strategic Assessment Area are therefore considered part of the same population.	All populations were considered to be important as the species is critically endangered.
Leucopogon exolasius	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	No important populations were identified for *L. exolasius*. All populations are non-important.
Litoria aurea	Vulnerable	All available BioNet records from 1995 onwards were included in the assessment, based on the guidance in the EPBC Act Policy Statement 3.19 (DEWHA, 2009).	Populations were considered separate if records were more than 10km apart OR where landscape features interrupted connectivity, based on the guidance in the EPBC Act Policy Statement 3.19 (DEWHA, 2009).	The populations of Green and Golden Bell Frog were considered important within the Strategic Assessment Area because they met the following criteria: • A population identified or inferred in a Commonwealth conservation advice, plan, final determination, or other relevant policy document as being important
Macquaria australasica	Endangered	All BioNet records have been included in the assessment.	Populations in distinct rivers and streams are considered separate populations.	All populations were considered to be important as the species is endangered.
Melaleuca deanei	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	A population is considered to be individuals within 500 m of each other, as species dispersal is unlikely to occur beyond this distance (NSW DECCW, Goeth et al., 2010).	Populations of *M. deanei* were considered important because they met one or more of the following criteria: • A large population • A population within a conservation reserve • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program
Micromyrtus minutiflora	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Populations were defined by clustered records connected by relatively intact and continuous vegetation and not separated by a distance of >1 km (approx.). This is based on the distance travelled by insect pollinators and potential unrecorded individuals.	All populations of *M. minutiflora* were considered important within the Strategic Assessment Area because the species is identified as an SAII entity through the BC Act process.
Persicaria elatior	Vulnerable	All available BioNet records were used to identify populations.	Biological populations were defined based on clustered records connected by relatively intact and continuous	Populations of *P. elatior* were considered important because they met one or more of the following criteria:

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
			vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollination.	• A large population (number of individuals)
Persoonia bargoensis	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	All recorded plants were mapped as a single population as occurrence of the species within the Plan Area spans 20 km, and genetic flow (fruit dispersal by birds and pollination) could potentially move across the population within the life span of each plant (expected to be 20 years (OEH, 2019a)).	Populations of *P. bargoensis* were considered important within the Strategic Assessment Area because they met one or more of the following criteria: • A large population (number of individuals) • Only known population of this species
Persoonia glaucescens	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Individuals within 500 m of each other are likely to be interbreeding and are therefore considered to be the same population.	Populations of *P. glaucescens* were considered important because they met one or more of the following criteria: • A population that is important for maintaining the Extent off Occurrence of a species • A population within a conservation reserve • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program
Persoonia hirsuta	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	All populations of *P. hirsuta* are considered to be important as the species is endangered.
Persoonia nutans	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Populations were defined by clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	All populations of *P. nutans* are considered to be important as the population is endangered.
Petauroides volans	Vulnerable	BioNet records were restricted to post 2003 to account for the average 15 year lifespan of the species.	The species occupies a relatively small home range with an average size of 1 to 3 ha and they have a low dispersal ability. Records separated by several kilometres and/or cleared developed areas were identified as separate populations.	The populations of Greater Glider were considered important within the Strategic Assessment Area because they met the following criteria: • A population within a conservation reserve
Pimelea curviflora var. *curviflora*	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or	Populations were defined by clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent	Populations of *P. curviflora* var. *curviflora* were considered important because they met the following criteria:

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
		disturbance to, habitat.	barriers likely to obstruct pollinators.	• A large population
Pimelea spicata	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.	All populations of *P. spicata* are considered to be important as the species is endangered.
Pomaderris brunnea	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Records within 1 km of one another are considered a single population.	Populations of *P. brunnea* were considered important because they met one or more of the following criteria: • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program • A population within a conservation reserve • A large population
Pommerhelix duralensis	Endangered	All available BioNet records were used to identify populations, with no lifespan restrictions.	Records have been grouped into populations based on geographic restrictions and connectivity between patches of suitable vegetation.	All populations were considered to be important as the species is endangered.
Pteropus poliocephalus	Vulnerable	Based on other bat species, the life expectancy is likely to be between two and ten years. BioNet records have been taken from 2008 onwards.	The Grey-headed Flying-fox is considered to be a single population across its range (DoEE, 2017)	The population of Grey-headed Flying-foxes was considered important within the Strategic Assessment Area because it met the following criteria: • A population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important
Pterostylis saxicola	Endangered	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Records within 500 m of one another considered a single population.	All populations of this species were considered to be important as the species is endangered.
Pultenaea parviflora	Vulnerable	Records in each population were interrogated to ascertain the likelihood of persistence based on the removal of, or disturbance to, habitat.	Records within 500 m of each other were considered to be a single population.	Populations of *P. parviflora* were considered important because they met one or more of the following criteria: • A population is important for maintaining the Extent of Occurrence of a species • A population within a conservation reserve • A large population

Scientific Name	EPBC listing	Logic for Including/Excluding Records	How to Define Biological Population	Importance criteria used to identify important populations of this species
				• Is associated with a commitment made under the Sydney Growth Centres conservation program • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program
Rostratula australis	Endangered	Records restricted to post 2002 to account for estimated 16 year lifespan of the species.	All records within the Cumberland subregion are representative of a portion of the east coast population and therefore records in the Strategic Assessment Area have been grouped as one single population.	All populations were considered to be important as the species is endangered.

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CUMBERLAND PLAIN ASSESSMENT REPORT

PART 4: MINIMISING IMPACTS

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 4 Contents

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This Part describes:

- Avoiding and minimising impacts under the Plan (Chapter 14)
- Managing indirect impacts of the urban and industrial, infrastructure, agribusiness, and transport development under the Plan (Chapter 15)
- Adaptive management for addressing uncertainty (Chapter 16)

This Part addresses the requirements for these matters under both the *Biodiversity Conservation Act 2016* (BC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), as well as for both Commonwealth-listed species and Threatened Ecological Communities (TECs) and NSW-listed species.

14 Avoiding and minimising impacts

The Department of Planning, Industry and Environment (the Department) and Transport for NSW have undertaken a strategic planning process to locate and design the urban capable land in the nominated areas and the transport corridors to avoid and minimise impacts on biodiversity values. This has been undertaken in accordance with:

- Guidance provided under section 8 of the Biodiversity Assessment Method (BAM)
- The draft *Guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification* (version 6) (EES, 2019)
- The Commonwealth Terms of Reference (ToR)

This Chapter:

- Discusses the importance of avoiding and minimising impacts to biodiversity values
- Defines the meaning of avoidance in the context of the strategic assessment
- Sets out the regulatory requirements for avoiding and minimising impacts under the BAM and ToR
- Describes the processes to avoid and minimise impacts of the transport corridors
- Describes the steps taken to locate and design the urban capable land within the nominated areas
- Identifies the avoidance outcomes for the nominated areas and justifies the location of the urban capable land

The avoidance and minimisation of impacts under the Plan in relation to other matters (such as other MNES) are provided in chapters specific to the assessments of those matters, including:

- Chapter 24 for prescribed impacts
- Chapter 25 for serious and irreversible impacts
- Chapters 29 to 31 for Commonwealth-listed species and TECs
- Chapters 32 to 35 for migratory species, Ramsar wetlands and World and National Heritage

14.1 WHY AVOIDING AND MINIMISING IMPACTS IS IMPORTANT

Avoiding and minimising impacts to biodiversity values is an important part of the planning and assessment process. It is a critical step in minimising the impacts of the development and reducing the need for commitments and actions to offset those impacts. It also provides opportunities to protect important areas of remaining biodiversity, through the application of commitments and actions (such as biodiversity stewardship agreements) to avoided lands.

Avoiding and minimising impacts on biodiversity values is fundamental to demonstrating that the commitments and actions proposed for a strategic biodiversity certification adequately address the impacts of the development under section 8.7 of the BC Act (see Part 7). Documenting the process is also a requirement of the ToR (section 4.5(2)).

14.2 DEFINITION OF AVOIDANCE

There may be several reasons why land is avoided and not impacted under the Plan, including because:

- Land has high biodiversity value and is avoided for biodiversity purposes

- Land is not suitable for development or biodiversity certification
- Land is excluded from the area proposed for development or biodiversity certification

Under the BAM, avoidance refers to land that is suitable for development and included in the area proposed for development or biodiversity certification, but has been avoided because of its biodiversity value. Land not impacted because it is not suitable for development or biodiversity certification, or land that has been excluded from the area proposed for development is not considered to have been avoided under the BAM.

Land that is avoided is not biodiversity certified under the Plan and is subject to separate site-by-site assessment and approval under the BC Act. Note that the Plan proposes that some development in some cases is able to be undertaken within avoided lands under the EPBC Act approval (see Chapter 7).

In accordance with the BAM, the Assessment Report determines avoidance outcomes for biodiversity values on the basis of the amount of land avoided because of its biodiversity value. The amount of land 'avoided' for other purposes (i.e. the land is not suitable for urban development) is also presented in this report for additional context.

14.2.1 DEFINITION OF LAND AVOIDED FOR OTHER PURPOSES

For the Assessment Report, the following land is considered to be avoided for other purposes:

- Riparian corridors consistent with the *Water Management Act 2000*:
  - Strahler stream order 2 - buffer 20 m either side
  - Strahler stream order 3 - buffer 30 m either side
  - Strahler stream order 4 and above - buffer 40 m either side
- State protected land (>18 degrees slope, considered too steep for urban development)

14.2.2 DEFINITION OF EXCLUDED LAND

Some land within the nominated areas was not considered for inclusion in the area proposed for development and has therefore been identified as 'excluded' land. These lands include:

- Existing protected land, including reserves and established offset sites
- Council owned land which is zoned for environmental conservation, environmental management or recreation
- Commonwealth land, such as Defence Establishment Orchard Hills
- Lands within the nominated areas already assessed as part of another development approval (Bingara Gorge), or lands progressing through an alternate assessment (Mount Gilead, Menangle Park, Sydney Metro Stage 1)
- Lands already developed (existing urban areas, urban land zones and roads)

PASSIVE RECREATION LANDS IN WESTERN SYDNEY AEROTROPOLIS

Some lands within Western Sydney Aerotropolis (WSA) have been identified as 'Environment and Recreation' lands within the updated Western Sydney Aerotropolis Stage 1 Structure Plan. These lands are shown in Figure 7-3, Part 2 and in the Plan as 'Non-certified – Western Sydney Aerotropolis' and are described in the Plan as 'land affected by the 1 per cent annual exceedance probability flood and…. other non-certified land'.

These lands have not been included in urban capable lands. However, the lands may be used for essential infrastructure or public open space or passive recreation, including supporting infrastructure such as information facilities, kiosks, or recreational areas (where this occurs, the Plan specifies that the objectives of the zoning for these lands will provide for both open space or recreation uses and the protection and enhancement of the natural environment).

For this reason, these lands are not considered avoided for either biodiversity or other purposes and have been included in the broad definition of excluded land for the purposes of the avoidance statistics in this Assessment Report.

The proposal to use 'Environment and Recreation' lands for essential infrastructure and public open space or passive recreation was made late in the development of the Plan and the potential impacts on these lands have not been assessed in the Assessment Report. This assessment will be completed following public exhibition of the report.

14.2.3 ALLOCATION OF LAND TO AVOIDANCE CATEGORIES

As land can be allocated to several categories (e.g. land can be allocated to both 'riparian corridor' and 'excluded land') a prioritisation process was used to allocate land to one of the four categories used.

The priority applied to the classification of land for avoidance calculations is provided in Table 14-1.

Table 14-1: Priority applied to classification of lands for avoidance calculations

Priority	Avoidance category	Input data
1	Biodiversity certified	Land proposed for urban development or transport corridors
2	Excluded/Non-certified – Western Sydney Aerotropolis	Land within the nominated areas already assessed as part of another development approval or lands progressing through an alternate development assessment (Bingara Gorge, Mount Gilead, Menangle Park, Sydney Metro Stage 1) Land already developed (existing urban areas, urban land zones and roads) Land not available to development (existing protected land, council owned land which is zoned for environmental conservation, environmental management or recreation, Commonwealth land and easements) Land identified as 'Environment and Recreation' lands within the updated Western Sydney Aerotropolis Stage 1 Structure Plan
3	Avoided for other purposes	Riparian corridors consistent with the *Water Management Act 2000* (Strahler stream order 2 and above) and state protected land (>18 degrees slope)
4	Avoided for biodiversity purposes	All other land (apart from land to be developed under the Plan)

14.2.4 METHOD TO CALCULATE AVOIDANCE OUTCOMES

The method to calculate avoidance outcomes for specific biodiversity values (e.g. a specific TEC, or group of TECs such as all critically endangered TECs) within the nominated areas is as follows:

- **Step 1:** determine the total existing area (in ha) of each biodiversity value within the assessed nominated areas.
- **Step 2:** determine the total area which could be impacted by urban development for each biodiversity value.
- **Step 3:** determine the total area which could be impacted by transport for each biodiversity value.
- **Step 4:** determine the area of each biodiversity value within excluded or non-certified – Western Sydney Aerotropolis.
- **Step 5:** determine the area avoided for other purposes, such as steep slopes or riparian corridors.
- **Step 6:** determine the area of land avoided for biodiversity purposes (this is done by subtracting the summed amount (ha) in steps 2, 3, 4 and 5 from step 1).

14.3 REGULATORY REQUIREMENTS

The BAM and ToR both require the Assessment Report to demonstrate how impacts to biodiversity values have been avoided and minimised. The BAM provides more detailed guidance than the ToR on how avoidance should be achieved.

14.3.1 BC ACT REQUIREMENTS

BAM

Section 8 of the BAM requires the BCAR to describe the actions taken to avoid and minimise impacts on biodiversity values through the location and design of the urban capable land and transport corridors on:

- Native vegetation and habitat

- Prescribed impacts

The BCAR must describe how actions taken to avoid and minimise impacts on biodiversity values have influenced both the project location and the design of the project. Specifically, the BCAR should explain how impacts on biodiversity values have influenced the location and design of the urban capable land and transport corridors, including the extent to which areas of higher biodiversity value have been identified and then excluded from the urban capable land and transport corridors.

The BAM provides that direct impacts on native vegetation and habitat can be avoided and minimised by:

- **Development location considerations:**
  - Locating development in areas where there are no or minimal biodiversity values
  - Locating development in areas where native vegetation or habitat is in the poorest condition (as measured by the Vegetation Integrity score for each vegetation zone)
  - Avoiding habitat for species with higher biodiversity risk weightings
  - Avoiding critically endangered or endangered TECs
  - Avoiding areas that maintain habitat connectivity between areas of nearby habitat
- **Development design considerations:**
  - Reducing the urban capable land and transport corridors of the project
  - Providing structures to enable species to move across barriers or habitat gaps
  - Making provision for the ecological restoration and ongoing maintenance of retained native vegetation

The BAM provides that prescribed impacts can be avoided and minimised by:

- **Development location considerations:**
  - Locating urban capable land or sub-surface works to avoid habitat features associated with prescribed impacts (such as caves, cliffs, water bodies, important non-native vegetation, or areas of habitat connectivity)
  - Avoiding areas that maintain habitat connectivity between areas of nearby habitat
- **Development design considerations:**
  - Designing project elements to minimise interactions with biodiversity values, such as designing fencing to prevent animal entry to roads or transport corridors or roads
  - Designing the project to maintain hydrological processes
  - Design the project to avoid and minimise downstream impacts on water bodies by controlling water quality

Section 8.1.1.4 and section 8.2.2.2 of the BAM requires the BCAR to:

- Analyse alternative locations for urban capable land that would further avoid or minimise impacts
- Justify the location of the final urban capable land

In justifying the selection of final urban capable land, a rationale should be provided for the location of the boundaries where they do not avoid areas of biodiversity value, such as strategic planning reasons.

GUIDELINES UNDER THE BAM

In addition to the BAM, the draft *Guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification* (version 6) (EES, 2019) provides a set of guiding principles for demonstrating that commitments and actions proposed for a strategic biodiversity certification adequately address impacts on biodiversity values.

The first principle relates to avoidance and requires that:

> *"Principle 1 – Potential serious and irreversible impacts are avoided and minimised"*

14.3.2 EPBC ACT REQUIREMENTS

Section 4.5(2) of the ToR requires the SAR to include an analysis of the likely adverse impacts of actions of the Plan on protected matters, including consideration of:

"How impacts on protected matters will be avoided through land use planning and other measures…"

14.4 PROCESSES TO AVOID AND MINIMISE IMPACTS OF TRANSPORT CORRIDORS

Avoidance and minimisation of impacts from the transport corridors is being undertaken in two stages:

- Processes to locate the transport corridors – this has already been undertaken
- Detailed design of the transport corridor footprints for each transport project to further avoid and minimise impacts

14.4.1 PROCESSES TO LOCATE THE TRANSPORT CORRIDORS

The process for identifying, selecting and designing future corridors and transport projects involves a detailed set of steps and processes to ensure optimum infrastructure, environmental, social and economic outcomes are achieved. The *Planning guideline for Major Infrastructure Corridors* (DPE, 2016) sets out the recommended processes for infrastructure agencies to follow through the different phases of corridor planning.

The guideline provides advice in relation to the three broad phases:

- Strategic planning – identification
- Corridor planning and selection
- Infrastructure delivery

The first two phases lead to the identification and protection of transport corridors. As part of this process, a Strategic Environmental Assessment (SEA) is prepared which provides an assessment of the environmental, economic and social impacts of reserving the corridor. SEAs are non-statutory documents that assist in the planning and decision-making process for the community and Government. They are subject to public consultation and include justification for a preferred corridor alignment and provide information on the assessment of alternative corridor alignments.

In making decisions on corridor selection, infrastructure agencies undertake a constraints analysis and multi-criteria comparison of options. These include consideration of a wide range of factors including:

- Aboriginal heritage
- Biodiversity
- Costs
- Engineering and construction limitations
- Land use and property impacts
- Landscape character and visual amenity
- Noise and vibration
- Non-Aboriginal heritage
- Socio-economic considerations
- Soils, geology and contamination
- Transport planning
- Water quality and hydrology

Box 1 provides an example of the process used to locate the Outer Sydney Orbital (OSO).

BOX 1: PROCESS USED TO LOCATE THE OSO

The Draft SEA for the OSO (AECOM, 2018) sets out the process that was followed to locate that transport corridor. Transport for NSW commissioned the OSO study "to identify the most appropriate location for the corridor and to protect land within that corridor for the future provision of critical road and freight rail infrastructure". The method for identifying the corridor involved (AECOM, 2018):

- *Identifying a study area – investigations commenced with a broad OSO study area to identify high-level constraints and opportunities*
- *Understanding constraints and opportunities – an analysis of constraints and opportunities within the study area included prioritisation of constraints as well as identification of key areas and values to avoid during corridor design development*
- *Developing guiding principles – a list of guiding principles was developed to inform the selection of a long list of corridor options. These principles followed the hierarchy of 'avoid, minimise, and mitigate impacts', to allow for the creation of a series of options*
- *Identifying corridor options – a range of tools, including computer software and specialist advice, was used to identify a long list of corridor options*
- *Evaluating corridor options – this included specialist investigations of identified options, comparative assessment and multi-criteria analyses*
- *Selecting a recommended OSO corridor – a continuation of the evaluation process where selection and refinement of a recommended corridor involved multi-criteria assessment, targeted stakeholder consultation and design development*
- *Consulting with the public on the recommended corridor – to obtain feedback on the recommended OSO corridor*

Potential impacts to biodiversity were a key consideration (amongst a range of considerations) in the SEA and the ultimate selection of the corridor. A similar process was followed for the other transport corridors.

14.4.2 DETAILED DESIGN OF TRANSPORT CORRIDOR FOOTPRINTS

The transport corridors included in the Plan have not completed the process to avoid and minimise impacts to biodiversity values as the alignments of the transport projects within each corridor are not currently certain (see Part 2).

The Plan includes commitments for further avoidance and minimisation of impacts to biodiversity values related to the transport corridors. This will be undertaken through:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor
- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process)

COMMITMENTS FOR FURTHER AVOIDANCE WITHIN TRANSPORT CORRIDORS

Transport corridors within nominated areas

For the parts of the transport corridors within the nominated areas, the Plan commits to avoiding and minimising impacts to TECs, species and habitat (Commitment 3). This includes avoiding where possible:

- Areas of high biodiversity value (defined by the 'avoidance criteria' set out in section 14.5.3)
- Areas of potential habitat connectivity, particularly vegetation in riparian corridors, for the following species
  - Eastern Pygmy Possum
  - Green and Golden Bell-Frog
  - Spotted-tailed Quoll
  - Squirrel Glider
  - Yellow-bellied Glider
- Known flora populations within the OSO and M7/Ropes Crossing Link Road corridors, including:
  - *Dillwynia tenuifolia*
  - *Grevillea juniperina* subsp. *juniperina*

   - *Pultenaea parviflora*
   - *Persoonia nutans*

Commitment 3 also includes a requirement for the Outer Sydney Orbital waterway crossings to minimise structures within riparian areas, waterway re-alignments, and bulk earthworks on adjacent floodplain areas

The Plan includes further commitments under Commitment 3 that require:

- Impacts to be minimised as far as possible where an action cannot feasibly or practically avoid impacts
- Transport for NSW to determine the area of avoidance achieved on the basis of:
   - The final construction footprint/concept design plan for each infrastructure corridor
   - The Plan's data and mapping for threatened species, populations and communities

Actions under this commitment specify how Transport for NSW is to implement the commitment. In summary, the commitment will be implemented through Transport for NSW doing the following:

- Considering avoidance of areas of high biodiversity value (as defined by the avoidance criteria in section 14.5.3) during the strategic planning phase and detailed design of the project
- Including avoidance of biodiversity values as well as the costs of offsets, into the evaluation of the route options (e.g. multi-criteria analysis) during the planning phase of the project
- Reporting to the Department on development impacts and adjustments identified through the NSW State Significant Infrastructure approval (or equivalent) for each transport project. This will include specific reporting on avoidance achieved within the transport corridors and any further impacts that occur outside of the corridors

The Department will use this information from Transport for NSW to track impacts and adjust offset requirements through the Plan's reconciliation accounting process, and publish adjustments to the Plan's impacts to biodiversity values and offset requirements through the Plan's annual updates and five yearly reviews (see Part 2).

Transport corridors outside nominated areas

For the parts of the transport corridors outside the nominated areas, the Plan commits to avoiding and minimising impacts to species and TECs in accordance with the:

- Major infrastructure corridors class of action description
- BC Act, including the BAM (Commitment 4)

This includes avoiding disturbance to the following where possible:

- Known flora populations within the OSO and M7/Ropes Crossing Link Road corridors, including:
   - *Dillwynia tenuifolia*
   - *Grevillea juniperina* subsp. *juniperina*
   - *Pultenaea parviflora*
   - *Cynanchum elegans*
- Protected lands within and adjacent to the tunnel footprints:
   - Mater Dei BioBank site within the OSO footprint near Camden
   - Registered Property Agreement site within the OSO footprint at Camden Airport
   - Metro Offset site within the footprints for the OSO and Metro Rail Future Extension near Harrington Park
- Nepean River and associated riparian corridor within the OSO footprint
- Camden Golf Club at Narellan adjacent to the Metro Rail Future Extension footprint
- Mount Annan Botanic Gardens within the Metro Rail Future Extension footprint
- Populations and habitat within or adjacent to the OSO and Metro Rail Future Extension footprints for:
   - *Eucalyptus benthamii*
   - *Pomaderris brunnea*
   - *Pimelea spicata*
   - Cumberland Plain Land Snail

- Commonwealth land at:
  - Camden Airport
  - Western Sydney University (Campbelltown Campus)
  - 12 Werombi Road, Grassmere

Actions under this commitment specify how Transport for NSW is to implement the commitment. In summary, the commitment will be implemented through Transport for NSW doing the following:

- Undertaking surveys to confirm biodiversity values and MNES using the BAM (or equivalent), including targeted surveys for at-risk species, during strategic planning phase and detailed design of the project
- Including avoidance of biodiversity values as well as the costs of offsets, into the evaluation of the route options (e.g. multi-criteria analysis) during the planning phase and detailed design of the project
- Preparing a Biodiversity Certification Assessment Report or Biodiversity Development Assessment Report (or equivalent) under relevant NSW planning and assessment legislation at the time
- Avoiding and minimising biodiversity impacts in accordance with the BAM (or equivalent)

As for the process within the nominated areas, Transport for NSW will report to the Department on development impacts and adjustments identified through the NSW State Significant Infrastructure approval (or equivalent) for each transport project. The Department will use this information from Transport for NSW to track impacts and adjust offset requirements through the Plan's reconciliation accounting process (see Part 2).

14.5 STEPS TAKEN TO AVOID AND MINIMISE IMPACTS OF NOMINATED AREAS

Consistent with Section 8.1.1.2 of the BAM, the process to identify the urban capable land within the nominated areas was an iterative one that began early in the assessment process before the final data on biodiversity values was completed. The urban capable land was identified in three phases:

- Strategic planning to locate the nominated areas
- Initial development of footprints through Land Use and Infrastructure Implementation Plans (LUIIP)
- Iterative refinement of the footprints through development of the Plan and assessment of impacts

14.5.1 STRATEGIC PLANNING TO DETERMINE THE LOCATION OF THE NOMINATED AREAS

The location of the nominated areas was determined through various strategic planning strategies and investigations over many years. Two key planning strategies that informed the location of the nominated areas were:

- *A Plan for Growing Sydney* (DPE, 2014) – this identified the general location of Wilton Growth Area (Wilton) and Greater Macarthur Growth Area (GMAC) and the Badgerys Creek Airport precinct, which was subsequently refined further by the Department to become WSA
- *A Metropolis of Three Cities* (GSC, 2017) – this identified the general location of Greater Penrith to Eastern Creek Investigation Area (GPEC) and establishes a 40-year vision for Sydney as a global metropolis of three cities, including the Western Parkland City covering the nominated areas

The nominated areas were located based on a broad range of strategic planning considerations, including:

- Proximity to current and planned locations of employment
- The cost of infrastructure provision including roads, water, sewerage, public transport, schools and health facilities
- The economic and social cost to communities of having poor access to employment and services, including transport
- Environmental constraints, including biodiversity values

Action 2.4.2 of *A Plan for Growing Sydney* (DPE, 2014) aimed to develop a long-term framework for the identification of new nominated areas to improve the management of future land release in Sydney. In preparing a framework for the identification of nominated areas, Action 2.4.2 indicates that a range of issues should be considered, including:

- The value of land for drinking water supply, agriculture, environmental management and other purposes
- Constraints to development, including environmental constraints and natural hazards

The Department undertook investigations into the location of the nominated areas in accordance with Action 2.4.2.

14.5.2 LAND USE AND INFRASTRUCTURE IMPLEMENTATION PLANS

Land Use and Infrastructure Implementation Plans (LUIIP) are currently being prepared for the nominated areas (see Part 2). LUIIPs are high level plans for the growth and development of each nominated area. They identify the location of urban capable land, as well as broad land uses and the location of infrastructure across a nominated area, as well as housing and employment targets.

Indicative urban capable land had been developed as part of the early preparation of the LUIIPs, including for Wilton, GMAC and part of WSA. Urban capable land was identified largely on the basis of avoiding large patches of intact native vegetation (Eco Logical Australia, 2017), including:

- BIO Map core areas and corridors (OEH, 2015)
- Priority Conservation Lands identified as part of the Cumberland Plain Recovery Plan methodology report (DECCW, 2010)

The early LUIIP footprints provided the starting point for the iterative refinement of the footprints through development of the Plan (see section 14.5.3). Any changes made through this process are, or will ultimately be, reflected in the LUIIPs.

14.5.3 ITERATIVE REFINEMENT OF URBAN CAPABLE LAND THROUGH DEVELOPMENT OF THE PLAN

Development of the Plan provided an important opportunity to iteratively refine the initial urban capable land with the aim of avoiding and minimising impacts to biodiversity values. The process involved:

- Compilation of data on biodiversity values of each nominated area
- Development of criteria to identify priorities for avoidance of biodiversity values
- Workshops to apply the avoidance criteria to each nominated area and refine urban capable land
- Consultation with key stakeholders and resolution of issues
- Finalisation of initial urban capable land

COMPILATION OF DATA ON BIODIVERSITY VALUES

The best available data on the biodiversity values of each of nominated area was compiled and used to identify areas of high biodiversity value and inform the location and design of the urban capable land.

The data on biodiversity values was compiled into a series of GIS datasets and used in two phases:

- Initial urban capable land was identified based on preliminary data on biodiversity values
- Finalisation of initial urban capable land was undertaken based on final data on biodiversity values

The preliminary data used to inform the initial urban capable land comprised:

- Draft native vegetation maps of each nominated area showing:
    - Extent and condition of Plant Community Types (PCTs)
    - Extent and condition of NSW-listed TECs
- Threatened species records derived from BioNet for all species needing to be assessed in the Assessment Report (all Commonwealth-listed Category 1 matters and all NSW-listed candidate species – see Part 3)
- Draft habitat maps for threatened species where available. In particular, this included Koala habitat mapping

The data used to finalise the initial urban capable land comprised:

- Final native vegetation maps of each nominated area showing:
    - Extent and condition of PCTs
    - Extent and condition of Commonwealth-listed and NSW-listed TECs
- Threatened species records derived from BioNet for all species needing to be assessed in the Assessment Report (all Commonwealth-listed Category 1 matters and all NSW-listed candidate species – see Part 3)
- Final habitat maps for threatened species where available

A more detailed description of each dataset used to inform the urban capable land is provided in Part 3.

DEVELOPMENT OF AVOIDANCE CRITERIA

Criteria were developed to identify priorities for the avoidance of biodiversity values. The purpose of the criteria were to provide detailed guidance, consistent with the guidance provided in the BAM, to inform decisions about the location and design of the urban capable land through the series of workshops with precinct planners and ecologists.

The avoidance criteria identified priorities for avoidance within three main categories:

- TECs and PCTs, including condition
- Threatened species
- Ecological processes

In applying the criteria, the highest priority within each category was given equal weight (the TEC/PCT priority 1 was given equal weight to the threatened species priority 1).

The avoidance criteria are provided in Box 2.

BOX 2: AVOIDANCE CRITERIA AND CATEGORIES

(a) TECs and PCTs

1. Critically endangered ecological communities (CEECs) or PCTs ≥90% cleared in large patches and in good condition; or serious and irreversible impact (SAII) entities (TECs)
2. Endangered ecological communities (EECs) or PCTs ≥70% to <90% cleared in large patches and in good condition
3. PCTs ≥50% to <70% cleared in large patches and in good condition
4. PCTs <50% cleared in large patches and in good condition

(b) Threatened species

1. Known habitat^ for critically endangered species, SAII entities (species), Saving Our Species (SOS) species polygons (where species-specific habitat is present), or large populations of threatened species (relative to typical size for that species); or known primary koala habitat
2. Known habitat^ for endangered species or known secondary koala habitat
3. Known habitat^ for vulnerable species

(c) Ecological processes

1. Land identified as priority conservation lands, BIO Map core areas, or important local habitat corridors for key species including Koalas
2. Land identified as BIO Map regional corridors or as areas that provide significant opportunities to support important local habitat corridors for key species, including Koalas
3. Areas identified on the Biodiversity Values Map

Boundary rationalisation

Consider removing:

- Small nodes or isolated patches of features identified in (a), (b) or (c) if future land use change will lead to significant edge effects and low viability over the timeframe identified, and there is no feasible opportunity to enhance connectivity and extent
- Corridors that do not link important areas of habitat, including 'blind corridors'

^ As indicated by BioNet records or recent survey data

APPLICATION OF AVOIDANCE CRITERIA

The avoidance criteria were applied through a series of workshops to each nominated area to identify areas of high biodiversity value and priorities for avoidance. The workshops included the following participants:

- The Department's strategic assessment team
- Accredited assessors and other expert ecologists who advised on biodiversity values and priorities
- The Department's precinct planning team who advised on urban development priorities and targets

Urban capable land identified in the LUIIP processes for Wilton, GMAC and part of WSA was used as a starting point. The workshops involved:

- Reviewing the data on biodiversity values compiled into a series of GIS datasets. Accredited assessors and other expert ecologists reviewed the accuracy of the data and made adjustments where necessary. As part of this process, consultation was undertaken with field ecologists to verify the accuracy of data
- Identifying areas of high biodiversity value and priorities for avoidance based on the identified criteria. This work focused on identifying priority 1 and priority 2 avoidance areas within each nominated area
- Rationalising the urban capable land to remove areas of biodiversity value that comprised:
  - Small nodes or isolated patches where future land use change will lead to significant edge effects and low viability and in which the opportunity to enhance connectivity and extent are not feasible
  - Habitat corridors that do not link important areas of habitat, including 'blind corridors'
- Identifying where priorities for avoidance of biodiversity were inconsistent with:
  - Indicative urban capable land identified in current LUIIPs, and/or
  - The achievement of urban development priorities reflected in relevant planning strategies and plans, including LUIIPs. These priorities included matters such as:
    - Urban planning/urban structure and design principles
    - Housing provision and dwelling targets
    - Transport and infrastructure provision and accessibility targets
    - Employment areas and targets
    - Open space provision and targets

Where priorities for avoidance of biodiversity values were inconsistent with urban development priorities, further consideration of the specific urban development imperative and needs, and further desktop investigation and validation of the biodiversity values of the site, was undertaken. Potential alternatives were explored and negotiations undertaken between the Department's strategic assessment team and the Department's planning team to:

- Explain and justify urban development and biodiversity avoidance priorities
- Explore alternative development locations to achieve the urban development priorities
- Seek a balance between urban development and biodiversity priorities

Box 3 provides a case study of the application of the avoidance criteria.

BOX 3: CASE STUDY - MINIMISING IMPACTS TO BIODIVERSITY VALUES IN AN AREA TARGETED FOR URBAN GROWTH IN WILTON

Step 1: Map the biodiversity values in Wilton and integrate this information with development plans for the area

The development of lands in north Wilton precinct identified there was the opportunity for a recreation reserve comprising ovals and sports fields in the northern end of the precinct to support open space targets for the precinct

The land is largely pasture within a matrix of Shale Sandstone Transition Forest vegetation zones, which cover the full range of condition classes (intact, thinned, scattered trees and derived native grassland)

The forested portions of this community comprise the CEEC under both the BC Act and EPBC Act. In addition, the land had been identified as a component of the regional primary Koala corridor

Furthermore, as part of the work to develop the Plan, the area where the recreation reserve was proposed was identified as a priority for ecological restoration, including because the land contained a Koala corridor and the TEC

Step 2: Initial amendment of footprint to minimise impacts to biodiversity values

Discussions were undertaken between the Department and the landholder to explore opportunities to reduce impacts on biodiversity values while still providing for a recreational reserve to support open space targets

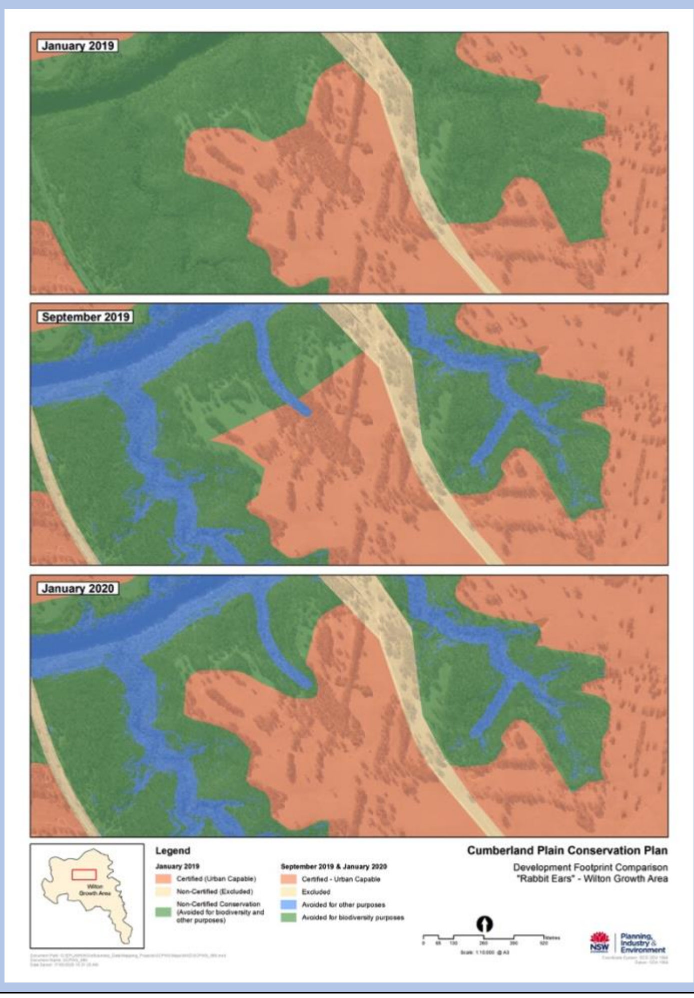
This led to reducing the footprint of the recreational reserve in key areas of biodiversity value, while still allowing for a road into the recreation area to provide and encourage public access to the area

Step 3: Further amend footprint and recreational design and use to further reduce impacts

The Department and the landholder met further to discuss opportunities to further amend the footprint and the recreational design and use of land to balance open space targets and impacts to biodiversity values

The agreed final design of the reserve will focus on passive, constructed play, and will retain of some of the original recreational land uses as well as potentially including car parking facilities. This allowed for a more effective wildlife corridor around the top of the Nepean River gorge to provide connectivity for animals such as Koala

These steps are reflected in the diagram below:



Consultation with key stakeholders

In some cases, consultation was undertaken with key stakeholders on indicative urban capable land.

Consultation occurred through:

- Public exhibition of draft LUIIPs that identified indicative urban capable land
- Targeted consultation with planning authorities, including Councils, to clarify urban development priorities particularly where these were inconsistent with avoidance priorities
- Consultation with accredited assessors and other expert ecologists to verify the accuracy of the data, particularly where urban development priorities were inconsistent with avoidance priorities
- Consultation with developers and landholders within the nominated areas to gain access to additional data

This consultation led to the adjustment of the urban capable land in some cases.

14.5.4 COMMITMENTS FOR AVOIDANCE RELATING TO URBAN CAPABLE LAND

The Plan includes a commitment (Commitment 2) to avoid and minimise impacts from urban and industrial, and infrastructure development, to at least 4,315 hectares of land within the nominated areas. This includes

- Avoiding 3,670 hectares of native vegetation comprising:
  - 2,735 hectares of native vegetation because of its biodiversity value
  - 935 hectares of riparian corridors and steep land
- Avoiding specific amounts of habitat for Commonwealth and NSW listed TECs
- Limiting cumulative direct impacts from essential infrastructure within non-certified land to the Commonwealth listed Shale Sandstone Transition Forest TEC and prioritising the avoidance of impacts from this infrastructure to specific known populations of flora species and important Koala corridors (see Chapter 37)

This commitment will be delivered through several actions, including:

- Introducing a planning provision to require that the urban capable lands in the precinct plans are consistent with the areas of certified land and avoided lands identified in the Plan
- Applying environment (E2) conservation zoning to land avoided for biodiversity or other purposes (see below)
- Applying further planning controls through the NSW planning system if the avoidance targets are not being met

The Plan also includes several commitments related to mitigation of indirect impacts that would lead to avoidance and minimisation of impacts on key habitat features within or adjacent to urban capable land. These include:

- Retain large trees (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction
- Retain areas of high density proteaceae shrubs where possible, particularly along riparian corridors
- If Green and Golden Bell Frog is confirmed present along Ropes Creek, consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced

Environmental protection zoning of avoided lands

The Plan will apply environment (E2) conservation zoning to land avoided for biodiversity and other purposes (riparian corridors, steep land) to strengthen the protection of avoided lands from the impacts of development. Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land[1]

[1] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10% to allow for potential future development of essential infrastructure in non-certified land

Environmental zones are designed to protect land in NSW that is of important environmental value. The zoning aims to prevent or control development that may have an adverse effect on the biodiversity and other values of the area.

Zoning will be implemented through the proposed SEPP for strategic conservation planning or the relevant place based Environmental Planning Instrument (EPI), such as the Growth Centres SEPP or the draft Aerotropolis SEPP (see Part 2).

14.6 AVOIDANCE OUTCOMES AND JUSTIFICATION FOR THE LOCATION OF URBAN CAPABLE LAND IN THE NOMINATED AREAS

This section describes the outcomes achieved in relation to avoiding and minimising impacts within the nominated areas and justifies the location of the urban capable land. Avoidance outcomes are described in relation to:

- Native vegetation generally
- High-condition native vegetation
- Threatened ecological communities
- Species habitats
- Important populations
- Areas important for connectivity
- Matters that are subject to serious and irreversible impacts

Avoidance outcomes are shown in Figure 14-1 to Figure 14-4.

14.6.1 NOTE ON AVOIDANCE OUTCOME CALCULATIONS

EXCLUDED LAND

As described in section 14.2.2, avoidance statistics in this Assessment Report have been calculated without including excluded land. This includes avoidance calculations for land:

- Avoided for biodiversity purposes
- Avoided for other reasons
- Total land avoided
- Per cent (%) of land avoided

Excluded land has not been included in these avoidance calculations because this land is not part of the approvals under this Plan and avoidance outcomes on this land are not able to be influenced by the Plan.

Of the estimated 9,790 ha of native vegetation communities in the nominated areas, 4,331 ha (44.2per cent) is excluded land. The amounts of excluded land are identified in each Table in this section only for context.

Passive recreation lands in WSA are not considered avoided for either biodiversity or other purposes and have been included in the definition of excluded land for the purposes of the avoidance statistics (see section 14.2.2).

TRANSPORT CORRIDORS

Avoidance outcomes have also been calculated assuming the whole of the transport corridors within the nominated areas will be impacted. Avoidance outcomes are therefore likely to have been underestimated as further avoidance will be undertaken within the transport corridors during detailed design of the transport projects (see section 14.4.2).

ESSENTIAL INFRASTRUCTURE WITHIN AVOIDED LANDS

Planning for essential infrastructure to support the nominated areas, such as water and electricity utilities, is in various stages of development, and this infrastructure may need to be located outside urban capable lands.

The Plan is seeking approval under the EPBC Act (but not the BC Act) for certain essential infrastructure development to occur within the nominated areas outside urban capable lands (i.e. within avoided lands). The Plan specifies that:

- Every effort should be made to ensure that essential infrastructure development is limited to urban capable lands

- Where essential infrastructure occurs outside urban capable lands (i.e. within the avoided lands), the development must comply with the 'Guidelines for Development' in Appendix A of the Plan

The avoidance outcome statistics do not include the potential impacts of essential infrastructure development in avoided lands as the need for these projects to be located in avoided lands, and their location, is not currently known.

The potential impacts of essential infrastructure within avoided lands is assessed in Chapter 37.

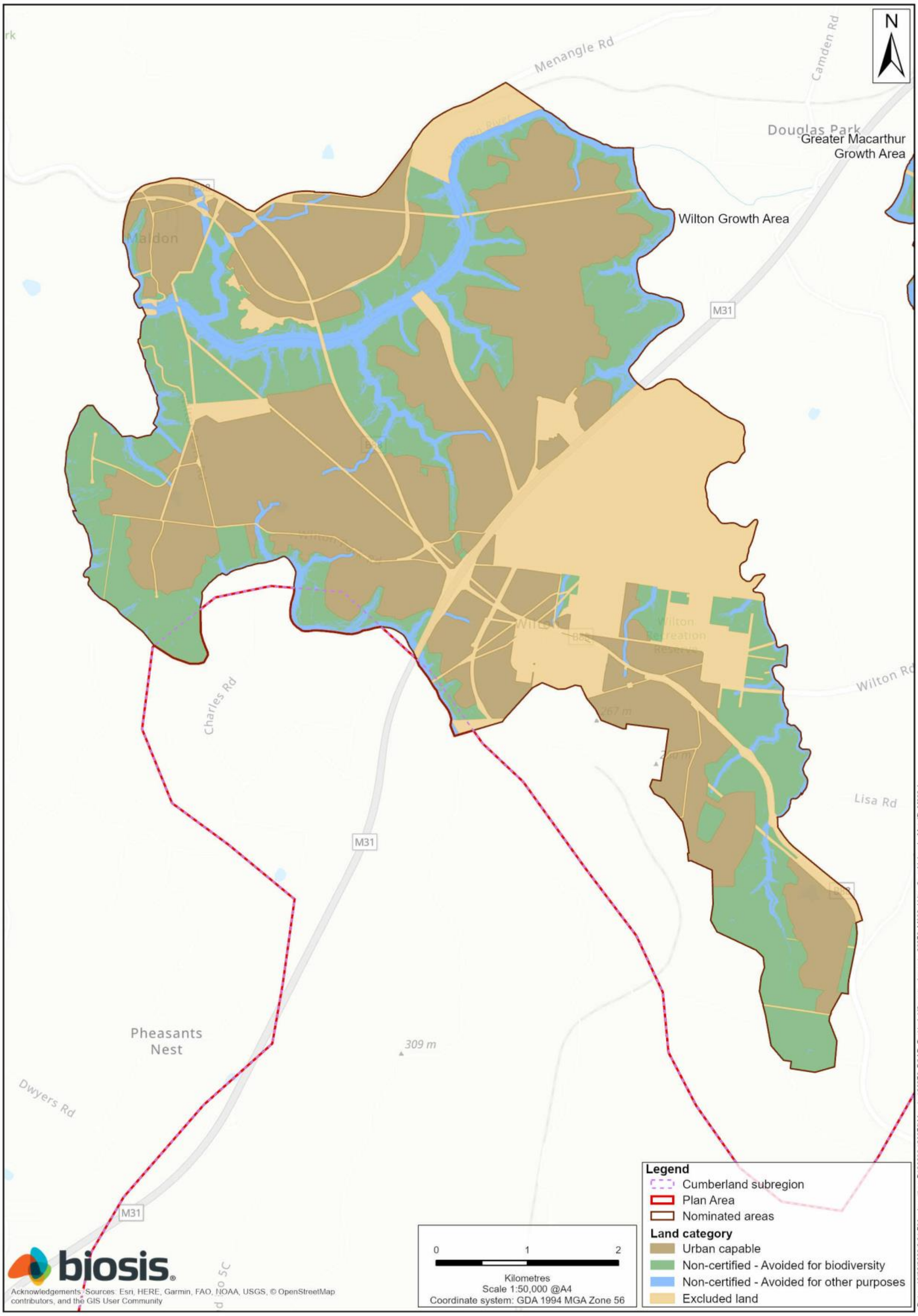


Figure 14-1: Avoidance outcomes – Wilton

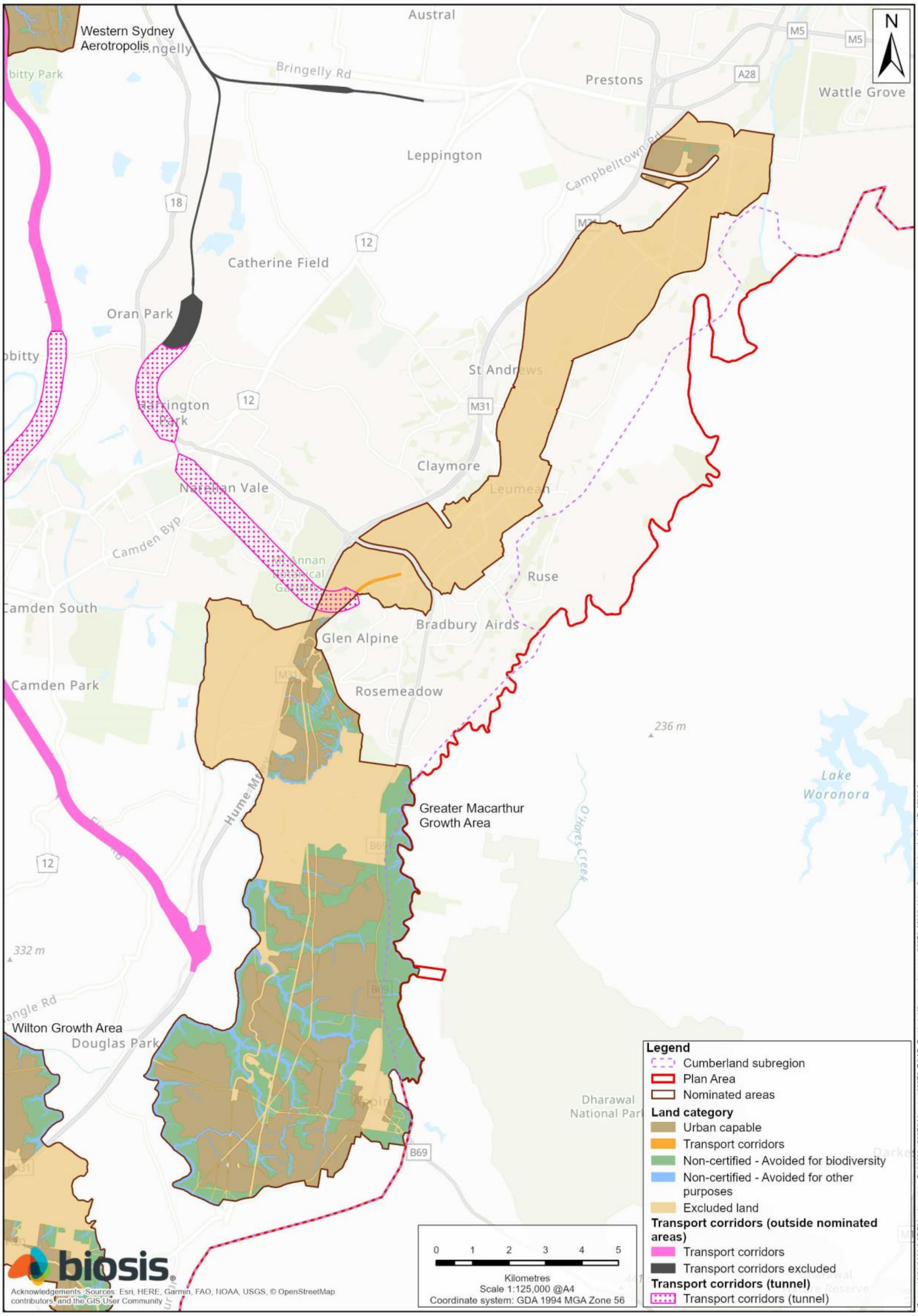


Figure 14-2: Avoidance outcomes – GMAC

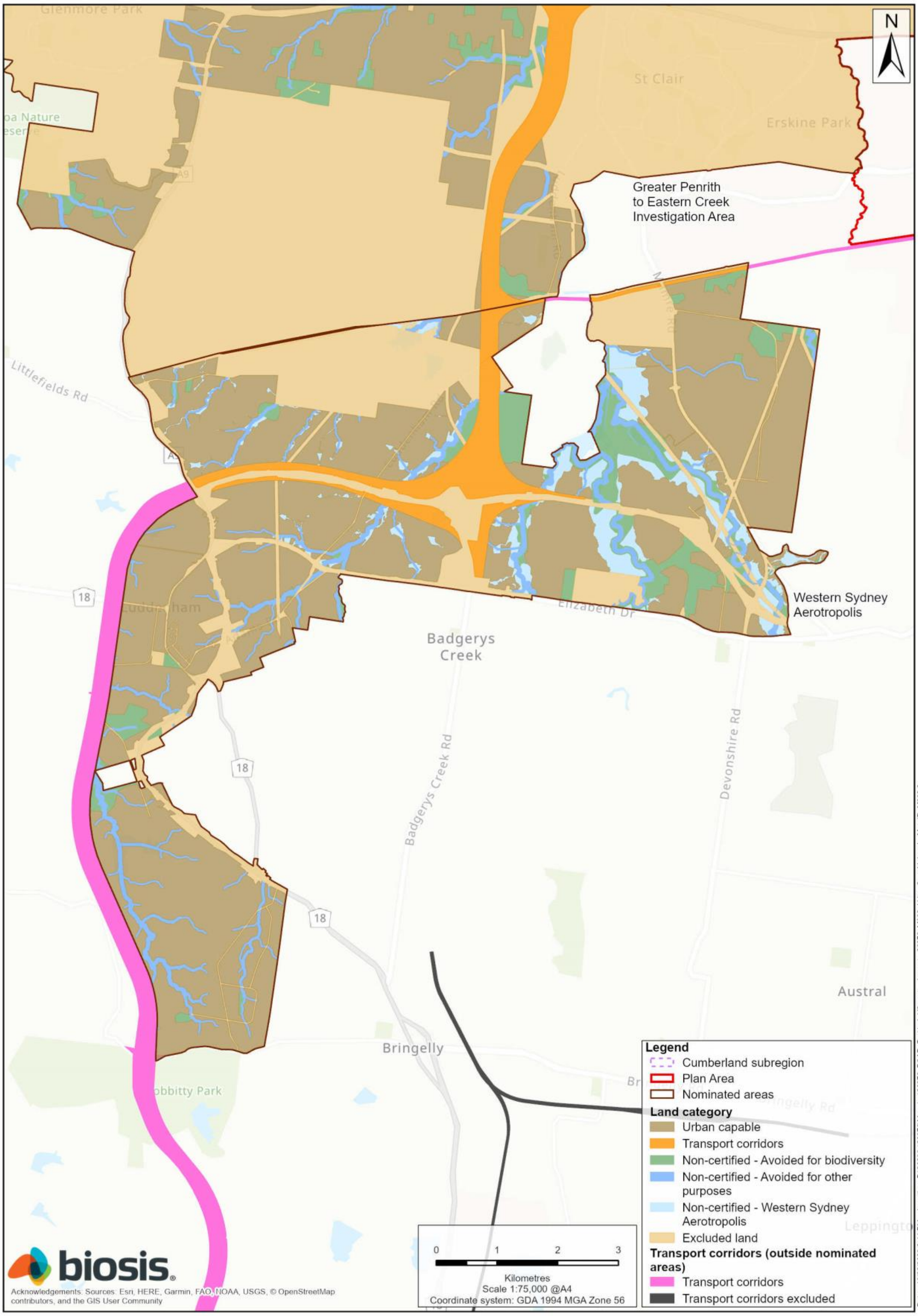


Figure 14-3: Avoidance outcomes – WSA

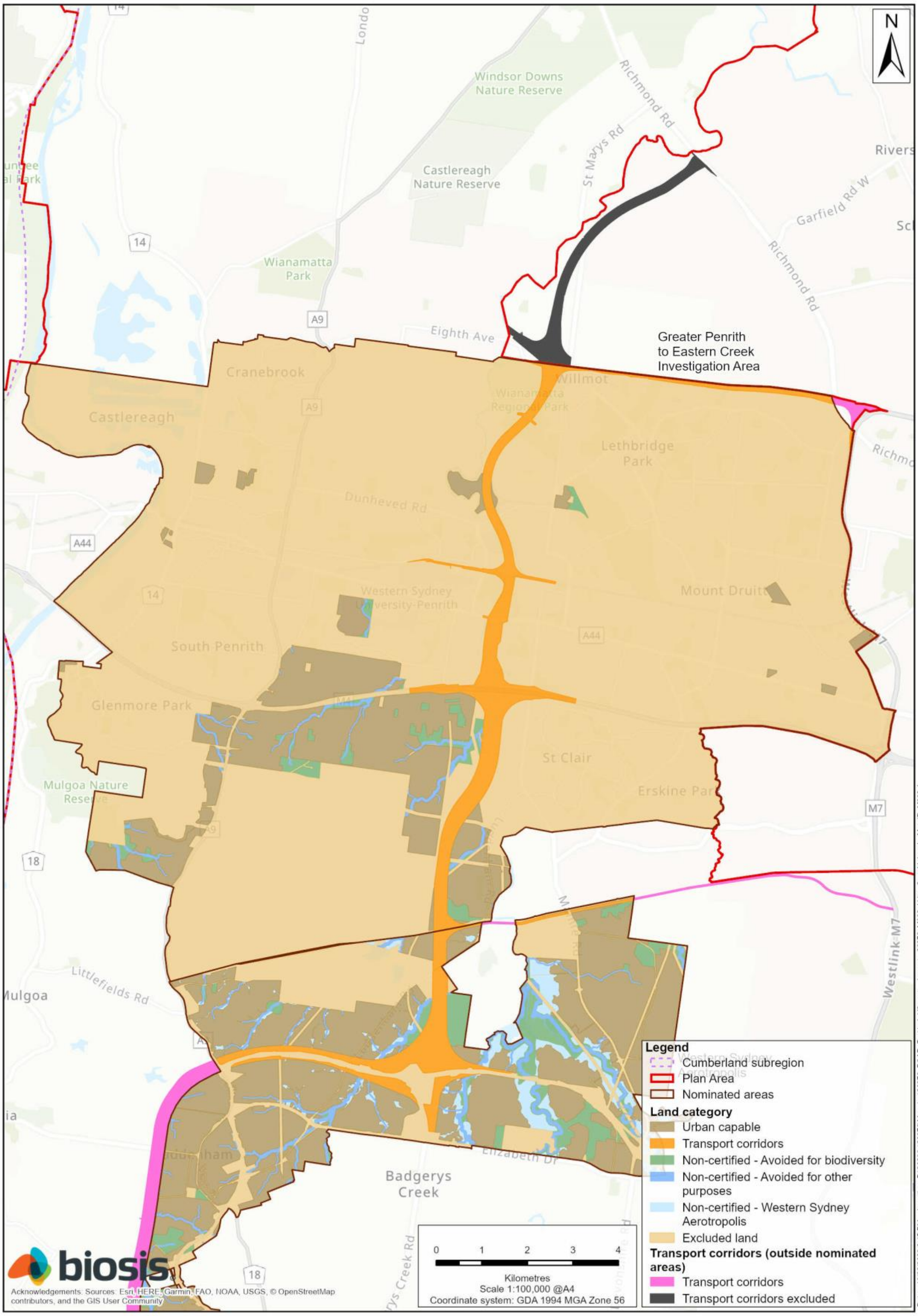


Figure 14-4: Avoidance outcomes – GPEC

14.6.2 NATIVE VEGETATION

Of the 5,460.5 ha of native vegetation occurring (not including excluded land) within the nominated areas:

- 2,734.7 ha (50.0 per cent) has been avoided for biodiversity purposes (as per the BAM definition)
- An additional 937.3 ha (17.2 per cent) has been avoided for other purposes and will not be directly impacted under the Plan

14.6.3 AVOIDANCE OF HIGH CONDITION NATIVE VEGETATION

Section 8.1.1.3 (b) of the BAM specifies that impacts can be avoided and minimised by locating development in areas where native vegetation is in the poorest condition, or by avoiding the highest condition native vegetation. For the purposes of this assessment high condition has been defined as vegetation mapped in the 'intact' condition state.

Table 14-2 indicates that the vast majority of the urban capable land for the nominated areas has been located in poorer condition native vegetation and avoided areas with the highest (intact) condition.

Of the high condition (intact) native vegetation in the nominated areas (2,472.5 ha, not including excluded lands):

- 1,678.5 ha (or 67.9 per cent) has been avoided for biodiversity purposes
- A total of 2,353.8 ha (or 95.2 per cent) has been avoided

AVOIDANCE IN GPEC

Avoidance outcomes of intact native vegetation for GPEC are lower than for other nominated areas. This is due to:

- The impacts of the transport corridors – the OSO within GPEC directly impacts about 36.9 ha of intact native vegetation (63.1 per cent of total area of intact vegetation in GPEC, not including excluded lands), while the urban capable land directly impacts about 2.1 ha of intact vegetation. It is important to note that avoidance within the transport corridors has not yet occurred (see section 14.4) and it is likely that further avoidance of intact native vegetation within the OSO footprint will occur during strategic planning and detailed design
- A relatively small urban capable land area within a nominated area that is largely already developed for urban purposes, meaning the opportunities for avoidance across the nominated area is generally more constrained

Despite this, it is considered that development under the Plan will generally avoid the areas that are most likely to be important for habitat connectivity within GPEC. The majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impacts occur:

- Within Wianamatta Regional Park where the OSO severs the eastern part of the regional park that is connected to Ropes Creek with the western part of the park
- Along Wianamatta (South Creek) where the OSO directly impacts the riparian corridor and severs the narrow connection along the corridor that links Wianamatta Regional Park and Orchard Hills

The other areas of potential habitat connectivity within GPEC comprise connected patches of vegetation (within 100 m of another patch) or isolated patches of vegetation (greater than 100 m from another patch) (there are no other areas of contiguous native vegetation forming habitat corridors outside Bio Map core areas/corridors). The development will result in the clearing of many small patches of connected vegetation, as well as the edges of several larger connected patches. This may reduce habitat connectivity across the area for more mobile species, such as bats and birds. Impacts to larger connected patches will reduce the size of the patches but will not generally sever connectivity between this connected vegetation and other areas of native vegetation, such as BIO Map corridors/core areas.

Table 14-2: Avoidance of high condition (intact) native vegetation in nominated areas

Nominated area	Area of high condition PCTs (ha) in nominated areas			Area of high condition PCTs avoided (ha) in nominated areas			
	Total area (ha)	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	Per cent avoided# (%)
Wilton	992.5	175.7	816.8	532.0	270.0	802.0	98.2
GMAC	1,971.0	449.0	1,522.0	1,082.6	386.1	1,468.7	96.5
WSA	80.7	5.5	75.2	48.9	14.8	63.7	84.8
GPEC	924.2	865.7	58.5	15.1	4.4	19.5	33.3
Total	**3,968.3**	**1,495.9**	**2,472.5**	**1,678.5**	**675.3**	**2,353.8**	**95.2**

* As per BAM definition of avoidance

Not including excluded lands

14.6.4 AVOIDANCE OF THREATENED ECOLOGICAL COMMUNITIES

Section 8.1.1.3 (c) of the BAM specifies that impacts can be avoided and minimised by locating proposed development in areas that avoid critically endangered and endangered TECs.

Table 14-3 and Table 14-4 indicate that within the nominated areas:

- Of the 3,936.7 ha of critically endangered and endangered NSW-listed TECs (not including excluded land), 2,259.1 ha (or 57.4 per cent) has been avoided for biodiversity purposes, and a total of 2,823.8 ha (or 71.7 per cent) has been avoided
- Of the 2,416.7 ha of critically endangered and endangered Commonwealth-listed TECs (not including excluded land), 1,807.4 ha (or 74.8 per cent) has been avoided for biodiversity purposes, and a total of 2,114.1 ha (or 87.5 per cent) has been avoided

Table 14-3: Avoidance of endangered (E) and critically endangered (CE) NSW-listed TECs in nominated areas

Nominated area and condition	Area of TECs in nominated areas (ha)						Area of TECs avoided in nominated areas (ha)						Per cent total CE and E TECs avoided# (%)
	Total area (ha)		Area in excluded lands (ha)		Area not including excluded lands (ha)		Avoided for biodiversity purposes*		Avoided for other reasons		Total avoided		
	CE	E	CE	E	CE	E	CE	E	CE	E	CE	E	
Wilton	**1,235.8**	**0.0**	**211.7**	**0.0**	**1,024.1**	**0.0**	**783.3**	**0.0**	**73.7**	**0.0**	**857.0**	**0.0**	**83.7**
Intact condition	545.6	0.0	73.7	0.0	471.9	0.0	401.3	0.0	55.8	0.0	457.1	0.0	96.9
Thinned condition	600.2	0.0	103.4	0.0	496.8	0.0	372.4	0.0	17.3	0.0	389.7	0.0	78.4
Scattered trees	90.0	0.0	34.6	0.0	55.4	0.0	9.6	0.0	0.6	0.0	10.2	0.0	18.5
GMAC	**2,409.7**	**206.5**	**709.1**	**169.1**	**1,700.6**	**37.4**	**1,193.6**	**17.0**	**228.4**	**15.0**	**1,422.0**	**32.0**	**83.7**
Intact condition	1476.2	57.9	324.3	45.7	1,151.9	12.3	904.2	5.1	194.7	7.0	1098.8	12.1	95.4
Thinned condition	746.4	140.2	314.2	115.1	432.2	25.0	254.9	11.9	30.8	8.0	285.7	19.9	66.8
Scattered trees	187.0	8.4	70.6	8.3	116.4	0.1	34.5	0.0	3.0	0.0	37.5	0.0	32.2
WSA	**443.3**	**366.3**	**56.1**	**64.2**	**387.2**	**302.2**	**101.4**	**96.8**	**31.5**	**129.3**	**132.9**	**226.1**	**52.1**
Intact condition	29.4	51.4	0.6	4.9	28.7	46.4	16.5	32.4	1.8	13.0	18.3	45.4	84.8
Thinned condition	325.1	268.9	40.1	45.7	284.9	223.2	81.0	61.3	27.5	105.4	108.6	166.6	54.2

Nominated area and condition	Area of TECs in nominated areas (ha)						Area of TECs avoided in nominated areas (ha)						Per cent total CE and E TECs avoided# (%)
	Total area (ha)		Area in excluded lands (ha)		Area not including excluded lands (ha)		Avoided for biodiversity purposes*		Avoided for other reasons		Total avoided		
	CE	E	CE	E	CE	E	CE	E	CE	E	CE	E	
Scattered trees	88.9	46.0	15.4	13.5	73.5	32.5	3.9	3.1	2.1	11.0	6.0	14.0	18.9
GPEC	**1,840.7**	**1,278.4**	**1,629.4**	**1,004.4**	**211.2**	**274.0**	**65.1**	**37.9**	**8.7**	**42.1**	**73.8**	**80.0**	**31.7**
Intact condition	430.8	487.0	426.2	433.1	4.6	53.9	0.3	14.7	0.0	4.4	0.3	19.1	33.3
Thinned condition	1280.1	772.8	1080.2	555.6	199.9	217.3	64.5	23.2	8.6	37.5	73.2	60.7	32.1
Scattered trees	129.8	18.6	123.1	15.7	6.7	2.9	0.2	0.0	0.1	0.1	0.3	0.2	4.9
Total	**5,929.5**	**1,851.2**	**2,606.4**	**1,237.6**	**3,323.1**	**613.7**	**2,143.4**	**151.7**	**342.4**	**186.4**	**2,485.7**	**338.1**	**71.7**

* As per BAM definition of avoidance

\# Not including excluded lands

Table 14-4: Avoidance of endangered (E) and critically endangered (CE) Commonwealth-listed TECs in nominated areas

Nominated area and condition	Area of TECs in nominated areas (ha)						Area of TECs avoided in nominated areas (ha)						Per cent total TECs (CE and E) avoided# (%)
	Total area (ha)		Area in excluded lands (ha)		Area not including excluded lands (ha)		Avoided for biodiversity purposes*		Avoided for other reasons		Total avoided		
	CE	E	CE	E	CE	E	CE	E	CE	E	CE	E	
Wilton	**990.1**	**0.0**	**169.3**	**0.0**	**820.8**	**0.0**	**683.9**	**0.0**	**69.8**	**0.0**	**753.7**	**0.0**	**91.8**
Intact condition	541.6	0.0	71.2	0.0	470.5	0.0	399.8	0.0	55.7	0.0	455.5	0.0	96.8
Thinned condition	448.4	0.0	81.4	0.0	367.0	0.0	279.1	0.0	13.7	0.0	292.8	0.0	79.8
Scattered trees	0.0	0.0	16.7	0.0	-16.7	0.0	5.1	0.0	0.3	0.0	5.4	0.0	-32.5
GMAC	**1,827.2**	**3.2**	**475.8**	**3.2**	**1,351.3**	**0.0**	**1,039.1**	**0.0**	**191.6**	**0.0**	**1,230.7**	**0.0**	**91.1**
Intact condition	1,290.3	0.0	260.4	0.0	1,029.8	0.0	823.7	0.0	170.7	0.0	994.4	0.0	96.6
Thinned condition	487.4	3.2	187.3	3.2	300.1	0.0	204.8	0.0	20.5	0.0	225.3	0.0	75.1
Scattered trees	49.5	0.0	28.1	0.0	21.4	0.0	10.6	0.0	0.3	0.0	11.0	0.0	51.4
WSA	**119.5**	**37.1**	**8.8**	**6.7**	**110.8**	**30.4**	**34.4**	**4.3**	**11.8**	**24.8**	**46.2**	**29.1**	**53.3**
Intact condition	21.0	0.0	0.2	0.0	20.8	0.0	19.4	0.0	0.2	0.0	19.7	0.0	94.5
Thinned condition	94.9	35.4	7.4	6.3	87.5	29.2	15.0	4.1	11.5	23.8	26.5	27.9	46.7

Nominated area and condition	Area of TECs in nominated areas (ha)						Area of TECs avoided in nominated areas (ha)						Per cent total TECs (CE and E) avoided# (%)
	Total area (ha)		Area in excluded lands (ha)		Area not including excluded lands (ha)		Avoided for biodiversity purposes*		Avoided for other reasons		Total avoided		
	CE	E	CE	E	CE	E	CE	E	CE	E	CE	E	
Scattered trees	3.6	1.7	1.2	0.4	2.4	1.3	0.0	0.1	0.0	1.0	0.0	1.2	31.0
GPEC	**1,115.2**	**57.4**	**1,015.6**	**53.6**	**99.6**	**3.8**	**45.4**	**0.3**	**5.7**	**3.0**	**51.1**	**3.3**	**52.7**
Intact condition	455.9	0.0	436.6	0.0	19.3	0.0	7.4	0.0	0.0	0.0	7.4	0.0	38.3
Thinned condition	656.9	57.4	576.7	53.6	80.2	3.8	38.0	0.3	5.7	3.0	43.7	3.3	56.0
Scattered trees	2.3	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.1
Total	**4,051.9**	**97.7**	**1,669.5**	**63.5**	**2,382.5**	**34.2**	**1,802.9**	**4.6**	**278.8**	**27.9**	**2,081.7**	**32.4**	**87.5**

* As per BAM definition of avoidance

\# Not including excluded lands

14.6.5 AVOIDANCE OF SPECIES HABITATS

Section 8.1.1.3(c) of the BAM specifies that the proposed development should avoid areas of habitat for species with a high biodiversity risk weighting. Risk-weightings are identified by EES for each species and used in credit calculations as part of assessing the impacts of a development on each species. Risk-weightings are based on the combination of the sensitivity of the species to loss at the development site, and sensitivity of the species to potential gain at an offset site.

Table 14-5 sets out the amounts of potential habitat avoided for NSW-listed candidate species credit species (SCS) with a high or very high biodiversity risk weighting in the nominated areas. The table indicates that within the nominated areas the average avoidance of habitat:

- Is 77.8 per cent for the three candidate SCS with a very high risk weighting (not including excluded lands) (*Allocasuarina glareicola*, *Hibbertia fumana* and *Chalinolobus dwyeri*)
- Is 78.6 per cent for the 31 candidate SCS with a high risk weighting (not including excluded lands) where an impact occurs

Avoidance outcomes for each Commonwealth-listed species are further described in Chapters 29 and 30, including in relation to important populations (this is also summarised in section 14.6.6).

Table 14-5: Avoidance of species habitat in nominated areas, showing avoidance of species with very high or high biodiversity risk-weighting (BRW)

Scientific name	Common name	NSW status	BRW	Cth status	Area of habitat in nominated areas (ha)			Area of habitat avoided in nominated areas (ha)			Per cent total avoided# (%)
					Total area (ha)	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Flora											
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	E	2	V	2,507.3	693.4	1,813.9	1,555.9	62.8	1,618.7	89.2
Acacia pubescens	Downy Wattle, Hairy Stemmed Wattle	V	2	V	6,193.7	3,340.4	2,853.3	1,884.9	233.5	2,118.4	74.2
Allocasuarina glareicola		E	3	E	185.6	163.7	21.9	10.0	0.1	10.1	45.9
Dillwynia tenuifolia		V	2		779.0	495.3	283.6	105.2	2.8	108.0	38.1
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	V	2	V	74.1	73.6	0.5	0.0	0.5	0.5	100.0
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	2	V	798.6	204.2	594.4	434.2	144.2	578.4	97.3
Hibbertia fumana		CE	3		1,649.7	404.8	1,244.9	1,064.3	143.1	1,207.4	97.0
Hibbertia puberula		E	2		1,646.4	409.3	1,237.1	1,053.0	142.5	1,195.5	96.6
Marsdenia viridiflora subsp. *viridiflora* - endangered population		E	2		4,432.4	3,157.7	1,274.7	616.6	245.7	862.4	67.7
Maundia triglochinoides		V	2		256.8	155.7	101.1	18.8	64.9	83.7	82.7

Scientific name	Common name	NSW status	BRW	Cth status	Area of habitat in nominated areas (ha)			Area of habitat avoided in nominated areas (ha)			Per cent total avoided# (%)
					Total area (ha)	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Melaleuca deanei	Deane's Melaleuca	V	2	V	2,321.8	564.3	1,757.5	1,553.3	101.7	1,655.1	94.2
Micromyrtus minutiflora		E	2	V	231.4	182.2	49.2	27.9	0.3	28.3	56.2
Persicaria elatior	Tall Knotweed	V	2		265.6	180.6	85.0	13.2	24.6	37.8	44.5
Persoonia bargoensis	Bargo Geebung	E	2	V	3,132.0	735.2	2,396.8	1,709.8	605.5	2,315.4	96.6
Persoonia nutans	Nodding Geebung	E	2	E	323.4	226.4	97.0	55.9	0.4	56.3	58.0
Pimelea curviflora var. *curviflora*		V	2	V	545.6	454.5	91.1	17.7	0.5	18.1	19.9
Pimelea spicata	Spiked Rice-flower	E	2	E	3,815.9	2,352.5	1,463.4	515.2	100.4	615.6	42.1
Pomaderris brunnea	Rufous Pomaderris	E	2	V	1,288.1	328.9	959.3	733.1	191.5	924.7	96.4
Pterostylis saxicola	Sydney Plains Greenhood	E	2	E	2,763.5	567.0	2,196.5	1,551.9	598.0	2,149.9	97.9
Pultenaea parviflora		E	2	V	330.1	198.8	131.3	56.5	0.4	56.9	43.3
Pultenaea pedunculata	Matted Bush-pea	E	2		1,970.6	1,179.6	791.1	533.5	49.9	583.4	73.7
Amphibians											
Litoria aurea	Green and Golden Bell Frog	E	2	V	1,654.5	1,629.9	24.6	11.2	0.0	11.3	45.8

Scientific name	Common name	NSW status	BRW	Cth status	Area of habitat in nominated areas (ha)			Area of habitat avoided in nominated areas (ha)			Per cent total avoided# (%)
					Total area (ha)	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Birds											
Callocephalon fimbriatum	Gang-gang Cockatoo	V	2		926.9	397.2	529.7	296.1	230.1	526.2	99.3
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	2		1,315.9	216.6	1,099.3	746.0	344.6	1,090.6	99.2
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	2		2,484.5	806.2	1,678.4	1,066.1	595.7	1,661.8	99.0
Ninox connivens	Barking Owl	V	2		522.3	106.1	416.2	20.3	395.9	416.2	100.0
Ninox strenua	Powerful Owl	V	2		527.6	110.6	417.0	20.3	396.4	416.7	99.9
Tyto novaehollandiae	Masked Owl	V	2		546.9	120.0	426.9	21.1	404.9	426.0	99.8
Invertebrates											
Meridolum corneovirens	Cumberland Plain Land Snail	E	2		6,758.8	3,374.7	3,384.1	2,210.0	437.7	2,647.7	78.2
Mammals											
Cercartetus nanus	Eastern Pygmy-possum	V	2		3,710.3	1,345.6	2,364.7	1,631.1	668.2	2,299.3	97.2
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	3	V	4,280.5	1,030.9	3,249.6	2,235.5	701.2	2,936.7	90.4
Myotis macropus	Southern Myotis	V	2		2,909.0	684.8	2,224.2	943.1	535.9	1,479.0	66.5
Petaurus norfolcensis	Squirrel Glider	V	2		6,516.7	3,193.3	3,323.4	2,309.9	691.5	3,001.4	90.3

Scientific name	Common name	NSW status	BRW	Cth status	Area of habitat in nominated areas (ha)			Area of habitat avoided in nominated areas (ha)			Per cent total avoided# (%)
					Total area (ha)	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Phascolarctos cinereus	Koala	V	2	V	3,897.4	771.6	3,125.9	2,182.9	682.4	2,865.3	91.7

* As per BAM definition of avoidance; # Not including excluded lands

14.6.6 AVOIDANCE OF IMPORTANT POPULATIONS

Table 14-6 summarises the avoidance outcomes for important populations for each Commonwealth-listed species.

In total 20 species have mapped important populations within the nominated areas, of which the important populations identified for 14 species are not entirely included on excluded land. Of 14 species with important populations identified outside excluded land 12 have important populations represented (either wholly or partially) on land avoided for biodiversity purposes. It is important to note that in some cases, records that form part of the important population may be located across several land categories (urban capable land, excluded land, or avoided lands).

The avoidance outcomes and extent of direct impacts under the Plan to each important population are further described in the assessments for each Commonwealth-listed species in Chapters 29 and 30. The location of each important population is also shown in the habitat maps for each species provided in those chapters.

Table 14-6: Summary of avoidance of important populations for Commonwealth-listed species

Scientific name	Important populations in nominated areas			Important populations avoided in nominated areas			Location of avoided population records
	Total number	Number in excluded lands	Number not including excluded lands	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Acacia bynoeana	1	1	0	0	0	0	N/A
Allocasuarina glareicola	1	1	0	0	0	0	N/A
Anthochaera phrygia	1	1	0	0	0	0	N/A
Chalinolobus dwyeri^	1	1	1	1	0	1	Population 424 occurs as a single important population across the Plan Area and surrounds. The majority of records lie outside of the nominated areas; however, 9 records occur within excluded lands and 2 records are located within avoided lands in central GMAC
Dasyurus maculatus maculatus^	2	1	1	1	0	1	Population 500 contains 4 records within and adjacent to GMAC. Of these, 1 record occurs within avoided lands in the east of GMAC
Genoplesium baueri	1	0	1	1	0	1	Population 21 contains 1 record within the Plan Area. The whole population occurs within avoided lands in the south east of GMAC next to Appin Road
Grevillea parviflora subsp. *parviflora*^	4	2	2	2	0	2	Population 104 contains 13 records. Of these, 8 occur within avoided lands in the north west of Wilton. Population 518 contains 1 record and the entire population occurs within avoided lands in the north west of Wilton
Lathamus discolor^	1	1	1	1	0	1	Population 186 is a single mapped important population across the Plan Area and surrounds. The population contains 205 records. Of these, 1 record occurs within avoided lands in the east of GMAC and 1 record occurs within avoided lands in the centre of GPEC

Scientific name	Important populations in nominated areas			Important populations avoided in nominated areas			Location of avoided population records
	Total number	Number in excluded lands	Number not including excluded lands	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Litoria aurea^	2	2	1	1	0	1	Population 190 contains 6 records. Of these, 1 record occurs within avoided lands in the north of GPEC
Melaleuca deanei	1	1	0	0	0	0	N/A
Micromyrtus minutiflora	1	1	0	0	0	0	N/A
Persoonia bargoensis^	1	1	1	1	0	1	Population 114 contains 343 records within the southern part of the Plan Area and surrounds. Of these, 3 records occur within avoided lands in the north west and east of Wilton
Persoonia nutans^	6	4	2	1	0	1	Population 60 contains 7 records and 1 record occurs within avoided lands in the east of WSA
Petauroides volans	1	1	1	0	0	0	N/A
Phascolarctos cinereus	1	1	1	1	1	1	Population 184 contains 895 records within and adjacent to the Plan Area, focused on the south-west corner of the Plan Area. Of these, 58 records occur within avoided lands along the eastern part of GMAC, east of Appin Road and 8 records are located on avoided land in Wilton
Pimelea spicata	6	4	2	1	0	1	Population 533 contains 1 record, with the entire population located within avoided lands on the edge of GMAC, east of Appin Road
Pomaderris brunnea	3	2	2	2	0	2	Population 586 contains 7 records. Of these, 3 records occur on avoided land in the centre of GMAC. Population 587 contains 2 records. The entire population occurs within avoided lands in the south-west of GMAC

Scientific name	Important populations in nominated areas			Important populations avoided in nominated areas			Location of avoided population records
	Total number	Number in excluded lands	Number not including excluded lands	Avoided for biodiversity purposes*	Avoided for other reasons	Total avoided	
Pteropus poliocephalus^	1	1	1	1	1	1	Population 537 is a single population across the entire Plan Area and surrounds. 1 record occurs within avoided lands in the north of Wilton and 4 records occur within avoided lands in the east of GMAC
Pultenaea parviflora	6	4	2	0	0	0	N/A
Rostratula australis	1	1	0	0	0	0	N/A

* As per BAM definition of avoidance

Not including excluded lands

14.6.7 AVOIDANCE OF AREAS IMPORTANT FOR CONNECTIVITY

Section 8.1.1.3(d) of the BAM specifies that the development should avoid areas important for maintaining habitat connectivity. BIO Map core areas and corridors (OEH, 2015) provide a surrogate measure of habitat connectivity and a useful approach to evaluating avoidance outcomes in terms of connectivity.

The purpose of BIO Map is to identify areas on the Cumberland subregion where investment in conservation actions will have maximum benefit. It is acknowledged that BIO Map is not intended to be used for land-use planning, as it does not identify all significant vegetation. However, BIO Map core areas represent the habitat most likely to support species persistence and the maintenance of interactions between species and landscape scale ecological processes, and BIO Map corridors play a crucial role in maintaining connectivity between species populations.

Table 14-7 and Table 14-8 set out the amounts of Bio Map core areas and corridors avoided in the nominated areas. The tables indicate that of the Bio Map core areas and corridors within the nominated areas (not including excluded land):

- 68.6 per cent of core areas have been avoided for biodiversity purposes, and a total of 88.3 per cent has been avoided
- 56.5 per cent of corridors have been avoided for biodiversity purposes, and a total of 86 per cent has been avoided

Table 14-7: Avoidance of areas important for habitat connectivity (BIO Map core areas)

Nominated area	Area of Bio Map core areas in nominated areas (ha)			Area of Bio Map core areas avoided in nominated areas (ha)			Per cent avoided # (%)
	Total area (ha)*	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes* (ha)	Avoided for other reasons (ha)	Total avoided (ha)	
Wilton	559.5	20.0	539.3	390.3	82.8	473.1	**87.7**
GMAC	1,330.5	215.3	1,116.5	791.6	255.2	1,046.7	**93.8**
WSA	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
GPEC	2,284.5	2,207.9	76.6	7.1	2.3	9.4	**12.3**
Total	**4,174.5**	**2,443.2**	**1,732.4**	**1,189.0**	**340.2**	**1,529.3**	**88.3**

* As per BAM definition of avoidance

Not including excluded lands

Table 14-8: Avoidance of areas important for habitat connectivity (BIO Map corridors)

Nominated area	Area of Bio Map corridors in nominated areas (ha)			Area of Bio Map corridors avoided in nominated areas (ha)			Per cent avoided # (%)
	Total area (ha)*	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes* (ha)	Avoided for other reasons (ha)	Total avoided (ha)	
Wilton	428.6	35.5	393.1	232.9	151.5	384.4	**97.8**
GMAC	484.4	225.0	259.5	219.9	39.1	259.0	**99.8**

Nominated area	Area of Bio Map corridors in nominated areas (ha)			Area of Bio Map corridors avoided in nominated areas (ha)			Per cent avoided # (%)
	Total area (ha)*	Area in excluded lands (ha)	Area not including excluded lands (ha)	Avoided for biodiversity purposes* (ha)	Avoided for other reasons (ha)	Total avoided (ha)	
WSA	317.6	57.3	260.3	139.7	98.3	238.0	**91.4**
GPEC	1,027.9	850.7	177.3	23.4	32.6	56.0	**31.6**
Total	**2,258.5**	**1,168.4**	**1,090.1**	**615.9**	**321.4**	**937.4**	**86.0**

* As per BAM definition of avoidance

Not including excluded lands

14.6.8 AVOIDANCE OF SERIOUS AND IRREVERSIBLE IMPACTS

The BAM requires an assessment of avoidance for serious and irreversible impact (SAII) entities.

A total of 12 SAII entities were identified as potentially impacted by the proposed development and needing assessment in accordance with the BAM. The avoidance outcomes for each of these SAII entities is assessed in Chapter 25.

14.6.9 CONCLUSION

The urban capable land was located by establishing a planning process that took into account and biodiversity values and prioritised the avoidance of high biodiversity values through a set of criteria.

Where biodiversity priorities were inconsistent with urban development priorities, the decision-making process sought to balance these priorities. This was achieved through negotiations on options between the Department's strategic assessment team and the Department's planning team to:

- Explain and justify urban development and avoidance priorities
- Explore alternative development locations to achieve the urban development priorities
- Make decisions on final urban capable land boundaries (see Box 3)

The planning process to avoid and minimise impacts has led to substantial avoidance outcomes for native vegetation, TECs, species habitats, and habitat connectivity.

Urban capable land has generally avoided the vast majority of native vegetation and key areas of high biodiversity values, including NSW and Commonwealth-listed TECs, species habitats, important populations and habitat connectivity. Within the nominated areas, total avoidance (not including excluded lands) includes:

- Approximately 67.2 per cent of all native vegetation, including 95.2 per cent of high (intact) condition native vegetation
- Approximately 87.5 per cent of critically endangered and endangered Commonwealth-listed TECs and 71.7 per cent of critically endangered and endangered NSW-listed TECs
- An average of 77.8 per cent of potential habitat for three species with a very high biodiversity risk weighting (>3), and an average of 78.6 per cent of potential habitat for 31 species with a high biodiversity risk weighting (≥2)
- Of 14 species with important populations identified outside excluded land 12 have important populations represented (either wholly or partially) on land avoided for biodiversity purposes
- Approximately 88.3 per cent of Bio Map core areas and 86.0 per cent of Bio Map corridors

Note that these figures include the amount of land 'avoided' for other purposes and not just biodiversity purposes (i.e. the figures include land that is not suitable for urban development because it is steep land or riparian corridors).

It is considered these avoidance outcomes are adequate and generally consistent with the guidance under the BAM and requirements of the ToR. Furthermore, commitments under the Plan ensure:

- The amount of avoidance to be achieved is clear and transparent
- Precinct planning proceeds in a way that ensures avoided lands are clearly identified and avoided
- The protection of avoided lands from the impacts of development is strengthened through environmental zoning

15 Managing indirect impacts

15.1 INTRODUCTION

The BAM and the Commonwealth ToR require indirect impacts to be identified and assessed.

Indirect impacts are any impacts that could adversely affect biodiversity values, such as native vegetation, TECs and threatened species habitat, beyond the urban capable land. Indirect impacts may also result from changes to land-use patterns, such as an increase in vehicular access and human activity.

This Chapter:

- Sets out the regulatory requirements for managing indirect impacts under the BAM and ToR
- Describes the approach applied to identify and assess indirect impacts
- Describes the indirect impacts relevant to the Plan, including their nature, extent and duration
- Identifies the threatened species and TECs at risk of indirect impacts
- Describes the general mitigation measures and processes that will be implemented to address each indirect impact
- Assesses the potential indirect impacts on each species and TEC taking into account the general mitigation measures that will be implemented under the Plan, and identifies whether there are any residual impacts
- Describes any additional species or TEC specific mitigation measures to address any residual impacts
- Identifies the threat abatement plans under the EPBC Act relevant to the Plan and how they relate to the Plan

Detailed assessments of the potential indirect impacts on each Commonwealth-listed TEC and species, as well as other EPBC Act protected matters, are undertaken in the following chapters:

- Chapter 29 – Commonwealth-listed flora
- Chapter 30 – Commonwealth-listed fauna
- Chapter 31 – Commonwealth-listed TECs
- Chapter 32 – Migratory species
- Chapter 33 – Ramsar wetlands
- Chapter 34 – World and National Heritage
- Chapter 35 – Commonwealth Land

This Chapter covers the aspects of the indirect impacts assessment listed above, and in particular, describes the detail of the general and specific mitigation measures and processes that are referred to in these other chapters. This Chapter also covers the assessment of indirect impacts on NSW-listed TECs and species as required under the BAM and summarises the assessment undertaken for Commonwealth-listed TECs and species in Chapters 29 to 31.

15.2 REGULATORY REQUIREMENTS

15.2.1 BC ACT REQUIREMENTS

Section 9 of the BAM requires the Assessment Report to assess the potential indirect impacts of the Plan on biodiversity values. The Assessment Report must:

- Describe the nature, extent and duration of short-term and long-term impacts
- Identify the species and TECs likely to be affected
- Predict the consequences of the impacts for the bioregional persistence of the species and TECs
- Document mitigation measures proposed to manage impacts
- Identify any measures for which there is risk of failure
- Evaluate the risk and consequence of any residual impacts likely to remain after mitigation measures are applied
- Document any adaptive management strategy proposed (this is described in Chapter 16)

15.2.2 EPBC ACT REQUIREMENTS

Section 4.5 of the Commonwealth ToR requires the Assessment Report to consider potential indirect impacts on MNES and describe what mitigation will be implemented to reduce indirect impacts.

Section 5.3 of the ToR requires the Assessment Report to consider the likely effectiveness of the conservation measures under the Plan in protecting and managing MNES and any related risks and uncertainties.

15.3 APPROACH TO THE ASSESSMENT

The steps taken to assess indirect impacts involved:

Step 1: Identify the range of indirect impact types associated with the development and describe the nature, extent, and duration of each indirect impact type. This involved:

- Nature of impacts – qualitatively describe each indirect impact type, including cause and scope of the impact
- Extent of impacts – identify the general location and extent of indirect impacts
- Duration – identify whether the impacts are short-term or long-term

Step 2: Identify the species and TECs likely to be affected by each indirect impact within each nominated area and the transport corridors. This was done by drawing on ecological and life history information in BioNet profiles, conservation advices, recovery plans, as well as species records and habitat maps prepared for this Assessment Report

Step 3: Describe the general mitigation measures and processes that will be implemented to mitigate indirect impacts and the likely effectiveness of these measures

Step 4: Assess the potential impacts on each species and TEC taking into account the general mitigation measures in the Plan to address the impacts. This was done taking into account:

- Likely presence/abundance of species/TEC and importance of the location at a local and regional scale
- Life history traits and susceptibility of the species/TEC to the indirect impact
- Location of the species/TEC relative to the likely extent of the indirect impact
- Amount and quality of un-impacted habitat remaining
- Levels of existing protection

A conclusion is provided about whether any residual risks remain for each species and TEC.

Step 5: Describe any additional species or TEC specific mitigation measures identified under the Plan to address residual impacts

15.4 NATURE, EXTENT AND DURATION OF INDIRECT IMPACTS

15.4.1 SUMMARY OF DEVELOPMENT UNDER THE PLAN

The types of development under the Plan that have the potential to cause indirect impacts on biodiversity values are described in detail in Part 2 and include:

- Urban and industrial development in the nominated areas
- Infrastructure in the nominated areas
- Agribusiness in the Western Sydney Aerotropolis
- Transport corridors

URBAN AND INDUSTRIAL DEVELOPMENT

Urban and industrial development will occur within the urban capable land in the nominated areas. This development may include:

- Mixed residential, commercial and industrial development

- Major town centres including shops and recreational facilities, and smaller village centres
- Social infrastructure including education, cultural, sports and entertainment facilities
- Essential health and emergency services facilities
- General industrial facilities such as retail outlets, technology facilities, material supply centres and distribution centres
- Warehouses, freight transport facilities and heavy industrial storage establishments

INFRASTRUCTURE

Infrastructure development will predominantly be located within urban capable land and may include:

- Electricity transmission or distribution networks
- Gas pipelines
- Road or road infrastructure facilities including public transport facilities
- Water systems and facilities, such as for storage, treatment and supply
- Telecommunications facilities
- Stormwater management system
- Waste facilities, including organic waste and composting facilities
- Supporting infrastructure for parks and public reserves

AGRIBUSINESS

The Agribusiness Precinct in WSA will provide for the movement and storage of agricultural commodities at the northern and western edges of the Western Sydney International (Nancy-Bird Walton) Airport. Development in this area may include:

- Intensive plant agriculture, including protective cropping structures
- Businesses associated with the production, processing, marketing and distribution of agricultural products
- Advanced food manufacturing and logistics
- Wholesale markets, including retail, accommodation, and large distribution centres, and infrastructure such as cold stores, ripening rooms, treatment facilities and waste management

TRANSPORT CORRIDORS

Transport development includes all activities associated with the design, construction and operation of major transport infrastructure. These activities include, but are not limited to:

- Vegetation clearing
- Earthworks
- Utility works
- Landscaping
- Erosion and sediment control
- Laydown areas
- Road and rail construction
- Tunnel construction
- Construction of supporting infrastructure such as stations, car parks and pedestrian access
- Electricity infrastructure
- Site offices and access roads
- Dust and noise suppression
- Stormwater management (including detention basins, ponds and dams)
- Vehicle and train movements
- Maintenance and upgrade activities
- Installation and maintenance of traffic control and safety infrastructure

15.4.2 IMPACTS ASSOCIATED WITH EACH DEVELOPMENT TYPE

Table 15-1 identifies each indirect impact type associated with each type of development under the Plan, and the nature, extent and duration of the indirect impacts.

The nature, extent and duration of the impacts are described broadly. Due to the large scale of the development and the staging of construction precinct by precinct over the life of the Plan, it is not possible to be specific about the nature and extent of impacts in relation to specific vegetation zones at any particular location, or the exact timing of the development at any particular location.

The nature of each indirect impact type is described in more detail in Sections 15.4.3 to 15.4.12.

Table 15-1: Indirect impact types and nature, extent and duration of indirect impacts associated with the Plan

Indirect impact type	Development types relevant to the indirect impact				Nature of indirect impact	Extent/general location of indirect impact and/or high risk areas	Duration of indirect impact
	Urban and industrial	Infrastructure	Agribusiness	Transport corridors			
Hydrological/ soil disturbance	✓	✓	✓	✓	Changes to surface water and groundwater flows and water quality due to development and infrastructure disrupting natural flows and pollutants associated with urban areas and soil erosion/disturbance to contaminated soils	Waterways, wetlands, flood-prone areas within or downstream of development	Short term to long-term
Ground settling or subsidence				✓	Settlement/subsidence of ground in the vicinity of transport tunnels due to the tunnel void or groundwater removal, which may cause disturbance to the land surface	Land within or in vicinity of the transport tunnels	Long-term
Spread of infection/disease	✓	✓	✓	✓	Spread of pathogens from contaminated clothing and equipment or surface water runoff	Native vegetation retained within or adjacent to development	Likely long-term
Spread of weeds	✓	✓	✓	✓	Spread of invasive species due to edge effects, surface water run-off, or changed fire regimes	Native vegetation retained within or adjacent to development	Likely long-term
Predation/ competition by pest/domestic fauna	✓		✓	✓	Increased predation and competition of species by pest/domestic fauna	Habitat retained within or adjacent to development including well-connected habitat corridors	Likely long-term
Altered fire regimes	✓		✓	✓	Altered fire regimes as a result of increased burns for asset protection or reduced ability to burn due to risk to surrounding urban areas	Native vegetation retained within or immediately adjacent to development, particularly asset protection zones	Long-term

Indirect impact type	Development types relevant to the indirect impact				Nature of indirect impact	Extent/general location of indirect impact and/or high risk areas	Duration of indirect impact
	Urban and industrial	Infrastructure	Agribusiness	Transport corridors			
Disturbance from increased public access to natural areas	✓				Trampling of species or habitat, removal of wood or bush rock, damage from mountain-biking and four-wheel driving	Publicly accessible natural areas retained within or immediately adjacent to development	Short term to permanent
Fauna mortality, displacement and barriers to movement	✓	✓	✓	✓	Potential for mortality of threatened fauna species by vehicle strike and reduced movement and connectivity between habitat areas from barriers	Habitat intersected by roads	Long-term
Fauna disturbance due to noise, dust or light	✓	✓	✓	✓	Noise, dust or light created by equipment during construction or by new structures during operation	Habitat retained within or immediately adjacent to development	Short-term to long-term
Inadvertent impacts on adjacent habitat or vegetation	✓	✓	✓	✓	Damage to adjacent habitat during construction activities or during ongoing management	Native vegetation immediately adjacent to development	Short-term to long-term

15.4.3 HYDROLOGICAL/SOIL DISTURBANCE

Reduction in surface water quality and changes to surface water flows

Development under the Plan may lead to changes to hydrology and water quality. This is primarily related to:

- Disruption to natural flows and processes
- Increase of hard surfaces leading to an increased volume of water entering downstream waterways
- Introduction of contaminants into surface water, such as nutrients, chemicals and sediment from urban and other development and land uses, including disturbance of soils/contaminated soils during construction

Changes to surface water quality and hydrology can impact a range of listed species and TECs. Species that rely on aquatic environments such as swamps and riparian corridors are particularly at risk from these types of impacts.

Changes to groundwater

Development under the Plan may affect groundwater quality, including from salinity and contamination. This is primarily related to:

- Clearing for construction
- Construction works involving large excavations
- Dewatering or structures buried below the water table, including groundwater removal from the tunnel voids associated with the transport corridor tunnels
- Diversion of surface water, including installation of buildings and hard surfaces

Changes to groundwater can affect groundwater-sensitive species and habitats and dependent ecosystems.

Soil disturbance

Development under the Plan may cause soil erosion and sedimentation and disturbance to contaminated soils, which can lead to changes in water quality. This is primarily related to:

- Vegetation clearing
- Construction works involving large excavations
- The management of spoil during construction, particularly for the construction of the transport corridor tunnels

15.4.4 GROUND SETTLEMENT/SUBSIDENCE

Construction of the transport corridor tunnels involves the creation of a tunnel void and removal of groundwater from the void. This may cause ground settlement and subsidence to the land surface above and in the vicinity of the tunnel, causing disturbance to any biodiversity or other values in the affected area.

15.4.5 SPREAD OF INFECTION/DISEASE

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

Spread of infection/disease can affect species and have associated impacts on TECs.

Key threatening processes listed under the BC Act and EPBC Act relevant to this indirect impact type are:

- Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC Act)/infection of frogs by amphibian chytrid causing the disease chytridiomycosis (BC Act)
- Infection and dieback caused by the root-rot fungus *Phytophthora cinnamomi* (EPBC Act)/infection of native plants by *Phytophthora cinnamomi* (BC Act)

- Introduction and establishment of Exotic Rust Fungi of the order *Pucciniales pathogenic* on plants of the family *Myrtaceae* (BC Act)
- Novel biota and their impact on biodiversity (EPBC Act)
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species (EPBC Act/BC Act)

15.4.6 SPREAD OF WEEDS

Development under the Plan has the potential to increase the spread of invasive species and weeds. This is primarily related to:

- New environmental conditions at the edges of developments such as altered light levels, windspeed, and temperature, that may facilitate the spread of weeds
- Use of inappropriate species in landscaping and revegetation
- Accidental dispersal of weed seeds and plant material
- Altered fire regimes

Species are most susceptible to this threat where new urban growth or transport corridors occur adjacent to known populations or habitat. Weeds can reduce the viability of adjacent habitat or vegetation for listed species and TECs, and can reduce the health of important habitat features. Invasive species of particular concern are:

- African lovegrass (*Eragrostis curvula*)
- African olive (*Olea europaea* subsp. *cuspidata*)
- Asparagus fern (*Asparagus aethiopicus*)
- Black nightshade (*Solanum nigrum)*
- Bridal creeper (*Asparagus asparagoides*)
- Buffalo grass (*Stenotaphrum secundatum*)
- Castor-oil plant (*Ricinus communis*)
- Coolatai Grass (*Hyparrhenia hirta*)
- Kikuyu grass (*Cenchrus clandestinus*)
- Lantana (*Lantana camara*)
- Long-leaf willow primrose (*Ludwigia longifolia*)
- Rhodes grass (*Chloris gayana*)
- Whisky grass (*Andropogon virginicus*)

Key threatening processes listed under the BC Act and EPBC Act relevant to this indirect impact type are:

- Invasion and establishment of exotic vines and scramblers (BC Act)
- Invasion, establishment and spread of Lantana (*Lantana camara*) (BC Act)
- Invasion of native plant communities by African Olive *Olea europaea* subsp. *cuspidata* (BC Act)
- Invasion of native plant communities by exotic perennial grasses (BC Act)
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants (EPBC Act/BC Act)
- Novel biota and their impact on biodiversity (EPBC Act)

15.4.7 PREDATION/COMPETITION/LAND DEGRADATION BY PEST/DOMESTIC FAUNA

Development under the Plan has the potential to increase the spread of pest fauna and/or access to natural areas by domestic fauna, leading to increased predation and competition with native fauna. This is primarily related to:

- Clearing that creates new movement pathways that can be used by pest fauna to expand their range
- Clearing that changes conditions at the edges of habitat that favour pest fauna
- Direct predation of native fauna by pest/domestic fauna
- Pest fauna destroying habitat and spreading disease

Domestic animals in this context is primarily related to increased numbers of cats, dogs and rabbits.

Key threatening processes listed under the BC Act and EPBC Act relevant to this indirect impact type are:

- Aggressive exclusion of birds from potential woodland and forest habitat by abundant Noisy Miners *Manorina melanocephala* (EPBC Act/BC Act)
- Competition and land degradation by rabbits (EPBC Act)/Competition and grazing by European rabbit (BC Act)
- Competition and land degradation by unmanaged goats (EPBC Act)/Competition and habitat degradation by Feral Goats, *Capra hircus* (BC Act)
- Competition from feral honeybees (EPBC Act/BC Act)
- Herbivory and environmental degradation caused by feral deer (BC Act)
- Predation and hybridisation by Feral Dogs, *Canis lupus familiaris* (BC Act)
- Predation by feral cats (EPBC Act/BC Act)
- Predation by the European red fox (EPBC Act/BC Act)
- Predation by the plague minnow (*Gambusia holbrooki*) (BC Act)
- Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (EPBC Act/BC Act)
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Rhinella marina*) (EPBC Act)/Invasion and establishment of the Cane Toad (*Rhinella marina*) (BC Act)

15.4.8 ALTERED FIRE REGIMES AND INCREASED FIRE RISK

Development under the Plan has the potential to alter fire regimes and increase fire risk. This is primarily related to:

- Arson or the accidental lighting of fires
- Increased burns for hazard reduction to protect assets, particularly within Asset Protect Zones
- Reduced burns in some areas due to risk to urban areas

Changed fire regimes can reduce habitat suitability for TECs and threatened species, affect foraging resources and prey species, and cause direct mortality from heat and smoke.

The key threatening process listed under the BC Act relevant to this indirect impact type is:

- Ecological consequences of high frequency fires (BC Act)

15.4.9 DISTURBANCE FROM INCREASED PUBLIC ACCESS TO NATURAL HABITAT AREAS

Development under the Plan will increase human activity in the vicinity of the nominated areas, which can impact avoided lands, conservation lands secured under the Plan and existing reserves. This is primarily related to:

- Trampling of threatened flora species/habitat for threatened fauna species
- Track creation
- Bush rock removal and disturbance
- Rubbish dumping and disturbance from associated clean-up activities
- Timber collection, removal of dead wood
- Illegal collection of threatened species
- Dog walking
- Recreational activities such as mountain-biking, four-wheel driving and fishing

Species and TECs most at risk from this threat occur on public land because these areas are publicly accessible.

Key threatening processes listed under the BC Act relevant to this indirect impact type are:

- Bushrock removal (BC Act)
- Removal of dead wood and dead trees (BC Act)

15.4.10 FAUNA MORTALITY AND INJURY, FAUNA DISPLACEMENT AND THE INTRODUCTION OF BARRIERS TO FAUNA MOVEMENT

Development under the Plan may increase the likelihood of fauna mortality and fauna displacement, and will introduce barriers to fauna movement. This is primarily related to:

- Direct mortality as a result of collisions with vehicles or new structures, shooting, poaching, or secondary poisoning during pest control
- Displacement due to clearing for the development
- Introduction of linear barriers such as fences, roads and railways, which can affect fauna movement and predation

Koala, birds, invertebrates and arboreal mammals are particularly susceptible to these impacts.

15.4.11 FAUNA DISTURBANCE DUE TO NOISE, DUST OR LIGHT

Development under the Plan will increase noise, dust and light. This is primarily related to:

- Clearing for the development
- Construction activities, including use of heavy vehicles and machinery
- Increased noise levels from traffic due to new roads or increased traffic on existing roads
- Artificial light from urban and commercial areas, and along transport routes

Increased noise can particularly impact on species that vocalise or rely on hearing for hunting or breeding. Artificial light can affect the behaviour of nocturnal and diurnal species, including disorientation, attraction to light sources resulting in collisions and mortality, and effects on light-sensitive life-cycles (e.g. flowering, breeding, and migration). Increased light can also influence the abundance, behaviour and movement of some predator species.

15.4.12 INADVERTENT IMPACTS ON ADJACENT HABITAT OR VEGETATION

Development under the Plan may cause inadvertent impacts on adjacent habitat, vegetation or important habitat features, such as hollow bearing trees. This could occur during construction or operation and is primarily related to:

- Impacts adjacent to construction sites
- Road, trail and powerline maintenance
- High frequency land management such as mowing and slashing or weed control

This can affect threatened species' habitat which is close to urban capable land and transport corridors.

15.5 SPECIES AND TECS LIKELY TO BE AFFECTED BY INDIRECT IMPACTS

Attachment A identifies the NSW and Commonwealth-listed threatened species and TECs potentially impacted by each indirect impact. Indirect impacts were identified as being relevant to a species or TEC if:

- The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, *and*
- The threat is present in the Cumberland subregion, *and*
- The Plan has the potential to exacerbate the threat

Relevant indirect impacts were identified by drawing on ecological and life history information in BioNet profiles, conservation advices and recovery plans, and species records and habitat maps prepared for this Assessment Report.

Note that ground settlement and subsidence is only relevant under the Plan to several species and TECs that occur in the vicinity of the transport corridor tunnels. The indirect impacts of the tunnels on these matters is assessed in Chapter 36.

15.6 GENERAL MITIGATION MEASURES

The Plan includes commitments to mitigate the indirect impacts of the urban, industrial, infrastructure, agribusiness and transport development on biodiversity values and other EPBC Act protected matters.

The types of mitigation measures and the processes to implement these mitigation measures are different for the types of development under the Plan. For the urban, industrial and agribusiness development, mitigation measures will be implemented through the NSW planning system. For infrastructure and transport corridors, mitigation measures will be implemented through the NSW environmental assessment and approval process current at the time of the development.

This section:

- Describes the relevant commitments and the actions under the Plan to mitigate indirect impacts and the processes to implement mitigation measures for each of the different types of development
- Summarises the general environmental controls that will be implemented through the NSW planning system to mitigate the indirect impacts of the urban, industrial and agribusiness development
- Summarises other commitments and actions under the Plan also relevant to addressing indirect impacts

15.6.1 REGULATION OF INDIRECT IMPACTS UNDER EXISTING LAWS

It is important to note that several potential indirect impacts associated with the urban, industrial, infrastructure, agribusiness and transport development are regulated in NSW under existing laws and additional mitigation measures under the Plan are not considered necessary to address any risks.

For example, the use of chemicals, fuels and other pollutants, including obligations to prevent spillage and leaks to the environment, is regulated under the *Protection of the Environment Operations Act 1997*. The Act is enforced by the NSW Environment Protection Authority and councils. This existing regulatory framework is considered adequate to manage the risk of spillage of pollutants and downstream impacts on environmental values such as the Towra Point Ramsar wetland (see Chapter 33) and migratory bird habitat (see Chapter 32).

15.6.2 MITIGATION MEASURES FOR URBAN, INDUSTRIAL, AND AGRIBUSINESS DEVELOPMENT

The Plan includes a commitment to mitigate indirect and prescribed impacts on TECs and species from development within the nominated areas to best practice standards (Commitment 5), including implementing development controls in the nominated areas to protected species, as prescribed in Appendix E of the Plan (Commitment 5.1)

Two broad types of development controls will be implemented:

- General environmental controls that will benefit the environment generally, including biodiversity values
- Specific controls that apply to specific species and TECs in specific locations or broader nominated areas. These controls have been identified through this Assessment Report and are needed to address residual risks to species or TECs that remain after implementation of the general environmental controls

The assessment of potential indirect impacts on each Commonwealth and NSW-listed species and TEC in section 15.7 was done taking into account the general environmental controls. Where these controls were not considered adequate to address the risks of indirect impacts to a particular species or TEC, additional specific controls were identified to be implemented under the Plan. These additional specific controls are set out in section 15.8.

PROCESS TO IMPLEMENT DEVELOPMENT CONTROLS

The commitment to manage indirect impacts of urban, industrial and agribusiness development within the nominated areas will be delivered primarily through the NSW planning system, and specifically, the nominated areas planning delivery framework. The overarching planning delivery framework is described in Chapter 9.

Implementation mechanisms

The key actions under the Plan to implement the development controls are set out in Table 15-2.

The key mechanism to implement the general environmental controls and the specific controls in the nominated areas is Development Control Plans (DCPs). DCPs will be prepared for each nominated area and set out the controls that need to be addressed by neighbourhood plans and development applications to mitigate indirect impacts.

Table 15-2: Actions taken under the Plan to mitigate indirect impacts within the nominated areas

Planning mechanism	Actions under the Plan to implement mitigation measures
State Environmental Planning Policies (SEPPs)	The Department is proposing a new SEPP as the key statutory mechanism to implement strategic conservation planning and to provide certainty that the Plan's commitments and actions to protect, enhance, maintain and restore biodiversity in Western Sydney will be met
Strategic land-use plans	Strategic land-use plans for nominated area precincts or neighbourhoods identify urban capable land and set out principles for protecting and managing biodiversity
DCPs	A DCP will be prepared for each nominated area Provisions will be incorporated in the DCPs for each nominated area setting out development controls that need to be addressed by neighbourhood plans and development applications to mitigate indirect and prescribed impacts on threatened species These provisions will include the list of controls in Appendix E of the Plan where relevant
Subdivision plans	Requirements to audit and monitor the implementation of development controls will be incorporated in standard conditions within subdivision plans
Support to councils	Provide ongoing support to councils in the application of DCP controls within the nominated areas, including the sharing of knowledge, maps and data

Implementation process

Who prepares the DCP?

In NSW, DCPs are typically prepared by councils for the purpose of regulating development and land use within a particular Local Government Area (LGA). Section 3.46 of the EPA Act provides that the purpose of a DCP is to:

- Give effect to the aims of any environmental planning instrument that applies to the development
- Facilitate development that is permissible under any such instrument
- Achieving the objectives of land zones under any such instrument

A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking approval for development.

DCPs are also used by councils in the assessment of development applications. When designing development proposals, applicants need to address the relevant requirements of any DCPs which apply to their land or proposal.

What is the process for preparing the DCP?

Each nominated area will be covered by a DCP prepared by either the Department (in the case of Department led precincts) or by the relevant councils in collaboration with the Department, and will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

Each DCP in the nominated area will also need to address:

- The Plan's draft DCP template prepared by the Department to apply to the nominated areas
- Information in the Assessment Report on the risks of indirect impacts to specific species and TECs and locations
- Data on biodiversity values collected as part of this Assessment Report, including:
  - Native vegetation
  - Extent and condition of TECs
  - Location of species records and potential habitat

Draft DCPs must be exhibited for public consultation, whether prepared by the council or the Department.

The Department will provide appropriate guidance and oversight of the development of DCPs to ensure each DCP is consistent with the commitments and actions under the Plan.

DCPs will be reviewed in five-year intervals and updated if necessary. This process allows new development controls to be incorporated into the DCP or controls to be amended to ensure they meet best practice standards.

General controls specified under this Plan in a draft DCP template

A draft DCP template is currently being prepared by the Department to support the Plan. The template will include:

- The key general environmental controls specific to the Plan to mitigate indirect impacts on biodiversity values and other EPBC protected matters, and which may not typically be included in DCPs by councils
- Any specific controls in section 15.8 for mitigating indirect impacts on certain species and TECs that are relevant to implementation through the planning system under a DCP

The purpose of the DCP template is to provide model provisions to ensure key general environmental controls specific to the Plan, as well as all specific controls for certain species and TECs, are applied consistently across the nominated areas and effectively address the mitigation requirements of the Plan.

The Department will work with councils to incorporate all of the controls in the draft DCP template where relevant and will include these controls in any DCPs developed by the Department for Department led precincts.

Other general environmental controls specified by councils

In preparing each DCP, councils typically incorporate a range of other general environmental controls (that are not included in the draft DCP template) relating to broader environmental, social and economic considerations. For example, councils typically include controls to manage:

- Water cycle and stormwater management, including water sensitive urban design principles
- Water quality, including water quality targets
- Soil erosion and sedimentation
- Disturbance to contaminated soils, saline soils, or acid sulphate soils

Councils will likely include this range of controls in each DCP for the nominated areas. For example, each of these types of controls were incorporated into the draft Wilton DCP that was publicly exhibited in 2019.

The specifics of each of these types of controls will be determined by councils during the preparation of each DCP.

How will the specific controls be incorporated in the DCP?

The specific controls are controls that have been identified through this Assessment Report as being needed to address residual risks to specific species or TECs that remain after implementation of the general environmental controls.

The draft DCP template will incorporate all the specific controls in section 15.8 that can be implemented through the NSW planning system (these do not include the controls related to the transport corridors). As described above, councils will be required to incorporate all of the controls in the draft DCP template where relevant into each DCP.

Implementation of the specific controls in the draft DCP template requires councils to make decisions around the circumstances, design specifics and exact locations where the controls should be applied. This is appropriate as the scale of the development and the long timeframe over which the development will be implemented does not allow these specific details to be determined as part of the Assessment Report.

The Department will support councils to make these decisions through providing:

- Information in the Assessment Report on the risks of indirect impacts to specific species and TECs and locations
- Data on biodiversity values collected as part of this Assessment Report
- Guidance on best practice standards, guidelines or targets
- Guidance on specific issues related to koala management and mitigation through the koala working group

How will the controls in the DCP be implemented?

Councils will be responsible for imposing conditions on developers requiring the implementation of development controls under the DCP through the development application process.

The Department will work with councils to ensure appropriate conditions are incorporated within each subdivision plan and development approval to support the implementation of the mitigation requirements in the DCPs by councils.

The Department will review how the DCP controls are working as part of the MER Framework under the Plan and provide feedback and support to precinct teams and councils.

What measures are in place to address any risk of failure of development controls?

The Plan puts in place several measures to address any uncertainty or risks of failure associated with the development controls in the DCPs. These measures include:

- Incorporate requirements to audit and monitor the implementation of development controls in the nominated areas
- Implement an MER Framework that will monitor and report and evaluate the delivery of actions and commitments and achievement of outcomes to inform adaptive management responses (see Chapter 9)
- An adaptive management approach linked to the MER framework that will adjust actions and other measures as necessary to ensure the Plan's outcomes are achieved (see Chapter 16)

Who will ensure compliance?

Councils or the relevant consent authority responsible for ensuring compliance with any conditions of consent that have been applied to a development based on the relevant controls in each DCP.

The NSW planning system provides an existing compliance framework under which councils can take action to ensure compliance with development conditions, including any requirements for managing indirect impacts under the Plan.

The Plan provides further support to this existing framework through:

- Preparing a draft DCP template that clearly set out details of the development controls to be addressed by neighbourhood plans and development applications to mitigate indirect impacts
- Incorporating provisions into relevant statutory land-use plans for the nominated areas, such as Precinct Plans to give legal effect to specific development standards as required

These actions that will be undertaken under the Plan means that development controls are clearly defined and understood and there is an existing process in place to enforce the controls where they are incorporated as conditions of consent in a development application.

A compliance strategy will also be prepared under the Plan to ensure that the development occurs in accordance with the Plan and conditions of approval (see Chapter 9). The compliance strategy will identify relevant compliance mechanisms, compliance monitoring and auditing priorities and processes, and roles and responsibilities for compliance monitoring and action. The Plan will also provide funding for at least three Council-based surveillance officers.

SUMMARY OF GENERAL ENVIRONMENTAL CONTROLS

This section summarises:

- Examples of general environmental controls typically incorporated into DCPs by councils in NSW
- General environmental controls specific to the Plan that are included in the draft DCP template

General environmental controls typically specified by councils

As described above, councils typically incorporate a range of general environmental controls in DCPs relating to broader environmental, social and economic considerations.

Examples of these types of controls included in the draft Wilton DCP are provided in Table 15-3.

These controls will be important to manage potential indirect impacts of the urban and industrial, and agribusiness development to the general environment, including downstream impacts on environmental values such as the Towra Point Ramsar wetland (see Chapter 33) and Commonwealth land (see Chapter 35).

Table 15-3: Examples of general environmental controls incorporated by council in the draft Wilton DCP

Control type	Summary of example control in draft Wilton DCP
Water cycle management	• Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles • Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
Water quality	• Stormwater systems must be constructed and maintained to achieve EES water quality targets
Soil erosion and sedimentation	• Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development • Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
Disturbance to saline soils	• Salinity Management Plans must be prepared in accordance with the Western Sydney Salinity Code of Practice 2004 (WSROC, 2004) and submitted with each subdivision development application
Contaminated soils	• All subdivision development applications must be accompanied by a Stage 1 Preliminary Site Investigation. Where this identifies potential site contamination, a Stage 2 detailed site investigation must be prepared • A Remediation Action Plan (RAP) must be prepared for areas identified as contaminated land in the Stage 2 Site Investigation
Air quality	• Development must comply with the Protection of the Environment Operations Act 1997 and supporting regulations. Submit an Odour Impact Assessment when required • Provide a barrier such as dense landscaping to mitigate dispersion of air pollutants, noise or odour where necessary
Noise	• Provide a barrier such as dense landscaping to mitigate dispersion of air pollutants, noise or odour • Development to include buffers (as outlined in the DCP) to limit noise impacts on surrounding areas • Provide an acoustic report to address the impact of noise generation from development on the surrounding area
Traffic/construction traffic	• Ensure the road networks are designed to control traffic speeds to appropriate limits • Provide a traffic report/statement to address the impact of the development on the local road system and address traffic safety issues

General environmental controls in the draft DCP template

The general environmental controls included in the draft DCP template are summarised in:

- Table 15-4 for mitigation of construction impacts
- Table 15-5 for protection of waterways and riparian corridors
- Table 15-6 for mitigation of the spread of disease/infection
- Table 15-7 for mitigation of spread of weeds
- Table 15-8 for mitigation of pest/domestic fauna impacts
- Table 15-9 for mitigation of altered fire regimes

- Table 15-10 for mitigation of fauna mortality, fauna displacement and impacts from linear barriers
- Table 15-11 for mitigation of fauna disturbance due to noise, dust and light
- Table 15-12 for mitigation of inadvertent impacts on adjacent habitat or vegetation
- Table 15-13 for retention of key habitat features

Construction impacts

Table 15-4: Development controls specific to mitigation of indirect impacts from construction

Summary of key controls	Relevant standards, targets or guidelines
• Prepare a Construction Environmental Management Plan (CEMP) setting out measures to protect the environment during construction, including: o Pre-clearance assessment for native fauna prior to any clearing native vegetation o Best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust o Site rehabilitation and installation of nest boxes for development adjacent to natural areas o Tree felling protocol to avoid impacts to species relying on tree hollows, dreys, dens, and other nests in trees that are to be cleared • Submit a weed eradication and management plan with development applications for subdivision outlining weed control measures during and after construction • Construction traffic to utilise clearly defined access and egress points to and from a development site to avoid remnant wildlife corridors and native vegetation communities • Parking and equipment and laydown areas to be located away from land with biodiversity values • Temporary fencing to be erected to manage inadvertent impacts on adjacent natural areas	Relevant council specifications Arrive Clean, Leave Clean: Guidelines (Commonwealth of Australia, 2015)

Waterways and riparian corridors

Table 15-5: Development controls to manage waterways and riparian corridors

Summary of key controls	Relevant standards, targets or guidelines
• Maintain waterways of Strahler order 2 or higher in a natural state, including the maintenance and restoration of riparian corridors • Where development will affect a waterway of Strahler order 2 or higher, rehabilitate the waterway to return it to a natural state • Design road crossings of waterways to minimise impacts to vegetated riparian corridors and species movements Note under the EPA Act, development within 40 m of a watercourse is Integrated Development and requires approval under the *Water Management Act 2000*	• Relevant councils design and construction specifications • Strahler ordering scheme for waterways

Spread of infection/disease

Table 15-6: Development controls to manage the spread of infection/disease

Summary of key controls	Relevant standards, targets or guidelines
• Prepare a Construction Environmental Management Plan (CEMP) setting out the measures methods to protect the environment during construction, including: o Best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust	Arrive Clean, Leave Clean: Guidelines (Commonwealth of Australia, 2015)

Spread of weeds

Table 15-7: Development controls to manage the spread of weeds

Summary of key controls	Relevant standards, targets or guidelines
• Submit a weed eradication and management plan with development applications for subdivision outlining weed control measures during and after construction • Subdivision design and bulk earthworks to minimise environmental weed spread and include measures to eradicate these weeds in accordance with relevant council weed policies • Weeds of National Significance and on the National Environmental Alert List under the National Weeds Strategy to be managed and eradicated. Proponent to reference NSW Weed Wise for current weed identification and management approaches	Relevant council weed policies National Weeds Strategy NSW Weed Wise Plan's weed control strategy

Predation/competition/land degradation by pest/domestic fauna

Table 15-8: Development controls to manage the impacts from pest/domestic fauna

Summary of key controls	Relevant standards, targets or guidelines
Domestic animals • Ensure that domestic animals are appropriately contained at urban/bushland interfaces • Property boundaries should have appropriate fencing to contain domestic animals within the landholders' property	
Pest animals • Appropriately manage and control pest animals as relevant to the site • Pest control techniques implemented during and post construction to be in accordance with regulatory requirements for chemical use	Plan's pest animal control strategy

Altered fire regimes and increased fire risk

Table 15-9: Development controls to manage impacts from altered fire regimes and increased fire risk

Summary of key controls	Relevant standards, targets or guidelines
• APZs for bushfire protection purposes are to be located wholly within the urban capable land for new development and not within land with biodiversity values As part of commitment 2, the Plan includes an action that specifies APZs are to be located wholly within urban capable land. The appropriate APZ distance is determined by the Rural Fire Service Standards for Asset Protection based on vegetation type, slope and the nature of the development and is measured from the edge of the retained habitat	RFS Standards for Asset Protection

Fauna mortality and injury, fauna displacement and the introduction of linear barriers

Table 15-10: Development controls to manage fauna mortality, fauna displacement and impacts from the introduction of linear barriers

Summary of key controls	Relevant standards, targets or guidelines
• Implement traffic calming measures in development areas not subject to koala exclusion fencing, including speed limit restrictions for areas adjacent to land with biodiversity values, and installation of wildlife signposting and speed humps and audible surfacing in accordance with relevant standards • Install and maintain fauna-friendly road design structures in appropriate areas adjacent to fauna habitat, such as underpasses, fauna bridges and overpasses	TfNSW Biodiversity Guidelines Relevant council guidelines Relevant Australian Standards

Fauna disturbance due to noise, dust or light

Table 15-11: Development controls to manage fauna disturbance due to noise and light

Summary of key controls	Relevant standards, targets or guidelines
• Where noise or light impacts from development on land adjacent to natural areas may affect wildlife, mitigation measures to manage impacts should be implemented, such as managing the timing of activities and/or installing appropriate noise barriers • High-intensity outdoor lighting, including commercial lighting, or sports fields lighting, should be designed to avoid light spill into adjoining natural areas • Development within 100 m of known microbat colonies or habitat likely to support microbat colonies must include street lighting that does not attract insects	Australian Standard AS 4282 Commonwealth's *Draft Light Pollution Guidelines for Wildlife*

Inadvertent impacts on adjacent habitat or vegetation

Table 15-12: Development controls to manage inadvertent impacts on adjacent habitat or vegetation

Summary of key controls	Relevant standards, targets or guidelines
• Parking and equipment and laydown areas to be located away from land with biodiversity values • Temporary fencing to be erected to manage inadvertent impacts on adjacent natural areas	

Retention of key habitat features or important sites

Table 15-13: Development controls to retain key habitat features

Summary of key controls	Relevant standards, targets or guidelines
• Establish ecological setbacks in accordance with distances in the DCP to provide a buffer to adjacent development for: o Raptor nests o Grey-headed Flying Fox camps	

Other relevant development controls

Asset protection zones

An asset protection zone (APZ) is a buffer zone between a bushfire hazard and buildings or other infrastructure that needs to be protected. It is managed to minimise fuel loads and reduce potential radiant heat levels, flames, localised smoke and ember attack. The width of the APZ is between generally between a minimum of 20 m and 60 m. This is determined based on vegetation type, slope and the nature of the development, in accordance with Rural Fire Service standards. As part of the subdivision design, the APZ may include perimeter roads or open space areas.

Commitment 2 of the Plan includes an action that specifies APZs are to be located wholly within urban capable land when preparing new precinct plans for nominated areas.

APZs will act as a buffer between the urban, industrial and agribusiness development under the Plan and biodiversity values, including avoided lands and other areas containing TECs and species populations. This buffer will reduce the risk, and support the mitigation of, several indirect impacts, including:

- Waterways and riparian corridors
- Water quality
- Weed invasion
- Altered fire regimes
- Inadvertent impacts on adjacent habitat or vegetation

Environmental protection zoning of avoided lands

Commitment 2 of the Plan includes an action to apply environment (E2) conservation zoning to land avoided for biodiversity purposes and other purposes (riparian corridors and steep land), to strengthen the protection of avoided lands from the impacts of development. Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land.[2]

This environmental zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will reduce the risk, and support the mitigation of, several indirect impacts, including:

- Removal of key habitat features, such as trees, firewood and bush rock
- Habitat disturbance from increased public access, including recreational activities

15.6.3 MITIGATION MEASURES FOR INFRASTRUCTURE

The Plan includes a commitment to mitigate indirect and prescribed impacts on TECs and species from development to best practice standards (Commitment 5), including the construction and operation of infrastructure projects (Commitment 5.3), as prescribed in Appendix E of the Plan.

Implementation mechanisms

This commitment will be delivered through future environmental assessment and approval processes that will apply to each infrastructure project under the EP&A Act current at the time the project is brought forward.

Infrastructure projects covering the broad types under the Plan (see Part 2) are subject to different environmental assessment and approval processes under the EP&A Act. The processes are summarised in Table 15-14. State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed and approved under the EPA Act. The SEPP sets out:

- What type of infrastructure is approved by council, the Minister for Planning, or Department under a traditional development consent process under Part 4 of the EP&A Act (this is known as 'development with consent')
- What type of infrastructure development is approved by a public authority under a separate process under Part 5 of EP&A Act (this is known as 'development without consent')
- What type of development is exempt from requiring approval (known as 'except development') or may be undertaken provided certain conditions are met (known as 'complying development')

Table 15-14: Potential assessment and approval processes for infrastructure under the Plan

	Approval	Assessment	Assessment mechanism	Approval body
Part 4	Approval required under Part 4 of EP&A Act	Must include an assessment of the 'likely impacts of the development, including environmental impacts on both the natural and built environments and social and economic impacts…' (s 79C(1)	Environmental Impact Statement (for State Significant Development) Statement of Environmental Effects (for other development)	Normally council For State Significant Development, may be: • Minister for Planning • Planning Assessment Commission • The Department
Part 5	Approval required under Part 5 of EP&A Act	Must 'examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of that activity' (s 111)	Review of Environmental Factors Environmental Impact Statement	Normally a public authority

[2] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10 per cent to allow for potential future development of essential infrastructure in non-certified land

	Approval	Assessment	Assessment mechanism	Approval body
SSI	Approval required under Part 5.1 of EP&A Act	Must prepare an Environmental Impact Statement in accordance with assessment requirements specified by the Department	Environmental Impact Statement	Minister for Planning

The key actions under the Plan to implement the commitment for infrastructure are set out in Table 15-15.

Table 15-15: Assessment and approval processes for infrastructure under the Plan

Legislative mechanism	Actions under the Plan to address indirect impacts
NSW environmental assessment and approval process under the EP&A Act for each project current at the time the project is brought forward	• The department will establish guidelines that will include the mitigation measures for indirect and prescribed impacts on biodiversity in the nominated areas, and these will need to be considered by the determining authority for activities assessed under Part 5 of the EP&A Act. These mitigation measures are described in Appendix E of the Plan

The indirect impacts of the infrastructure projects within urban capable land on biodiversity values under the EPBC Act and BC Act have been assessed as part of this Assessment Report, and the Plan includes mitigation measures for specific species and TECs to address these risks (see section 15.8). Public authorities will be required to take these mitigation measures into account when constructing and operating infrastructure projects.

The future processes of environmental assessment and approval summarised in Table 15-14 will assess and identify mitigation measures to manage the other potential environmental impacts of the infrastructure projects. This process will, for example, assess the potential for the project to result in soil erosion and sedimentation based on the detailed design of the infrastructure project, and identify mitigation measures to address this risk.

This future assessment process therefore provides a process through which:

- The specific mitigation measures identified in this Assessment Report and the Plan for species and TECs (see section 15.8) can be implemented based on the detailed design of the infrastructure project
- General mitigation measures to manage the risks to the environment generally (for example, soil erosion and sedimentation, or construction impacts) will be identified and implemented

Essential infrastructure

Some infrastructure to support the development in the nominated areas (called 'essential infrastructure') may be located within non-certified land in the nominated areas (i.e. within avoided or non-certified land but not excluded lands) provided it complies with specific guidelines under the Plan. The Plan is seeking approval under the EPBC Act (but not the BC Act) for essential infrastructure development to occur within these areas.

Planning for essential infrastructure is in various stages of development, and the location of this infrastructure has not yet been determined. The guidelines to avoid, mitigate and offset the potential direct and indirect impacts of essential infrastructure are described, along with an assessment of impacts, in Chapter 37.

15.6.4 MITIGATION MEASURES FOR THE TRANSPORT CORRIDORS

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport corridors on TECs and species (Commitment 6), including implementing mitigation measures as prescribed in Appendix E of the Plan.

Implementation mechanisms

The commitment to manage indirect impacts of the transport corridors will be delivered through the NSW environmental assessment and approval process (currently the State Significant Infrastructure approval process under the EP&A Act).

The key actions under the Plan to implement the commitment are set out in Table 15-16.

As described in Part 2, each transport project will be subject to future strategic planning and detailed design and a process of environmental assessment and approval:

- For the transport corridors within the nominated areas (where biodiversity impacts under both the EPBC Act and BC Act have already been assessed in this Assessment Report – see Part 1), this process will involve assessment under the State Significant Infrastructure approval process (or equivalent)
- For the transport corridors outside the nominated areas (where biodiversity impacts have only been assessed under the EPBC Act - see Part 1), this process will involve assessment under both:
  - State Significant Infrastructure approval process (or equivalent)
  - BC Act and BAM (or equivalent)

The biodiversity impacts of the transport corridors under the EPBC Act and BC Act (except for the transport corridors outside the nominated areas under the BC Act) have been assessed under this Assessment Report, and the Plan includes mitigation measures for specific species and TECs to address these risks (see section 15.8). Transport for NSW will be required to take these mitigation measures into account when constructing and operating transport projects.

The process under the State Significant Infrastructure approval process (or equivalent) will assess the other environmental impacts and matters that need to be considered prior to construction and operation of the transport project. This will include an assessment of risks to the environment and the identification of mitigation measures to manage these risks, such as impacts related to hydrological disturbance, noise, air quality, and construction.

This future assessment process therefore provides a process through which:

- The specific mitigation measures identified in this Assessment Report and the Plan for species and TECs (see section 15.8) can be implemented based on the detailed design of the transport project
- General mitigation measures to manage the risks to the environment generally (for example, groundwater drawdown from tunnels, or construction impacts) will be identified and implemented

Table 15-16: Actions taken under the Plan to mitigate indirect impacts from the transport corridors

Legislative mechanism	Actions under the Plan to address indirect impacts
NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process under the EPA Act)	Transport for NSW will undertake the following: • Assess indirect impacts on biodiversity (for transport corridors outside the nominated areas) and other environmental values based on detailed design • Implement mitigation measures based on the outcomes of the assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines • Identify potential design options for major watercourse crossings to reduce disruption to connectivity and the risk of vehicle strikes • Undertake ongoing monitoring of high-value environmental areas, and review and adjust mitigation measures (where practical) in response to monitoring outcomes • Apply further mitigation according to BAM requirements for transport corridors outside the nominated areas • Report to the Department on mitigation measures proposed to manage impacts of each infrastructure project, including proposed techniques, timing, frequency and responsibility for implementing each measure

Implementation process

How does the process work?

Currently the EP&A Act provides the primary legislative basis for assessing and approving the impacts of transport development on the environment. The EP&A Act includes provisions to ensure that all potential environmental impacts of a development, including indirect impacts, are rigorously assessed and considered in the decision-making process.

Major road and rail projects are typically dealt with under the State Significant Infrastructure provisions (Division 5.2 of the EP&A Act) and require approval of the Minister for Planning. Under this Division, proponents must:

- Prepare an Environmental Impact Statement (EIS) for the project that assesses the impacts of the development
- Prepare the EIS in accordance with the Planning Secretary's environmental assessment requirements

The Department has prepared a standard set of environmental assessment requirements for State Significant Infrastructure Projects (DPIE, 2020b). The SEARs reflect the Department's preferred approach to conditioning projects through the provision of performance or outcome focused conditions, and currently requires the assessment to:

- Assess and identify impacts, including indirect impacts
- Propose measures to mitigate impacts
- Nominate and commit to performance outcomes for managing impacts
- Identify the detail of proposed management plans and monitoring programs

These actions that will be undertaken under the Plan means that mitigation measures to be applied to transport development are clearly defined and understood and the process to implement them is legally robust and enforceable.

Will all relevant indirect impacts be mitigated?

The Plan ensures all relevant indirect impacts will be mitigated by utilising the environmental impact assessment process under NSW planning and assessment legislation current at the time of construction.

This process currently requires the environmental impact assessment to identify all relevant indirect impacts, propose measures to mitigate those impacts and commit to performance outcomes for managing the impacts, and identify the detail of proposed management plans and monitoring programs (DPIE, 2020b).

Under the current process, the Department has prepared indicative standard conditions for linear State Significant Infrastructure Projects (DPIE, 2020b). These conditions include requirements to prepare a Construction Environmental Management Plan and Operational Environmental Management Plan to set out how performance outcomes, commitments and mitigation measures identified in the environment impact assessment, including in relation to managing indirect impacts, will be implemented and achieved. The plans must include:

- A program for ongoing analysis of the key environmental risks associated with the development
- Details of how the development will be undertaken to meet the performance outcomes identified in the environmental impact assessment and manage the risks identified in the risk analysis
- A protocol for managing and reporting any non-compliances with the approval

In addition to these legislative requirements for mitigating indirect impacts, Transport for NSW has prepared *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (Roads and Maritime Service, 2011). These guidelines provide detailed guidance on how to minimise and mitigate impacts on biodiversity during construction and maintenance of transport projects, including in relation to managing indirect impacts.

Are mitigation standards best practice and can they be adapted over time?

The environmental impact assessment process provides a mechanism to identify and implement best practice mitigation approaches and standards at the time of the construction of the transport projects.

The Department's current preferred approach to conditioning major development projects such as transport projects is through performance or outcome focused conditions where appropriate. Under this approach, performance outcomes are identified that must be complied with to achieve an appropriate environmental outcome, but how those outcomes are best achieved through mitigation measures is flexible. An advantage of this approach is that it allows flexibility over time about what mitigation measures are implemented to best achieve the outcome.

The Department has prepared guidelines for identifying mitigation measures to manage impacts in environmental impact assessments, including guidance on implementing performance-based approaches to mitigation (DPE, 2017). Furthermore, the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (Roads and Maritime Service, 2011), are not static and will be updated at regular intervals to ensure they reflect best practice.

As set out below, the indicative standard conditions for linear State Significant Infrastructure Projects (DPIE, 2020b) require development of monitoring programs during construction and operation of major projects so that adjustments to performance outcomes, commitments and mitigation measures can be made if necessary.

What measures are in place to address any risk of failure of mitigation measures?

By undertaking environmental impact assessments under NSW planning and assessment legislation, the Plan ensures a detailed process is put in place to address any risk of failure of mitigation measures.

Under the current process, the Department has prepared indicative standard conditions for linear State Significant Infrastructure Projects (DPIE, 2020b). These conditions include requirements to prepare a Conservation Monitoring Program and Operational Monitoring Program to monitor performance outcomes, commitments and mitigation measures identified in the environmental impact assessment. The purpose of the monitoring is to enable a comparison of actual performance against the predicted performance in the environmental impact assessment so that adjustments to performance outcomes, commitments and mitigation measures can be made if necessary.

The monitoring programs must provide details of:

- Baseline data to be obtained
- Parameters of the project to be monitored
- Frequency and location of monitoring
- Reporting on monitoring results
- Procedures to identify and implement additional mitigation measures where necessary

The Plan also puts in place several measures to address any uncertainty or risks of failure associated with mitigation measures to manage indirect impacts. These measures include:

- Implement an MER Framework that will monitor and report and evaluate the delivery of actions and commitments and achievement of outcomes to inform adaptive management responses (see Chapter 9)
- An adaptive management approach linked to the MER framework that will adjust actions and other measures as necessary to ensure the Plan's outcomes are achieved (see Chapter 16)

Who will ensure compliance?

Under the current environmental impact assessment process, the indicative standard conditions for linear State Significant Infrastructure Projects (DPIE, 2020b) provide a detailed set of conditions for each state significant infrastructure project. Any breach of these conditions is a breach of the approval and is enforceable under EP&A Act.

The set of conditions require the preparation of compliance reports that report on the monitoring and compliance program and the compliance status of a project in relation to compliance with the conditions of approval. Compliance reports must be prepared in accordance with detailed guidelines on compliance reporting (DPE, 2018a). The Department will review the compliance report and respond to any non-compliances in accordance with powers under the EP&A Act and processes outlined in the Department's Compliance Policy (DPE, 2018b).

A compliance strategy will also be prepared under the Plan to ensure that the development occurs in accordance with the Plan and conditions of approval (see Chapter 9).

15.6.5 MITIGATION MEASURES FOR KOALA

The Plan includes a commitment to mitigate indirect impacts from urban, infrastructure and transport development on the Southern Sydney Koala population to best practice standards and in line with the Chief Scientist Koala Report (Commitment 7). A set of actions under the commitment specify how this will be done, including:

- Constructing exclusion fencing between important koala habitat and urban capable land in Wilton and GMAC
- Applying development controls within 60 m of koala habitat in accordance with the *Koala Habitat Protection Guideline* (DPIE, 2020a) (made under State Environmental Planning Policy (Koala Habitat Protection) 2019)

The key actions under the Plan to implement the commitment are set out in Table 15-17.

Table 15-17: Actions taken under the Plan to mitigate indirect impacts from urban, infrastructure and transport development on the Southern Sydney Koala Population

Actions under the Plan to address indirect impacts
• Install koala exclusion fencing between important koala habitat and urban capable land within GMAC and Wilton, except where exclusion fencing is not feasible due to slope, heritage or water courses • Ensure all koala exclusion fencing is at least 3 metres from koala habitat trees • In areas where exclusion fencing is not feasible, apply mitigation actions 60 metres from koala habitat. These actions include implementing controls from the *Koala Habitat Protection Guideline* and including design requirements in relevant DCPs. Specific locations are identified in the Plan • Install koala exclusion fencing on both sides of Appin Road between Rosemeadow and Appin to mitigate koala vehicle strikes at roadkill hotspots • Where fencing must cross existing or planned linear infrastructure such as gas and electricity transmission, consider appropriate access treatments such as gates to ensure the integrity of the koala exclusion fencing • Establish a koala working group including koala experts and relevant government agencies to determine priorities for koala conservation consistent with the objectives of the NSW Koala Strategy

<u>Exclusion fencing</u>

The exclusion fencing will be implemented through a program administered by the Department and funded under the Plan. Exclusion fencing will separate Koalas from urban capable land. The exact location of exclusion fencing will be determined during implementation of the Plan. Further details of the fencing program are provided in sub plan B.

<u>Development controls</u>

Where exclusion fencing is not possible due to topography, roads, waterways or heritage constraints, development controls will be applied within 60 m of koala habitat in accordance with the *Koala Habitat Protection Guideline*.

Design requirements and development controls specified in the koala guideline will be incorporated into relevant DCPs and implemented through the NSW planning system. The development and implementation of controls will be informed by the koala working group where appropriate.

15.6.6 OTHER COMMITMENTS RELEVANT TO INDIRECT IMPACTS

The Plan includes several other commitments and actions which support the mitigation of indirect impacts from the development under the Plan. These commitments are:

- Commitment 16 to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This commitment will be implemented through:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land

- Commitment 17 to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This commitment will be implemented through:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Commitment 18 to manage fire in strategic locations across the Strategic Assessment Area. This commitment will be implemented through:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a Fire Management Strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- Commitment 19 to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This commitment will be implemented through:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Commitment 21 to provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas
- Commitment 23 to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the Weed Implementation Strategy
- Commitment 28 to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal rubbish dumping and vegetation clearing

15.7 ASSESSMENT OF POTENTIAL INDIRECT IMPACTS

The potential indirect impacts from the urban, industrial, infrastructure, agribusiness and transport development on each Commonwealth and NSW-listed species and TEC are assessed in this section.

This assessment was done taking into account:

- The general mitigation measures to address indirect impacts, where these are relevant to a species or TEC
- Likely presence/abundance of species and TEC and importance of the location at a local and regional scale
- Life history traits and susceptibility of the species and TEC to the indirect impact
- Location of the species and TEC relative to the likely extent of the indirect impact
- Amount and quality of un-impacted habitat remaining
- Levels of existing protection

A conclusion is provided about whether any residual risks remain for each species and TEC. Additional species or TEC specific mitigation measures under the Plan to address residual risks are described in Section 15.8.

The assessment of potential indirect impacts is set out in the following tables:

- Fauna – Table 15-18
- Flora – Table 15-19
- TECs – Table 15-20

Detailed assessments of the potential indirect impacts on each Commonwealth-listed TEC and species, as well as other EPBC Act protected matters, are undertaken in the following chapters:

- Chapter 29 – Commonwealth-listed flora
- Chapter 30 – Commonwealth-listed fauna
- Chapter 31 – Commonwealth-listed TECs
- Chapter 32 – Migratory species
- Chapter 33 – Ramsar wetlands
- Chapter 34 – World and National Heritage
- Chapter 35 – Commonwealth Land

This section covers the assessment of indirect impacts on NSW-listed TECs and species as required under the BAM and summarises the assessment undertaken for Commonwealth-listed TECs and species in Chapters 29 to 31.

15.7.1 FAUNA

Table 15-18: Assessment of indirect impacts – fauna

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
BIRDS							
Anthochaera phrygia	Regent Honeyeater	CE	CE	ECS SCS	Removal of trees and firewood collection Spread of weeds Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in each nominated area As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes
Artamus cyanopterus cyanopterus	Dusky Wood-swallow	N/A	V	ECS	Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in each nominated area. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Botaurus poiciloptilus	Australasian Bittern	E	E	ECS	Hydrological changes Predation by introduced vertebrates Weed invasion Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Most records of the species surround the subregion, and the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including hydrological changes, predation, weed invasion, inappropriate fire regimes. These measures are expected to manage any residual impacts to the species	No
Calidris canutus	Red Knot, Knot	E Mig.	N/A	N/A	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A
Calidris ferruginea	Curlew Sandpiper	CE Mig.	E	ECS	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Callocephalon fimbriatum	Gang-gang Cockatoo	N/A	V	ECS SCS	Inappropriate hazard reduction burns Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in GPEC, Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Most records of the species surround the subregion, and the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. These measures are expected to manage any residual impacts to the species	No
Calyptorhynchus lathami	Glossy Black-cockatoo	N/A	V	ECS SCS	Loss of hollow bearing trees due to land management Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Most records of the species surround the subregion, and the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion. These measures are expected to manage any residual impacts to the species	No
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	V Mig.	N/A	N/A	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Chthonicola sagittata	Speckled Warbler	N/A	V	ECS	Weed invasion Nest failure due to predation by native and non-native birds, cats, dogs and foxes	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Many records of the species surround the subregion or occur in protected lands in the subregion, and the subregion does not appear to be a stronghold for the species As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and predation. These measures are expected to manage any residual impacts to the species	No
Circus assimilis	Spotted Harrier	N/A	V	ECS	Loss of mature trees from rural landscapes Secondary poisoning from the use of pindone in rabbit control and rodenticides	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas This species is reliant on mature trees and at risk from secondary poisoning, therefore specific mitigation measures have been identified to mitigate potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Climacteris picumnus victoriae	Brown Treecreeper	N/A	V	ECS	Weed invasion Degradation of habitat, particularly loss of tree hollows	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to the urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion • The subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion. In addition, there is a specific measure in the Plan for some other species to retain large trees during precinct planning, which is likely to benefit the Brown Treecreeper. These measures are expected to manage any residual impacts to the species	No
Daphoenositta chrysoptera	Varied Sittella	N/A	V	ECS	Weed invasion Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to the urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion • Many records in the subregion occur in protected lands • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Ephippiorhynchus asiaticus	Black-Necked Stork	N/A	E	ECS	Modification or degradation of wetlands	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in WSA. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion; the subregion doesn't appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes. These measures are expected to manage any residual impacts to the species	No
Epthianura albifrons	White-Fronted Chat	N/A	V	ECS	None	While the Plan has the potential to exacerbate several threats to the species, this species is unlikely to be indirectly impacted because the species is wide-ranging with areas of habitat (as indicated by records) occurring some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted	N/A
Glossopsitta pusilla	Little Lorikeet	N/A	V	ECS	Weed invasion Inappropriate fire regimes Loss of old hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Grantiella picta	Painted Honeyeater	V*	V	ECS	Removal of large, old trees with heavy mistletoe infestations Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes
Haliaeetus leucogaster	White-bellied Sea-Eagle	N/A	V	ECS SCS	Reduction of suitable nesting habitat Non-target poisoning during vertebrate pest control Disturbance by humans or human activity when nesting	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species. In particular, development controls to establish ecological setbacks between development and raptor nests These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on mature trees for nesting and at risk from secondary poisoning, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Hieraaetus morphnoides	Little Eagle	N/A	V	ECS SCS	Degradation of breeding habitat Secondary poisoning from rabbit baiting	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas This species is reliant on mature trees and at risk from secondary poisoning, therefore additional specific mitigation measures have been identified to mitigate potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Hirundapus caudacutus	White-throated Needletail	V	N/A	N/A	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, the species is known to forage above a wide range of habitats and is unlikely to be disrupted or displaced by development	N/A
Irediparra gallinacea	Comb-Crested Jacana	N/A	V	ECS	Loss and degradation of wetland habitat Predation on breeding birds and their nests by feral predators such as the European red fox	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in WSA. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur elsewhere in the bioregion; the subregion doesn't appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes and predation. These measures are expected to manage any residual impacts to the species	No
Ixobrychus flavicollis	Black Bittern	N/A	V	ECS	Impacts to riparian vegetation Predation by foxes and feral cats	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species is wide-ranging and the subregion does not appear to be a stronghold for the species • Many records in the subregion occur in existing conservation areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to riparian vegetation and predation. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Lathamus discolor	Swift Parrot	CE	E	ECS SCS	Collision mortality Inappropriate fire regimes Predation by feral cats	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land in the nominated areas and transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes
Limicola falcinellus	Broad-Billed Sandpiper	N/A	V	ECS	None	While the Plan has the potential to exacerbate several threats to the species, this is unlikely to result in indirect impacts to the species because there are no records of the species in the subregion and areas of habitat (as indicated by records) occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted	N/A
Limosa lapponica baueri	Bar-tailed Godwit	V Mig.	N/A	N/A	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A
Limosa limosa	Black-tailed Godwit	Mig.	V	ECS	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Lophoictinia isura	Square-tailed kite	N/A	V	ECS SCS	Disturbance to or removal of potential nest trees near watercourses Secondary poisoning	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in WSA and GPEC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species. In particular, development controls to establish ecological setbacks between development and raptor nests These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on mature trees for nesting and at risk from secondary poisoning, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Melanodryas cucullata cucullata	Hooded Robin (South-Eastern Form)	N/A	V	ECS	Weed invasion Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to the urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species is wide-ranging and records occur throughout the bioregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Melithreptus gularis gularis	Black-Chinned Honeyeater (Eastern subsp.)	N/A	V	ECS	Weed invasion Inappropriate fire regimes Removal of large trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes
Neophema pulchella	Turquoise Parrot	N/A	V	ECS	Loss of hollow-bearing trees hollows and critical habitat feature degradation Weed invasion Inappropriate fire regimes Predation by foxes and cats	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in each nominated area. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species is wide-ranging and the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion, inappropriate fire regimes and predation. In addition, there is a specific measure in the Plan for some other species to retain large trees during precinct planning, which is likely to benefit the Turquoise Parrot. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Ninox connivens	Barking Owl	N/A	V	ECS SCS	Removal of old, hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in GPEC, Wilton and GMAC This species is reliant on mature trees and the specific measure in Table 15-21 to retain large trees may benefit the species to some extent, particularly in areas adjacent to large patches of potential habitat. This is expected to manage any residual impacts to the species	Yes
Ninox strenua	Powerful Owl	N/A	V	ECS SCS	Loss of hollow-bearing trees High frequency hazard reduction burning Predation of fledglings by foxes, dogs and cats	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in GPEC, Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	CE Mig.	N/A	N/A	None	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan	N/A
Pandion cristatus	Eastern Osprey	N/A	V	ECS	None	While the Plan has the potential to exacerbate several threats to the species, this is unlikely to result in indirect impacts to the species because the species favours coastal areas and usually nests within 1 km of the coast. The majority of areas of habitat (as indicated by records) occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted	N/A

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Petroica boodang	Scarlet Robin	N/A	V	ECS	Weed invasion Predation by feral cats (*Felis catus*)	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in each nominated area. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion; the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and predation. These measures are expected to manage any residual impacts to the species	No
Petroica phoenicea	Flame Robin	N/A	V	ECS	Weed invasion	The Plan has the potential to increase weed invasion in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in each nominated area. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion; the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Rostratula australis	Australian Painted Snipe	E	E	ECS	Loss or degradation of wetlands Predation by feral animals Vegetation changes caused by introduced plants Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species occurs elsewhere in the bioregion, with relatively few records in the subregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes, predation, weed invasion and inappropriate fire regimes. These measures are expected to manage any residual impacts to the species	No
Stagonopleura guttata	Diamond Firetail	N/A	V	ECS	Weed invasion	The Plan has the potential to increase weed invasion in areas of habitat for this species (as indicated by records) that occur adjacent to urban capable land and transport corridors in each nominated area. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Stictonetta naevosa	Freckled Duck	N/A	V	ECS	Hydrological disturbance	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in WSA. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur elsewhere in the bioregion; there are very few recent records in the subregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including hydrological disturbance. These measures are expected to manage any residual impacts to the species	No
Tyto novaehollandiae	Masked Owl	N/A	V	ECS SCS	Loss of mature hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas This species is reliant on mature trees and the specific measure in Table 15-21 to retain large trees may benefit the species to some extent, particularly in areas adjacent to large patches of potential habitat. This is expected to manage any residual impacts to the species	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
MAMMALS							
Cercartetus nanus	Eastern Pygmy-possum	N/A	V	SCS	Changed fire regimes that affect the abundance of flowering proteaceous and myrtaceous shrubs Predation from cats, dogs and foxes Road mortality	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on nectar and pollen from Proteaceae shrubs and at risk of predation from cats, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	SCS	Disturbance of roosts from human recreational activities Fire in the proximity of roosts	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land in the nominated areas and transport corridors. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species occurs across the bioregion, the subregion does not appear to be a stronghold for the species • There are no known roost or breeding sites close to areas at risk of indirect impacts from the development As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including disturbance and increased fire risk. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tailed Quoll	E	V	ECS	Competition and predation from introduced predators Road mortality Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in GMAC, Wilton and the OSO transport corridor As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including road mortality and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on nectar and pollen from Proteaceae shrubs and at risk of predation from cats, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Falsistrellus tasmaniensis	Eastern False Pipistrelle	N/A	V	ECS	Loss of roosting habitat, primarily hollow-bearing eucalypts	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC This species is reliant on mature trees, therefore a specific mitigation measure has been identified to mitigate potential residual impacts	Yes
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	N/A	V	ECS	Loss of hollow-bearing trees Artificial light sources spilling on to foraging and/or roosting habitat Hazard reduction burns on foraging and/or roosting habitat	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including light pollution and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees for roosting and sensitive to disturbance, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Miniopterus australis	Little Bent-winged Bat	N/A	V	ECS	Disturbance to and loss of known maternity and roost sites such as caves, and roosts within culverts, tunnels and under bridges Hazard reduction fires Predation from cats and foxes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees for roosting and sensitive to disturbance, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Miniopterus orianae oceanensis	Large Bent-winged Bat	N/A	V	ECS	Disturbance by general public accessing caves and adjacent areas Hazard reduction fires Predation by feral cats	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including disturbance, inappropriate fire regimes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees for roosting and sensitive to disturbance, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Myotis macropus	Southern Myotis	N/A	V	SCS	Loss or disturbance of roosting sites Reduction in stream water quality	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including disturbance and impacts to hydrological processes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because this species is reliant on large mature trees for roosting and sensitive to disturbance, additional specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Petauroides volans	Greater Glider	V	N/A	N/A	Inappropriate fire regimes Habitat loss or degradation from *Phytophthora* root fungus	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because roosting habitat for the species may be affected by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks to this species	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Petaurus australis	Yellow-bellied Glider	N/A	V	ECS	Loss of hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur elsewhere in the bioregion; there are very few recent records in the subregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development). There is a specific measure in the Plan for some other species to retain large trees during precinct planning, which is likely to benefit the Yellow-bellied Glider. These measures are expected to manage any residual impacts to the species	No
Petaurus norfolcensis	Squirrel Glider	N/A	V	SCS	Loss of hollow-bearing trees Inappropriate fire regimes Road mortality	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in GPEC, Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur elsewhere in the bioregion; there are very few recent records in the subregion • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and road mortality. In addition, there is a specific measure in the Plan for some other species to retain large trees during precinct planning, which is likely to benefit the Squirrel Glider. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Phascolarctos cinereus	Koala	V	V	ECS SCS	Vehicle strike Effects of urban development including predation by dogs Disruption of connectivity Fire Disease (Chlamydiosis caused by infection with Chlamydia)	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including road mortality, impacts from domestic animals and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because the species is at risk from vehicle strike and loss of key habitat features additional specific mitigation measures have been identified to mitigate residual risks to this species (see section 15.6.4 and Chapter 30 for the full Koala impact assessment)	Yes
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	ECS	Camp disturbance Loss of large trees for foraging and roosting	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas This species is reliant on large mature trees and sensitive to camp disturbance, therefore specific mitigation measures have been identified to mitigate residual risks to this species	Yes
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	N/A	V	ECS	Disturbance to roosting and summer breeding sites Loss of hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address indirect impacts This species is reliant on large mature trees for roosting and sensitive to disturbance, therefore additional specific mitigation measures have been identified to mitigate residual risks	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Scoteanax rueppellii	Greater Broad-nosed Bat	N/A	V	ECS	Disturbance to roosting and summer breeding sites Loss of hollow-bearing trees	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts This species is reliant on large mature trees for roosting and sensitive to disturbance, therefore additional specific mitigation measures have been identified to mitigate residual risks	Yes
REPTILES							
Hoplocephalus bungaroides	Broad-headed Snake	V	E	ECS	Bush rock removal Inappropriate fire regimes Predation by cats Road mortality	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because • There are no current records of the species in the Strategic Assessment Area, greater densities of records occur in surrounding areas, in particular to the south east of the subregion • The removal of bush rock in many reserves is prohibited and management plans for reserves typically include measures to control public access within reserves, which may reduce the risk of bush rock removal for the species As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and predation. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Varanus rosenbergi	Rosenberg's Monitor	N/A	V	ECS	Removal of habitat elements, such as termite mounds and fallen timber Predation by cats and dogs	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • There are no records of the species in the nominated areas and very few records in the subregion • Greater densities of records occur elsewhere in the bioregion • The species is considered unlikely to rely on the habitat at risk of indirect impacts for persistence in the subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including predation. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
AMPHIBIANS							
Heleioporus australiacus	Giant Burrowing Frog	V	V	SCS	Hydrological changes Inappropriate fire regimes Predation by foxes and cats Vehicle strike Infection with amphibian chytrid fungus	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • There are limited records of the species in the Strategic Assessment Area and a lack of suitable habitat in the subregion • Greater densities of records occur in surrounding areas, in particular to the south east of the subregion • The species does not appear to rely on the habitat at risk of indirect impacts for persistence in the subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes, inappropriate fire regimes, predation and disease. These measures are expected to manage any residual impacts to the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Litoria aurea	Green and Golden Bell Frog	V	E	SCS	Changes to the structure and diversity of aquatic vegetation Changes to hydrology and water quality Intensification of public access to habitat Predation cats Inappropriate fire regimes Infection with amphibian *chytrid* fungus	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the OSO transport corridor in GPEC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes and predation These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because the population associated with Ropes Creek corridor is on the edge of the western range for the species and could be potentially impacted by development under the Plan, therefore species-specific commitments are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Pseudophryne australis	Red-crowned Toadlet	N/A	V	SCS	Changes to hydrology and pollution/ degradation of water quality Inappropriate fire regimes Habitat degradation through four-wheel driving and trail bikes Bush rock removal	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • Records occur throughout the bioregion and the subregion does not appear to be a stronghold for the species • The species does not appear to rely on the habitat at risk of indirect impacts for persistence in the subregion • The removal of bush rock in many reserves is prohibited and management plans for reserves typically include measures to control public access within reserves, which may reduce the risk of bush rock removal for the species As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes, and inappropriate fire regimes. These measures are expected to manage potential residual impacts	No
INVERTEBRATES							
Meridolum corneovirens	Cumberland Plain Land Snail	N/A	E	SCS	Weed invasion Inappropriate fire regimes Removal of fallen logs for firewood Loss of ground shelter habitat by slashing Ground subsidence	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in each nominated area As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because the species is restricted to the subregion, additional species-specific commitments are required to address potential residual impacts and to support critical actions for the species under the Saving our Species program	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Pommerhelix duralensis	Dural Land Snail	E	E	N/A	Inappropriate fire regimes Disturbance due to weed control activities	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in WSA and GPEC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • There are no records close to urban capable land or transport corridors, or in areas at risk of indirect impacts from development • The species does not appear to rely on the habitat at risk of indirect impacts for persistence in the subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and disturbance from weed control activities. These measures are expected to manage potential residual impacts	No
FISH							
Macquaria australasica	Macquarie Perch	E	N/A	N/A	Hydrological changes Degradation caused by bushfires Recreational fishing	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur in Erskine Creek, Glenbrook Creek, Georges River and Cordeaux River As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because recreational fishing is identified as a threat to the species, additional species-specific commitments are required to address potential residual impacts	Yes

15.7.2 FLORA

Table 15-19: Assessment of indirect impacts – flora

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	V	E	SCS	Inappropriate habitat disturbance Weed invasion Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC and Wilton. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of records occur away from urban capable land and transport corridors • Some habitat for the species is subject to approval conditions to protect and manage it from indirect impacts, under an existing EPBC Act approval in the Bingara area. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. These measures are expected to manage potential residual impacts	No
Acacia pubescens	Downy Wattle, Hairy Stemmed Wattle	V	V	SCS	Weed invasion Habitat disturbance through illegal track creation and maintenance activities Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in the nominated areas and transport corridors outside the nominated areas. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of records occur away from urban capable land and transport corridors • The species does not appear to rely on the habitat at risk of indirect impacts for persistence in the subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion, disturbance and inappropriate fire regimes. These measures are expected to manage potential residual impacts	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Allocasuarina glareicola		E	E	SCS	Habitat degradation from increased public access Inappropriate fire regimes Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GPEC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of records and potential habitat occur away from urban capable land and transport corridors • Several areas of potential habitat and records are managed in existing conservation reserves As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including habitat degradation, inappropriate fire regimes and weed invasion. These measures are expected to manage potential residual impacts	No
Commersonia prostrata	Dwarf Kerrawang	E	E	N/A	None	While the Plan has the potential to exacerbate some threats to the species, this is unlikely to result in indirect impacts to the species because the majority of areas of habitat occur some distance away from the urban capable land and transport corridors and away from associated areas that could be impacted	N/A
Cynanchum elegans	White-flowered Wax Plant	E	E	N/A	Degradation of habitat due to weed invasion, grazing and inappropriate fire management Hydrological disturbance	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur near to the OSO transport corridor near Cobbitty, south of WSA As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because an important population occurs close to the OSO transport corridor, additional species-specific commitments are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Deyeuxia appressa		E	E	N/A	None	While the Plan has the potential to exacerbate some threats to the species, this is unlikely to result in indirect impacts to the species because all three records of the species (if extant) and potential habitat occur outside the Strategic Assessment Area and some distance from the urban capable land and transport corridors and transport corridors and away from associated areas that could be impacted	N/A
Dillwynia tenuifolia		N/A	V	SCS	Inappropriate fire regimes Disturbance from human activity such as rubbish dumping and uncontrolled vehicular access Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in WSA and GPEC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion, disturbance and inappropriate fire regimes These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the subregion is a key location for the species and records and potential habitat occurs close to urban capable land and transport corridors, additional species-specific commitments are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Epacris purpurascens var. *purpurascens*		N/A	V	SCS	Urban run-off Inappropriate fire regimes Disturbance from human activity such as rubbish dumping, trampling and uncontrolled vehicular access Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes, disturbance, inappropriate fire regimes and weed invasion. These measures are expected to manage potential residual impacts	No
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	V	V	SCS	Inappropriate fire regimes Changed hydrology Weed invasion Myrtle rust Ground subsidence	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to GPEC, GMAC and the OSO transport corridor As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, impacts to hydrological processes, weed invasion and spread of disease These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the species has been identified as being at risk from indirect impacts from the OSO tunnel, and additional specific measures are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Genoplesium baueri	Yellow Gnat-orchid	E	E	N/A	Habitat disturbance from recreational use, rubbish dumping, and nearby urban areas	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC There are very few records of this species in the subregion, however, a population (no. 21) occurs close to the urban capable land in GMAC and an additional species-specific commitment is required to address potential residual impacts in this location	Yes
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	N/A	V	SCS	Inappropriate fire regimes Disturbance from human activity such as rubbish dumping, trampling and increased fire risk Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in WSA and GPEC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the subregion is a key location for the species, records and potential habitat occur close to urban capable land and transport corridors, so additional species-specific commitments are required to address potential residual impacts	Yes
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	SCS	Road maintenance Weed invasion Habitat disturbance from recreational activities and rubbish dumping Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur near to the urban capable land and transport corridors in Wilton As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. In addition, some habitat for the species is subject to approval conditions to protect and manage it from indirect impacts, under an existing EPBC Act referral (EPBC 2014/7400) in the Bingara area These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because an important population occurs close to the urban capable land in Wilton, additional species-specific commitments are required to address potential residual impacts in that location	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Hibbertia fumana		N/A	CE	SCS	Inappropriate fire regimes Weed invasion Habitat disturbance from uncontrolled movement of vehicles	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • A large number of records occur in protected areas in Moorebank to the north of GMAC, which is a proposed priority management site under the NSW Saving our Species strategy • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, weed invasion and disturbance. These measures are expected to manage potential residual impacts	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Hibbertia puberula		N/A	E	SCS	Weed invasion Disturbance from human activity such as from trailbikes, 4WDs and mountain bikes	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GPEC, in particular the northern boundary adjacent to Shanes Park. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • A large number of records occur in protected areas in Moorebank to the north of GMAC, which is a proposed priority management site under the NSW Saving our Species strategy • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and disturbance. These measures are expected to manage potential residual impacts	No
Hibbertia puberula subsp. *glabrescens*		CE	N/A	N/A	None	While the Plan has the potential to exacerbate some threats to the species, this is unlikely to result in indirect impacts to the species because the species is only known from one location outside the Strategic Assessment Area in Bankstown, some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted	N/A

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Leucopogon exolasius	Woronora Beard-heath	V	V	N/A	Inappropriate fire regimes Weed invasion	The Plan has the potential to exacerbate some threats in areas of habitat for this species that occur adjacent to GMAC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion • The populations nearest to the nominated area have been classified as non-important populations As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. These measures are expected to manage potential residual impacts	No
Marsdenia viridiflora subsp. *viridiflora*		N/A	E	SCS	Stochastic events (e.g. fire) due to small population size	The Plan has the potential to exacerbate some threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC, WSA and GPEC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including undertaking bushfire reduction measures close to the urban capable land, which is likely to reduce the likelihood of stochastic events such as wildfires affecting the species	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Maundia triglochinoides		N/A	V	SCS	Hydrological changes Weed invasion	The Plan has the potential to exacerbate some threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC and WSA. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes and weed invasion	No
Melaleuca deanei	Deane's Melaleuca	V	V	SCS	Inappropriate fire regimes and mechanical methods of bushfire removal Inappropriate habitat disturbance from construction and maintenance of tracks and easements, unrestricted access and rubbish dumping Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. However, because the species is sensitive to inappropriate habitat disturbance from construction and maintenance of tracks and easements, unrestricted access and rubbish dumping, an additional species-specific commitment is required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Micromyrtus minutiflora		V	E	SCS	Inappropriate fire regimes Weed invasion Habitat degradation through arson, grazing, trail bike riding, and rubbish dumping	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GPEC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion • Many records occur in existing conservation reserves in the north of the subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, weed invasion and disturbance. These measures are expected to manage potential residual impacts	No
Persicaria elatior	Tall Knotweed	V	V	SCS	Hydrological changes Inappropriate habitat disturbance, such as through road, track and trail maintenance Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to GMAC, WSA, GPEC and transport corridors. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The majority of the records in the subregion are protected in an existing conservation reserve some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including impacts to hydrological processes, disturbance and weed invasion. These measures are expected to manage potential residual impacts	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Persoonia bargoensis	Bargo Geebung	V	E	SCS	Inappropriate fire regimes and fire maintenance activities Inappropriate habitat disturbance Infection by *Phytophthora cinnamomi*	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur near to the urban capable land and transport corridors in Wilton and GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion. In addition, some habitat for the species is subject to approval conditions to protect and manage it from indirect impacts, under an existing EPBC Act referral (EPBC 2014/7400) in the Bingara area These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because the species is sensitive to inappropriate fire regimes, disturbance from habitat maintenance and at risk from *Phytophthora cinnamomi*, additional species-specific commitments are required to address potential residual impacts	Yes
Persoonia glaucescens	Mittagong Geebung	V	E	N/A	None	While the Plan has the potential to exacerbate some threats to the species, this is unlikely to result in indirect impacts to the species because the records and majority of areas of habitat occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted	N/A
Persoonia hirsuta	Hairy Geebung, Hairy Persoonia	E	E	N/A	Inappropriate fire regimes Disturbance from recreational users Altered hydrology Weed invasion Infection by *Phytophthora cinnamomi*	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to all nominated areas and the OSO transport corridor As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, altered hydrology and weed invasion. In addition, all known populations are on privately owned land which reduces the risk of disturbance from recreational users These measures are expected to address potential indirect impacts from development under the Plan on this species, and are expected to manage potential residual impacts	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Persoonia nutans	Nodding Geebung	E	E	SCS	Inappropriate fire regimes Habitat degradation and rubbish dumping related to unrestricted access Infection by root-rot fungus *Phytophthora cinnamomi* Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur near to the urban capable land and transport corridors in WSA and GPEC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, because an important population and potential habitat occur close to the OSO transport corridor within Wianamatta Regional Park in GPEC, additional specific measures are required to address potential residual impacts in that area	Yes
Pimelea curviflora var. *curviflora*		V	V	SCS	Weed invasion Habitat degradation from recreational activities, road and trail maintenance, and bush rock removal Inappropriate fire regimes	The Plan has the potential to exacerbate threats in areas of habitat for this species (as indicated by records) that occur adjacent to the urban capable land and transport corridors in GMAC, Wilton and GPEC. Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species occurs elsewhere in the bioregion • The majority of the records in the subregion occur some distance away from the urban capable land and transport corridors, and away from associated areas that could be impacted • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion or subregion • Many records are protected in existing conservation reserves As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, disturbance and weed invasion. These measures are expected to manage potential residual impacts	No

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Pimelea spicata	Spiked Rice-flower	E	E	SCS	Illegal dumping of rubbish and garden waste Weed invasion and competition High frequency land-use/management activities Inappropriate fire regimes Hydrological disturbance Ground subsidence	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur near to the urban capable land and transport corridors in all nominated areas and transport corridors outside the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, impacts to hydrological processes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the species has been identified as being at risk from human disturbance and indirect impacts from the OSO tunnel, so additional specific measures are required to address potential residual impacts	Yes
Pomaderris brunnea	Rufous Pomaderris	V	E	SCS	Weed invasion Disturbance from trampling and recreational vehicle use Stormwater run-off Altered fire regimes Ground subsidence	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC and Wilton and transport corridors outside the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes, impacts to hydrological processes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the species has been identified as being at risk from indirect impacts from the OSO tunnel, and additional specific measures are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Pterostylis saxicola	Sydney Plains Greenhood	E	E	SCS	Weed invasion Inappropriate fire regimes Inappropriate habitat disturbance Unrestricted access	The Plan has the potential to exacerbate in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GPEC, GMAC and Wilton Should this occur, the consequence for the persistence of the species in the bioregion is likely to be minor because: • The species is cryptic and hard to identify • The species does not appear to rely on the habitat at risk of indirect impacts from the development for persistence in the bioregion As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including weed invasion and inappropriate fire regimes. However, the species has been identified as being at risk from indirect impacts associated with habitat disturbance, and additional specific measures are required to address potential residual impacts	Yes
Pultenaea parviflora		V	E	SCS	Inappropriate habitat disturbance from uncontrolled vehicle access and rubbish dumping Inappropriate fire regimes Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GPEC and WSA As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the subregion is a key location for the species, records and potential habitat occur close to urban capable land and transport corridors, so additional species-specific commitments are required to address potential residual impacts	Yes

Scientific name	Common name	Cth status	NSW status	BAM species type	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Pultenaea pedunculata	Matted Bush-pea	N/A	E	SCS	Inappropriate fire regimes Disturbance from human activity Weed invasion	The Plan has the potential to exacerbate threats in areas of habitat for this species that occur adjacent to the urban capable land and transport corridors in GMAC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this species, including inappropriate fire regimes and weed invasion These measures are expected to address the majority of potential indirect impacts from development under the Plan on this species. However, the subregion is a key location for the species, records and potential habitat occur close to urban capable land in GMAC, so additional species-specific commitments are required to address potential residual impacts	Yes

15.7.3 THREATENED ECOLOGICAL COMMUNITIES

Table 15-20: Assessment of indirect impacts – TECs

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	*Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion*	E	V	Inappropriate fire regimes Weed invasion Invasive fauna Diseases, pathogens and dieback Damage caused by human disturbance	While areas of mapped TEC occur some distance from the urban capable land and transport corridors, the Plan has the potential to exacerbate several threats to the TEC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC. These measures are expected to manage any residual impacts to the TEC	No
Coastal floodplain eucalypt forest of eastern Australia (previously referred to as *River-flat Eucalypt Forest on Coastal Floodplains of New South Wales*)	*River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	FPAL	E	Inappropriate fire regimes Weed invasion Changes to hydrology Invasive fauna Diseases, pathogens and dieback Damage caused by human disturbance Ground subsidence	The Plan has the potential to exacerbate threats in areas of the TEC that occur adjacent to the urban capable land in the nominated areas and in the transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	*Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	E	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of the TEC that occur adjacent to the urban capable land and transport corridors in WSA and GPEC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	CE	E	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of the TEC that occur adjacent to urban capable land and transport corridors in WSA and GPEC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks. In addition, there is a TEC-specific commitment to undertake all control measures in line with the *Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest* and *Recovering Bushland on the Cumberland Plain: best practice guidelines on the management and restoration of bushland*	Yes

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest		CE		Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna Ground subsidence	The Plan has the potential to exacerbate threats in areas of the TEC that occur adjacent to the urban capable land in the nominated areas and transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes
	Cumberland Plain Woodland in the Sydney Basin Bioregion		CE	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna Ground subsidence	The Plan has the potential to exacerbate threats in areas of the TEC that occur adjacent to the urban capable land in the nominated areas and transport corridors inside and outside the nominated areas As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
	Shale Gravel Transition Forest in the Sydney Basin Bioregion		E	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of this TEC that occur adjacent to the urban capable land and transport corridors in WSA and GPEC As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	*Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion*	CE	CE	Changes to hydrology	The Plan has the potential to exacerbate threats in areas associated with the OSO and Metro Rail Future Extension tunnels. As described in section 15.6, mitigation measures will be implemented through future environmental assessment processes (for transport development) that will address potential indirect impacts from hydrological disturbance in the vicinity of the tunnel footprints. These measures are expected to manage any residual impacts to the TEC	No
	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions		E	Hydrological disturbance Weed invasion Inappropriate habitat disturbance	The Plan has the potential to exacerbate threats in areas of this TEC that occur in GPEC. However, there is limited TEC mapped in the subregion and it occurs away from urban capable land and transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC, including hydrological disturbance and weed invasion. These measures are expected to manage any residual impacts to the TEC	No

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	CE	CE	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changes to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of this TEC that occur adjacent to the urban capable land and transport corridors in Wilton and GMAC. As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC These measures are expected to address the majority of potential indirect impacts from development under the Plan on this TEC. However, because the TEC is at risk from dieback caused by *Phytophthora cinnamomi*, an additional specific mitigation measure has been identified to mitigate residual risks	Yes
Turpentine-Ironbark Forest of the Sydney Basin Bioregion		CE		None	Areas of mapped TEC occur away from the urban capable land and transport corridors and away from areas at risk of indirect impacts from the development	N/A
Western Sydney Dry Rainforest and Moist Woodland on Shale		CE		Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changed to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of this TEC that occur adjacent to the urban capable land in Wilton, GMAC and the transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC, including inappropriate fire regimes and weed invasion. These measures are expected to manage any residual impacts to the TEC	No

Cth TEC name	NSW TEC name	Cth status	NSW status	Key relevant indirect impacts / threats	Assessment of indirect impacts	Residual impacts
	Moist Shale Woodland in the Sydney Basin Bioregion		E	Inappropriate fire regimes Weed invasion Inappropriate habitat disturbance Changed to hydrology Diseases, pathogens and dieback Invasive fauna	The Plan has the potential to exacerbate threats in areas of this TEC that occur adjacent to the urban capable land in Wilton, GMAC and the transport corridors As described in section 15.6, mitigation measures will be implemented through development controls (for urban, industrial and agribusiness development) or future environmental assessment processes (for transport and infrastructure development) that will address relevant indirect impacts to this TEC, including inappropriate fire regimes and weed invasion. These measures are expected to manage any residual impacts to the TEC	No

15.8 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

This section identifies additional specific mitigation measures considered necessary to address residual risks from the potential indirect impacts of the urban, industrial, infrastructure, agribusiness and transport development on Commonwealth and NSW-listed TECs and species, and other EPBC Act protected matters.

These mitigation measures are provided in Appendix E of the Plan, and are incorporated into several commitments and actions under the Plan. The measures will be implemented as described above in section 15.6 though either:

- The draft DCP template
- An environmental impact assess process (for infrastructure and transport development)
- An action under the Plan

These additional mitigation measures, along with the package of relevant commitments in the Plan (see section 15.6) are considered to adequately address residual risks to each of these matters.

15.8.1 FAUNA

The specific mitigation measures to address residual risks to flora are provided in Table 15-21.

Table 15-21: Specific mitigation measures to address residual risks – fauna

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
HABITAT FEATURES AND CONNECTIVITY						
Urban and industrial, infrastructure, agribusiness	Retain large trees (including dead trees) (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction	Large trees within urban landscapes are likely to be important for the persistence of several species within the subregion. Microbats benefit directly through roosting opportunities and indirectly through foraging opportunities. Flying-foxes and nectivorous birds benefit directly through foraging opportunities (high volumes of nectar). Owls and raptors benefit indirectly through large trees providing habitat for prey species	**Microbats:** Southern Myotis, Little Bent-winged Bat, Eastern Coastal Free-tailed Bat, Large Bent-winged Bat, Yellow-bellied Sheathtail-bat, Eastern False Pipistrelle, Greater Broad-nosed Bat **Flying-foxes and nectivorous birds:** Grey-headed Flying-fox, Regent Honeyeater, Swift Parrot, Little Lorikeet, Painted Honeyeater, and Black-chinned Honeyeater **Owls and raptors:** Barking Owl, Powerful Owl, Masked Owl, Little Eagle, White-bellied Sea Eagle, Square-tailed Kite, Spotted Harrier	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
Urban and industrial, infrastructure, agribusiness	Retain areas of high density proteaceae shrubs where possible, particularly along riparian corridors	Proteaceae shrubs such as banksias are a favoured foraging resource for the species and the species is likely to use riparian corridors as habitat or for movement between other areas of suitable habitat	Eastern Pygmy-possum	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
Urban and industrial, infrastructure	If Green and Golden Bell Frog is confirmed present along Ropes Creek, consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced	Aims to protect an important population of the species (if confirmed present) at Ropes Creek in GPEC	Green and Golden Bell Frog	GPEC (mapped potential habitat along Ropes Creek)	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	N/A
Urban and industrial, infrastructure, agribusiness	Undertake pre-construction surveys prior to removal or disturbance (seasonally dependent, before torpor) to human made structures to ensure any roosting habitat for microbat species including mine shafts, storm water tunnels, old or derelict buildings, bridges and culverts are retained where possible	Minimises the potential impacts of urban development to human-made structures that may be used by microbats for roosting or breeding	Eastern Coastal Free-tailed Bat Little Bent-winged Bat Large Bent-winged Bat Southern Myotis Yellow-Bellied Sheathtail-Bat	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
Transport corridors	Incorporate artificial breeding and roosting habitat (e.g. bat boxes, structural cavities) in the design of bridges associated with the transport corridors in accordance with relevant	Minimises the potential impacts of the transport corridors to human-made structures that may be used by microbats for roosting or breeding	Eastern Coastal Free-tailed bat Large Bent-winged Bat Southern Myotis Yellow-Bellied Sheathtail-	All transport corridors within and outside nominated areas	Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure	EIA process for transport

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
	guidelines or standards		bat		(transport) development on threatened species and their habitat	
PEST/DOMESTIC ANIMALS						
Urban and industrial, infrastructure, agribusiness	Modify pest control techniques implemented during construction and operation of the development and under the pest control strategy to reduce the risk of secondary poisoning (e.g. from Pindone or second-generation rodenticides)	There is a risk of pest control measures causing secondary poisoning of raptors	White-bellied Sea-Eagle Little Eagle Square-tailed kite Spotted Harrier	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
				SCAs	Commitment 17: Manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the strategic conservation area	Pest control strategy
Urban and industrial, infrastructure	Where permitted and appropriate, contain domestic cats and dogs in new residential areas during operation of the development at the urban/bushland interface consistent with relevant Council guidelines	Increased numbers of domestic cats and dogs associated with urban development increases the threat of predation to native animals	Eastern Pygmy-possum Spotted-tailed Quoll	Wilton GMAC	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
HUMAN DISTURBANCE						
Urban and industrial, infrastructure, agribusiness	Establish minimum setbacks for urban development around flying fox camps	Minimises disturbance to known populations	Grey-headed Flying-fox	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP
Urban and industrial, infrastructure, agribusiness	Consult with relevant resource managers to consider: • Prohibiting recreational fishing along the stretches of habitat associated with Erskine Creek, Glenbrook Creek, Georges River and Cordeaux River known to support the species • Installing signs/interpretive displays at appropriate sites used to access fishing locations at Erskine Creek, Glenbrook Creek, Georges River and Cordeaux River to assist with identification and awareness of threats	Minimises the risk of increased recreational fishing affecting the species due to larger urban populations associated with urban development	Macquarie Perch	Erskine Creek Glenbrook Creek Georges River Cordeaux River	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	N/A

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
DISEASE						
Urban and industrial, infrastructure	If Green and Golden Bell Frog is confirmed present along Ropes Creek, incorporate best practice site hygiene protocols to manage the potential spread of chytrid fungus	Minimises the risk of the spread of chytrid fungus due to construction activities within potential habitat for the species	Green and Golden Bell Frog	GPEC (mapped potential habitat along Ropes Creek)	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
Transport corridors				OSO within GPEC (mapped potential habitat along Ropes Creek)	Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat	EIA process for transport
Urban and industrial, infrastructure, agribusiness	Incorporate best practice site hygiene protocols to manage the potential spread of pathogens, such as *Phytophthora* and Myrtle Rust within or adjacent to potential habitat for relevant species	Minimises the risk of the spread of pathogens due to construction activities adjacent to potential habitat for the species	Greater Glider	All nominated areas All transport corridors within and outside nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
Transport corridors					Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on	EIA process for transport

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
					threatened species and their habitat	
OTHER						
Urban and industrial, infrastructure, agribusiness	Consult with relevant land managers to implement critical actions for Cumberland Plain Land Snail under the Save our Species program (EES, 2020) on public land adjacent to urban development during construction and operation of the development, taking into account relevant guidance in the Weed Control Implementation Strategy and the Fire Management Strategy	Minimises indirect impacts and supports maintenance of known populations adjacent to urban capable land	Cumberland Plain Land Snail	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	N/A
Urban and industrial, infrastructure, agribusiness development	Implement 'open structure design' when designing structures such as roads adjacent to known populations of Cumberland Plain Land Snail where possible, consistent with the critical actions for this species under the Save our Species program (EES, 2020)	Development in the nominated areas may isolate patches of habitat. This action is consistent with a critical action for this species under the Save our Species program (EES, 2020)	Cumberland Plain Land Snail	All nominated areas	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP

15.8.2 FLORA

The specific measures to address residual risks to flora are provided in Table 15-22.

Table 15-22: Specific mitigation measures to address residual risks – flora

<table>
<tr><th>Relevant impact</th><th>Mitigation measure</th><th>Rationale for measure</th><th>Relevant species</th><th>General location of measure</th><th>Relevant commitment</th><th>Implementation mechanism</th></tr>
<tr><td colspan="7">WEED INVASION</td></tr>
<tr><td rowspan="2">Transport corridors</td><td rowspan="2">Implement mitigation measures to manage weeds for flora populations and habitat adjacent to transport corridors during construction and operation of the development, taking into account relevant guidance in the Weed Control Implementation Strategy</td><td rowspan="2">Minimises indirect impacts to flora populations and habitat adjacent to transport corridors</td><td>Dillwynia tenuifolia
Pultenaea parviflora
Persoonia nutans</td><td>OSO (Wianamatta Regional Park)
M7/Ropes Crossing link Road</td><td rowspan="2">Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat
Commitment 16: Manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land</td><td rowspan="2">EIA process for transport</td></tr>
<tr><td>Grevillea juniperina subsp. juniperina</td><td>OSO (GPEC)
M7/Ropes Crossing link Road
Western Sydney Freight Line</td></tr>
</table>

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
			Cynanchum elegans	OSO (Cobbitty)	secured within the strategic conservation area	
Urban and industrial, infrastructure, agribusiness	Implement mitigation measures to manage weeds for flora populations and habitat adjacent to urban capable land during construction and operation of the development, taking into account relevant guidance in the Weed Control Implementation Strategy	Minimises indirect impacts to flora populations and habitat adjacent to urban capable land and supports the general environmental controls to manage weeds	*Dillwynia tenuifolia* *Grevillea juniperina* subsp. *juniperina* *Pultenaea parviflora*	GPEC WSA	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards Commitment 16: Manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the strategic conservation area	DCP EIA process for infrastructure Weed Control Implementation Strategy
			Pultenaea pedunculata	GMAC		
			Grevillea parviflora subsp. *parviflora* (important population no. 104)	Wilton		
ALTERED FIRE REGIMES						
Urban and industrial	Consult with land managers of land containing known populations or habitat for relevant species to mitigate	Minimises indirect impacts to flora populations and habitat adjacent to urban capable land	*Dillwynia tenuifolia* *Grevillea juniperina* subsp. *Juniperina*	GPEC WSA	Commitment 5: Mitigate indirect and prescribed impacts on threatened species,	N/A

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
	indirect impacts from fire during construction and operation of the development, taking into account guidance in the Fire Management Strategy		*Pultenaea parviflora*		populations and communities to best practice standards Commitment 18: Manage fire in strategic locations in the Cumberland subregion to support the maintenance of biodiversity values on conservation land	
			Persoonia nutans	GPEC		
			Pultenaea pedunculata	GMAC		
			Grevillea parviflora subsp. *parviflora* (important population no. 104)	Wilton		
			Persoonia bargoensis	Wilton GMAC		
HUMAN DISTURBANCE						
Urban and industrial, infrastructure, agribusiness	Consult with land managers of land containing known populations or habitat for relevant species to mitigate indirect impacts from habitat disturbance during construction and operation of the development, including controlling public access, managing maintenance activities such as mowing and	Minimises indirect impacts to flora populations and habitat adjacent to urban capable land	*Dillwynia tenuifolia* *Grevillea juniperina* subsp. *Juniperina* *Pultenaea parviflora*	GPEC WSA	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards Commitment 5.3 This includes consulting with	N/A
			Persoonia nutans	GPEC		
			Grevillea parviflora subsp. *parviflora* (important population no. 104)	Wilton		

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
	weed control, and managing rubbish dumping		*Pultenaea pedunculata* *Genoplesium baueri* (important population no. 21)	GMAC	public land managers to minimise exposure to human disturbance for the specified threatened species	
			Persoonia bargoensis *Melaleuca deanei* *Pterostylis saxicola*	Wilton GMAC		
			Pimelea spicata For this species in particular, ensure weed management activities involving the use of herbicides will minimise risks and maintain the species	All nominated areas		
HYDROLOGY						
Transport corridors	Implement mitigation measures to manage hydrology impacts to relevant flora species and habitat adjacent to transport corridors during construction and operation of the development	Minimises the risk of hydrological impacts to the species	*Cynanchum elegans*	OSO (Cobbitty)	Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat	EIA process for transport

Relevant impact	Mitigation measure	Rationale for measure	Relevant species	General location of measure	Relevant commitment	Implementation mechanism
SPREAD OF INFECTION/DISEASE						
Urban and industrial, infrastructure, agribusiness	Incorporate best practice site hygiene protocols to manage the potential spread of pathogens, such as Phytophthora and Myrtle Rust adjacent to potential habitat for relevant species	Minimises the risk of the spread of pathogens due to construction activities adjacent to potential habitat for the species	*Persoonia bargoensis*	Wilton GMAC	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
			Persoonia nutans	GPEC WSA		
Transport corridors			*Persoonia nutans*	OSO (Wianamatta Regional Park)	Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat	EIA process for transport

Relevant impact	**Mitigation measure**	**Rationale for measure**	**Relevant species**	**General location of measure**	**Relevant commitment**	**Implementation mechanism**
TUNNELS						
Transport corridors	Manage key threats to the species, including: • Hydrological disturbance • Spread of weeds • Spread of infection/disease • Soil erosion and sedimentation • Ground settling or subsidence	Minimises the risk of indirect impacts during tunnel construction and operation	*Eucalyptus benthamii*	OSO tunnel	Commitments 6 and 6.2: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat	EIA process for transport
			Pimelea spicata	Metro Rail Future Extension tunnel		
			Pomaderris brunnea	OSO tunnel		

15.8.3 THREATENED ECOLOGICAL COMMUNITIES

The specific measures to address residual risks to TECs are provided in Table 15-23.

Table 15-23: Specific mitigation measures to address residual risks – TECs

Relevant impact	Mitigation measure	Rationale for measure	Key relevant TECs	General location of measure	Relevant commitment	Implementation mechanism
Urban and industrial, infrastructure, agribusiness	When implementing mitigation measures to manage indirect impacts to Cooks River/Castlereagh Ironbark Forest, undertake mitigation in accordance with Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest (NSW DECC, 2008) within and adjacent to the TEC	Minimises the risk of several indirect impact types on the TEC adjacent to urban development and transport corridors	Cooks River/Castlereagh Ironbark Forest (NSW and Cth)	WSA (Kemps Creek)	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
Transport corridors				OSO (Wianamatta Regional Park)	Commitment 6: Mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat	EIA process for transport
Urban and industrial, infrastructure, agribusiness	Incorporate best practice site hygiene protocols to manage the potential spread of pathogens, such as *Phytophthora* and Myrtle Rust adjacent to potential habitat for relevant TECs	Minimises the risk of the spread of pathogens due to construction activities for urban development or transport corridors adjacent to TECs	Cooks River/Castlereagh Ironbark Forest (NSW and Cth)	WSA (Kemps Creek)	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure
			Cumberland Plain Woodland (NSW and Cth)	GPEC WSA		
			River-flat Eucalypt Forest (NSW)/Coastal Floodplain Eucalypt Forest (Cth)	All nominated areas		

Relevant impact	Mitigation measure	Rationale for measure	Key relevant TECs	General location of measure	Relevant commitment	Implementation mechanism
			Shale Gravel Transition Forest (NSW)	GPEC WSA (Kemps Creek)		
			Shale Sandstone Transition Forest (Cth)	Wilton GMAC		
			Swamp Oak Floodplain Forest (NSW)/Coastal Swamp Oak Forest (Cth)	GPEC WSA		
Transport corridors			Cooks River/Castlereagh Ironbark Forest (NSW and Cth)	OSO (Wianamatta Regional Park)	Commitment 3: Avoid and minimise impacts to threatened species, populations and communities within major infrastructure corridors in the nominated areas Commitment 4: Avoid and minimise impacts to threatened species, populations and communities in the four major infrastructure corridors outside the nominated areas	EIA process for transport
			Cumberland Plain Woodland (NSW and Cth)	OSO (adjacent to WSA) Western Sydney Freight Line		
			River-flat Eucalypt Forest (NSW)/Coastal Floodplain Eucalypt Forest (Cth)	All nominated areas		
			Shale Gravel Transition Forest (NSW)	OSO (Wianamatta Regional Park)		
			Swamp Oak Floodplain Forest (NSW)/Coastal Swamp Oak Forest (Cth)	OSO (GPEC)		

15.8.4 OTHER PROTECTED MATTERS

The specific measure to address residual risks to other EPBC Act protected matters (Commonwealth land) is provided in Table 15-24.

A detailed assessment of potential indirect impacts relevant to Commonwealth land is provided in Chapter 35.

Table 15-24: Specific mitigation measures to address residual risks – other protected matters

Relevant impact	Mitigation measure	Rationale for measure	Key relevant protected matter	General location of measure	Relevant commitment	Implementation mechanism
Urban and industrial, infrastructure, agribusiness	Ensure development adjacent to the southern and western boundaries of Commonwealth land comprising the Orchard Hills Defence Establishment mitigates impacts to surface water flows and the water quality of Blaxland Creek	Minimises the risk of indirect impacts from hydrological disturbance on an important waterway on Commonwealth land that occurs adjacent to urban development	Commonwealth land	Orchard Hills Defence Establishment	Commitment 5: Mitigate indirect and prescribed impacts on threatened species, populations and communities to best practice standards	DCP EIA process for infrastructure

15.9 ANALYSIS OF THREAT ABATEMENT PLANS

15.9.1 INTRODUCTION

Under the EPBC Act, the impact assessment should address whether the actions under the Plan are inconsistent with any approved Threat Abatement Plans (TAPs).

TAPs have been developed under the EPBC Act to address listed KTPs and include actions to reduce their impact on threatened species and TECs.

There are seven TAPs which address KTPs that are potentially relevant to the Plan, which are discussed below.

15.9.2 THREAT ABATEMENT PLAN FOR COMPETITION AND LAND DEGRADATION BY UNMANAGED GOATS

The goal of this is TAP is to minimise the impact of competition and land degradation by unmanaged goats (*Capra hircus*) on biodiversity. Unmanaged goats are free-living and not owned, identified, restrained or managed. Unmanaged goats can affect threatened species and TECs by:

- Grazing on threatened native vegetation and therefore preventing regeneration
- Overgrazing and causing soil erosion
- Competing with threatened fauna species for food and shelter
- Introducing weeds through seeds carried in their dung
- Polluting watercourses (DEWHA, 2008)

OBJECTIVES AND ACTIONS UNDER THE TAP

The TAP sets out five objectives to achieve the goal, they are:

- Prevent unmanaged goats occupying new areas and eradicate them from high conservation-value 'islands'
- Promote the maintenance and recovery of native species and ecological communities that are affected by competition and land degradation by unmanaged goats
- Improve knowledge and understanding of unmanaged goat impacts and interactions with other species and ecological processes
- Improve the effectiveness, target specificity and humaneness of control options for unmanaged goats
- Increase awareness of all stakeholders of the objectives and actions of the TAP, and of the need to control unmanaged goats (DEWHA, 2008)

A set of actions accompanies each objective to help achieve the goal of the TAP. There are four actions to prevent unmanaged goats occupying new areas. These relate to collating data on areas of high conservation value, and developing and implementing management plans for these areas.

There are three actions to promote the maintenance and recovery of native species and ecological communities that are affected by this threat. These relate to identifying priority areas to control unmanaged goats, and conducting and monitoring goat control.

There are four actions to improve knowledge and understanding of unmanaged goat impacts and interactions. These relate to developing methods for assessing and monitoring the impact of unmanaged goats, and improving knowledge of interactions between unmanaged goats and other key species.

There are seven actions to improve the control options for unmanaged goats. These relate to investigating ways to improve control methods and programs including:

- Improving self-mustering trap systems
- Assessing goat toxins for undesirable side effects
- Testing exclusion fence designs
- Developing training programs to help land managers
- Promoting the adoption and adaptation of the model codes of practice

There are two actions to increase awareness of stakeholders of the objectives and actions of the TAP which relate to the promotion of the objectives and actions in the TAP.

Relevance of the TAP to the Plan

There is little information to suggest that unmanaged goats are a problem in the Strategic Assessment Area and there are no activities under the Plan which are likely to lead to the introduction of unmanaged goats in the area.

The Plan has the potential to exacerbate the threat of goats to some extent, and includes a commitment to manage priority pest animals in strategic locations in the Cumberland Subregion to reduce threats to land within the SCAs.

Consistency with the TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 2, to "promote the maintenance and recovery of native species and ecological communities that are affected by competition and land degradation by unmanaged goats"

15.9.3 THREAT ABATEMENT PLAN FOR COMPETITION AND LAND DEGRADATION BY RABBITS

The goal of this TAP is to minimise the impact of competition and land degradation by rabbits (*Oryctolagus cuniculus*) on biodiversity. Rabbits are abundant in Australia and cause damage to native flora and fauna, vegetation communities and crops. Rabbits can affect threatened species and TECs by:

- Grazing on threatened native vegetation and therefore preventing regeneration
- Competing with threatened fauna species for food and shelter
- Reversing the normal processes of plant succession
- Altering ecological communities and changing soil structure and nutrient cycling, leading to significant erosion
- Removal of critical habitat for arboreal mammals and birds, leading to increased predation
- Supporting elevated population densities of pest predators such as foxes and feral cats
- Promoting growth of introduced and unpalatable species such as weeds (DoEE, 2016a)

Objectives and actions under the TAP

The TAP sets out four objectives to achieve the goal, they are:

- Strategically manage rabbits at the landscape scale and suppress rabbit populations to densities below threshold levels in identified priority areas
- Improve knowledge and understanding of the impact of rabbits and their interactions with other species and ecological processes
- Improve the effectiveness of rabbit control programs
- Increase engagement of the community of the environmental impacts of rabbits and the need for integrated control

A set of actions have been identified to achieve the objectives of the TAP. There are five actions to support the strategic management of rabbits at a landscape scale. These relate to identifying priority areas for rabbit control on a regional scale, coordinating efforts across all land tenures such as private land and urban areas, and developing regular monitoring and reporting mechanisms to track progress.

There are three actions to improve knowledge and understanding of the impact of rabbits. These relate to further investigating the interaction of rabbits with other species and threats to improve rabbit control measures.

There are eight actions to improve the effectiveness of rabbit control programs through further research.

There are four actions to increase communication with stakeholders around the impacts caused by rabbits. These relate to developing training programs for land managers, promoting and seeking engagement from all people in the community and promoting adoption of model codes of practice for rabbit control (DoEE, 2016a).

Relevance of the TAP to the Plan

There is no likelihood of national rabbit eradication, so rabbit control is an ongoing issue across Australia. Current rabbit control programs focus on long-term management and suppression of rabbit populations.

The Plan has the potential to exacerbate the threat of rabbits to some extent, and includes a commitment to manage priority pest animals in strategic locations in the Cumberland Subregion to reduce threats to land within the SCAs.

Consistency with the TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 1, to "strategically manage rabbits at the landscape scale and suppress rabbit populations to densities below threshold levels in identified priority areas"

15.9.4 Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*

The goal of this TAP is to minimise the impacts of Phytophthora on EPBC-listed threatened species, TECs and MNES. The TAP applies to *Phytophthora cinnamomi*, however, other species of *Phytophthora* can also be found in Australia and may benefit from the same controls.

Phytophthora cinnamomi (Phytophthora) is a soil-borne plant pathogen, infection in plants can result in:

- Inability of infected plants to develop new shoots, flowers, fruit and seed
- Extinction of populations of some flora species
- A dramatic modification of the native plant community's structure and composition
- A significant reduction in primary productivity and functionality
- Habitat loss and degradation of dependent flora and fauna
- Local extinction and a significant loss of genetic diversity
- Major declines in some animal species due to the loss of shelter and nesting sites or food (DoEE, 2018b)

Objectives and actions under the TAP

The TAP sets out four objectives to achieve the goal, they are:

- Identify and prioritise for protection biodiversity assets that are, or may be, impacted by Phytophthora. Prioritised biodiversity assets may include:
    - Listed threatened species and ecological communities
    - Areas where there is potential for Phytophthora to cause unlisted native species or ecological communities to become eligible for listing under the EPBC Act (in any category other than conservation dependent)
- Reduce the spread and mitigate the impacts of Phytophthora to protect:
    - Priority biodiversity assets
    - Areas where there is potential for Phytophthora to cause native species or ecological communities not yet listed to become eligible for listing under the EPBC Act (in any category other than conservation dependent)
- Inform and engage the community by promoting information about Phytophthora, its impacts on biodiversity and actions to mitigate these impacts
- Encourage research on Phytophthora species and options to manage infestations and protect biodiversity assets

A set of actions have been identified to achieve the objectives of the TAP. There are five actions to identify and prioritise for protection biodiversity assets that are, or may be, impacted by Phytophthora which relate to developing a list of flora, fauna and communities that are at risk and areas at risk of infection spatially to inform threat management.

There are seven actions to reduce the spread and mitigate the impacts of Phytophthora which relate to safeguarding priority biodiversity assets through adherence to hygiene protocols, integrating management of Phytophthora dieback with other natural resource management systems (in particular fire management), and including management actions in National Recovery Plans for EPBC-listed threatened species and TECs.

There are six actions to inform and engage the community about the impacts of Phytophthora which relate to developing communication and training strategies for relevant stakeholder groups and ensuring the currency and accessibility of the relevant mapping, guidelines and signage.

There are nine actions to encourage research on Phytophthora species which relate to:

- Learning more about the Phytophthora genus
- Developing new and effective treatments for the disease
- Developing resistance and resilience in vulnerable species and communities
- Developing improved techniques for rapid diagnosis of Phytophthora infestation
- Developing restoration methods for priority sites that are degraded by Phytophthora dieback

RELEVANCE OF THE TAP TO THE PLAN

There is no effective mechanism to remove the Phytophthora pathogen from an area, and therefore the TAP aims to minimise the spread of the disease, especially when undertaking high-risk activities, such as:

- Land development
- Road construction
- Construction and maintenance of recreational tracks and walking trails
- Construction of straight-line infrastructure (for example power lines and telecommunication structures)
- Soil and gravel extraction
- Fencing
- Installation of drainage (DoEE, 2018a)

The activities above will be undertaken as part of the Plan and could exacerbate the threat of Phytophthora.

While there is a risk of the spread of Phytophthora as a result of the activities proposed in the Plan, there are commitments to manage the risk of indirect impacts due to the development under the Plan, including managing the risk of spread of Phytophthora at construction sites, and to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion.

CONSISTENCY WITH THE TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 2, to “protect priority biodiversity asses through reducing the spread and mitigating the impacts of *Phytophthora cinnamomi*”

15.9.5 THREAT ABATEMENT PLAN FOR INFECTION OF AMPHIBIANS WITH CHYTRID FUNGUS RESULTING IN CHYTRIDIOMYCOSIS

The goal of this TAP is to minimise the impacts of amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) on affected native species and ecological communities.

Chytrid fungus causes chytridiomycosis in amphibians which is a highly infectious disease that can be found in all areas in Australia except the Northern Territory. The fungus invades the surface layers of the skin and disrupts its normal function which results in electrolyte depletion and osmotic imbalance. This can affect the nervous system of some animals and paralysis, and ultimately death, occurs. Susceptibility to the disease varies between populations but the reasons for this are unknown. (DoEE, 2016b)

OBJECTIVES AND ACTIONS UNDER THE TAP

The TAP sets out four objectives to help achieve the goal, they are:

- Improve understanding of the extent and impact of infection by amphibian chytrid fungus and reduce its spread to uninfected areas and populations
- Identify and prioritise key threatened amphibian species, populations and geographical areas and improve their level of protection by implementing coordinated, cost-effective on-ground management strategies
- Facilitate collaborative applied research that can be used to inform and support improved management of amphibian chytrid fungus
- Build scientific capacity and promote communication among stakeholders

A set of actions have been identified to achieve the objectives of the TAP. There are four actions to improve the understanding of infection by chytrid fungus and reduce its spread which relate to monitoring at-risk species, mapping the distribution of chytridiomycosis (and chytrid fungus), including control measures in amphibian translocation strategies, and ensuring appropriate hygiene protocols are implemented in chytrid-free areas.

There are six actions to support the identification and prioritisation of key threatened species, populations and geographical areas and the implementation of management strategies, which relate to completing risk assessments for high-priority species, implementing biosecurity measures around high-priority areas, and coordinating conservation efforts.

There are seven actions to facilitate research to improve management of chytrid fungus which include obtaining knowledge on:

- Assisted colonisation strategies
- The mechanisms for resistance
- The severity of chytrid fungus
- The best treatment protocols

There are three actions to build scientific capacity and promote communication among stakeholders which relate to developing an effective communication strategy, supporting a central information storage site, and encouraging participation in the National Chytrid Working Group.

RELEVANCE OF THE TAP TO THE PLAN

Most of populations susceptible to chytrid fungus that occur adjacent to or within proximity to proposed development, such as the Green and Golden Bell Frog, already exist within a highly built up and urbanised environment. Development under the Plan is unlikely to change the current level of risk in these areas in relation to chytrid fungus.

Despite this, there are commitments to manage the risk of indirect impacts due to the development under the Plan, including managing the risk of spread of chytrid fungus at Ropes Creek should a population of Green and Golden Bell Frog occur at that location, and to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion.

CONSISTENCY WITH THE TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 2, to "identify and prioritise key threatened amphibian species, populations and geographical areas and improve their level of protection by implementing coordinated, cost-effective, on-ground management strategies"

15.9.6 THREAT ABATEMENT PLAN FOR PREDATION BY EUROPEAN RED FOX

The goal of this TAP is to minimise the impact of the European red fox (*Vulpes Vulpes*) on biodiversity in Australia.

The European red fox can be found all over the Australian mainland, apart from in the far North. Fox predation is a threat to many threatened fauna species, in particular terrestrial mammals and ground-nesting birds.

Objectives and actions under the TAP

The TAP sets out four objectives to achieve the goal, they are:

- Prevent foxes occupying new areas in Australia and eradicate foxes from high-conservation-value 'islands'
- Promote the maintenance and recovery of native species and ecological communities that are affected by fox predation
- Improve knowledge and understanding of fox impacts and interactions with other species and other ecological processes
- Improve the effectiveness, target specificity, integration and humaneness of control options for foxes
- Increase awareness of all stakeholders of the objectives and actions of the TAP, and of the need to control and manage foxes

A set of actions have been identified to help achieve the objectives of the TAP. There are four actions to prevent foxes occupying new areas in Australia which relate to collating data on areas with high conservation values, developing and implementing management plans, and eradicating populations of foxes from lands adjacent to priority areas.

There are three actions to promote the recovery of native species and ecological communities that are affected by fox predation which relate to identifying priority areas for fox control and undertaking and monitoring fox control at these locations.

There are five actions to improve the knowledge and understanding of fox impacts which relate to developing methods for monitoring foxes, exploring the interactions between foxes, feral cats, wild dogs and rabbits, and estimating the costs of impacts from foxes.

There are seven actions to improve the control options for foxes which relate to investigating existing and new control techniques, developing training programs for land managers and promoting best practice standards.

There is one action to increase awareness of the need to control and manage foxes which relates to ensuring that the actions in the TAP are better communicated.

Relevance of the TAP to the Plan

The Plan has the potential to exacerbate the threat of foxes to some extent, and includes a commitment to manage priority pest animals in strategic locations in the Cumberland Subregion to reduce threats to land within the SCAs.

Consistency with the TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 2, to "promote the maintenance and recovery of native species and ecological communities that are affected by fox predation"

15.9.7 THREAT ABATEMENT PLAN FOR PREDATION BY FERAL CATS

The goal of this TAP is to minimise predation of native species by feral cats (*Felis catus*).

Feral cats are found throughout all habitats in mainland Australia and Tasmania and on some offshore islands. They are known to have a devastating effect on native fauna, predominantly from predation but also through competition and disease transmission (DoE, 2015).

Objectives and actions under the TAP

The TAP sets out four objectives to achieve the goal, they are:

- Effectively control feral cats in different landscapes
- Improve effectiveness of existing control options for feral cats
- Develop or maintain alternative strategies for threatened species recovery
- Increase public support for feral cat management and promote responsible cat ownership

A set of actions have been identified to help achieve the objectives of the TAP. There are nine actions to improve the control of feral cats in different landscapes which relate to further research and development of current and new feral cat control options, improving understanding of the interactions between feral cats and other predators, and development of Code of Practice and/or Standard Operating Procedures for new tools.

There are four actions to improve the effectiveness of existing feral cat control options which relate to understanding how best to encourage land managers to include cat management programs within their activities, providing information regarding best practice methods and standard operating procedures, and implementing a consistent regulatory approach across all state and territory governments.

There are five actions to support the investigation of alternative strategies for threatened species recovery which include eradicating or controlling cats in priority areas, implementing or improving biosecurity measures in cat-free areas, and creating fenced reserves to support the recovery of threatened species.

There are four actions to increase public support for cat management which relate to increasing awareness and understanding about:

- The threat to biodiversity posed by cats
- The need for responsible cat ownership
- The containment of cats where their roaming may impact priority areas

RELEVANCE OF THE TAP TO THE PLAN

Total eradication of feral cats is not currently feasible and cat control is an ongoing issue across Australia. Current control programs focus on long-term management and suppression of feral cat populations.

Existing land use within the nominated areas and surrounding region includes residential areas and farming, which means cats are unlikely to pose a novel threat to native fauna in the area. However, the extent of proposed new urban development under the Plan means the threat is likely to be exacerbated. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is low.

The Plan includes a commitment to manage indirect impacts due to the development under the Plan, including to restrict the keeping of domestic animals where there is unacceptable residual risk and ensure property boundaries have appropriate fencing to contain domestic animals within the landholders' property.

CONSISTENCY WITH THE TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 4, to "increase public support for feral cat management and promote responsible car ownership"

15.9.8 THREAT ABATEMENT PLAN FOR PREDATION, HABITAT DEGRADATION, COMPETITION AND DISEASE TRANSMISSION BY FERAL PIGS (*SUS SCROFA*)

The goal of this TAP is to prevent further species and ecological communities from becoming threatened or extinct due to the impacts of feral pigs.

Feral pigs are widespread throughout Australia and can affect threatened species and ecological communities by:

- Consuming threatened fauna species
- Destroying threatened flora species
- Altering ecological parameters such as plant species composition and succession, nutrient and water cycles, and water quality
- Changing the composition of threatened plant communities
- Altering soil structure
- Increasing the spread of weeds
- Spreading animal diseases such as leptospirosis, brucellosis and plant pathogens such as *Phytophthora cinnamomi*

OBJECTIVES AND ACTIONS UNDER THE TAP

The TAP sets out six objectives to achieve the goal, they are:

- Prioritise key species, ecological communities, ecosystems and locations across Australia for strategic feral pig management
- Encourage the integration of feral pig management into land management activities at regional, state and territory, and national levels
- Encourage further scientific research into feral pig impacts on nationally threatened species and ecological communities, and feral pig ecology and control
- Record and monitor feral pig control programs, so their effectiveness can be evaluated
- Build capacity for feral pig management and raise feral pig awareness amongst landholders and land managers
- Improve public awareness about feral pigs and the environmental damage and problems they cause, and the need for the feral pig control

A set of actions have been identified to help achieve the objectives of the TAP. There are two actions to support strategic feral pig management which include identifying priority species, ecological communities, ecosystems and locations for priority protection, and implementing control measures in these areas.

There is one action to support the integration of feral pig management into land management activities which relates to encouraging government departments and agencies, and regional groups, to integrate feral pig management into their land management activities.

There are four actions to encourage further scientific research into feral pig impacts which include undertaking more research into:

- Feral pig impacts
- Feral pig population dynamics and ecology
- Special and temporal use of landscapes by feral pigs
- The effectiveness of feral pig control methods

There are three actions to evaluate the effectiveness of feral pig control programs which relate to developing better monitoring techniques and encouraging centralised recording of feral pig control actions.

There are two actions to raise feral pig awareness amongst landholders and land managers which relate to increased delivery of training programs to build feral pig management skills and improve the understanding of special impediments to feral pig control.

There are two actions to improve public awareness about feral pigs which include developing a public education program about feral pigs and the environmental damage and problems they could cause.

RELEVANCE OF THE TAP TO THE PLAN

Feral pigs are widely established in Australia and it is not currently possible to completely eradicate them (DoEE, 2017).

The Plan has the potential to exacerbate the threat of feral pigs to some extent, and includes a commitment to manage priority pest animals in strategic locations in the Cumberland Subregion to reduce threats to land within the SCAs.

CONSISTENCY WITH THE TAP

The Plan is not inconsistent with the TAP on the basis that:

- The Plan will not prevent any of the actions of the TAP from being implemented
- The measures under the Plan are consistent with the intent behind the actions to deliver on Objective 2, to "encourage the integration of feral pig management into land management activities at regional, state and territory, and national levels"

16 Adaptive management for addressing uncertainty

This Chapter:

- Discusses what is adaptive management and why it is important
- Sets out the regulatory requirements for adaptive management under the BAM and ToR
- Identifies key uncertainties and risks in implementation
- Describes the Plan's approach to adaptive management
- Assesses the adequacy of the Plan's approach to adaptive management

The analysis in this Chapter is supported by the detailed evaluation of the Plan in Part 7.

16.1 WHAT IS ADAPTIVE MANAGEMENT AND WHY IS IT IMPORTANT

Adaptive management is a process for improving management practices through learning from the outcomes of previous management (DSEWPC, 2011). It is based on information derived from monitoring and can be applied anywhere uncertainty in management exists. Adaptive management typically involves the following steps:

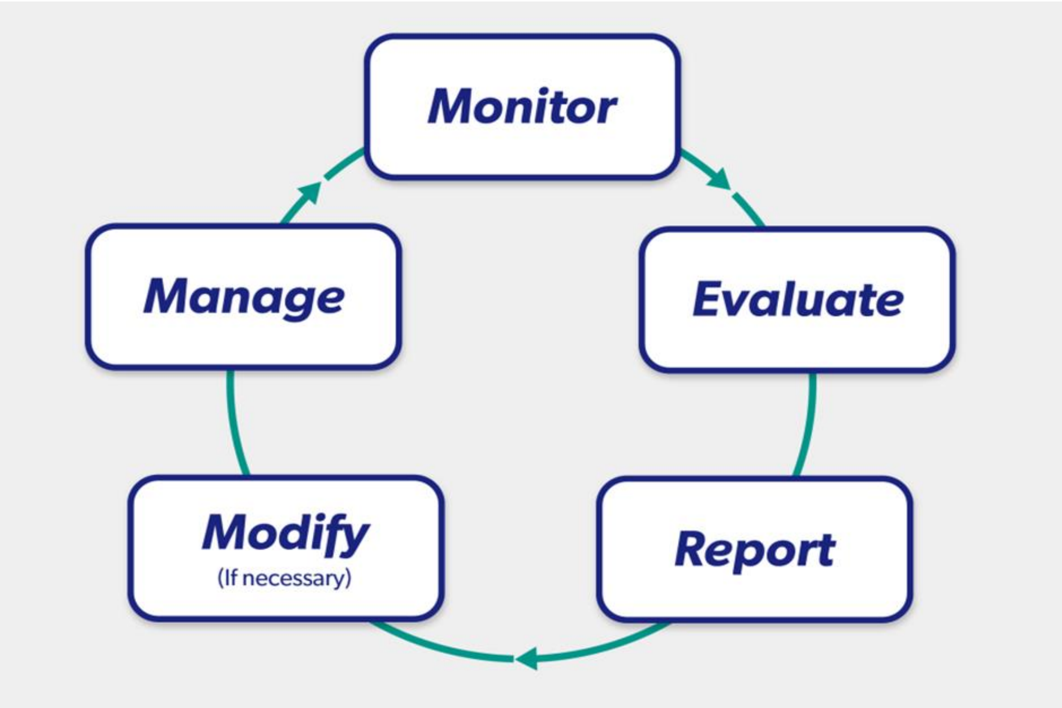


Figure 16-1: Adaptive management steps (taken from Sub-Plan B)

Adaptive management is an essential part of the implementation framework for strategic assessments. It is important because:

- The scale and complexity of strategic assessments means that there may be uncertainty relating to some impacts during the assessment process that need to be addressed during implementation
- The timeframes for strategic assessments are long and implementing agreed outcomes will be subject to a range of uncertainties over the life of the Plan
- Factors relating to the environment are likely to change over the life of a strategic assessment and an adaptive approach to management will be important for achieving the Plan's outcomes
- Changes to State and Commonwealth legislation, policies, plans and advice will occur over the life of the Plan

Providing a process to address uncertainty and deal with changing circumstances during the life of the Plan is therefore critical.

16.2 REGULATORY REQUIREMENTS

The BAM and ToR both require the Assessment Report to demonstrate how uncertainty will be addressed through adaptive management during implementation.

The BAM applies a narrower focus around just dealing with uncertain impacts, while the ToR has a broader focus on addressing uncertainty across all elements of implementation (including conservation commitments and actions).

16.2.1 BC ACT REQUIREMENTS

BAM

Section 9.4 of the BAM requires the BCAR to outline the adaptive management strategy proposed for minimising impacts that are uncertain. The BAM identifies the following impacts on biodiversity that are uncertain:

- Impacts related to damage to karst, caves, crevices, cliffs and other geological features of significance
- Impacts related to subsidence and upsidence resulting from underground mining
- Impacts related to wind turbine strikes
- Impacts related to vehicle strikes

Impacts related to vehicle strikes is the only relevant consideration for development within the nominated areas. Mining and the construction of wind turbines are not within the scope of the project and are not considered further.

Chapter 24 (Prescribed Biodiversity Impacts) examines the potential for impacts related to karst, caves, crevices, cliffs and other geological features of significance. It concludes that impacts to these features will not occur within the nominated areas and it is therefore not considered further in this chapter.

GUIDELINES

In addition to the BAM, the draft *Guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification* (version 6) provide a set of guiding principles for demonstrating that commitments and actions proposed for a strategic biodiversity certification adequately address impacts on biodiversity values.

The last principle relates to certainty of implementation and requires that:

> *"Principle 8 – The delivery of conservation measures is timely and certain"*

16.2.2 EPBC ACT REQUIREMENTS

Section 6 of the ToR requires the SAR to identify key uncertainties and risks associated with implementing the Plan, and describe and assess the adequacy of the procedures proposed in the Plan to ensure an adaptive approach to implementation of the Plan.

The relevant ToR are:

> *6.1 The Report must identify key uncertainties and risks associated with implementing the Plan, responses to these and proposed adaptations to changing circumstances. Key uncertainties may include:*
>
> - *Knowledge gaps in scientific understanding and responding to new knowledge.*
> - *Assumptions made in assessing potential impacts and benefits.*
> - *How changes to State and Commonwealth legislation, policies, plans and advice is to be accounted for in the management of the areas impacted by the Plan.*
> - *Effectiveness or capacity to ensure the Plan is implemented.*
>
> *6.2 The Report must describe and assess the adequacy of the procedures proposed in the Plan to ensure an adaptive approach to implementation of the Plan. This must include:*
>
> 1. *How the results of monitoring will be used to understand the effectiveness of conservation outcomes for protected matters and improve implementation.*

2. *How new information relating to protected matters and biodiversity, including legislative changes, may be assessed and accounted for in implementation of the Plan.*

16.3 KEY UNCERTAINTIES AND RISKS IN IMPLEMENTATION

The ToR (Clause 6.1) provide a framework for identifying the key uncertainties and risks in implementation. This framework includes BAM requirements around uncertain impacts and is addressed below.

16.3.1 KNOWLEDGE GAPS IN SCIENTIFIC UNDERSTANDING AND RESPONDING TO NEW KNOWLEDGE

KNOWLEDGE GAPS IN SCIENTIFIC UNDERSTANDING

There are two key types of gaps in scientific understanding relevant to the assessment:

- Data gaps
- Gaps in understanding of ecological processes

Data gaps

Data gaps for this assessment can be defined as a lack of information about a particular element of the environment. For example, presence or absence information for a threatened species at a particular site may not be available at the time required.

Given the large spatial scale of the Plan, it is not possible to have perfect information about the environment and some level of uncertainty in data is inherent in the project. However, the requirements of the BAM and the ToR define what is an acceptable level of data to understand the environment and to conduct the assessment. As outlined in Part 3, a comprehensive data set has been collected for the assessment which addresses the BAM and ToR.

The data that has been used in the assessment and any limitations are discussed in detail in:

- Chapter 13: Data and limitations
- Individual assessment chapters for protected matters

Understanding of ecological processes

Sufficient understanding of ecological processes is a key challenge for all environmental impact assessments. There is commonly a lack of information about issues such as:

- Species distribution
- Species habitat requirements
- Species population numbers and dynamics
- The effects of key threatening processes (e.g. climate change)
- The best approaches for minimising and mitigating potential impacts

The assessment addresses these uncertainties through:

- Gathering the best available information from scientific literature, expert knowledge, on-ground surveys
- Applying a precautionary approach to understanding and evaluating potential impacts. An analysis of the application of the precautionary principle is provided in Part 7

The Plan addresses uncertainty through its monitoring, evaluation and reporting (MER) framework combined with ongoing adaptive management.

RESPONDING TO NEW KNOWLEDGE

Given the long timeframe of the Plan, new knowledge about environmental issues will become available through:

- New scientific research
- Monitoring as part of implementation of the Plan

It will be critical that the Plan can consider this information and respond appropriately. The Plan's approach to this is discussed below in Section 16.4.

16.3.2 ASSUMPTIONS MADE IN ASSESSING POTENTIAL IMPACTS AND BENEFITS

One of the key risks in environmental impact assessment is making incorrect assumptions about the nature of potential impacts and benefits of a project. In particular, it is important that the consequences of potential impacts are not understated and the benefits of conservation measures are not overstated.

To address this risk, the assessment report takes a precautionary approach to identifying and analysing impacts and benefits. For example, the habitat mapping for threatened species generally overestimates the amount of habitat in the Plan Area which means the impacts that are assessed are likely to be larger than what will ultimately occur on the ground.

The assumptions made in assessing potential impacts and benefits are:

- Outlined in Part 3 – Assessment Approach which describes the methods used in the assessment
- Set out in relation to each protected matter in the individual assessment chapters

The application of the precautionary principle to the assessment is evaluated in Part 7.

16.3.3 HOW CHANGES TO STATE AND COMMONWEALTH LEGISLATION, POLICIES, PLANS AND ADVICE IS TO BE ACCOUNTED FOR IN THE MANAGEMENT OF THE AREAS IMPACTED BY THE PLAN

Given the long timeframes of the Plan, changes to legislation, policies, plans and advice are inevitable. These changes may lead to risks around:

- Implementation processes. For example, changes to State planning policies may affect the approaches to addressing indirect impacts
- Conservation priorities for threatened species and ecological communities. For example, changes to a Conservation Advice may provide new information about the key threats to a species and the recommended mitigation strategies
- Compliance. For example, changes to legislation may have implications for compliance under what would then be an approval under outdated legislation

The Plan addresses these risks through:

- Clearly establishing outcomes and commitments that will be delivered despite any changes to legislation, policies, plans and advice
- Its approach to MER and adaptive management (discussed below in Section 16.4) which will provide a way of responding to any changes to legislation, policies, plans and advice

16.3.4 EFFECTIVENESS OR CAPACITY TO ENSURE THE PLAN IS IMPLEMENTED

Effective implementation is particularly important for strategic assessments because of the size and complexity of the programs, the long timeframes over which they are implemented, the number of stakeholders and the diversity of their interests, the amount of money the programs cost, and the complexity of the legal frameworks they operate within.

Lessons learnt from other strategic assessments around Australia suggest that effective implementation requires:

- Clear and feasible outcomes that the Plan will deliver
- Clarity about the delivery framework and mechanisms to implement the Plan
- Appropriate flexibility within the Plan to ensure it remains relevant over time
- Clear governance arrangements, including certain funding
- Comprehensive processes to monitor and report on implementation, and adapt implementation as needed

The Plan has been designed to address these issues. A detailed evaluation of the implementability of the Plan is provided in Chapter 41.

16.4 THE PLAN'S APPROACH TO ADAPTIVE MANAGEMENT

The Plan includes a commitment (Commitment 27) to "implement an evaluation program for the Plan that sets out requirements for monitoring, evaluation, reporting and adaptive management". The approach to adaptive management is set out in Sub-Plan A. The approach is designed around:

- Clearly defining outcomes through program logic
- Undertaking regular data collection/monitoring to track progress
- Completing regular evaluations to investigate cause and effect, efficiency and effectiveness, and test assumptions
- Establishing programs of research to test and improve management interventions

Adaptive management will be applied across the entire conservation program. It will use the data sourced through monitoring and the findings of program evaluation to determine if actions need to be revised to more-effectively deliver the Plan's commitments (and consequently the Plan's outcomes). Evaluations will consider any new information that becomes available over the life of the Plan (in addition to monitoring data). Information about the Plan's approach to MER is provided in Part 2 and evaluated in Part 7.

Where evaluation suggests a commitment is not tracking as planned, it will trigger a review and potential modification to the required action or delivery of action. This process will include delivery partners as appropriate.

Changes to actions may be made in the case that:

- Targets are not being met
- The program logic does not adequately translate into the desired outcomes (i.e. the commitments are not leading to the outcomes as anticipated)
- External factors arise that affect the assumptions, logic or delivery of the Plan. This may relate to large-scale changes (e.g. unpredicted climate variation) or smaller scale changes (e.g. local events such as fires, floods or disease)

One particularly important part of the adaptive management process will be a series of adaptive management steps that will be triggered in the case that biodiversity offsets are not secured in line with development impacts. Where the total amount of secured offsets is less than 80 per cent of the offset liability at a point in time, the following remediation actions will be considered:

- Encourage uptake of conservation lands by:
  - Incentivising landowners to enter into Biodiversity Stewardship Agreements
  - Engaging with the community and landowners
  - Working with delivery partners to strengthen the effectiveness of the Biodiversity Stewardship Agreement and reserve programs
- Invest in active restoration technologies and projects
- Manage for new and emerging threats to biodiversity
- Undertake research to better understand how species and communities respond to change, and implement relevant management practices
- Review data needs and update conservation priority mapping as required

16.5 ADEQUACY OF THE PLAN'S APPROACH TO ADAPTIVE MANAGEMENT

The Plan's approach to adaptive management is considered appropriate because:

- There is a clear commitment in the Plan to take an adaptive approach to ensure the outcomes and commitments are delivered
- The approach addresses the key uncertainties and risks in implementation of the Plan
- The approach is supported by:
  - Clear processes and steps as part of the MER framework
  - The broader governance arrangements of the Plan which identify roles and responsibility for implementation
  - Commitments to fund implementation of the Plan

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 4: ATTACHMENT

ATTACHMENT A - INDIRECT IMPACTS RELEVANT TO EACH SPECIES AND TEC

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 4 Attachment Contents

Part 4 Attachment List of Tables

A. Indirect impacts relevant to each species and TEC

Identification of indirect impacts relevant to each matter is presented in:

- Table A-1 – NSW and Commonwealth-listed threatened fauna
- Table A-2 – NSW and Commonwealth-listed threatened flora
- Table A-3 – NSW and Commonwealth-listed TECs

Table A-1: Potential indirect impacts which may affect threatened fauna

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
BIRDS														
Anthochaera phrygia	Regent Honeyeater	CE	CE	ECS SCS				✓		✓	✓			✓
Artamus cyanopterus cyanopterus	Dusky Wood-swallow	N/A	V	ECS				✓						
Botaurus poiciloptilus	Australasian Bittern	E	E	ECS	✓			✓	✓	✓				
Calidris canutus	Red Knot	E Mig.	N/A	N/A	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Calidris ferruginea	Curlew Sandpiper	CE Mig.	N/A	ECS	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Callocephalon fimbriatum	Gang-gang Cockatoo	N/A	V	ECS SCS				✓						

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
Calyptorhynchus lathami	Glossy Black-cockatoo	N/A	V	ECS SCS				✓		✓				✓
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	V Mig.	V	N/A	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Chthonicola sagittata	Speckled Warbler	N/A	V	ECS				✓	✓					
Circus assimilis	Spotted Harrier	N/A	V	ECS								✓		✓
Climacteris picumnus victoriae	Brown Treecreeper	N/A	V	ECS				✓						✓
Daphoenositta chrysoptera	Varied Sittella	N/A	V	ECS				✓		✓				
Ephippiorhyn-chus asiaticus	Black-necked Stork	N/A	E	ECS	✓									
Epthianura albifrons	White-Fronted Chat	N/A	V	ECS	No relevant threats to bioregional persistence identified. The species is wide-ranging and habitat is away from areas that could be impacted									
Glossopsitta pusilla	Little Lorikeet	N/A	V	ECS				✓		✓				✓
Grantiella picta	Painted Honeyeater	V	V	ECS						✓				✓
Haliaeetus leucogaster	White-bellied Sea-Eagle	N/A	V	ECS SCS							✓	✓		✓

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
Hieraaetus morphnoides	Little Eagle	N/A	V	ECS SCS								✓		✓
Hirundapus caudacutus	White-throated Needletail	V	N/A	N/A	As discussed in the Migratory Species Impact Assessment – Chapter 32, the species is known to forage above a wide range of habitats and is unlikely to be disrupted or displaced by development									
Irediparra gallinacea	Comb-crested Jacana	N/A	V	ECS	✓				✓					
Ixobrychus flavicollis	Black Bittern	N/A	V	ECS					✓					✓
Lathamus discolor	Swift Parrot	CE	E	ECS SCS					✓	✓		✓		
Limicola falcinellus	Broad-billed Sandpiper	N/A	V	ECS	No relevant threats to bioregional persistence identified. There are no records in the subregion and habitat is away from areas that could be impacted									
Limosa lapponica baueri	Bar-tailed Godwit	V Mig.	N/A	N/A	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Limosa limosa	Black-tailed Godwit	Mig.	V	ECS	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Lophoictinia isura	Square-tailed kite	N/A	V	ECS SCS								✓		✓
Melanodryas cucullata cucullata	Hooded Robin	N/A	V	ECS					✓		✓			

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
Melithreptus gularis gularis	Black-chinned Honeyeater	N/A	V	ECS				✓		✓				✓
Neophema pulchella	Turquoise Parrot	N/A	V	ECS				✓	✓	✓				✓
Ninox connivens	Barking Owl	N/A	V	ECS SCS										✓
Ninox strenua	Powerful Owl	N/A	V	ECS SCS					✓	✓				✓
Numenius madagascariensis	Eastern Curlew	CE Mig.	N/A	N/A	As discussed in the Migratory Species Impact Assessment – Chapter 32, there are no important habitat areas for the species which are at risk of indirect impacts from development under the Plan									
Pandion cristatus	Eastern Osprey	N/A	V	ECS	No relevant threats to bioregional persistence identified. The species prefers coastal areas and habitat is away from areas that could be impacted									
Petroica boodang	Scarlet Robin	N/A	V	ECS				✓	✓					
Petroica phoenicea	Flame Robin	N/A	V	ECS				✓						
Rostratula australis	Australian Painted Snipe	E	E	ECS	✓			✓	✓	✓				
Stagonopleura guttata	Diamond Firetail	N/A	V	ECS				✓						
Stictonetta naevosa	Freckled Duck	N/A	V	ECS	✓									
Tyto novaehollandiae	Masked Owl	N/A	V	ECS SCS										✓

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
MAMMALS														
Cercartetus nanus	Eastern Pygmy-possum	N/A	V	SCS					✓	✓		✓		
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	SCS					✓	✓	✓			
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll	E	V	ECS					✓	✓		✓		
Falsistrellus tasmaniensis	Eastern False Pipistrelle	N/A	V	ECS										✓
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	N/A	V	ECS						✓			✓	✓
Miniopterus australis	Little Bent-winged Bat	N/A	V	ECS					✓	✓	✓			✓
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	N/A	V	ECS					✓	✓	✓			
Myotis macropus	Southern Myotis	N/A	V	SCS	✓						✓			
Petauroides volans	Greater Glider	V	N/A	N/A			✓			✓				

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
Petaurus australis	Yellow-Bellied Glider	N/A	V	ECS										✓
Petaurus norfolcensis	Squirrel Glider	N/A	V	SCS						✓		✓		✓
Phascolarctos cinereus	Koala*	V	V	ECS SCS			✓		✓	✓	✓	✓		
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	ECS							✓			✓
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	N/A	V	ECS							✓			✓
Scoteanax rueppellii	Greater Broad-nosed Bat	N/A	V	ECS							✓			✓
REPTILES														
Hoplocephalus bungaroides	Broad-headed Snake	V	E	ECS					✓	✓	✓	✓		✓
Varanus rosenbergi	Rosenberg's Monitor	N/A	V	ECS					✓					✓
AMPHIBIANS														
Heleioporus australiacus	Giant Burrowing Frog	V	V	SCS	✓		✓		✓	✓		✓		

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance	Fauna mortality / barriers to movement	Fauna disturbance due to noise, dust or light	Inadvertent impacts on adjacent habitat
Litoria aurea	Green and Golden Bell Frog	V	E	SCS	✓		✓		✓	✓	✓	✓		
Pseudophryne australis	Red-crowned Toadlet	N/A	V	SCS	✓					✓	✓			✓
INVERTEBRATES														
Meridolum corneovirens	Cumberland Plain Land Snail	N/A	E	SCS		✓		✓		✓	✓			✓
Pommerhelix duralensis	Dural Land Snail	E	E	N/A				✓		✓				
FISH														
Macquaria australasica	Macquarie Perch	E	N/A	N/A	✓					✓	✓			

* The Koala is assessed in further detail in Chapter 30

Table A-2: Potential indirect impacts which may affect threatened flora

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	V	E	SCS				✓		✓	✓
Acacia pubescens	Downy Wattle, Hairy Stemmed Wattle	V	V	SCS				✓		✓	✓
Allocasuarina glareicola		E	E	SCS				✓		✓	✓
Commersonia prostrata	Dwarf Kerrawang	E	E	N/A	No relevant threats to bioregional persistence identified. Areas of mapped habitat occur away from the urban capable land and transport corridors						
Cynanchum elegans	White-flowered Wax Plant	E	E	N/A	✓			✓		✓	
Deyeuxia appressa		E	E	N/A	No relevant threats to bioregional persistence identified. Areas of mapped habitat occur away from the urban capable land and transport corridors						
Dillwynia tenuifolia		N/A	V	SCS				✓		✓	✓
Epacris purpurascens var. *purpurascens*		N/A	V	SCS	✓			✓		✓	✓
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	V	V	SCS	✓	✓	✓	✓		✓	
Genoplesium baueri	Yellow Gnat-orchid	E	E	N/A							✓

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	N/A	V	SCS			✓	✓		✓	✓
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	ECS				✓		✓	✓
Hibbertia fumana		N/A	CE	SCS				✓		✓	✓
Hibbertia puberula		N/A	E	SCS				✓			✓
Hibbertia puberula subsp. *glabrescens*		CE	N/A	N/A	No relevant threats to bioregional persistence identified. Areas of mapped habitat occur away from the urban capable land and transport corridors						
Leucopogon exolasius	Woronora Beard-heath	V	V	N/A				✓		✓	
Marsdenia viridiflora subsp. *viridiflora*		N/A	E	SCS						✓	✓
Maundia triglochinoides		N/A	V	SCS	✓			✓			✓
Melaleuca deanei	Deane's Melaleuca	V	V	SCS				✓		✓	✓
Micromyrtus minutiflora		V	E	SCS				✓		✓	✓

Scientific name	Common name	Cth status	NSW status	BAM species type	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance
Persicaria elatior	Tall Knotweed	V	V	SCS	✓			✓			✓
Persoonia bargoensis	Bargo Geebung	V	E	SCS			✓			✓	✓
Persoonia glaucescens	Mittagong Geebung	V	E	N/A	No relevant threats to bioregional persistence identified. Areas of mapped habitat occur away from the urban capable land and transport corridors						
Persoonia hirsuta	Hairy Geebung, Hairy Persoonia	E	E	N/A	✓		✓	✓		✓	✓
Persoonia nutans	Nodding Geebung	E	E	SCS			✓	✓		✓	✓
Pimelea curviflora var. *curviflora*		V	V	SCS				✓		✓	✓
Pimelea spicata	Spiked Rice-flower	E	E	SCS	✓	✓		✓		✓	✓
Pomaderris brunnea	Rufous Pomaderris	V	E	SCS	✓	✓		✓		✓	✓
Pterostylis saxicola	Sydney Plains Greenhood	E	E	SCS				✓		✓	✓
Pultenaea parviflora		V	E	SCS				✓		✓	✓
Pultenaea pedunculata	Matted Bush-pea	N/A	E	SCS				✓		✓	✓

Table A-3: Potential indirect impacts which may affect TECs

Threatened Ecological Community name	Cth status	NSW status	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	E	N/A			✓	✓	✓	✓	✓
Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion	N/A	V			✓	✓	✓	✓	✓
Coastal Floodplain Eucalypt Forest of Eastern Australia (used to be river-flat eucalypt forest on coastal floodplains of New South Wales	FPAL	N/A	✓	✓	✓	✓	✓	✓	✓
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	E	N/A	✓		✓	✓	✓	✓	✓
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	CE	N/A	✓		✓	✓	✓	✓	✓
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	N/A	E	✓		✓	✓	✓	✓	✓
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	N/A	✓	✓	✓	✓	✓	✓	✓
Cumberland Plain Woodland in the Sydney Basin Bioregion	N/A	CE	✓	✓	✓	✓	✓	✓	✓
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	CE	N/A	✓						
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	N/A	E	✓			✓	✓		✓
Moist Shale Woodland in the Sydney Basin Bioregion	N/A	E	✓			✓	✓	✓	✓

Threatened Ecological Community name	Cth status	NSW status	Hydrology / soil disturbance	Ground subsidence	Spread of infection / disease	Spread of weeds	Pest / domestic animals	Altered fire regimes	Increased public access / disturbance
River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	N/A	E	✓	✓	✓	✓	✓	✓	✓
Shale Gravel Transition Forest in the Sydney Basin Bioregion	N/A	E			✓	✓	✓	✓	✓
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE	N/A	✓		✓	✓	✓	✓	✓
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	N/A	CE	✓			✓	✓	✓	✓
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	N/A	E	✓		✓	✓	✓	✓	✓
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	CE	N/A	No relevant threats to bioregional persistence identified. Areas of mapped TEC occur away from the urban capable land and transport corridors and implementation of the Plan will not exacerbate these threats						
Western Sydney Dry Rainforest and Moist Woodland on Shale	CE	N/A	✓		✓	✓	✓	✓	✓

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 5A: BCAR STAGE 1 (BIODIVERSITY ASSESSMENT)

CHAPTER 17 – INTRODUCTION

CHAPTER 18 – LANDSCAPE FEATURES AND SITE CONTEXT

CHAPTER 19 – NATIVE VEGETATION

CHAPTER 20 – THREATENED ECOLOGICAL COMMUNITIES

CHAPTER 21 – THREATENED SPECIES AND HABITAT

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 5A Contents

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17 Introduction

This Part describes the existing biodiversity values within the nominated areas for matters listed under the *Biodiversity Conservation Act 2016* (BC Act) in accordance with the Biodiversity Assessment Method (BAM), including:

- Landscape features and site context
- Native vegetation, including native vegetation extent, type and condition
- NSW listed Threatened Ecological Communities (TECs)
- NSW listed threatened species and habitat

The BAM uses the term Subject Land to mean land to which the BAM is applied in Stage 1 to assess the biodiversity values of the land, including land within urban capable land or proposed for biodiversity certification. In this Assessment Report, the terms 'nominated areas' and 'urban capable land' are used instead of the term Subject Land.

18 Landscape features and site context

This Chapter provides an assessment of the landscape features and site context of the nominated areas in accordance with section 4 of the BAM, including:

- Interim Biogeographic Regionalisation of Australia (IBRA) bioregions and subregions
- Native vegetation extent – buffer area
- NSW (Mitchell) Landscapes
- Rivers and streams
- Wetlands
- Habitat connectivity and fragmentation
- Areas of geological significance and soil hazards
- Areas of outstanding biodiversity value
- Site context

These landscape features are shown in the site and location maps for each nominated area:

- Wilton: Figure 18-1 (site map) and Map 10.1 (location map)
- GMAC: Figure 18-2 (site map) and Map 10.2 (location map)
- WSA: Figure 18-3 (site map) and Map 10.3 (location map)
- GPEC: Figure 18-4 (site map) and Map 10.4 (location map)

18.1 IBRA BIOREGIONS AND SUBREGIONS

The nominated areas occur within the Sydney Basin IBRA bioregion (version 7) and the Cumberland and Cataract subregions. The percentages of each subregion within each nominated area is shown in Table 18-1.

Table 18-1: Per cent of nominated areas representing each subregion

Nominated area	Subregion	Per cent of nominated area within each subregion
Wilton Growth Area (Wilton)	Cumberland	98.46
	Sydney Cataract	1.54
Greater Macarthur Growth Area (GMAC)	Cumberland	96.45
	Sydney Cataract	3.55
Western Sydney Aerotropolis (WSA)	Cumberland	100.00

Nominated area	Subregion	Per cent of nominated area within each subregion
Greater Penrith to Eastern Creek Growth Area (GPEC)	Cumberland	100.00

The Sydney Basin bioregion lies on the central east coast of NSW and covers an area of approximately 3,624,008 hectares. It occupies about 4.53 per cent of NSW and is one of three bioregions contained wholly within the State.

The Sydney Basin bioregion extends from just north of Batemans Bay to Nelson Bay on the lower North Coast, and west to Merriwa. It is bordered to the north mostly by the NSW North Coast and Brigalow Belt South bioregions, to the south by the South East Corner bioregion and to the west by the South Eastern Highlands and NSW South Western Slopes bioregions. The bioregion is one of the most species-diverse in Australia (OEH, 2016).

The Cumberland subregion geology is dominated by Triassic age Wianamatta Group shales and lithic sandstones. Quaternary alluvium occurs along the main streams and a large plume of Tertiary-era sandy and gravelly alluvium occurs in the northern end between Wianamatta (South Creek) and the Nepean/Hawkesbury River. The characteristic landform is low rolling hills and wide valleys within a rain shadow area between the Blue Mountains and the coast. There are also swamps and lagoons on the floodplain of the Nepean and Hawkesbury Rivers and major creeks including Wianamatta (South Creek).

Typical soils of the Cumberland subregion are red and yellow texture contrast soils on slopes, becoming harsher and sometimes affected by dryland salinity in tributary valley floors. There is uniform red to brown clays and poor uniform stony soils, often with texture contrast profiles on older gravels with high quality loams on modern floodplain alluvium (DPIE, 2019).

Characteristic landforms of the Cumberland subregion include low rolling hills and wide valleys in a rain shadow area below the Blue Mountains. At least three terrace levels are evident in the gravel splays which occur within the subregion. Swamps and lagoons occur on the floodplain of the Nepean River. Typical vegetation of the Cumberland subregion includes Grey Box, Forest Red Gum, Narrow-Leaved Ironbark woodland to open forest with some Spotted Gum on the shale hills. Hard-leaved Scribbly Gum, Narrow-leaved Apple and Old Man Banksia occur on alluvial sands and gravels. Broad-Leaved Apple, Cabbage Gum and Forest Red Gum with abundant Swamp Oak occur on low-lying flats. Tall Spike Rush, and *Juncus* sp. with Swamp Oak occur in lagoons and swamps (OEH, 2016).

The Sydney Cataract subregion occurring to the south east of Wilton and the east of GMAC is Triassic era geology with Hawkesbury Sandstone on the coastal edge of the Sydney Basin above the Illawarra escarpment. The characteristic landform is a sandstone plateau with shallow creeks flowing through hanging swamps in the highest parts, ramping down to low hills in the Georges River and Botany Bay. There are coastal cliffs north of the Illawarra and a large barrier system with beach, dunes, swamps, and estuary at the westernmost edge of Kurnell.

Typical soils of the Sydney Cataract subregion are deep sands and clayey sands with peat in hanging swamps, yellow earths on better drained sandstone ridges. Siliceous sands occur in younger dunes and well-developed podzols occur in older dunes.

Characteristic landforms of the Sydney Cataract include a sandstone plateau with shallow creeks flowing through hanging swamps in the highest part of the subregion, ramping down to low hills in the Georges River and Botany Bay areas. Coastal cliffs occur to the north of the Illawarra and a large barriers system with dunes, swamps and estuary occurs at Kurnell. Vegetation of the Sydney Cataract subregion is typically Red Bloodwood and Silvertop Ash Woodland with abundant shrubs on sandstone and extensive *Gahnia* and *Banksia* in hanging swamps. There is a coastal dune sequence of Tea-Tree, Coast Wattle, Smooth-Barked Apple, Blackbutt and Swamp Mahogany on the barrier system (OEH, 2016).

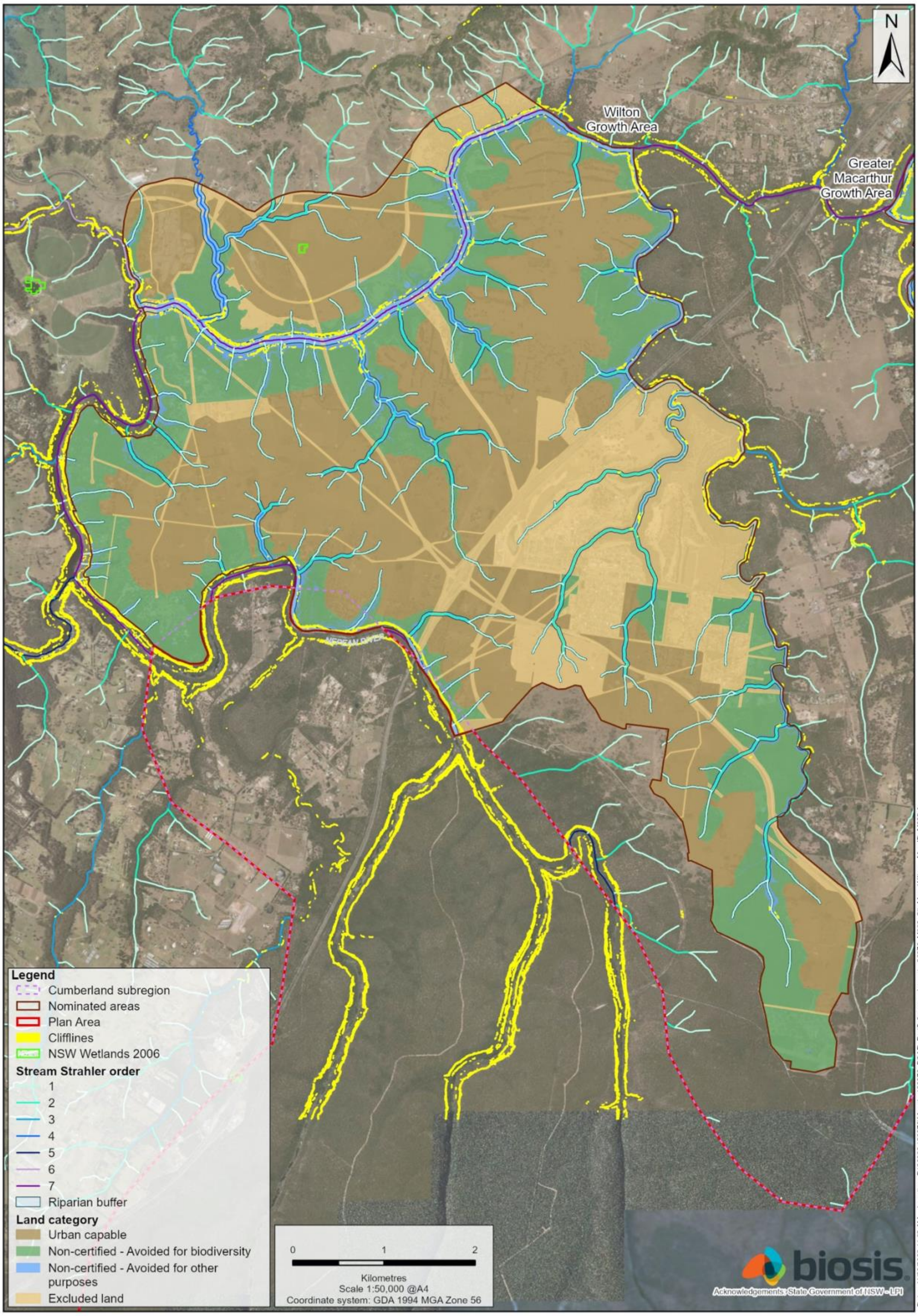

Figure 18-1: Site map – Wilton

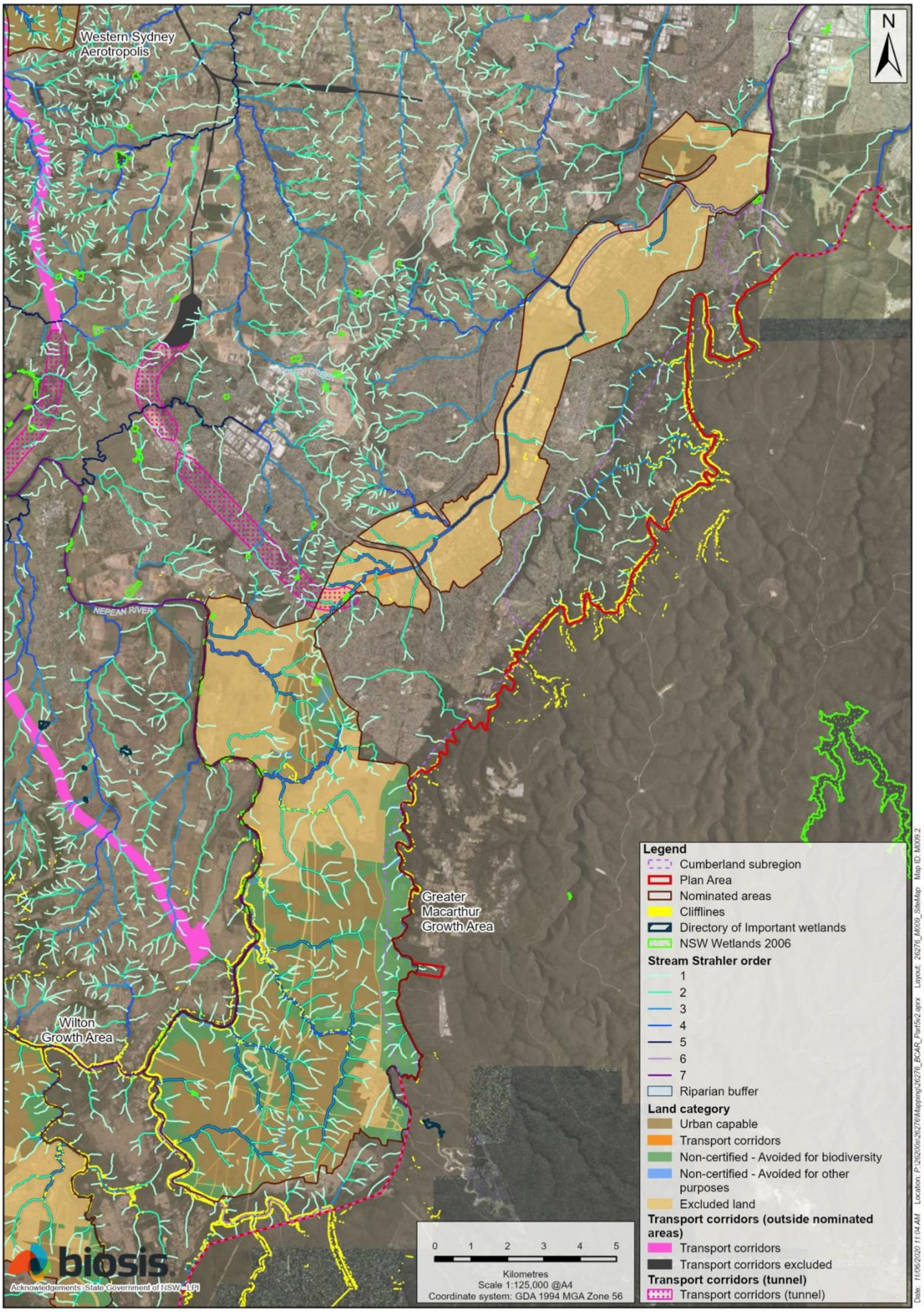

Figure 18-2: Site map – GMAC

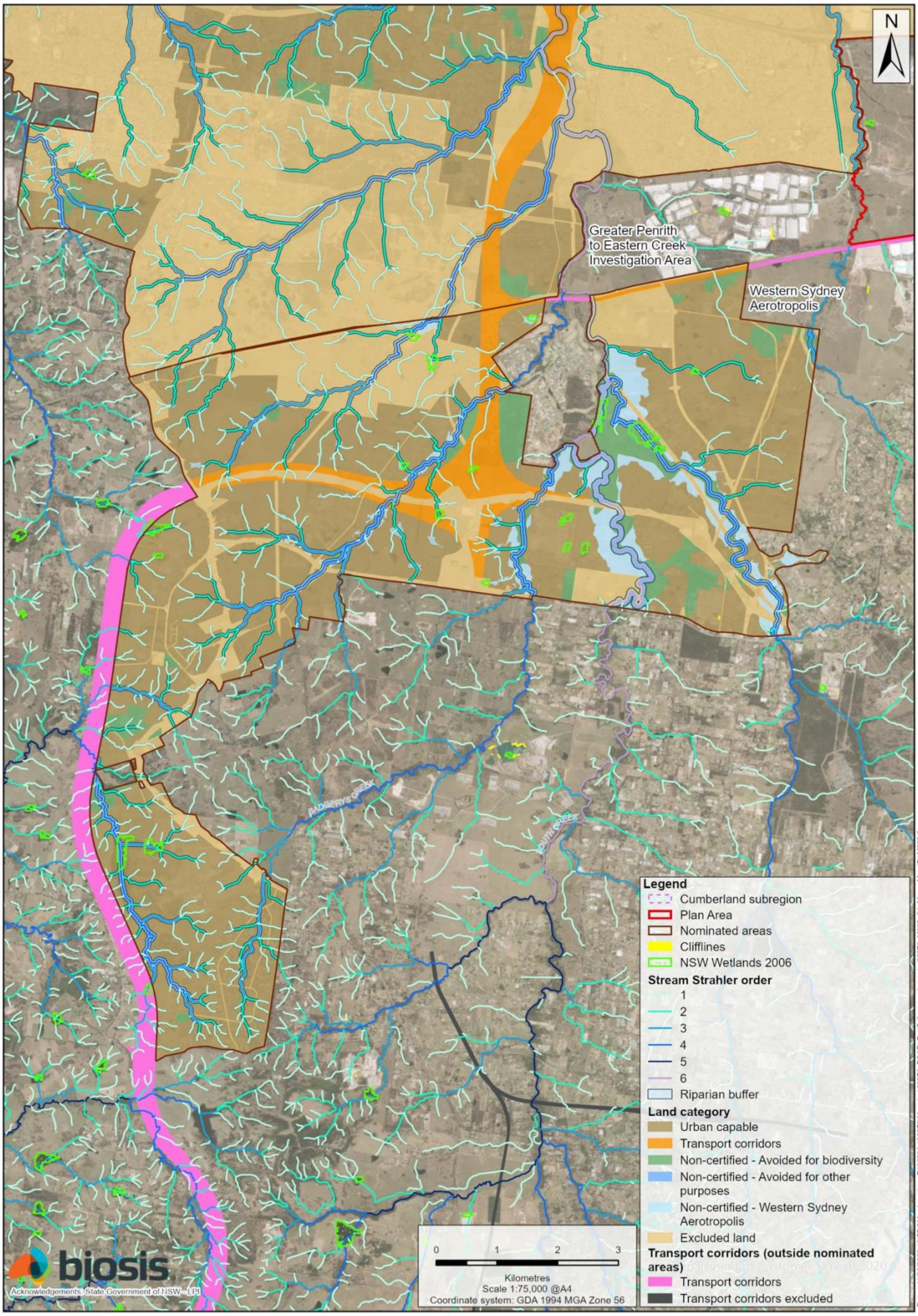

Figure 18-3: Site map – WSA

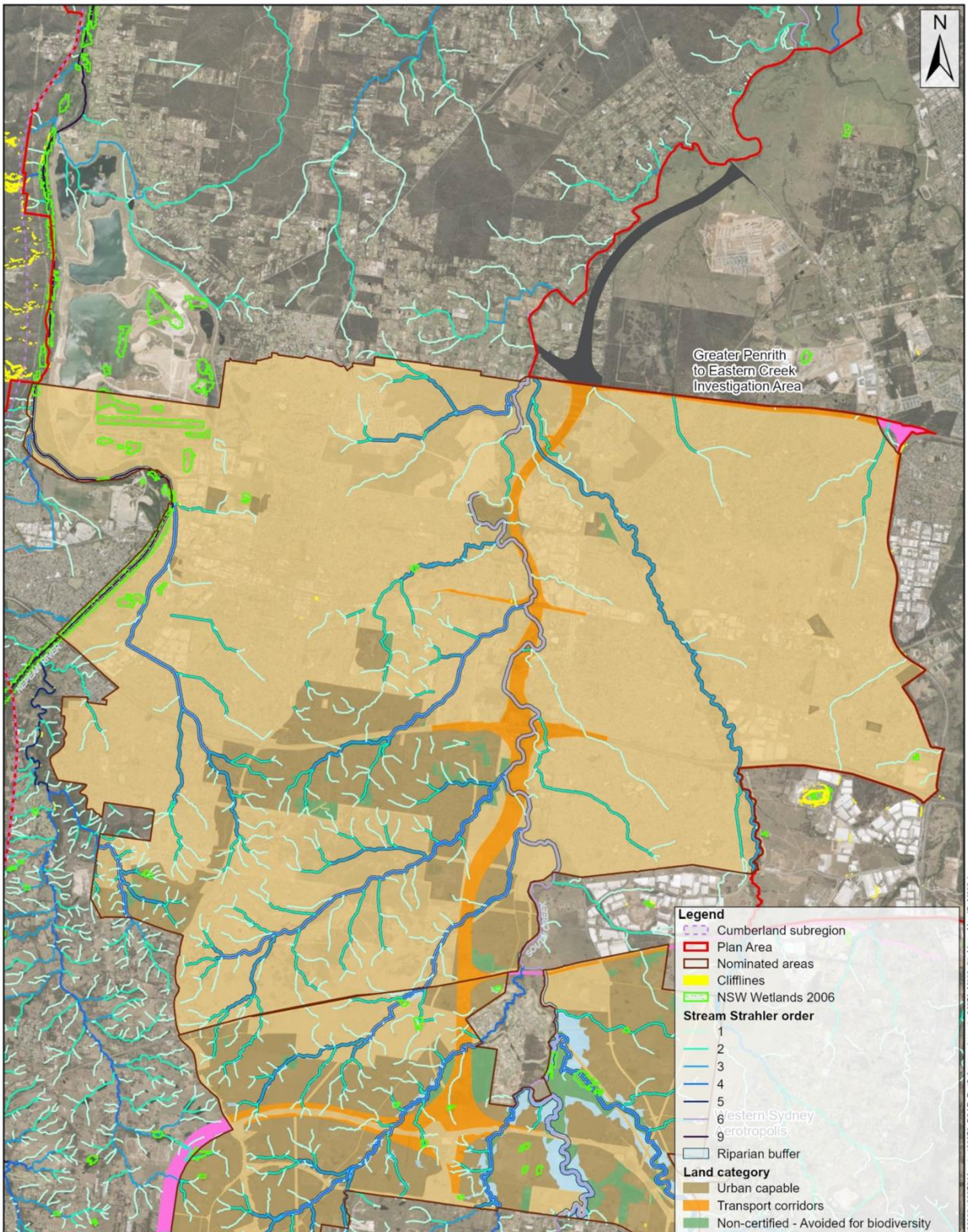

Figure 18-4: Site map – GPEC

18.2 NATIVE VEGETATION EXTENT – BUFFER AREA

Table 18-2 provides the percentage cover of native woody and derived grassland vegetation within the urban capable land of each nominated area, and the 1,500 m buffer. The vegetation mapping within the 1,500 m buffer was undertaken using existing vegetation mapping only, therefore the native vegetation extent for derived grasslands is likely to be under-represented.

Table 18-2: Native vegetation cover

Nominated area	Native vegetation extent (ha) (%)	Native vegetation extent (%) within urban capable land*		Native vegetation extent (%) within 1,500 m buffer*		
		Woody	Derived grasslands	Woody	Derived grasslands	Cover Class
Wilton	2,354 (58%)	11	28	55	7	>30-70%
GMAC	3,284 (30%)	11	3	40	1	>30-70%
WSA	901 (15%)	8	2	21	1	>10-30%
GPEC	3,255 (18%)	14	1	21	1	>10-30%

* Percentages rounded to whole numbers

18.3 NSW (MITCHELL) LANDSCAPES

NSW landscapes (also known as Mitchell Landscapes (Mitchell, 2002)) that occur within the nominated areas are described in Table 18-3. The landscape entered into the BAM calculator for each nominated area is the landscape in which most of the likely impacts within a nominated area occur, and is marked with an asterisk in the table.

Table 18-3: NSW (Mitchell) landscapes

NSW (Mitchell) landscape	Subregion	Nominated area	Area of landscape in nominated area (ha)	Description
Upper Nepean Gorges	Cataract	Wilton	1,476	The Upper Nepean Gorges landscape is characterised by steep-sided benched slopes of the Nepean River tributaries on Triassic age quartz sandstones, with elevation of 250 to 350 m and local relief of 80 m. The landscape has shallow, well-drained sands with limited development of yellow texture-contrast soils on benches underlain by clayey sandstone of thin shale units
		GMAC	1,433	
Picton-Razorback Hills	Cumberland and Cataract	Wilton	2,496*	The Picton-Razorback Hills landscape is a plateau ridge with steep slopes on horizontal upper Triassic shale, carbonaceous claystone, and lithic sandstone, subject to extensive earthflows on slopes above 120 m. General elevation is 180 to 300 m with local relief of 90 m. Soils are harsh, red, brown or yellow texture-contrast soils with reactive clay subsoils
		GMAC	3,127	
Cumberland Plain	Cumberland and Cataract	Wilton	109	The Cumberland Plain landscape is characterised by low, rolling hills and valleys in a rain shadow area between the Blue Mountains and the coast on horizontal Triassic shales and lithic sandstones forming a down-warped block on the coastal side of the Lapstone monocline. It is partly covered by Tertiary river gravels and sands (Hawkesbury-Nepean Terrace Gravels landscape). Quaternary alluvium occurs along the mains streams. General elevation is 30 to 120 m, with local relief of 50 m. The landscape is sometimes affected by dryland salinity in tributary valley floors. Soils are pedal uniform red to brown clays on volcanic hills, and red and brown texture-contrast soils on crests grading to yellow harsh texture-contrast soils in valleys
		GMAC	3,810*	
		WSA	5,361*	
		GPEC	14,499*	
Hawkesbury - Nepean Channels and Floodplains	Cumberland	GMAC	450	The Hawkesbury –Nepean Channels and Floodplains landscape is a meandering channel and moderately wide floodplain of the Hawkesbury and Nepean rivers on Quaternary sand and gravel. Sand is dominant upstream of the Warragamba River junction with general elevation 0 to 20 m and local relief of less than 10 m. Soils are characterised as undifferentiated alluvial sand to poorly structured gradation profiles of sandy loam or clay loam
		WSA	873	
		GPEC	3,347	
Woronora Plateau	Cataract and Cumberland	GMAC	353	The Woronora Plateau landscape is an extensive plateau developed on Triassic quartz sandstone with benched, low angle slopes and a marked break to steep sided, deep valleys controlled by joint patterns. General elevation is 400 to 500 m with local relief of 100 m. There are small areas of nodular ironstone on ridge crests, with deep uniform sands or texture-contrast soils on slopes and deep, uniform, grey or white organic sands on swampy valley floors. Rock outcrop is common on ridgelines and in creeks, and absent from most slopes

NSW (Mitchell) landscape	Subregion	Nominated area	Area of landscape in nominated area (ha)	Description
Ashfield Plains	Cumberland	GMAC	723	The Ashfield Plains landscape is a coastal extension of the Cumberland Plain landscape and is characterised by undulating hills and valleys on horizontal Triassic shale and siltstone, and occasional quartz sandstones, especially near the margin of the Port Jackson landscape. General elevation is 0 to 45 m with local relief of less than 20 m. Soils are red and brown texture-contrast on crests, grading to yellow harsh texture-contrast soils in valleys
Georges River Alluvial Plain	Cumberland	GMAC	1,134	Georges River Alluvial Plain comprises channel, floodplain and terraces of the Georges River on Quaternary and Tertiary alluvial sediments. Mostly clayey sand and sand with limited gravel on the highest terrace, general elevation 0 to 30 m, local relief 10 m. Massive uniform or gradational profiles on yellow brown to orange clayey sand. Podzols with well-developed double pans on limited areas of deep quartz sand, stony, harsh, yellow, texture-contrast soils on higher terraces
Sydney Basin Diatremes	Cumberland	GMAC	12	Sydney Basin Diatremes are widely distributed across the Sydney Basin and distinguished as a landscape because they always contain locally different landform, soil and vegetation. Diatremes are circular volcanic vents filled with layered, brecciated country rock cemented by a fine-grained basaltic matrix. Some contain a core of basalt. In sandstone country the volcanic breccia weathers and erodes more rapidly than the sandstone and the landform is circular with the appearance of a crater. Soils in the crater are dominated by sandstone detritus from the surrounding slopes but the subsoils are a fertile well, structured clay derived from the breccia and these protected sites carry more mesic variants of the local vegetation. In shale country the breccia is more resistant than the shale and the diatremes form a low rounded hill with red-brown gradational profiles of clay loam and structured clay with moderate to high fertility. General elevation varies considerably across the basin
		WSA	5	
		GPEC	28	
Hawkesbury - Nepean Terrace Gravels	Cumberland	GPEC	719	Hawkesbury - Nepean Terrace Gravels comprise three levels of river terrace dating into the Tertiary. General elevation is 20 to 45 m, local relief 10 m. Planar, poorly drained terraces with harsh texture-contrast soils and heavy clays in swamps and cut-off meanders
Kurrajong Fault Scarp	Cumberland	GPEC	3	Kurrajong Fault Scarp dissected and broken slopes on Triassic Quartz sandstone and shale across the Lapstone monocline and Kurrajong fault scarp. Local dips on the sedimentary rocks up to 300, general elevation 100 to 250 m, local relief 100 m. Abundant rock outcrop with pockets of yellow-brown sand and occasional yellow texture-contrast soils

*NSW (Mitchell) Landscape entered into the BAM calculator for each nominated area

18.4 RIVERS AND STREAMS

The nominated areas are located within two catchments (OEH, 2010):

- Hawkesbury
- Port Jackson/Georges River

Within the nominated areas, the watercourses and creeks provide riparian connectivity, and connections to the major watercourses of the Georges River (to the east) and the Hawkesbury-Nepean River (to the west).

Major watercourses of each nominated area are described in Table 18-4. Unnamed and minor tributaries are numerous throughout the nominated areas and are not listed in the tables.

Table 18-4: Watercourses of the nominated areas

Nominated areas	General Information	Major watercourses	Watercourse Strahler order*
Wilton	Wilton is located at the southern end of the Cumberland subregion. Four major watercourses run through the area, which generally have a south to north flow regime. There are several creeks that junction into the major watercourses	Nepean River, flowing west then north of Wilton	The Strahler order of the watercourses across Wilton is as follows: • One seventh-order watercourse • Three fourth-order watercourses • Six third-order watercourses • 26 second-order watercourses • 110 first order watercourses
		Allen's Creek, starting just south east of Wilton, flowing north into the Nepean River	
		Other smaller creeks include Sand Gully Creek, a second-order tributary as well as Clements Creek, a third order tributary	
		Stringybark Creek, a third-order tributary situated downstream of Clements Creek	
GMAC	GMAC stretches from Glenfield to Appin. There are three major watercourses that have a south to north flow regime	Bow Bowing Creek, a major watercourse that runs north east through northern GMAC The creek has several lower-order tributaries associated with it including: Smith's Creek, McBarron Creek, Leumeah Creek, Fishers Ghost Creek, Birunji Creek and Keanes Creek Georges River is generally east of GMAC	The Strahler order of the watercourses across GMAC is as follows: • Three seventh-order watercourses • Four sixth-order watercourses • One fifth-order watercourse • 11 fourth-order watercourses • 16 third-order watercourses • 68 second-order watercourses • 245 first-order watercourses
		Nepean River borders the south west portion of GMAC, it is the major watercourse flowing south to north There are four creeks that converge into the Nepean River that run through the southern portion of GMAC: • Menangle Creek, a fourth-order tributary, flowing west • Leafs Gully Creek, a second-order tributary, flowing north west • Ousedale Creek, a fourth-order tributary flowing north west • Simpsons Creek, a third-order	

Nominated areas	General Information	Major watercourses	Watercourse Strahler order*
		tributary, flowing north-west into the Nepean River	
		The Cataract River forms the southern border of GMAC Rocky Ponds Creek, a third-order tributary, converges into Cataract River	
WSA	The WSA contains five major watercourses. All watercourses have several tributaries	Ropes Creek forms the eastern border of WSA, it is a perennial creek, flowing northwards. Wianamatta (South Creek) which also flows northwards has four high-order tributaries (some listed below) and two third-order creeks that junction into it. Badgerys Creek is a fourth-order watercourse that has several unnamed tributaries	The Strahler order of the watercourses across the WSA is as follows: • One sixth-order watercourse • Four fourth-order water courses • 15 third-order watercourses. • 59 second-order watercourses • 208 first-order watercourses
		Kemps Creek, flows in a north-west direction, it is a perennial creek that converges into Wianamatta (South Creek). Kemps Creek has three unnamed tributaries that come from an easterly direction	
		Cosgroves Creek flows through WSA in a north-east direction. It has several creeks and tributaries that converge with it, including Oaky Creek	
		Duncans Creek drains the south west corner of WSA and junctions into the Nepean River in the west	
GPEC	The GPEC has three major watercourses. There are several creeks that junction into these major watercourses	Nepean River forms the western border for GPEC, flowing from south to north Four creeks flow into the Nepean River: • Boundary Creek, a second-order tributary with a westerly flow • Peach Tree Creek, a fourth-order tributary with a northern flow • Surveyors Creek, which junctions just north of the western motorway School House Creek is the most southern creek to junction into the Nepean River	The Strahler order of the watercourses across GPEC is as follows: • One ninth-order watercourse • Two sixth-order watercourses • Seven fourth-order water courses • 15 third-order watercourses • 53 second-order watercourses • 193 first-order watercourses
		Ropes Creek, runs through GPEC and is a major watercourse	
		Wianamatta (South Creek) flows south to north through the middle of GPEC. It has several smaller	

Nominated areas	General Information	Major watercourses	Watercourse Strahler order*
		tributaries that feed into the large watercourse including: • Werrington Creek • Claremont Creek • Blaxland Creek • Byrnes Creek	
		Kemps Creek, flows in a north-west direction, it is a perennial creek that converges into Wianamatta (South Creek). Kemps Creek has three unnamed tributaries that come from an easterly direction	
		Cosgroves Creek flows through WSA in a north-east direction. It has several creeks and tributaries that converge with it, including Oaky Creek	
		Duncans Creek drains the south west corner of WSA and junctions into the Nepean River in the west	

* This stream order system was originally developed by Strahler (1964). It functions by adding two streams of equal order at their confluence to form a higher order stream. As stream order increases, so does the likelihood that it would be a perennial source of water

18.5 WETLANDS

There are no wetlands protected under the Coastal Management State Environmental Planning Policy (SEPP) within the nominated areas. These wetlands were previously listed as SEPP 14 – Coastal Wetlands.

Locally occurring wetlands that provide wetland habitats include areas of floodplain wetland along the Nepean River, Wianamatta (South Creek) and Werrington Creek, farm dams and reservoirs. There are more than 60 of these types of wetland habitats mapped across the nominated areas (OEH, 2011a).

There are no nationally important wetlands or Ramsar-listed wetlands within the nominated areas. The closest nationally important wetlands to the nominated areas are (DoEE, 2018):

- Towra Point (Ramsar site) 25 kilometres east of Glenfield
- Lake Illawarra, 30 kilometres to the south-east of Wilton
- Bicentennial Park, Newington Wetlands, Silverwater Nature Reserve, 17 kilometres east of Prospect Reservoir
- Pitt Town Lagoon, Pitt Town
- Longneck Lagoon, Pitt Town

The closest Ramsar wetland is located at the Towra Point Nature Reserve, in Botany Bay.

18.6 HABITAT CONNECTIVITY AND FRAGMENTATION

The soils of the Cumberland subregion are relatively fertile, particularly when compared to the surrounding Hawkesbury Sandstone landscapes. This fertility has resulted in extensive clearing of native vegetation for agriculture, market gardens and orchards. More recently, clearing has occurred for urban development.

Only approximately 13 per cent of the pre-1970 extent of native vegetation in the Cumberland subregion remains intact and in good condition, with an additional 12 per cent occurring as scattered trees in disturbed areas (DECCW, 2011).

Remaining native vegetation is often highly fragmented. In 2010, an estimated 2,446 individual native vegetation remnants remained in the subregion, ranging from less than 1 hectare to 3,598 hectares in area (DECCW, 2010). Eighty one of the largest patches (those greater than 50 hectares) represent 51 per cent of the remaining native vegetation (DECCW, 2011).

Fragmentation of habitats across and between the nominated areas mirrors this general pattern of clearing and development in the Cumberland subregion, with significant areas of native vegetation community restricted to reserves, major riparian corridors, sandstone geologies and areas not suited to agriculture, such as steep slopes and escarpments.

The impacts of the development on habitat connectivity is assessed in Chapter 24.

18.6.1 WILTON

Connectivity of intact vegetation within Wilton is generally in the hilly, gorge and riparian corridors on the fringes of the nominated area. There is intact vegetation creating connectivity along Allens Creek from the west of the nominated area towards the areas of more intact vegetation south of the nominated area. Habitat for native species within the central parts of the nominated area (predominantly on shale soils) is restricted to scattered trees and derived grasslands or small native remnants of less than 5 hectares, which are under pressure from weed invasion, edge impacts and ongoing agricultural practices.

Map 19 shows habitat connectivity within Wilton.

18.6.2 GMAC

Fragmentation of habitat within GMAC is also typical of that seen in the Cumberland subregion, with clearing of vegetation from the fertile crests, and the low-lying and alluvial soils. However, due to the presence of riparian corridors and sandstone geologies there is some connectivity of intact habitats along a number of east-west corridors in the southern portion of GMAC. These connections reach from the Nepean River riparian corridor on the western boundary, to near the eastern boundary, where the habitats of the Georges River riparian corridor are located.

Habitat connectivity within the highly developed northern portion of the nominated area is restricted to small local connections such as largely cleared riparian corridors and urban bushland parks. Scattered trees and urban native vegetation are also present in this area, providing some connectivity for highly mobile species.

Map 19 shows habitat connectivity within GMAC.

18.6.3 WSA

WSA is characterised predominantly by an agricultural landscape with limited small acreage subdivision in the far south and larger acreage and small residential subdivisions in the centre and northern parts. Some small acreage subdivisions contain native vegetation, providing local connections for native fauna and flora species.

Other native vegetation habitats are present along the many riparian corridors that cross WSA, including Wianamatta (South Creek), Duncans Creek and Badgerys Creek corridors and tributaries. There are remnant patches of vegetation located between Willowdene Avenue and the Northern Road in the central part of the nominated area around Duncans Creek, providing some limited connectivity east-west. There are also many waterbodies within WSA that provide habitat connectivity for species dependent on these environments for dispersal and reproduction.

Map 19 shows habitat connectivity within WSA.

18.6.4 GPEC

GPEC has been extensively developed for housing. Intact native vegetation and habitats are restricted to the far north of the nominated area around the Wianamatta Regional Park, and the Orchard Hills Defence Establishment in the far south of the nominated area. These two areas of remnant habitats are connected via the riparian corridors of Wianamatta (South Creek). The Ropes Creek corridor reaches from the Wianamatta Regional Park through to the south east of the nominated area. Both of these major riparian corridors have been subject to varying levels of clearing and disturbance. However, they provide the only vegetated link within the local and regional landscape for native flora and fauna species.

Map 19 shows habitat connectivity within GPEC.

18.7 AREAS OF GEOLOGICAL SIGNIFICANCE AND SOIL HAZARDS

Areas of geological significance occur outside urban capable land on the edges of some of the nominated areas, including rocky escarpments associated with surrounding sandstone landscapes. These areas may be important for species that have specific habitat constraints and associations. Areas of potential soil hazard within the nominated areas include:

- Acid Sulfate Soils
- Sodic soils
- Salinity
- Land contamination
- Soil compaction
- Unstable soils

The impacts of the development on karst, caves, crevices and cliffs is assessed in Chapter 24.

18.7.1 ACID SULFATE SOILS

Table 18-5 provides a description of the soil hazard map units identified in the Atlas of Australian Acid Sulfate Soils (Fitzpatrick, Powell et al., 2011).

Areas of high probability Acid Sulfate Soils within the nominated areas are shown in Map 11.

Table 18-5: Acid Sulfate Soils within the nominated areas

Map Units	Probability of occurrence	Map unit	Subscript	Confidence	Nominated area
Bn(p4)	B - Low (6-70%)	n - Inland landscapes in wet/riparian corridors associated with sodosols, chromosols and dermosols. Acid Sulfate Soils generally within upper 1 m of wet / riparian corridors	p - Potential acid sulfate soil (PASS) = sulfidic material	4- Classification is provisional	GMAC GPEC
Cq(p4)	C- Extremely low (1-5%)	q - Inland landscapes in wet/riparian corridors associated with kandosols, tenosols and rudosols. Acid Sulfate Soils generally within 1 m of wet/riparian corridor	p - Potential acid sulfate soil (PASS) = sulfidic material	4- Classification is provisional	Wilton GMAC WSA GPEC
Cu(--)	C- Extremely low (1-5%)	u - unclassified Not Acid Sulfate Soils	Not Acid Sulfate Soils	Not Acid Sulfate Soils	GMAC GPEC
An(p4)	A - High (>70%)	n - Inland landscapes in wet/riparian corridors associated with sodosols, chromosols and	p - Potential Acid Sulfate Soil (PASS) = sulfidic material	4- Classification is provisional	WSA GPEC

Map Units	Probability of occurrence	Map unit	Subscript	Confidence	Nominated area
		dermosols. Acid Sulfate Soils generally within upper 1 m of wet / riparian corridors			
Aq(p4)	A - High (>70%)	q - Inland landscapes in wet/riparian corridors associated with kandosols, tenosols and rudosols. Acid Sulfate Soils generally within 1 m of wet/riparian corridor	p - Potential acid sulfate soil (PASS) = sulfidic material	4- Classification is provisional	WSA GPEC
Cn(p4)	C- Extremely low (1-5%)	n - Inland landscapes in wet/riparian corridors associated with sodosols, chromosols and dermosols. Acid Sulfate Soils generally within upper 1 m of wet / riparian corridors	p - Potential Acid Sulfate Soil (PASS) = sulfidic material	4- Classification is provisional	WSA GPEC

18.7.2 SODIC SOILS

Sodicity refers to the proportion of exchangeable sodium cations held on the surface of clay particles. The greater the proportion of sodium in the total exchangeable cations, the greater the sodicity of the soil.

Sodic soils cause clay dispersion, an undesirable condition.

Sodic soils could occur within the nominated areas, most likely in riparian corridors and near dams. A site assessment would be necessary to determine extent at specific locations.

18.7.3 SALINITY

Salinity refers to the amount of dissolved salt in the soil. A large concentration of salt gives high salinity and increasing salinity makes it difficult for plant roots to absorb water.

The Western Sydney Hydrogeological Landscape maps show the majority of Western Sydney as having high land salinity. Wilton is mapped as having low to moderate land salinity, while parts of the assessment area north of Wilton are predominantly high land salinity areas (OEH, 2011b).

Site assessments would be required to determine the salinity of individual sites.

18.7.4 LAND CONTAMINATION

Land contamination can threaten human health and the environment, limit land use potential or increase development costs. Contaminated sites are typically found in areas that have been used for heavy industry or agriculture, chemical storage areas and service stations and dry cleaning sites (NSW EPA, 2019).

Declarations of significantly contaminated lands have been made for various sites across each of the nominated areas, primarily relating to industrial sites. The list of current declarations for each Local Government Area (LGA) within the nominated areas is available through the NSW Environment Protection Authority website.

18.7.5 SOIL COMPACTION

Compaction of soils can occur through movement of stock, machinery or vehicles. When soil becomes compacted, air and water movement through the soil are restricted, limiting their use.

Compacted soils within the nominated areas are most likely to be found in areas used for grazing or agriculture. Areas of susceptibility are likely to occur on the alluvial plains and the Cumberland Plain Mitchell Landscape.

Site assessments would be required to determine soil compaction levels at individual sites.

18.7.6 UNSTABLE SOILS

Unstable soils are referred to as 'dispersible soils' and are often associated with high levels of salt. They are vulnerable to compaction, surface sealing and erosion. Areas of potential high land salinity within the nominated areas are more likely to exhibit unstable soils. Potential areas of instability and potential for gully erosion within the nominated areas are most likely to occur in areas of high slope, salinity and reduced vegetation ground cover.

Within the nominated areas, the Wianamatta (South Creek) soil landscape has high to extreme potential for erosion, and stream bank and gully erosion in this landscape can result from concentrated water flows. The Luddenham Soil Landscape has a moderate to very high potential for erosion, with minor gully erosion and sheet erosion in disturbed areas.

18.8 AREAS OF OUTSTANDING BIODIVERSITY VALUE

No areas identified as Areas of Outstanding Biodiversity Value occur within the nominated areas (OEH, 2020).

18.9 SITE CONTEXT

This section describes the site context, in accordance with section 4.3 of the BAM, for each of the nominated areas.

18.9.1 PER CENT NATIVE VEGETATION COVER

Per cent native vegetation cover is shown in Table 18-6 for the:

- Nominated areas
- Urban capable land
- 1500 m buffer areas

Table 18-6: Native vegetation cover

Nominated area	Native vegetation cover (%)	Cover Class	Native vegetation cover (%) – urban capable land*	Cover Class	Native vegetation cover (%) – 1,500 m buffer*	Cover Class
Wilton	58	>30-70%	39	>30-70%	62	>30-70%
GMAC	30	>10-30%	14	>10-30%	41	>30-70%
WSA	15	>10-30%	10	0-10%	22	>10-30%
GPEC	18	>10-30%	15	>10-30%	22	>10-30%
Average	30	>10-30%	20	>10-30%	37	>30-70%

* Percentages rounded to whole numbers

18.9.2 CHANGES TO THE MAPPED NATIVE VEGETATION EXTENT

Several areas of native vegetation shown on the existing native vegetation maps (OEH, 2013, 2016) have been cleared since the maps were prepared and no longer exist. These areas were discernible on Nearmap aerial imagery (Nearmap, 2018) and were excluded from the updated vegetation maps. Areas of urban vegetation such as roadside plantings were also excluded. These areas were ground-truthed during surveys where possible to positively identify them as being non-native vegetation or native vegetation with a cultivated origin.

18.9.3 PATCH SIZE

Patch size for BAM credit calculations was defined as greater than 100 hectare for all vegetation zones in the nominated areas. This served to not limit the potential threatened species that could be recorded or identified in the assessment for consideration.

19 Native vegetation

This Chapter describes the native vegetation communities in the nominated areas, including vegetation extent, PCTs and vegetation condition (native vegetation integrity).

The method for identifying and mapping native vegetation within the nominated areas is provided in Chapter 11.

19.1 NATIVE VEGETATION EXTENT

The total extent of vegetation within the nominated areas is 11,806 hectares (see Table 19-3). This includes:

- 9,791 ha of native vegetation, including areas with native dominated ground cover and canopy area of trees
- 2,015 ha of 'Urban Native/Exotic' vegetation, which comprises areas of exotic vegetation or with few native species, as well as planted vegetation, landscaped areas, gardens, and other areas that are not considered representative of 'native vegetation' and/or a PCT

Map 12 shows the extent of native vegetation within the nominated areas, including the extent of the 'Urban Native/Exotic' vegetation.

19.2 PLANT COMMUNITY TYPES

A total of 15 different PCTs occur within the nominated areas. In addition to these 15 PCTs, a category of vegetation called 'Urban Native/Exotic' vegetation also occurs (see Table 19-1).

A description of the PCTs that occur within the nominated areas, including the percentage of each PCT that has been cleared (up to 2018) (OEH, 2018) is provided in Table 19-1.

Table 19-2 provides a justification for the identification of each PCT in accordance with section 5.2.1.12 of the BAM. Table 19-3 provides the amount (hectares) of each PCT within the nominated areas.

The five most extensive PCTs (including the Urban Native/Exotic category of vegetation) within the nominated areas are:

- 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest – 3,326 ha
- 849 Grey Box - Forest Red Gum grassy woodland on flats – 3,049 ha
- Urban Native/Exotic – 2,015 ha
- 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats – 1,170 ha
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes – 780 ha

Map 13.1, Map 13.2, Map 13.3 and Map 13.4 show the distribution of PCTs within the nominated areas.

Table 19-1: PCTs within the nominated areas

PCT	Name	Vegetation formation	Vegetation class	Description*	Per cent cleared value (2018)
724	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Dry Sclerophyll Forest	Cumberland Dry Sclerophyll Forest	This community is associated with shale-influenced sandy soils that support a component of ironstone gravels. The vegetation typically consists of an open eucalypt forest with an understorey that varies between dense shrubs and a low sparse shrub cover with an abundant ground cover of grasses. The canopy typically includes Broad-leaved Ironbark *Eucalyptus fibrosa* along with a wide variety of other eucalypts depending on location. White Feather Honeymyrtle *Melaleuca decora* is sometimes present above a lower open shrub layer of Blackthorn *Bursaria spinosa* and Gorse Bitter Pea *Daviesia ulicifolia*. The ground cover is a mix of grasses, sedges and herbs. On the basis of floristic composition alone, Castlereagh Shale-Gravel Transition Forest is closely related to Castlereagh Ironbark Forest	75%
725	Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Dry Sclerophyll Forest (Shrub/grass sub-formation)	Cumberland Dry Sclerophyll Forest	This community is associated with clay soils derived from Tertiary alluvial deposits (Tozer 2003). It is one of two closely related ironbark shrub-grass forests found in western Sydney. The structure ranges from a moderately tall open eucalypt forest or woodland to a low dense thicket of paperbarks with low emergent eucalypts. Human-induced changes to the original forest structure have resulted in the presence of varying structures of the community Benson and Howell (1994a). Broad-leaved Ironbark is the most commonly recorded eucalypt although at some sites it may be absent Woollybutt *Eucalyptus longifolia* is also common although sites often have a diverse canopy composition which reflects subtle grades between substrates sourced from Tertiary sand, sandstone bedrock, shale and ironstone gravels. For this reason, there are localised occurrences of Hard-leaved Scribbly Gum *Eucalyptus sclerophylla*, Smooth-barked Apple *Angophora costata* and Narrow-leaved Apple *Angophora bakeri*, species more typically associated with siliceous soils of sand deposits and the sandstone plateau. A prominent small tree layer of White Feather Honeymyrtle features above a dense cover of shrubs that include *Melaleuca nodosa*, Blackthorn and Peach Heath *Lissanthe strigosa* The ground layer is a sparse cover of grasses and forbs. These may be very depauperate in locations where dense shrub layers exclude light	95%

PCT	Name	Vegetation formation	Vegetation class	Description*	Per cent cleared value (2018)
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Freshwater Wetlands	Coastal Freshwater Lagoons	This community is associated with freshwater lagoons and swamps on alluvial flats and sand depressions across the NSW east coast. Lagoons have fluctuating levels of standing water that gives rise to a varied assemblage of species. They include a range of sedges, rushes and aquatic herbs with woody shrubs and small trees found only on the margins of the wetlands in low abundance. Tall reedlands (reaching over 3 m in height) may dominate individual wetlands. Cumbungi *Typha orientalis* is typically dominant in urban wetlands and may be joined by Common Reed *Phragmites australis*. Other tall reeds include *Eleocharis sphacelata* and tall sedges such as Twig-rushes *Baumea* spp. The margins of open water carry a range of aquatic herbs such as *Isachne gibbosa* and *Persicaria decipiens*. Less frequently inundated wetlands support only a few species of sedges or rushes such as *Carex appressa* and *Baumea* spp. which do not reach the height of the taller reedlands found elsewhere	74%
830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	This community occurs on protected aspects on steeper shale hills and rises of the southern half of the Cumberland Plain. It differs from the grassy woodlands found in Western Sydney by the prevalence of waxy-leaved shrubs and small trees in the understorey and a ground cover of herbs, fleshy twiners and grasses. Some of these species, such as Hairy Clerodendrum *Clerodendrum tomentosum* and Slender Grape *Cayratia clematidea*, are features of the Hinterland Dry Rainforest, a community that occasionally occurs in more protected situations nearby. Across its range in Western Sydney the canopy is mostly dominated by Forest Red Gum *Eucalyptus tereticornis* and Grey Box *Eucalyptus moluccana*. Much of this habitat has been extensively cleared, with remaining stands commonly choked by dense thickets of African Olive *Olea europaea* subsp. *cuspidata* and Lantana *Lantana camara*. This reduces species diversity and in chronic situations it may be difficult to correctly diagnose the community due to low numbers of native species	75%
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Forested Wetlands	Coastal Floodplain Wetlands	This community is located on broad alluvial flats of the Hawkesbury and Nepean river systems. It also forms narrower ribbons alongside streams and creeks that drain the Cumberland Plain. The canopy typically includes one of either Rough-barked Apple *Angophora floribunda* or Broad-leaved Apple *Angophora subvelutina* and one or both of Forest Red Gum and Cabbage Gum *Eucalyptus amplifolia*. However, eucalypt species will vary between localities, including Blue Box *Eucalyptus baueriana*, Sydney Blue Gum *Eucalyptus saligna* and Blackbutt *Eucalyptus pilularis*. The understorey within this community is characterised by an occasional sparse to open small tree stratum of Paper Bark *Melaleuca* spp. and Wattles *Acacia* spp. A sparse lower shrub layer features Blackthorn *Bursaria spinosa* at most sites. The ground layer is characterised by an abundant cover of grasses with herbs and ferns	93%

PCT	Name	Vegetation formation	Vegetation class	Description*	Per cent cleared value (2018)
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	This community is one of two grassy woodlands that comprise Cumberland Plain Woodland listed under the BC Act. The community includes an open grassy woodland dominated by Grey Box, Forest Red Gum and Narrow-leaved Ironbark and Broad-leaved Ironbark. Like the related community Cumberland Shale Hills Woodland, it is typified by a sparse to moderate cover of shrubs and a high cover of grasses and forbs	93%
850	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	This community is one of two grassy woodlands that comprise the Cumberland Plain Woodland listed under the BC Act. The community is an open woodland of Grey Box and Forest Red Gum with Narrow-leaved Ironbark also common. Hickory Wattle *Acacia implexa* occurs amongst the small tree layer, often amongst regrowth stands. This species is one of the more distinctive floristic attributes that helps distinguish between the two components of the EEC. Other features are similar in that the two woodland units are characterised by an open shrub layer and a grassy ground cover. Fire history can have an important influence on the abundance of shrubs (Watson et al. 2009), with density of Blackthorn *Bursaria spinosa* increasing with time since fire	88%
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Sand Flats Dry Sclerophyll Forests	This community is one of several unique dry shrub woodland communities found on poorly consolidated sand deposits on hinterland plains and valleys of the Sydney region. The woodland comprises an open, low-growing eucalypt cover dominated by Hard-leaved Scribbly Gum *Eucalyptus sclerophylla*, Narrow-leaved Apple and Drooping Red Gum *Eucalyptus parramattensis* subsp. *parramattensis*. A sparse cover of White Feather Honeymyrtle is often present. Banksias, hakeas, wattles, tea-trees and paperbarks provide a well-developed shrub layer. The ground cover is usually a diverse mix of species typically including a high cover of grasses and sedges	50%
1081	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Hinterland Dry Sclerophyll Forests	This community is equivalent to DSF 146 identified by Tindall et al. (2004) and is a eucalypt woodland with an open understorey of sclerophyll shrubs, sedges, forbs and grasses. This transition woodland encircles the Cumberland Plain rainshadow, on loamy soils typically derived from sediments belonging to the Hawkesbury or Mittagong formations. 40 per cent of this community's original distribution has been cleared, and clearing continues in localised areas of suburban expansion. However, considerable areas are represented within conservation reserves	40%

PCT	Name	Vegetation formation	Vegetation class	Description*	Per cent cleared value (2018)
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Forested Wetlands	Eastern Riverine Forests	Open *Casuarina* forest, 10-40 m tall, with a variable non-sclerophyll shrub stratum and patchy groundcover of sedges and herbs, interspersed with leaf litter, cobbles and open sand. Restricted to narrow bands along rivers of the coast and tablelands north from Bega continuing into central Queensland	40%
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Dry Sclerophyll Forests (Shrubby sub-formation)	Sydney Coastal Dry Sclerophyll Forests	This community is equivalent to DSF 142 identified by Tindall et al. (2004) and is an open eucalypt forest with an abundant sclerophyll shrub stratum and a groundcover dominated by sedges. This community grades from Hinterland Sandstone Gully Forest into Sandstone Riparian Scrub immediately adjacent to creeklines and is replaced by Coastal Sandstone Ridgetop Woodland or Wingecarribee-Burragorang Sandstone Forest on upper slopes and exposed positions. Dominant trees include; Smooth-barked Apple, Red Bloodwood *Corymbia gummifera*, Sydney Peppermint *Eucalyptus piperita*. As rainfall increases toward the coast, it is replaced by Coastal Sandstone Gully Forest. Much of this community's original distribution has been cleared. Large areas remain, including examples in conservation reserves, though edge effects such as weed invasion and high fire frequency are evident in some locations	20%
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Forested Wetlands	Eastern Riverine Forests	This low scrub comprises a mix of hardy shrubs growing on rocky creek lines or shallow alluvial soils at the base of deep sandstone gully systems. The vegetation cover is highly variable as it is interspersed by rock pools, rock pavements and open sandy banks. It is a zone of occasional flooding and plants must survive fast-moving waters to persist. Water gums *Tristaniopsis laurina* and *Tristania neriifolia* are invariably present, often in combination with wattles, hakeas, grevilleas, tea-trees and casuarinas. Two shrub species, River Lomatia *Lomatia myricoides* and Blunt-leaved Wattle *Acacia obtusifolia*, are particularly common in this community; both are easily distinguished by their long leaves. Small moisture-loving ferns and sedges may form dense clumps on or near stream banks. A sparse cover of overhanging eucalypts may also be present, though these are often rooted in the adjoining slopes rather than the creek line itself	10%

PCT	Name	Vegetation formation	Vegetation class	Description*	Per cent cleared value (2018)
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Grassy Woodlands	Coastal Valley Grassy Woodlands	This community is found on the fringes of the Cumberland Plain. It is one of a suite of forests that are associated with the subtle intergrade between clay-rich shale soil and the coarse sandy substrates of the sandstone plateau. It is a moderately tall eucalypt forest with a mixed understorey of sclerophyll shrubs and grasses (Tozer et al. 2010). Sites invariably have one of two species of Ironbark, Narrow-leaved Ironbark and Broad-leaved Ironbark, present in the canopy along with Grey Gum *Eucalyptus punctata* and Red Bloodwood. A sparse cover of tall Casuarinas *Allocasuarina littoralis*/*Allocasuarina torulosa* is common. The understorey supports a mix of shrubs that are common on shale substrates such as Blackthorn *Bursaria spinosa* and those more commonly associated with sandstone soils such as Geebungs (*Persoonia* spp). Beneath this diverse mix of shrubs is a high cover of grass and forbs. The grass layer includes a wide range of species, most of which occur more extensively on the Cumberland Plain	80%
1790	Red Bloodwood - Grey Gum - Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	Dry Sclerophyll Forest (shrubby formation)	Sydney Hinterland Dry Sclerophyll Forests	This forest is primarily found on the broad ridges associated with Mittagong formation sandstone in the western stretches of the Woronora Plateau between Appin and Holsworthy. These bedrocks have interbanding layers of shale and sandstone material that erode to a sandy soil with a gentle shale influence. It is most extensive within the Campbelltown and Liverpool LGAs. Outside of the Plan Area it is likely to occur on the fringes of the Cumberland Plain in north-west Sydney and the lower Blue Mountains. The community consists of a tall open eucalypt forest dominated by Grey Gum *Eucalyptus punctata* and Red Bloodwood *Corymbia gummifera*. A sparse small tree layer of Casuarina *Allocasuarina littoralis* and *Allocasuarina torulosa* is common. The understorey is typically shrubby with a diverse mix of plants common on sandstone soils including Wattles, Tea-trees, Banksias and Geebungs. Unlike sandstone woodlands however, the ground layer supports a relatively high number of grass species including Kangaroo Grass *Themeda triandra* and Spear Grass *Austrostipa pubescens* and are indicative of the presence of shale in the soil	40%
1800	Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley	Forested Wetlands	Coastal Floodplain Wetlands	This community is found on the river flats of the Cumberland Plain in western Sydney. The distinguishing feature is the prominent stands of Swamp Oak *Casuarina glauca* found along or near streams. Often these are relatively young trees, swarming amongst a mix of old and young eucalypts such as Rough-barked Apple *Angophora floribunda*, Forest Red Gum and Grey Box. This community features an open grassy and herbaceous understorey, as is typical of river flat forests	60%
	Urban Native/Exotic			Vegetation that is not consistent with floristic composition and landscape positions for native plant community types as defined by the NSW BioNet Vegetation Classification system; most commonly communities comprise of very few native species or consist of an assorted mix of planted natives	

*Adapted from the BioNet Vegetation Information System (VIS) database

Table 19-2: Justification for the identification of PCTs

PCT	Name	Species relied on for identification of the PCT*	Justification of evidence to identify the PCT
724	Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	*E. fibrosa, M. decora*	Associated with shale-gravelly soils. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open eucalypt forest with an understorey that may vary between dense shrubs and a low sparse shrub cover with an abundant ground cover of grasses, sedges and herbs, consistent with the species assemblage for this PCT
725	Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	*E. fibrosa, E. longifolia, Melaleuca decora* and *M. nodosa*	Associated with clay soils derived from Tertiary alluvial deposits and laterized deeply weathered shale. This PCT was found in varying degrees of condition and species composition. In intact condition, the structure ranges from a moderately tall open eucalypt forest or woodland to a low dense thicket of paperbarks with low emergent eucalypts, consistent with the species assemblage for this PCT
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	*Typha orientalis, Phragmites australis, Eleocharis sphacelata, Baumea* spp. and *Persicaria decipiens*	Associated with freshwater lagoons and swamps on alluvial flats, found generally at low elevations less than 20 m above sea level, and up to 50 m above sea level. This PCT was found in varying degrees of condition and species composition. In intact condition, the lagoons consist of a range of sedges, rushes and aquatic herbs with woody shrubs and small trees, consistent with the species assemblage for this PCT
830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	*E. tereticornis, E. moluccana, Corymbia maculata, Clerodendrum tomentosum* and *Breynia oblongifolia*	Associated with protected aspects on steeper shale hills and rises of the southern half of the Cumberland Plain. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open grassy woodland with prevalence of waxy-leaved shrubs and small trees in the understorey and a ground cover of herbs, fleshy twiners and grasses, consistent with the species assemblage for this PCT
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	*Angophora floribunda, A. subvelutina, Eucalyptus tereticornis, E. amplifolia, Melaleuca* spp. and *Acacia* spp.	Associated with broad alluvial flats, streams and creeks at altitudes between one and 160 m above sea level. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open eucalypt forest, with occasional sparse to open small tree stratum and a sparse lower shrub layer, with an abundant cover of grasses, small herbs and ferns, consistent with the species assemblage for this PCT

PCT	Name	Species relied on for identification of the PCT*	Justification of evidence to identify the PCT
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	*E. moluccana, E. tereticornis, E. crebra* and *E. fibrosa*	Associated with gentle topography generally at less than 150 m above sea level, and can occur over 300 m above sea level in some locations. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open grassy eucalypt woodland with a sparse to moderate cover of shrubs and a high cover of grasses and forbs, consistent with the species assemblage for this PCT
850	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	*E. moluccana, E. tereticornis* and *E. crebra*	Associated with elevations between 50 m and 350 m above sea level in more rugged landforms separating this from more gentle landforms occupied by PCT 849. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open woodland with an open shrub layer and a grassy ground cover, consistent with the species assemblage for this PCT
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	*E. sclerophylla, Angophora bakeri, E. parramattensis* subsp. *parramattensis* and *Melaleuca decora*	Associated with soils derived from Tertiary alluvium, or on sites located on adjoining shale or Holocene alluvium, with sandy deposits. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as a shrubby woodland with an open, low-growing eucalypt cover, well developed shrub layer, and a diverse mix of species typically including a high cover of grasses and sedges, consistent with the species assemblage for this PCT
1081	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	*Corymbia gummifera, E. punctata,* and *Angophora costata*	This community is present on loamy soils on dry ridges in the rainshadow zone surrounding the Cumberland Plain. It occurs at elevations below 400 m above sea level. This PCT was predominantly found in moderate condition, with an intact native canopy over ground and midstorey layers subject to weed incurrence. The species composition was consistent with the species assemblage for this PCT and Proteaceae (particularly banksias) are often present
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	*Casuarina cunninghamiana*	Associated with sand or gravel alluvium along rivers and streams between 1 m and 600 m. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open or tall open forest with an open shrub layer and a dense or patchy groundcover of grasses and forbs, consistent with the species assemblage for this PCT
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	*Angophora costata, Corymbia gummifera, E. piperita, E. pilularis, E. punctata* and *Syncarpia glomulifera*	Associated with lower slopes of dry sandstone gullies up to 600 m above sea level. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as an open eucalypt forest with an abundant sclerophyll shrub stratum and a groundcover dominated by sedges, consistent with the species assemblage for this PCT

PCT	Name	Species relied on for identification of the PCT*	Justification of evidence to identify the PCT
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	*Tristaniopsis laurina, Ceratopetalum apetalum, Tristania neriifolia,* and *Lomatia myricoides*	This community is present on sandy banks and sandstone beds of streams draining sandstone plateaux below 450 m elevation. It was mainly present in good condition within the Plan Area, with a species composition and structure that aligns with the descriptive characteristics for the PCT
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	*E. crebra, E. fibrosa, E. punctata* and *Corymbia gummifera*	Associated with clay-rich shale soil and the coarse sandy substrates of sandstone plateaus. This PCT was found in varying degrees of condition and species composition. In intact condition, it occurs as a moderately tall eucalypt forest with a mixed understorey of sclerophyll shrubs and grasses, consistent with the species assemblage for this PCT. Generally with few to no Proteaceae present, which distinguishes the community from PCT 1081
1790	Red Bloodwood - Grey Gum - Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	*Corymbia gummifera, E. punctata, E. oblonga and E. pilularis*	Primarily found on the broad ridges associated with Mittagong formation sandstone in the western stretches of the Woronora Plateau between Appin and Holsworthy. The community is associated with bedrocks of interbanding layers of shale and sandstone material that erode to a sandy soil with a gentle shale influence. Restricted to a narrow band of rainfall of 850-1050 mm per annum at elevations between 23 and 275 m above sea level
1800	Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley	*Casuarina glauca, Angophora floribunda, E. tereticornis* and *E. moluccana*	Associated with grey-black clay-loams and sandy loams, on drainage lines, lake margins and estuarine fringes associated with coastal floodplains, generally below 20 m elevation but up to 60 m ASL in the upper Wianamatta (South Creek) reaches. This PCT was found in varying degrees of condition and species composition. In intact condition it occurs as an open grassy and herbaceous understorey, consistent with the species assemblage for this PCT
	Urban Native/Exotic	Exotic species	This PCT is associated with exotic species, and the species assemblage was not associated with a PCT

*All plot data were entered into the BioNet PCT ID tool and the Tozer vegetation identification tool and then reviewed by ecologists with experience in the vegetation of the Cumberland Plain

Table 19-3: Amount (ha) of each PCT within the nominated areas*

PCT	Name	Nominated areas				
		Wilton	GMAC	WSA	GPEC	Total
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion.	0.0	0.0	52.9	138.3	**191.2**
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion.	0.0	0.0	39.9	127.5	**167.4**
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion.	0.0	0.0	3.5	65.4	**68.9**
830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion.	0.0	18.8	0.0	2.8	**21.5**
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion.	0.0	183.8	160.0	826.1	**1,169.8**
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion.	286.5	443.5	525.8	1,793.5	**3,049.2**
850	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion.	164.5	269.4	9.1	80.8	**523.8**
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion.	0.0	0.9	0.0	6.5	**7.4**
1081	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion.	66.7	7.5	0.0	0.0	**74.2**
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion.	0.0	44.4	0.0	94.1	**138.6**

PCT	Name	Nominated areas				
		Wilton	GMAC	WSA	GPEC	Total
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.	365.8	414.7	0.0	0.0	**780.5**
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion.	38.4	1.3	0.0	0.0	**39.8**
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.	1,428.5	1,895.1	0.0	2.0	**3,325.6**
1790	Red Bloodwood - Grey Gum - Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	0.0	0.4	0.0	0.0	**0.4**
1800	Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley.	0.0	4.1	110.1	118.4	**232.6**
	Urban Native/Exotic.	106.5	594.6	136.7	1,177.6	**2,015.4**
Total (including urban native/exotic)		**2,456.9**	**3,878.4**	**1,038.0**	**4,432.9**	**11,806**
Total (excluding urban native/exotic)		**2,350.4**	**3,283.8**	**901.3**	**3,255.3**	**9,790.9**

*Areas of NOG are not included in this table

19.3 NATIVE VEGETATION CONDITION

Vegetation zones have been identified within the nominated areas in accordance with the method described in Chapter 11. A vegetation zone is an area of native vegetation that is the same PCT and has a similar condition state (BAM 5.3.1.1).

There is a total of 39 vegetation zones within the nominated areas.

Table 19-4 identifies the area of each vegetation zone within each nominated area. A description of the vegetation condition categories shown in Table 10 is provided in Chapter 11.

Table 19-5 identifies the area of Non-Offsettable Grassland (NOG) in the nominated areas.

The current vegetation integrity score (a measure of vegetation condition) of each vegetation zone within the nominated areas is provided in Table 19-6. The vegetation integrity score has not been calculated for each nominated area separately as the nominated areas comprise a single biodiversity certification area over which all plots were collected.

Map 14.1, Map 14.2, Map 14.3 and Map 14.4 show the vegetation zones within each nominated area.

Table 19-4: Vegetation condition and amount (ha) of each PCT and condition type within the nominated areas

Vegetation zone ID	Vegetation zone		Area (ha) in nominated areas				
	PCT	Condition	Wilton	GMAC	WSA	GPEC	Total
724_Intact	724	Intact	0.0	0.0	3.3	69.2	**72.5**
724_Thinned	724	Thinned	0.0	0.0	49.5	65.6	**115.2**
724_Scattered_trees	724	Scattered Trees	0.0	0.0	0.1	3.4	**3.5**
725_Intact	725	Intact	0.0	0.0	20.0	87.4	**107.4**
725_Thinned	725	Thinned	0.0	0.0	16.4	33.9	**50.3**
725_Scattered_trees	725	Scattered Trees	0.0	0.0	3.4	6.2	**9.6**
781_Thinned	781	Thinned	0.0	0.0	3.5	65.4	**68.9**
830_Intact	830	Intact	0.0	2.2	0.0	2.8	**5.0**
830_Thinned	830	Thinned	0.0	16.4	0.0	0.0	**16.4**
830_DNG	830	DNG	0.0	0.2	0.0	0.0	**0.2**
835_Intact	835	Intact	0.0	55.7	13.4	321.4	**390.5**
835_Thinned	835	Thinned	0.0	119.6	108.1	496.5	**724.2**
835_Scattered_trees	835	Scattered Trees	0.0	8.4	38.4	8.2	**55.0**

Vegetation zone ID	Vegetation zone		Area (ha) in nominated areas				
	PCT	Condition	Wilton	GMAC	WSA	GPEC	Total
835_DNG	835	DNG	0.0	0.0	0.1	0.0	**0.1**
849_Intact	849	Intact	4.2	94.8	29.3	430.5	**558.9**
849_Thinned	849	Thinned	66.5	176.1	319.3	1,225.2	**1,787.0**
849_Scattered_trees	849	Scattered Trees	39.5	71.9	85.9	125.7	**322.8**
849_DNG	849	DNG	176.4	100.6	91.4	12.1	**380.5**
850_Intact	850	Intact	0.0	86.8	0.1	0.2	**87.1**
850_Thinned	850	Thinned	0.0	133.6	5.8	52.9	**192.3**
850_Scattered_trees	850	Scattered Trees	1.1	24.8	3.0	4.1	**33.0**
850_DNG	850	DNG	163.4	24.2	0.2	23.5	**211.3**
883_Intact	883	Intact	0.0	0.0	0.0	6.4	**6.4**
883_Thinned	883	Thinned	0.0	0.9	0.0	0.1	**1.0**
1081_Intact	1081	Intact	44.7	7.5	0.0	0.0	**52.2**
1081_Thinned	1081	Thinned	22.0	0.0	0.0	0.0	**22.0**

Vegetation zone ID	Vegetation zone		Area (ha) in nominated areas				
	PCT	Condition	Wilton	GMAC	WSA	GPEC	Total
1105_Intact	1105	Intact	0.0	13.6	0.0	0.0	**13.6**
1105_Thinned	1105	Thinned	0.0	30.9	0.0	94.1	**125.0**
1181_Intact	1181	Intact	363.8	414.0	0.0	0.0	**777.7**
1181_Thinned	1181	Thinned	2.1	0.7	0.0	0.0	**2.7**
1292_Intact	1292	Intact	38.4	1.3	0.0	0.0	**39.8**
1395_Intact	1395	Intact	541.3	1,294.6	0.0	0.0	**1,836.0**
1395_Thinned	1395	Thinned	533.7	436.7	0.0	2.0	**972.4**
1395_Scattered_trees	1395	Scattered Trees	49.5	90.4	0.0	0.0	**139.9**
1395_DNG	1395	DNG	303.9	73.4	0.0	0.0	**377.3**
1790_Intact	1790	Intact	0.0	0.4	0.0	0.0	**0.4**
1800_Intact	1800	Intact	0.0	0.0	14.6	6.3	**20.9**
1800_Thinned	1800	Thinned	0.0	4.1	91.4	111.4	**206.9**
1800_Scattered_trees	1800	Scattered Trees	0.0	0.0	4.2	0.7	**4.9**

Vegetation zone ID	Vegetation zone		Area (ha) in nominated areas				
	PCT	Condition	Wilton	GMAC	WSA	GPEC	Total
Total			**2,350.4**	**3,283.8**	**901.3**	**3,255.3**	**9,791.0**

Table 19-5: NOG (Non-Offsettable Grassland) within the nominated areas

Vegetation zone			Area (ha) impacted				
Vegetation zone ID	PCT	Condition	Wilton	GMAC	WSA	GPEC	Total
835_NOG	835	NOG	0.0	777.7	1,092.2	1,758.4	**3,628.3**
849_NOG	849	NOG	858.5	2,674.5	3,340.5	5,986.1	**12,859.6**
850_NOG	850	NOG	12.6	841.7	11.0	469.6	**1335.0**
1395_NOG	1395	NOG	537.0	1,075.1	0.0	3.5	**1,615.6**

Table 19-6: Current vegetation integrity score for each vegetation zone within urban capable lands of the nominated areas*

Vegetation zone			Composition score	Structure score	Function score	Current vegetation integrity score
Vegetation zone ID	PCT	Condition				
724_Intact	724	Intact	75.1	44.2	70.8	61.7
724_Thinned	724	Thinned	34.0	49.4	51.0	44.1
724_Scattered_trees	724	Scattered trees	33.9	4.0	41.9	17.8
725_Intact	725	Intact	83.7	30.6	46.7	49.2
725_Thinned	725	Thinned	57.1	27.1	52.4	43.3
725_Scattered_trees	725	Scattered trees	13.3	11.9	47.4	19.6
781_Thinned	781	Thinned	66.4	58.9	-	62.5
830_Thinned	830	Thinned	14.8	9.6	57.3	20.1
835_Intact	835	Intact	85.1	54.3	97.5	76.6
835_Thinned	835	Thinned	64.4	30.5	94.8	57.1
835_Scattered_trees	835	Scattered trees	54.1	66.4	90.4	68.7
835_NOG	835	NOG	15.3	14.9	10.8	13.5
849_Intact	849	Intact	39.3	65.4	60.9	53.9

Vegetation zone			Composition score	Structure score	Function score	Current vegetation integrity score
Vegetation zone ID	PCT	Condition				
849_Thinned	849	Thinned	32.9	33.9	68.0	42.3
849_Scattered_trees	849	Scattered trees	11.1	10.8	51.2	18.3
849_DNG	849	DNG	25.9	35.0	15.4	24.1
849_NOG	849	NOG	10.5	8.3	11.8	10.1
850_Intact	850	Intact	61.1	35.6	90.2	58.1
850_Thinned	850	Thinned	37.2	38.6	51.2	41.9
850_Scattered_trees	850	Scattered trees	35.8	27.0	57.4	38.1
850_DNG	850	DNG	30.6	39.1	14.1	25.7
850_NOG	850	NOG	10.6	15.8	11.1	12.3
1395_Intact	1395	Intact	75.0	63.1	82.0	72.9
1395_Thinned	1395	Thinned	56.4	68.1	67.9	63.9
1395_Scattered_trees	1395	Scattered trees	31.5	34.5	24.9	30.0
1395_DNG	1395	DNG	33.5	44.1	15.4	28.4
1395_NOG	1395	NOG	19.0	2.8	3.0	5.4

Vegetation zone			Composition score	Structure score	Function score	Current vegetation integrity score
Vegetation zone ID	PCT	Condition				
1800_Intact	1800	Intact	35.2	35.3	64.7	43.2
1800_Thinned	1800	Thinned	37.5	31.7	85.2	46.6
1800_Scattered_trees	1800	Scattered trees	29.3	61.6	38.9	41.2

*Vegetation integrity scores are only calculated for zones impacted by the proposed development. Of the 39 zones in the nominated areas, 30 are impacted

20 Threatened ecological communities

A total of nine NSW-listed TECs occur within the nominated areas.

The method to determine the TECs that occur within the nominated areas is explained in Chapter 11.

Identification of the NSW-listed TECs that occur within the nominated areas, as well as the extent of each TEC within each nominated area, is provided in Table 20-1.

Table 20-1 also indicates whether a PCT is notionally associated with a Commonwealth-listed TEC. It is important to note that Commonwealth-listed TECs often do not align exactly to a PCT and are usually defined differently to NSW-listed TECs. Commonwealth-listed TECs are described and assessed in Chapter 31.

The five most extensive NSW TECs within the nominated areas are:

- Cumberland Plain Woodland – 3,573 ha (this comprises 3,049 ha of PCT 849, and 524 ha of PCT 850)
- Shale Sandstone Transition Forest – 3,326 ha
- River-flat Eucalypt Forest on Coastal Floodplains – 1,170 ha
- Swamp Oak Floodplain Forest – 233 ha
- Shale Gravel Transition Forest – 191 ha

Map 15.1, Map 15.2, Map 15.3 and Map 15.4 show the distribution of TECs within each nominated area.

Table 20-1: TECs and amount (ha) of each TEC within the nominated areas

PCT	NSW TEC name	NSW status^	Area (ha)					Commonwealth TEC name	Cth status^
			Wilton	GMAC	WSA	GPEC	Total		
724	*Shale Gravel Transition Forest in the Sydney Basin Bioregion*	E	0.0	0.0	52.9	138.3	**191.2**	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	CE
725	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	E	0.0	0.0	39.9	127.5	**167.4**	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	CE
781	*Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	0.0	0.0	3.5	65.4	**68.9**	N/A	N/A
830	*Moist Shale Woodland in the Sydney Basin Bioregion*	E	0.0	18.8	0.0	2.8	**21.5**	*Western Sydney Dry Rainforest and Moist Woodland on Shale*	CE
835	*River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	0.0	183.8	160.0	826.1	**1,169.8**	N/A Note the Cth status of this TEC is currently being assessed by the Cth Threatened Species Scientific Committee	N/A
849	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	CE	286.5	443.5	525.8	1,793.5	**3,049.2**	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	CE
850	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	CE	164.5	269.4	9.1	80.8	**523.8**	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest*	CE
883	*Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion*	V	0.0	0.9	0.0	6.5	**7.4**	*Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion*	E
1395	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	CE	1,428.5	1,895.1	0.0	2.0	**3,325.6**	*Shale Sandstone Transition Forest of the Sydney Basin Bioregion*	CE

PCT	NSW TEC name	NSW status^	Area (ha)					Commonwealth TEC name	Cth status^
			Wilton	GMAC	WSA	GPEC	Total		
1800	*Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	0.0	4.1	110.1	118.4	**232.6**	*Coastal Swamp Oak Casuarina glauca Forest of New South Wales and South East Queensland ecological community*	E

^CE = critically endangered; E = endangered; V = vulnerable

21 Threatened species and habitat

This Chapter identifies the NSW-listed ecosystem credit species (ECS) and candidate species credit species (SCS) predicted to occur within the nominated areas and provides maps of the locations of the habitat for candidate SCS.

The method to predict the ECS and SCS within the nominated areas is explained in Chapter 9.

21.1 ECOSYSTEM CREDIT SPECIES

The ECS predicted to occur within the nominated areas are provided in Table 21-1.

The method to predict the ECS within the nominated areas is explained in Chapter 11.

A total of 45 ECS are predicted to occur within the nominated areas.

For this assessment, it was assumed that all ECS predicted to occur within the nominated areas are present, and no ECS were excluded from the assessment as allowed under section 6.4 of the BAM.

Table 21-1: Ecosystem credit species predicted to occur within the nominated areas

Scientific name	Common Name	NSW status^	Cth status^	Habitat constraints	Sensitivity to gain class	Predicted location			
						Wilton	GMAC	WSA	GPEC
*Anthochaera phrygia**	Regent Honeyeater	CE	CE	N/A	High	Yes	Yes	Yes	Yes
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Botaurus poiciloptilus	Australasian Bittern	E	E	Waterbodies; brackish or freshwater wetlands.	Moderate	No	Yes	Yes	Yes
*Calidris ferruginea**	Curlew Sandpiper	E	CE	N/A	High	No	No	Yes	No
*Callocephalon fimbriatum**	Gang-Gang Cockatoo	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
*Calyptorhynchus lathami**	Glossy Black Cockatoo	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Chthonicola sagittata	Speckled Warbler	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Circus assimilis	Spotted Harrier	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Climacteris picumnus victoriae	Brown Treecreeper	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Daphoenositta chrysoptera	Varied Sittella	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Dasyurus maculatus	Spotted-tailed Quoll	V	E	N/A	High	Yes	Yes	Yes	Yes

Scientific name	Common Name	NSW status^	Cth status^	Habitat constraints	Sensitivity to gain class	Predicted location			
						Wilton	GMAC	WSA	GPEC
Ephippiorhynchus asiaticus	Black-Necked Stork	E	N/A	Swamps and shallow, open freshwater or saline wetlands or shallow edges of deeper wetlands within 300 m of these swamps; waterbodies and shallow lakes, lake margins and estuaries within 300 m of these waterbodies.	Moderate	No	No	Yes	No
Epthianura albifrons	White-Fronted Chat	V	N/A	N/A	Moderate	No	No	Yes	No
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	N/A	N/A	High	Yes	Yes	No	No
Glossopsitta pusilla	Little Lorikeet	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Grantiella picta	Painted Honeyeater	V	V	Mistletoes present at a density of greater than five mistletoes per ha.	Moderate	Yes	Yes	Yes	Yes
*Haliaeetus leucogaster**	White-Bellied Sea-Eagle	V	N/A	Within 1 km of rivers, lakes, large dams or creeks, wetlands and coastlines	High	Yes	Yes	Yes	Yes
*Hieraaetus morphnoides**	Little Eagle	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Irediparra gallinacea	Comb-Crested Jacana	V	N/A	Waterbodies; freshwater wetlands with a good surface cover of floating aquatic vegetation.	Moderate	No	No	Yes	No
Ixobrychus flavicollis	Black Bittern	V	N/A	Waterbodies; land within 40 m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation.	Moderate	No	Yes	Yes	Yes
*Lathamus discolor**	Swift Parrot	E	CE	N/A	Moderate	Yes	Yes	Yes	Yes

Scientific name	Common Name	NSW status^	Cth status^	Habitat constraints	Sensitivity to gain class	Predicted location			
						Wilton	GMAC	WSA	GPEC
*Limicola falcinellus**	Broad-Billed Sandpiper	V	N/A	N/A	High	No	No	Yes	No
*Limosa limosa**	Black-Tailed Godwit	V	N/A	N/A	High	No	No	Yes	No
*Lophoictinia isura**	Square-Tailed Kite	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Melanodryas cucullata cucullata	Hooded Robin (South-Eastern Form)	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Melithreptus gularis gularis	Black-Chinned Honeyeater (Eastern subsp.)	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V	N/A	N/A	High	Yes	Yes	Yes	Yes
*Miniopterus australis**	Little Bent-winged Bat	V	N/A	N/A	High	Yes	Yes	Yes	Yes
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Neophema pulchella	Turquoise Parrot	V	N/A	N/A	High	Yes	Yes	Yes	Yes
*Ninox connivens**	Barking Owl	V	N/A	N/A	High	Yes	Yes	Yes	Yes
*Ninox strenua**	Powerful Owl	V	N/A	N/A	High	Yes	Yes	Yes	Yes
*Pandion cristatus** (foraging)	Eastern Osprey	V	N/A	N/A	Moderate	No	Yes	Yes	Yes
Petaurus australis	Yellow-Bellied Glider	V	N/A	Hollow-bearing trees; hollows > 25 cm diameter.	High	Yes	Yes	No	No

Scientific name	Common Name	NSW status^	Cth status^	Habitat constraints	Sensitivity to gain class	Predicted location			
						Wilton	GMAC	WSA	GPEC
Petroica boodang	Scarlet Robin	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Petroica phoenicea	Flame Robin	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
*Phascolarctos cinereus**	Koala	V	V	N/A	High	Yes	Yes	Yes	Yes
*Pteropus poliocephalus**	Grey-Headed Flying-fox	V	V	N/A	High	Yes	Yes	Yes	Yes
Rostratula australis	Australian Painted-Snipe	E	E	N/A	Moderate	No	No	Yes	No
Saccolaimus flaviventris	Yellow-bellied Sheathtail-Bat	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Scoteanax rueppellii	Greater Broad-Nosed Bat	V	N/A	N/A	High	Yes	Yes	No	No
Stagonopleura guttata	Diamond Firetail	V	N/A	N/A	Moderate	Yes	Yes	Yes	Yes
Stictonetta naevosa	Freckled Duck	V	N/A	N/A	Moderate	No	No	Yes	No
*Tyto novaehollandiae**	Masked Owl	V	N/A	N/A	High	Yes	Yes	Yes	Yes
Varanus rosenbergi	Rosenberg's Monitor	V	N/A	N/A	High	Yes	Yes	No	Yes

^CE = critically endangered; E = endangered; V = vulnerable; E.pop. = endangered population

*These species are ECS in relation to foraging habitat only

21.1.1 SPECIES CREDIT SPECIES

Section 6.4 of the BAM sets out a process for determining the SCS that need to be assessed in the Assessment Report. The method to predict the candidate SCS within the nominated areas is explained in Chapter 11.

In summary, the steps involve:

- Generating a list of SCS predicted to occur within the nominated areas according to the BAM calculator
- Identifying candidate SCS that require further assessment by considering whether any SCS can be excluded on the basis of specific considerations under the BAM. Where this occurs, adequate justification must be provided

A SCS may be excluded from needing further assessment because:

- Ecological information about a species provided in BioNet or published, peer reviewed literature, suggests that the SCS is unlikely to occur, or habitat is unlikely to be suitable (BAM section 6.1.1.2)
- Habitat constraints (defined in Threatened Biodiversity Data Collection) are not present (BAM section 6.4, step 2)
- Habitat is not suitable because it is substantially degraded (BAM section 6.4, step 3)
- An expert report determines that habitat for the species is unlikely to be present (BAM section 6.4, step 3)

For any SCS not excluded from needing further assessment, section 6.4.1.21 of the BAM requires a determination of whether the SCS is present, or likely to use suitable habitat, within the urban capable lands, by either:

- Assuming the species is present (this was done using a knowledge-based method (KBM) (see Chapter 11)
- Undertaking a threatened species survey
- Providing an expert report

Table 21-2 identifies the list of SCS predicted to occur according to the BAM calculator, and:

- The nominated area that the SCS is predicted to occur within (marked with a tick or cross)
- Whether the SCS has been removed from needing further assessment within a nominated area (marked with an 'R')
- The remaining list of candidate SCS
- The method used to determine the presence of each candidate SCS

Attachment A in Chapter 11 provides a justification for each SCS removed from needing further assessment and identifies the relevant section of the BAM under which a SCS was removed. Section 6.1.1.2 of the BAM was the primary basis used for removing a SCS from needing further assessment.

A total of 84 SCS were predicted to occur within the nominated areas.

Of these, 40 SCS were determined to be candidate SCS needing further assessment, and 44 were removed.

Table 21-3 identifies the amount of habitat for each candidate SCS in the nominated areas.

The following maps show the distribution of habitat within the nominated areas for each candidate SCS:

- Map 16.1 – *Acacia bynoeana*
- Map 16.2 – *Acacia pubescens*
- Map 16.3 – *Allocasuarina glareicola*
- Map 16.4 – *Callocephalon fimbriatum*
- Map 16.5 – *Calyptorhynchus lathami*
- Map 16.6 – *Cercartetus nanus*
- Map 16.7 – *Chalinolobus dwyeri*
- Map 16.8 – *Dillwynia tenuifolia*
- Map 16.9 – *Epacris purpurascens* var. *purpurascens*
- Map 16.10 – *Eucalyptus benthamii*
- Map 16.11 – *Grevillea juniperina* subsp. *juniperina*

- Map 16.12 – *Grevillea parviflora* subsp. *parviflora*
- Map 16.13 – *Haliaeetus leucogaster*
- Map 16.14 – *Heleioporus australiacus*
- Map 16.15 – *Hibbertia fumana*
- Map 16.16 – *Hibbertia puberula*
- Map 16.17 – *Hieraaetus morphnoides*
- Map 16.18 – *Litoria aurea*
- Map 16.19 – *Lophoictinia isura*
- Map 16.20 – *Marsdenia viridiflora* subsp. *viridiflora*
- Map 16.21 – *Maundia triglochinoides*
- Map 16.22 – *Melaleuca deanei*
- Map 16.23 – *Meridolum corneovirens*
- Map 16.24 – *Micromyrtus minutiflora*
- Map 16.25 – *Myotis macropus*
- Map 16.26 – *Ninox connivens*
- Map 16.27 – *Ninox strenua*
- Map 16.28 – *Persicaria elatior*
- Map 16.29 – *Persoonia bargoensis*
- Map 16.30 – *Persoonia nutans*
- Map 16.31 – *Petaurus norfolcensis*
- Map 16.32 – *Phascolarctos cinereus*
- Map 16.33 – *Pimelea curviflora* subsp. *curviflora*
- Map 16.34 – *Pimelea spicata*
- Map 16.35 – *Pomaderris brunnea*
- Map 16.36 – *Pseudophryne australis*
- Map 16.37 – *Pterostylis saxicola*
- Map 16.38 – *Pultenaea parviflora*
- Map 16.39 – *Pultenaea pedunculata*
- Map 16.40 – *Tyto novaehollandiae*

Table 21-2: Species credit species predicted to occur within the nominated areas and candidate species requiring further assessment

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Acacia bynoeana	Bynoe's Wattle	E	V			2	High	✓	✓	✓	✓	Yes	Expert report
Acacia gordonii	Gordon's Wattle	E	E			2	High	R	X	X	X	No	N/A
Acacia prominens	Gosford Wattle	E. pop.	N/A			2	Moderate	R	X	R	R	No	N/A
Acacia pubescens	Downy Wattle	V	V			2	High	✓	✓	✓	✓	Yes	Expert report
Allocasuarina glareicola		E	E			3	High	X	X	R	✓	Yes	KBM
*Anthochaera phrygia**	Regent Honeyeater	CE	CE			3	High	R	R	R	R	No	N/A
Burhinus grallarius	Bush Stone-curlew	E	N/A		Fallen/standing dead timber, including logs	2	High	R	R	R	R	No	N/A
Caladenia tessellata	Thick Lip Spider Orchid	E	V			3	Moderate	R	R	R	R	No	N/A
*Calidris ferruginea**	Curlew Sandpiper	E	CE			3	High	X	X	R	X	No	N/A

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Callistemon linearifolius	Netted Bottle Brush	V	N/A			1.5	Moderate	R	R	R	R	No	N/A
*Callocephalon fimbriatum**	Gang-gang Cockatoo	V	N/A			2	High	✓	✓	R	✓	Yes	KBM
*Callocephalon fimbriatum**	Gang-gang Cockatoo	E Pop.	N/A	Hornsby and Ku-ring-gai Local Government Areas		2	High	R	R	X	X	No	N/A
*Calyptorhynchus lathami**	Glossy Black Cockatoo	V	N/A			2	High	✓	✓	R	✓	Yes	KBM
Cercartetus nanus	Eastern Pygmy-possum	V	N/A			2	High	✓	✓	✓	✓	Yes	KBM

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Chalinolobus dwyeri	Large-eared Pied Bat	V	V		Cliffs; within two km of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two km of old mines/tunnels	3	Very High	✓	✓	✓	✓	Yes	KBM
Cynanchum elegans	White-flowered Wax Plant	E	E			2	High	R	R	R	R	No	N/A
Darwinia biflora		V	V			2	High	R	X	X	X	No	N/A
Darwinia peduncularis		V	N/A			3	Moderate	R	X	X	X	No	N/A
Deyeuxia appressa		E	E			3	High	R	X	R	X	No	N/A
Dillwynia tenuifolia		V	N/A			2	Moderate	R	R	✓	✓	Yes	Expert report

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Dillwynia tenuifolia		E. pop.	N/A	The area bounded by western Road, Elizabeth Drive, Devonshire Road and Cross Street, Kemps Creek in the Liverpool Local Government Area		2	High	X	X	R	X	No	N/A
Epacris purpurascens var. *purpurascens*		V	N/A			1.5	Moderate	✓	✓	R	R	Yes	KBM
Eucalyptus benthamii	Camden White Gum	V	V			2	High	✓	✓	R	R	Yes	KBM
Eucalyptus sp. *Cattai*		CE	CE			3	Very High	R	X	X	X	No	N/A
Grammitis stenophylla	Narrow-leaf Finger Fern	E	N/A			2	Moderate	R	X	X	X	No	N/A

Scientific name	**Common name**	**NSW status^**	**Cth status^**	**Geographic limitations**	**Habitat constraints**	**Bio. risk weight**	**Sens. to gain class**	**Predicted location** ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				**Candidate species needing further assessment**	**Method to determine presence**
								Wilton	**GMAC**	**WSA**	**GPEC**		
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	V	N/A			1.5	Moderate	R	R	✓	✓	Yes	Expert report
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V			2	High	✓	✓	✓	✓	Yes	KBM
Grevillea parviflora subsp. *supplicans*		E	N/A			2	High	R	R	X	R	No	N/A
Gyrostemon thesioides		E	N/A			3	High	R	R	R	R	No	N/A
*Haliaeetus leucogaster**	White-bellied Sea-Eagle	V	N/A			2	High	✓	✓	✓	✓	Yes	KBM

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Haloragis exalata subsp. *exalata*	Square Raspwort	V	V		Waterbodies; edges of coastal lakes after flooding has removed other vegetation; creek banks within flood zone; areas close to these features subject to human disturbance, including road verges and powerline easements or within 100 m of these features	1.5	Moderate	X	X	R	X	No	N/A
Haloragodendron lucasii		E	E			3	Very High	R	X	X	X	No	N/A
Heleioporus australiacus	Giant Burrowing Frog	V	V			1.5	Moderate	✓	✓	X	✓	Yes	KBM

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Hibbertia fumana		CE	N/A			3	Very High	✓	✓	✓	✓	Yes	Expert report
Hibbertia puberula		E	N/A			2	High	✓	✓	✓	✓	Yes	Expert report
Hibbertia sp. *Bankstown*		CE	CE			3	High	X	R	R	R	No	N/A
Hibbertia spanantha	Julian's Hibbertia	CE	CE			3	High	R	R	X	R	No	N/A
Hibbertia superans		E	N/A		Ridgetops	2	High	R	R	X	R	No	N/A
*Hieraaetus morphnoides**	Little Eagle	V	N/A		Nest trees - live (sometimes dead) large old trees in vegetation.	1.5	Moderate	✓	✓	✓	✓	Yes	Expert report / KBM
*Hoplocephalus bungaroides**	Broad-headed Snake	E	V			3	High	R	R	X	X	No	N/A
Lasiopetalum joyceae		V	V		Rocky areas; lateritic to shaly ridgetops.	1.5	High	R	X	X	X	No	N/A

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
*Lathamus discolor**	Swift Parrot	E	CE			3	Moderate	R	R	R	R	No	N/A
Leucopogon exolasius		V	V			2	High	R	X	R	R	No	N/A
Leucopogon fletcheri subsp. *fletcheri*		E	N/A			2	High	R	R	X	R	No	N/A
*Limicola falcinellus**	Broad-billed Sandpiper	V	N/A			2	High	X	X	R	X	No	N/A
*Limosa limosa**	Black-tailed Godwit	V	N/A			2	High	X	X	R	X	No	N/A
Litoria aurea	Green and Golden Bell Frog	E	V		Semi-permanent/ ephemeral wet areas; within 1 km of wet areas; swamps; within 1 km of swamps; waterbodies; within 1 km of waterbodies.	2	High	✓	✓	✓	✓	Yes	Expert report

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
*Lophoictinia isura**	Square-tailed Kite	V	N/A			1.5	Moderate	✓	✓	✓	✓	Yes	Expert report / KBM
Marsdenia viridiflora subsp. *viridiflora*		E. pop.	N/A	Those LGAs named in the population's listing		2	Moderate	X	✓	✓	✓	Yes	KBM
Maundia triglochinoides		V	N/A		Swamps; swamps or shallow fresh water on clay.	2	High	X	X	✓	✓	Yes	KBM
Melaleuca deanei	Deane's Paperbark	V	V			2	High	✓	✓	X	R	Yes	Expert report
Meridolum corneovirens	Cumberland Plain Land Snail	E	N/A			2	High	✓	✓	✓	✓	Yes	Expert report
Micromyrtus minutiflora		E	V			2	High	X	X	✓	✓	Yes	KBM
*Miniopterus australis**	Little Bentwing-bat	V	N/A			3	Very High	R	R	R	R	No	N/A
*Miniopterus orianae oceanensis**	Large Bent-winged Bat	V	N/A			3	Very High	R	R	R	R	No	N/A

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Myotis macropus	Southern Myotis	V	N/A			2	High	✓	✓	✓	✓	Yes	KBM
*Ninox connivens**	Barking owl	V	N/A			2	High	✓	✓	R	✓	Yes	KBM
*Ninox strenua**	Powerful owl	V	N/A			2	High	✓	✓	✓	✓	Yes	KBM
*Pandion cristatus**	Eastern Osprey	V	N/A			1.5	Moderate	X	R	R	R	No	N/A
Persicaria elatior	Tall Knotweed	V	V			2	High	X	✓	✓	✓	Yes	KBM
Persoonia bargoensis	Bargo Geebung	E	V			2	High	✓	✓	R	R	Yes	KBM
Persoonia glaucescens	Mittagong Geebung	E	V			2	High	R	X	X	X	No	N/A
Persoonia hirsuta	Hairy Geebung	E	E			3	High	R	R	R	R	No	N/A
Persoonia mollis subsp. *maxima*	Soft Geebung	E	E			2	High	R	X	X	X	No	N/A
Persoonia nutans	Nodding Geebung	E	E			2	Moderate	R	R	✓	✓	Yes	Expert report

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Petaurus norfolcensis	Squirrel Glider	V	N/A			2	High	✓	✓	R	✓	Yes	KBM
*Phascolarctos cinereus**	Koala	V	V			2	High	✓	✓	R	R	Yes	KBM
Pilularia novae-hollandiae	Austral Pillwort	E	N/A			3	High	X	R	R	R	No	N/A
Pimelea curviflora var. *curviflora*		E	V			2	High	R	R	R	✓	Yes	KBM
Pimelea spicata	Spiked Rice-flower	E	E			2	High	✓	✓	✓	✓	Yes	Expert report
Pomaderris brunnea	Brown Pomaderris	E	V			2	High	✓	✓	R	R	Yes	KBM
Pomaderris prunifolia		E. pop.	N/A			2	High	R	X	R	R	No	N/A

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Pommerhelix duralensis	Dural Woodland Snail	E	E		Leaf litter and shed bark or within 50 m of litter or bark; rocky areas; rocks or within 50 m of rocks; fallen/standing dead timber; logs and bark or within 50 m.	2	High	R	R	R	R	No	N/A
Pseudophryne australis	Red-crowned Toadlet	V	N/A	Margin of Cumberland Plain where sandstone outcrops intersect		1.5	Moderate	✓	✓	X	✓	Yes	KBM
*Pteropus poliocephalus**	Grey-headed Flying-fox	V	V			2	High	R	R	R	R	No	N/A
Pterostylis saxicola	Sydney Plains Greenhood	E	E			2	Moderate	✓	✓	✓	✓	Yes	Expert report
Pultenaea parviflora		E	V			2	Moderate	X	X	✓	✓	Yes	KBM

Scientific name	Common name	NSW status^	Cth status^	Geographic limitations	Habitat constraints	Bio. risk weight	Sens. to gain class	Predicted location ✓ = predicted to occur X = not predicted to occur R = predicted to occur but removed from needing further assessment				Candidate species needing further assessment	Method to determine presence
								Wilton	GMAC	WSA	GPEC		
Pultenaea pedunculata	Matted Bush-pea	E	N/A			2	High	✓	✓	✓	✓	Yes	KBM
Tetratheca glandulosa		V	N/A			2	High	R	R	X	R	No	N/A
Thesium australe	Austral Toadflax	V	V			1.5	Moderate	R	R	R	R	No	N/A
Tyto novaehollandiae	Masked Owl	V	N/A			2	High	✓	✓	R	✓	Yes	KBM
Wahlenbergia multicaulis	Tadgell's Bluebell	E. pop.	N/A			2	High	R	R	R	R	No	N/A
Zannichellia palustris	Horned Pondweed	E	N/A		Waterbodies; land containing freshwater bodies.	2	High	X	X	R	X	No	N/A
Zieria involucrata		E	V			2	High	R	X	X	X	No	N/A

^CE = critically endangered; E = endangered; V = vulnerable; E.pop. = endangered population

*These species are SCS in relation to breeding/important habitat only

Table 21-3: Amount of habitat for each candidate species credit species within the nominated areas

Scientific name	Common name	NSW status^	Cth status^	Area of habitat (ha) within nominated areas					Species habitat directly impacted?
				Wilton	GMAC	WSA	GPEC	Total	
Acacia bynoeana	Bynoe's Wattle	E	V	1,000.74	1,365.81	35.11	105.67	**2,507.33**	Yes
Acacia pubescens	Downy Wattle	V	V	1,123.29	1,997.69	580.86	2,491.88	**6,193.73**	Yes
Allocasuarina glareicola		E	E	0.0	0.0	0.0	185.61	**185.62**	Yes
*Callocephalon fimbriatum**	Gang-gang Cockatoo	V	-	194.63	472.12	0.0	260.14	**926.89**	Yes
*Calyptorhynchus lathami**	Glossy Black Cockatoo	V	-	453.21	862.73	0.0	0.0	**1,315.95**	Yes
Cercartetus nanus	Eastern Pygmy-possum	V	-	978.58	1,930.95	42.32	758.65	**3,710.50**	Yes
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	1,618.82	2,592.84	0.0	68.85	**4,280.51**	Yes
Dillwynia tenuifolia		V	-	0.0	0.0	171.30	607.68	**778.97**	Yes

Scientific name	Common name	NSW status^	Cth status^	Area of habitat (ha) within nominated areas					Species habitat directly impacted?
				Wilton	GMAC	WSA	GPEC	Total	
Epacris purpurascens var. *purpurascens*		V	-	1,264.06	1,889.33	0.0	0.0	**3,153.39**	Yes
Eucalyptus benthamii	Camden White Gum	V	V	0.0	73.83	0.14	0.16	**74.13**	No
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	V	-	0.0	0.0	552.54	1,961.01	**2,513.55**	Yes
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	427.95	285.37	17.03	68.17	**798.52**	Yes
*Haliaeetus leucogaster**	White-bellied Sea-Eagle	V	-	697.07	1,268.04	67.85	451.70	**2,484.65**	Yes
Heleioporus australiacus	Giant Burrowing Frog	V	V	290.36	108.04	0.0	0.0	**398.40**	Yes
Hibbertia fumana		CE	-	757.59	732.47	52.16	107.48	**1,649.71**	Yes

Scientific name	Common name	NSW status^	Cth status^	Area of habitat (ha) within nominated areas					Species habitat directly impacted?
				Wilton	GMAC	WSA	GPEC	Total	
Hibbertia puberula		E	-	745.14	732.47	52.16	116.58	**1,646.36**	Yes
*Hieraaetus morphnoides**	Little Eagle	V	-	1,274.63	2,447.41	25.04	415.56	**4,162.64**	Yes
Litoria aurea	Green and Golden Bell Frog	E	V	0.0	232.93	0.0	1,421.58	**1,654.52**	Yes
*Lophoictinia isura**	Square-tailed Kite	V	-	1,310.10	2,441.73	34.32	460.23	**4,246.38**	Yes
Marsdenia viridiflora subsp. *viridiflora*		E. pop.	-	0.0	1,112.35	579.37	2,740.64	**4,432.36**	Yes
Maundia triglochinoides		V	-	0.0	0.0	102.94	153.86	**256.80**	Yes
Melaleuca deanei	Deane's Paperbark	V	V	909.36	1,412.39	0.0	0.0	**2,321.75**	Yes
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	1,122.56	2,362.59	539.31	2,734.37	**6,758.83**	Yes

Scientific name	Common name	NSW status^	Cth status^	Area of habitat (ha) within nominated areas					Species habitat directly impacted?
				Wilton	GMAC	WSA	GPEC	Total	
Micromyrtus minutiflora		E	V	0.0	0.0	34.79	196.62	**231.41**	Yes
Myotis macropus	Southern Myotis	V	-	473.44	882.91	948.95	603.67	**2,908.97**	Yes
*Ninox connivens**	Barking Owl	V	-	255.03	265.01	0.19	2.09	**522.33**	No
*Ninox strenua**	Powerful Owl	V	-	255.06	270.01	0.44	2.09	**527.60**	Yes
Persicaria elatior	Tall Knotweed	V	V	0.0	7.33	37.57	220.71	**265.61**	Yes
Persoonia bargoensis	Bargo Geebung	E	V	1,279.82	1,852.16	0.0	0.0	**3,131.98**	Yes
Persoonia nutans	Nodding Geebung	E	E	0.0	23.65	80.03	219.71	**323.38**	Yes
Petaurus norfolcensis	Squirrel Glider	V	-	1,458.62	2,603.14	0.0	2,455.03	**6,516.79**	Yes
*Phascolarctos cinereus**^^	Koala	V	V	1,529.3	2,369.0	0.0	0.0	**3,898.3**	Yes
Pimelea curviflora var. *curviflora*		E	V	0.0	0.44	0.0	545.11	**545.55**	Yes

Scientific name	Common name	NSW status^	Cth status^	Area of habitat (ha) within nominated areas					Species habitat directly impacted?
				Wilton	GMAC	WSA	GPEC	Total	
Pimelea spicata	Spiked Rice-flower	E	E	664.42	475.31	512.04	2,164.13	**3,815.90**	Yes
Pomaderris brunnea	Brown Pomaderris	E	V	531.68	756.38	0.007	0.009	**1,288.08**	Yes
Pseudophryne australis	Red-crowned Toadlet	V	-	421.0	668.83	0.0	0.0	**1,089.82**	Yes
Pterostylis saxicola	Sydney Plains Greenhood	E	E	953.95	1,795.21	0.0	14.30	**2,763.46**	Yes
Pultenaea parviflora		E	V	0.0	0.91	80.17	249.03	**330.11**	Yes
Pultenaea pedunculata	Matted Bush-pea	E	-	233.30	629.28	188.74	919.37	**1970.70**	Yes
*Tyto novaehollandiae**	Masked Owl	V	-	260.46	281.56	0.55	4.35	**546.91**	Yes

^CE = critically endangered; E = endangered; V = vulnerable; E.pop. = endangered population

*These species are SCS in relation to breeding/important habitat only

^^ Important habitat defined as Primary and Secondary Koala corridors

Part 5A References

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 5B: BCAR STAGE 2 (IMPACT ASSESSMENT)

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 5B Contents

Part 5B List of Tables

22 Introduction

This Part provides an assessment of the impacts of the urban, industrial, infrastructure, agribusiness and transport development under the Plan within the nominated areas for matters listed under the BC Act in accordance with the BAM, including:

- Direct impacts on Plant Community Types (PCTs), threatened ecological communities (TECs), and threatened species and habitat (Chapter 23)
- Prescribed impacts (Chapter 24)
- Serious and irreversible impacts (SAII) (Chapter 25)
- Impact summary, including the number of credits that would be required to be retired to offset the impacts (Chapter 26)

Direct impacts described in Chapter 23 are identified in terms of:

- Impacts of urban, industrial, infrastructure, and agribusiness development within each nominated area and total impacts across all nominated areas
- Total impacts of the transport development across all nominated areas
- Total impacts of the urban, industrial, infrastructure, agribusiness and transport development across all nominated areas

Note that the only development types in Wilton Growth Area (Wilton) are urban, industrial and infrastructure development.

Avoidance and minimisation of impacts on biodiversity values is described in Chapter 14.

Indirect impacts on native vegetation and habitat are described in Chapter 15.

23 Direct impacts on native vegetation and habitat

23.1 APPROACH TO THE ASSESSMENT

The BAM defines in detail the method for addressing direct impacts. In summary, this involved:

- Assessing the direct impacts that will result from the clearing of native vegetation, TECs and threatened species habitat (Section 9.1.2 of the BAM)
- Calculating:
  - The change in vegetation integrity for each vegetation zone and species polygon (Section 9.1.3 of the BAM)
  - The required number of ecosystem credits for direct impacts (Section 11.2.3 of the BAM)
  - The required number of species credits for direct impacts (Section 11.2.4 of the BAM)
- Identifying the credit class for ecosystem credits and species credit (Section 11.3 of the BAM)

23.2 NATIVE VEGETATION

23.2.1 VEGETATION ZONES

Table 23-1 summarises the amount (hectares) of each vegetation zone that will be directly impacted within the nominated areas, including:

- Urban, industrial, infrastructure, and agribusiness development
- Transport development
- Total impacts from the urban, industrial, infrastructure, agribusiness and transport development

A total of 1,777.79 ha of native vegetation occurs within the urban capable land and transport corridors and will be impacted by the development. The five most impacted vegetation zones (excluding non-offsettable grassland) are:

- PCT 849_Thinned – 335.61 ha
- PCT 849_DNG – 239.17 ha
- PCT 1395_DNG – 237.30 ha
- PCT 850_DNG – 188.45 ha
- PCT 1395_Thinned – 155.05 ha

Table 23-1: Direct impacts on vegetation zones within each nominated area

Vegetation zone			Area (ha) impacted						Hollow-bearing trees^
			Urban, industrial, infrastructure and agribusiness development				Transport development	Total*	
Vegetation zone ID	PCT	Condition	Wilton	GMAC	WSA	GPEC			
724_Intact	724	Intact	0.0	0.0	0.0	0.97	7.04	**8.01**	Yes
724_Thinned	724	Thinned	0.0	0.0	19.25	6.64	18.11	**44.01**	Yes
724_Scattered_trees	724	Scattered trees	0.0	0.0	0.08	0.10	0.0	**0.18**	Yes
725_Intact	725	Intact	0.0	0.0	0.41	0.0	15.16	**15.57**	No
725_Thinned	725	Thinned	0.0	0.0	8.21	6.38	3.72	**18.30**	No
725_Scattered_trees	725	Scattered trees	0.0	0.0	2.98	0.0	0.0	**2.98**	Yes
781_Thinned	781	Thinned	0.0	0.0	0.0	2.01	0.07	**2.08**	No
830_Thinned	830	Thinned	0.0	0.09	0.0	0.0	0.0	**0.09**	No
835_Intact	835	Intact	0.0	0.0	0.0	1.04	11.14	**12.18**	Yes
835_Thinned	835	Thinned	0.0	4.19	10.67	14.97	105.31	**135.14**	Yes
835_Scattered_trees	835	Scattered trees	0.0	0.0	11.68	0.90	5.24	**17.82**	Yes

Vegetation zone			Area (ha) impacted						Hollow-bearing trees^
			Urban, industrial, infrastructure and agribusiness development				Transport development	Total*	
Vegetation zone ID	PCT	Condition	Wilton	GMAC	WSA	GPEC			
849_Intact	849	Intact	1.56	13.45	5.61	0.07	9.00	**29.69**	Yes
849_Thinned	849	Thinned	22.38	31.69	149.26	68.15	64.13	**335.61**	Yes
849_Scattered_trees	849	Scattered trees	24.12	31.40	56.32	3.62	9.83	**125.29**	Yes
849_DNG	849	DNG	139.47	32.33	32.97	8.76	25.64	**239.17**	No
850_Intact	850	Intact	0.0	8.05	0.01	0.0	0.0	**8.06**	Yes
850_Thinned	850	Thinned	0.0	44.52	5.69	15.88	0.0	**66.09**	Yes
850_Scattered_trees	850	Scattered trees	0.91	17.15	2.05	2.06	0.0	**22.17**	Yes
850_DNG	850	DNG	151.11	14.19	0.19	22.97	0.0	**188.45**	No
1395_Intact	1395	Intact	13.28	31.62	0.0	0.0	0.0	**44.89**	Yes
1395_Thinned	1395	Thinned	84.71	70.34	0.0	0.0	0.0	**155.05**	Yes
1395_Scattered_trees	1395	Scattered trees	20.12	30.36	0.0	0.0	0.0	**50.48**	No

Vegetation zone			Area (ha) impacted						Hollow-bearing trees^
			Urban, industrial, infrastructure and agribusiness development				Transport development	Total*	
Vegetation zone ID	PCT	Condition	Wilton	GMAC	WSA	GPEC			
1395_DNG	1395	DNG	205.84	31.46	0.0	0.0	0.0	**237.30**	No
1800_Intact	1800	Intact	0.0	0.0	0.23	0.0	0.0	**0.23**	Yes
1800_Thinned	1800	Thinned	0.0	0.0	5.93	2.24	10.40	**18.58**	Yes
1800_Scattered_trees	1800	Scattered trees	0.0	0.0	0.23	0.0	0.14	**0.37**	No
Total			**663.50**	**360.81**	**311.78**	**156.75**	**284.95**	**1,777.79**	

^ While hollow-bearing trees were not recorded within plots used to assess that vegetation zone, they may occur elsewhere within the vegetation zone

* Totals highlighted in blue are based on raw vegetation data outputs. Some rounding errors may occur between the impact areas quoted for each nominated area and the summed total for each vegetation zone.

23.2.2 NON-OFFSETTABLE GRASSLAND

Table 23-2 provides a summary of impacts to non-offsettable grassland vegetation types within the nominated areas.

Non-offsettable grassland comprises grassland vegetation zones with a vegetation integrity score of <15 and does not require offsetting for the associated PCT under the BAM. However, where non-offsettable grasslands support species credit species habitat, offsets may be required for those species.

Table 23-2: Direct impacts on non-offsettable grassland (NOG) within the nominated areas

Vegetation zone			Area (ha) impacted					
Vegetation zone ID	PCT	Condition	Wilton	GMAC	WSA	GPEC	Transport development	Total*
835_NOG	835	NOG	0.0	14.42	432.24	285.24	209.69	**941.59**
849_NOG	849	NOG	653.31	1,283.23	2,266.76	619.44	312.34	**5,135.07**
850_NOG	850	NOG	12.27	441.48	9.96	219.05	0.0	**682.75**
1395_NOG	1395	NOG	331.06	447.38	0.0	0.0	0.0	**778.44**

* Totals highlighted in blue are based on raw vegetation data outputs. Some rounding errors may occur between the impact areas quoted for each nominated area and the summed total for each vegetation zone.

23.2.3 VEGETATION INTEGRITY

Table 23-3 shows the change in vegetation integrity as a result of the urban, industrial, infrastructure, agribusiness and transport development within the nominated areas. Change in vegetation integrity is a measure of the direct impact on native vegetation and species habitat.

It has been assumed that all vegetation will be removed within the urban capable land of each nominated area and within the transport corridors and therefore the future vegetation integrity score will be zero.

In practice some vegetation will likely be retained through Development Control Plans and other instruments, including hollow-bearing trees and other vegetative features required for the threatened species habitat be retained across the landscape (see Chapter 15).

Table 23-3: Change in vegetation integrity due to urban, industrial, infrastructure, agribusiness and transport development

Vegetation zone			Area (ha) impacted	Current vegetation integrity score before development	Future vegetation integrity score after development	Change in vegetation integrity score
Vegetation zone ID	PCT	Condition				
724_Intact	724	Intact	8.01	61.7	0.0	-61.7
724_Thinned	724	Thinned	44.01	44.1	0.0	-44.1
724_Scattered_trees	724	Scattered trees	0.18	17.8	0.0	-17.8
725_Intact	725	Intact	15.57	49.2	0.0	-49.2
725_Thinned	725	Thinned	18.30	43.3	0.0	-43.3
725_Scattered_trees	725	Scattered trees	2.98	19.6	0.0	-19.6
781_Thinned	781	Thinned	2.08	62.5	0.0	-62.5
830_Thinned	830	Thinned	0.09	20.1	0.0	-20.1
835_Intact	835	Intact	12.18	76.6	0.0	-76.6
835_Thinned	835	Thinned	135.14	57.1	0.0	-57.1
835_Scattered_trees	835	Scattered trees	17.82	68.7	0.0	-68.7
835_NOG	835	NOG	941.59	13.5	0.0	-13.5
849_Intact	849	Intact	29.69	53.9	0.0	-53.9

Vegetation zone			Area (ha) impacted	Current vegetation integrity score before development	Future vegetation integrity score after development	Change in vegetation integrity score
Vegetation zone ID	PCT	Condition				
849_Thinned	849	Thinned	335.61	42.3	0.0	-42.3
849_Scattered_trees	849	Scattered trees	125.29	18.3	0.0	-18.3
849_DNG	849	DNG	239.17	24.1	0.0	-24.1
849_NOG	849	NOG	5,135.07	10.1	0.0	-10.1
850_Intact	850	Intact	8.06	58.1	0.0	-58.1
850_Thinned	850	Thinned	66.09	41.9	0.0	-41.9
850_Scattered_trees	850	Scattered trees	22.17	38.1	0.0	-38.1
850_DNG	850	DNG	188.45	25.7	0.0	-25.7
850_NOG	850	NOG	682.75	12.3	0.0	-12.3
1395_Intact	1395	Intact	44.89	72.9	0.0	-72.9
1395_Thinned	1395	Thinned	155.05	63.9	0.0	-63.9
1395_Scattered_trees	1395	Scattered trees	50.48	30.0	0.0	-30.0
1395_DNG	1395	DNG	237.30	28.4	0.0	-28.4
1395_NOG	1395	NOG	778.44	5.4	0.0	-5.4

Vegetation zone			Area (ha) impacted	Current vegetation integrity score before development	Future vegetation integrity score after development	Change in vegetation integrity score
Vegetation zone ID	PCT	Condition				
1800_Intact	1800	Intact	0.23	43.2	0.0	-43.2
1800_Thinned	1800	Thinned	18.58	46.6	0.0	-46.6
1800_Scattered_trees	1800	Scattered trees	0.37	41.2	0.0	-41.2

23.3 THREATENED ECOLOGICAL COMMUNITIES

Table 23-4 summarises the amount (hectares) of each TEC that will be directly impacted within the nominated areas, including:

- Urban, industrial, infrastructure and agribusiness development
- Transport development
- Total impacts from the urban, industrial, infrastructure, agribusiness and transport development

A total of 1,777.79 ha of TECs occurs within the urban capable land and transport corridors and will be impacted by the development. The TEC mapping method used is generally conservative and is more likely to over-predict distribution of TECs. Limitations to the mapping are further discussed in Chapter 13.3.

The five most impacted TECs are:

- Cumberland Plain Woodland – 1,014.52 ha
- Shale Sandstone Transition Forest – 487.72 ha
- River-flat Eucalypt Forest on Coastal Floodplains – 165.14 ha
- Shale Gravel Transition Forest – 52.20 ha
- Cooks River/Castlereagh Ironbark Forest – 36.85 ha

Table 23-4: Direct impacts on TECs within the nominated areas

PCT	Condition	NSW status^	NSW TEC name	Area (ha) impacted						Cth TEC name	Cth status^
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total*		
				Wilton	GMAC	WSA	GPEC				
724	Intact	E	*Shale Gravel Transition Forest in the Sydney Basin Bioregion*	0.0	0.0	0.0	0.97	7.04	8.01	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (part)*	CE
724	Thinned			0.0	0.0	19.25	6.64	18.11	44.01		
724	Scattered Trees			0.0	0.0	0.08	0.10	0.0	0.18		
Total Shale Gravel Transition Forest									**52.20**		
725	Intact	E	*Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion*	0.0	0.0	0.41	0.0	15.16	15.57	*Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion*	CE
725	Thinned			0.0	0.0	8.21	6.38	3.72	18.30		
725	Scattered Trees			0.0	0.0	2.98	0.0	0.0	2.98		
Total Cooks River/Castlereagh Ironbark Forest									**36.85**		

PCT	Condition	NSW status^	NSW TEC name	Area (ha) impacted						Cth TEC name	Cth status^
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total*		
				Wilton	GMAC	WSA	GPEC				
781	Thinned	E	*Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	0.0	0.0	0.0	2.01	0.07	2.08	N/A	N/A
Total Freshwater Wetlands on Coastal Floodplains									**2.08**		
830	Thinned	E	*Moist Shale Woodland in the Sydney Basin Bioregion*	0.0	0.09	0.0	0.0	0.0	0.09	*Western Sydney Dry Rainforest and Moist Woodland on Shale (part)*	CE
Total Moist Shale Woodland									**0.09**		
835	Intact	E	*River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	0.0	0.0	0.0	1.04	11.14	12.18	N/A Note the Commonwealth status of this TEC is currently being assessed by the Threatened Species Scientific Committee	N/A
835	Thinned			0.0	4.19	10.67	14.97	105.31	135.14		
835	Scattered Trees			0.0	0.0	11.68	0.90	5.24	17.82		

PCT	Condition	NSW status^	NSW TEC name	Area (ha) impacted						Cth TEC name	Cth status^
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total*		
				Wilton	GMAC	WSA	GPEC				
Total River-flat Eucalypt Forest on Coastal Floodplains									**165.14**		
849	Intact	CE	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	1.56	13.45	5.61	0.07	9.00	29.69	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (part)*	CE
849	Thinned			22.38	31.69	149.26	68.15	64.13	335.61		
849	Scattered Trees			24.12	31.40	56.32	3.62	9.83	125.29		
849	DNG			139.47	32.33	32.97	8.76	25.64	239.17		
850	Intact	CE	*Cumberland Plain Woodland in the Sydney Basin Bioregion*	0.0	8.05	0.0	0.0	0.0	8.06	*Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (part)*	CE
850	Thinned			0.0	44.52	5.69	15.88	0.0	66.09		
850	Scattered Trees			0.91	17.15	2.05	2.06	0.0	22.17		
850	DNG			151.11	14.19	0.19	22.97	0.0	188.45		
Total Cumberland Plain Woodland									**1,014.52**		

PCT	Condition	NSW status^	NSW TEC name	Area (ha) impacted						Cth TEC name	Cth status^
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total*		
				Wilton	GMAC	WSA	GPEC				
1395	Intact	CE	*Shale Sandstone Transition Forest in the Sydney Basin Bioregion*	13.28	31.62	0.0	0.0	0.0	44.89	*Shale Sandstone Transition Forest of the Sydney Basin Bioregion*	CE
1395	Thinned			84.71	70.34	0.0	0.0	0.0	155.05		
1395	Scattered Trees			20.21	30.36	0.0	0.0	0.0	50.48		
1395	DNG			205.84	31.46	0.0	0.0	0.0	237.30		
Total Shale Sandstone Transition Forest									**487.72**		
1800	Intact	E	*Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	0.00	0.0	0.23	0.0	0.0	0.23	*Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community*	E
1800	Thinned			0.00	0.0	5.93	2.24	10.4	18.58		
1800	Scattered Trees			0.00	0.0	0.23	0.0	0.14	0.37		
Total Swamp Oak Floodplain Forest									**19.18**		

^CE = critically endangered; E = endangered; V = vulnerable

* Totals highlighted in blue are based on raw vegetation data outputs. Some rounding errors may occur between the impact areas quoted for each nominated area and the summed total for each TEC.

23.4 THREATENED SPECIES AND SPECIES HABITAT

Table 23-5 identifies the amount of habitat (in hectares) of each candidate species credit species (SCS) that will be directly impacted within the nominated areas, including:

- Urban, industrial, infrastructure, and agribusiness development
- Transport development
- Total impacts from the urban, industrial, infrastructure, agribusiness and transport development

The five SCS with the largest area of potential habitat impacted are:

- *Pimelea spicata* – 847.75 ha
- *Myotis macropus* – 745.24 ha
- *Meridolum corneovirens* – 736.40 ha
- *Acacia pubescens* – 734.15 ha
- *Grevillea juniperina* subsp. *juniperina* – 457.75 ha

It is important to note that the knowledge-based method used to determine habitat for some species is based on assuming presence within areas of potential habitat. The method is therefore likely to greatly overestimate the amount of actual or known habitat for these species impacted by the development (see Chapter 11).

The BAM requires certain candidate SCS to be assessed by a count of the species individuals directly impacted, rather than the area of habitat. One candidate SCS, *Epacris purpurascens* var. *purpurascens* requires assessment by a count of individuals. As the KBM process is limited to modelling habitat based on area, a modelled count of individuals is not possible. To address this for *Epacris purpurascens* var. *purpurascens* the following process was used to derive a biodiversity credit requirement for impacts to the species:

- The ratio of credits per hectare required for impacts to all species credit species was determined by dividing the number of credits by the area of impact (in hectares)
- The Biodiversity Risk Weighting (BRW) was assessed for all candidate species credit species. This included *Epacris purpurascens* var. *purpurascens* which was found to by 1.5
- The average credits per hectare ratio was calculated for all other species with a BRW of 1.5
  - Little Eagle and Square-tailed Kite were excluded due to an over-representation of impacts associated with Non-offsettable Grassland, which brings down the ratio of credits per hectare
- Modelled impact to *Epacris purpurascens* var. *purpurascens* habitat were multiplied by the average credits per hectare ratio for all other species with a BRW of 1.5 to determine the biodiversity credit for *Epacris purpurascens* var. *purpurascens*
  - This calculation was undertaken separately for the Wilton and Greater Macarthur Growth Areas (GMAC) due to a difference in the average credits per hectare ratio
- This biodiversity credit requirement was then used to determine the stem count required to be entered into the BAM Calculator by dividing the number of credits required by *Epacris purpurascens* var. *purpurascens'* offset multiplier of 1.5

Note that Little Eagle and Square-tailed Kite are candidate SCS for breeding habitat only. Expert reports were prepared for these species that mapped areas of 'breeding and foraging habitat' (equating to potential breeding habitat) within Wilton and GMAC. An additional 1,322.98 ha of foraging habitat for Little Eagle and 510.84 ha of foraging habitat for Square-tailed Kite were mapped within the expert reports which have not been included in the candidate SCS calculations, as they are not considered to be impacts to the species as required by the BAM and include mainly grassed paddocks. Potential breeding habitat is generally restricted to heavily vegetated areas outside urban capable lands, however there is considerable overlap between potential forage habitat and urban capable land. In addition, impacts of 0.80 ha to a buffer around a confirmed stick nest (species not known) in GPEC, associated with grassed paddocks commensurate with the habitat mapped as potential forage habitat by the expert in Wilton and GMAC, has also been excluded from the candidate SCS calculations.

Table 23-5: Direct impacts on candidate species credit species habitat within the nominated areas

Scientific name	Common name	NSW status^	Cth status^	Habitat area (ha) impacted					
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total~
				Wilton	GMAC	WSA	GPEC		
Acacia bynoeana	Bynoe's Wattle	E	V	122.19	63.04	8.31	1.63	0.06	**195.23**
Acacia pubescens	Downy Wattle	V	V	167.48	120.63	226.31	88.42	132.06	**734.90**
Allocasuarina glareicola		E	E	0.0	0.0	0.0	7.36	4.50	**11.87**
*Callocephalon fimbriatum**	Gang-gang Cockatoo	V	-	0.66	2.80	0.0	0.0	0.04	**3.50**
*Calyptorhynchus lathami**	Glossy Black Cockatoo	V	-	1.50	7.20	0.0	0.0	0.0	**8.70**
Cercartetus nanus	Eastern Pygmy-possum	V	-	7.96	33.31	5.39	1.07	17.67	**65.41**
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	123.47	187.39	0.0	0.93	1.05	**312.84**
Dillwynia tenuifolia		V	-	0.0	0.0	65.10	34.13	76.39	**175.61**
Epacris purpurascens var. *purpurascens*		V	-	38.76	48.80	0.0	0.0	0.0	**87.55**
Eucalyptus benthamii	Camden White Gum	V	V	0.0	0.0	0.0	0.0	0.0	**0.00**
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	V	-	0.0	0.0	226.76	82.43	148.56	**457.75**
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	3.94	1.06	7.02	0.11	3.88	**16.02**
*Haliaeetus leucogaster**	White-bellied Sea-Eagle	V	-	2.04	8.52	0.23	0.29	5.48	**16.56**
Heleioporus australiacus	Giant Burrowing Frog	V	V	0.30	0.29	0.0	0.0	0.0	**0.59**

Scientific name	Common name	NSW status^	Cth status^	Habitat area (ha) impacted					
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total~
				Wilton	GMAC	WSA	GPEC		
Hibbertia fumana		CE	-	25.90	8.44	3.11	0.0	0.0	**37.45**
Hibbertia puberula		E	-	25.36	8.44	3.11	0.0	4.67	**41.58**
*Hieraaetus morphnoides**	Little Eagle	V	-	0.0	14.71	0.47	0.53	3.20	**18.91**
Litoria aurea+	Green and Golden Bell Frog	E	V	0.0	0.0	0.0	11.03	2.31	**13.34**
*Lophoictinia isura**	Square-tailed Kite	V	-	0.0	14.71	0.23	0.29	12.61	**27.84**
Marsdenia viridiflora subsp. *viridiflora*		E. pop.	-	0.0	26.83	165.29	95.96	124.27	**412.34**
Maundia triglochinoides		V	-	0.0	0.0	4.64	2.38	10.45	**17.46**
Melaleuca deanei	Deane's Paperbark	V	V	46.29	56.17	0.0	0.0	0.0	**102.46**
Meridolum corneovirens	Cumberland Plain Land Snail	E	-	102.99	161.13	178.25	96.28	197.75	**736.40**
Micromyrtus minutiflora		E	V	0.0	0.01	10.91	6.61	4.50	**22.03**
Myotis macropus	Southern Myotis	V	-	92.77	148.01	253.31	89.62	161.54	**745.24**
*Ninox connivens**	Barking Owl	V	-	0.0	0.0	0.0	0.0	0.0	**0.00**
*Ninox strenua**	Powerful Owl	V	-	0.0	0.25	0.0	0.0	0.06	**0.31**
Persicaria elatior	Tall Knotweed	V	V	0.0	0.0	0.0	0.63	46.51	**47.14**
Persoonia bargoensis	Bargo Geebung	E	V	39.38	41.99	0.0	0.0	0.0	**81.37**
Persoonia nutans	Nodding Geebung	E	E	0.0	0.0	25.43	7.24	8.03	**40.71**
Petaurus norfolcensis	Squirrel Glider	V	-	64.26	118.21	0.0	48.13	91.46	**322.06**

Scientific name	Common name	NSW status^	Cth status^	Habitat area (ha) impacted					
				Urban, industrial, infrastructure and agribusiness development				Transport development	Total~
				Wilton	GMAC	WSA	GPEC		
*Phascolarctos cinereus**	Koala	V	V	116.66	143.92	0.0	0.0	0.0	**260.58**
Pimelea curviflora var. *curviflora*		E	-	0.0	0.0	0.0	22.19	50.79	**72.97**
Pimelea spicata#	Spiked Rice-flower	E	E	398.35	61.16	195.65	59.13	133.45	**847.75**
Pomaderris brunnea	Brown Pomaderris	E	V	16.32	17.35	0.0	0.0	0.92	**34.59**
Pseudophryne australis	Red-crowned Toadlet	V	-	3.27	5.75	0.0	0.0	0.0	**9.02**
Pterostylis saxicola	Sydney Plains Greenhood	E	E	14.33	31.34	0.0	0.93	0.0	**46.60**
Pultenaea parviflora		E	V	0.0	0.0	22.89	7.68	43.82	**74.40**
Pultenaea pedunculata	Matted Bush-pea	E	-	30.69	27.74	62.38	36.84	50.07	**207.72**
*Tyto novaehollandiae**	Masked Owl	V	-	0.01	0.36	0.0	0.0	0.52	**0.89**
Total				**1,444.88**	**1,359.56**	**1,464.79**	**701.84**	**1,336.62**	**6,307.69**

^CE = critically endangered; E = endangered; V = vulnerable; E.pop. = endangered population

*These species are SCS in relation to breeding habitat or mapped "important habitat" only

+7.58 hectares of impact to Green and Golden Bell Frog is associated with vegetation removal and hence has been entered into the BAM Calculator to determine the resultant credit requirement. The remaining 5.76 hectares of impact is associated with man-made structures and has been assessed under Prescribed Impact in Section 16.3 of the BCAR

#839.18 hectares of impact to *Pimelea spicata* is associated with vegetation removal and hence has been entered into the BAM Calculator to determine the resultant credit requirement. The remaining 8.6 hectares of impact (as mapped by the species expert) is associated with Non-Native Vegetation and has been assessed under Prescribed Impact in Section 16.3 of the BCAR

~ Totals highlighted in blue are based on raw habitat data outputs. Some rounding errors may occur between the impact areas quoted for each nominated area and the summed total for each species

24 Prescribed biodiversity impacts

24.1 INTRODUCTION

The BAM requires prescribed impacts to be identified and assessed.

This Chapter sets out:

- The definition of prescribed impacts
- The approach taken to assessing prescribed impacts
- Identification of relevant prescribed impacts
- Assessment of the impacts of the urban, industrial, infrastructure, agribusiness and transport development within the nominated areas under the Plan in relation to each relevant prescribed impact

24.2 DEFINITION OF PRESCRIBED IMPACTS

Prescribed impacts can be defined generally as impacts on biodiversity values that do not comprise direct clearing of native vegetation that are assessed through credits. Prescribed impacts can be direct impacts (e.g. impacts on species' habitat of a type that is not native vegetation, such as rocks) or indirect impacts (e.g. impacts on species associated with the severing of a habitat corridor). Prescribed impacts comprise impacts on (Clause 6.1, BC Regulation):

- Habitat features for threatened species or TECs:
  - Karst, caves, crevices, cliffs and other geological features of significance
  - Rocks
  - Human-made structures
  - Non-native vegetation
- Connectivity of habitat of threatened species that facilitates the movement of those species across their range
- Movement of threatened species that maintains their lifecycle
- Water quality, water bodies and hydrological processes that sustain threatened species and TECs
- Wind turbine strikes on protected fauna
- Vehicle strikes on threatened fauna or fauna that is part of a TEC

24.3 APPROACH TO THE ASSESSMENT

The BAM requires the BCAR to identify and assess prescribed impacts within the nominated areas.

Section 6.7 of the BAM requires the BCAR to:

- Identify occurrences of habitats associated with prescribed impacts
- List the candidate SCS or ecosystem credit species (ECS) or TECs associated with those habitats
- Undertake targeted surveys for any relevant candidate SCS

Section 9.1.1.2 and 9. 2 of the BAM requires the BCAR to:

- Describe the nature, extent, frequency, duration and timing of prescribed impacts relevant to the proposed development, including impacts during construction and operation
- Evaluate the consequences of prescribed impacts

The steps taken to assess prescribed impacts involved:

Step 1: Identify the relevant species and TECs (including ECS and candidate SCS) associated with each prescribed impact type within the nominated areas. This was done by drawing on ecological and life history information in BioNet profiles, as well as species records, habitat maps, and surveys undertaken for this assessment.

The following was described for each species or TEC:

- Likely presence/abundance of species/TEC in the nominated areas
- Use and importance of the prescribed impact type for the TEC/species

A combination of targeted surveys and habitat assessments was undertaken within urban capable land by senior ecologists for the range of species associated with prescribed impacts where land access was granted. Survey effort and species subject to targeted surveys (based on tracks or survey points) is set out in Chapter 11.

Step 2: Map the occurrence of each prescribed impact type within the nominated areas where possible. Where mapping was not possible (human-made structures, vehicle strikes) or not necessary (rock outcrops – see Section 24.7), the occurrence of the prescribed impact type in each nominated area was described and assessed qualitatively.

Mapping was undertaken for:

- Karst, caves, crevices, cliffs and other geological features of significance
- Non-native vegetation
- Habitat connectivity and movement
- Water bodies and hydrological processes

The mapping of each prescribed impact type was overlayed on the urban capable land within each nominated area to provide impact data and other information on the nature, extent and duration of impacts

Step 3: Describe the nature, extent, and duration of each prescribed impact type:

- Nature of impacts – qualitatively describe any direct impacts (e.g. removal or destruction of habitat) or indirect impacts (e.g. reduction in habitat connectivity, human use/disturbance, urban run-off)
- Extent of impacts – quantify the amount of direct impacts where possible (e.g. the amount of habitat removed or destroyed (ha)) or the general location and extent of indirect impacts
- Duration – identify whether the impacts are permanent or temporary

Step 4: Describe the commitments and general environmental controls that will be implemented under the Plan through the NSW planning system to mitigate the prescribed impacts

Step 5: Assess the likelihood of residual prescribed impacts on each TEC and species taking into account the general environmental controls to mitigate the impacts. This was done taking into account matters such as:

- Likely presence/abundance of species/TEC and importance of the location at a local and regional scale
- Life history traits and susceptibility of the species/TEC to the prescribed impact
- Location of the species/TEC relative to the likely extent of the prescribed impact
- Amount and quality of unimpacted habitat remaining and levels of existing protection

Step 6: Describe any additional specific mitigation measures for particular species/TECs that will be implemented under the Plan to address residual prescribed impacts remaining after the application of general environmental controls

24.4 RELEVANT PRESCRIBED IMPACTS

The following prescribed impact types are relevant to the development:

- Karst, caves, crevices, cliffs and other geological features of significance
- Rocks
- Human-made structures
- Non-native vegetation
- Habitat connectivity and movement
- Water bodies and hydrological processes
- Vehicle strikes

Prescribed impacts may be associated with direct or indirect impacts. Table 24-1 sets out the potential types of impacts associated with each prescribed impact type that are relevant to the development.

The prescribed impact type 'wind turbine strikes on protected fauna' is not relevant to the development and has not been considered further in this Assessment Report.

Table 24-1: Types of impacts associated with each prescribed impact type

Prescribed impact type	Associated potential direct impacts	Associated potential indirect impacts
Karst, caves, crevices, cliffs	Removal or destruction (e.g. cracking or collapse) of habitat	Recreational use/disturbance Noise or light disturbance
Rocks	Removal of habitat (rocks)	
Human-made structures	Removal of habitat (structures)	Human disturbance Noise or light disturbance
Non-native vegetation	Removal of habitat (non-native vegetation)	Recreational use/disturbance Weed invasion Spread of plant/animal disease Pest animals/predation/competition Soil erosion/sedimentation Urban run-off (water quality)
Habitat connectivity/movement	N/A	Reduction in habitat connectivity
Water bodies/hydrological processes	Removal of habitat (water bodies)	Change in water flows/quantity Urban run-off (water quality)
Vehicle strikes	Death of species individuals	N/A

24.5 PRESENCE/ABUNDANCE OF RELEVANT SPECIES

Table 24-2 identifies the presence and abundance of species and TECs associated with each prescribed impact type.

Note about Koala: development under the Plan within the nominated areas has the potential to impact the Southern Sydney Koala population. The direct, indirect and prescribed impacts from the development within the Plan Area on Koala has been assessed in detail in Chapter 30 and is not covered in this chapter.

Table 24-2: Relevant species/TECs potentially subject to prescribed impacts

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Plants			
Acacia bynoeana	Bynoe's Wattle	Records occur to the north of GPEC where there are a significant number of populations, and in Wilton in avoided/excluded lands	• Non-native vegetation
Grevillea juniperina subsp. *Juniperina*	Juniper-leaved Grevillea	Records occur in Western Sydney Aerotropolis (WSA) and Greater Penrith to Eastern Creek Investigation Area (GPEC). Most records for the species occur just north of GPEC. The species is known to occur in disturbed land at Marsden Park (Weston, 2019)	• Non-native vegetation

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Hibbertia fumana		Species is only known from the Moorebank and Bankstown areas outside the nominated areas. However, the species is recently described and if present, could have been recorded under a different name in previous studies	• Non-native vegetation
Hibbertia puberula		There are no records within the Plan Area. This species is only known from Bankstown Airport and has not been recorded at any other sites, despite targeted surveys throughout the Bankstown area	• Non-native vegetation
Persoonia bargoensis	Bargo Geebung	Records occur on the edge of Wilton within avoided/excluded lands. These records are part of a single population of the species that spans from Bargo, to Picton in the north west, through to Appin in the east	• Non-native vegetation
Pimelea spicata	Spiked Rice-flower	Records occur in GPEC and GMAC in avoided/excluded lands. Most records occur in the Blacktown, Prospect, Bankstown and Narellan districts. One population in GMAC occurs within roadside vegetation	• Non-native vegetation
Bats			
Chalinolobus dwyeri	Large-eared Pied Bat	Records occur throughout the Cumberland subregion. Breeding habitat is associated with sandstone caves, crevices and cliffs. Most records occur in the south of the subregion around Wilton. Interrogation of BioNet records suggests no roost sites occur in the nominated areas	• Karsts, caves, crevices and cliffs • Non-native vegetation • Habitat connectivity
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Records occur within and surrounding the Cumberland subregion. Most records in the subregion occur in the eastern and northern parts. Few records occur in the nominated areas. The species has not been recorded in WSA	• Human-made structures • Non-native vegetation • Habitat connectivity
Miniopterus australis	Little Bentwing-bat	Few records occur within the Cumberland subregion. The species has been recorded in three of the nominated areas (not WSA), including recently (< 5 years ago) in Wilton. Most records surrounding the subregion occur in coastal areas to the north	• Karsts, caves, crevices and cliffs • Human-made structures • Non-native vegetation • Habitat connectivity
Miniopterus orianae oceanensis	Large Bent-winged Bat	Records are widespread within and surrounding the Cumberland subregion. The species has been recorded in all four nominated areas, including recently (< 5 years ago)	• Karsts, caves, crevices and cliffs • Human-made structures • Non-native vegetation • Habitat connectivity
Mormopterus norfolkensis	Eastern Freetail-bat	Records are widespread within and surrounding the Cumberland subregion. The species has been recorded in all four nominated areas, including recently (< 5 years ago) in Wilton and GPEC	• Human-made structures • Non-native

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
			vegetation • Habitat connectivity
Myotis macropus	Southern Myotis	Records are widespread within and surrounding the Cumberland subregion. The species has been recorded in all four nominated areas, including recently (< 5 years ago) particularly in Wilton and GPEC and just outside the northern part of GMAC. Suitable habitat has been mapped within each of the nominated areas. Suitable habitat occurs as scattered small to moderate size patches associated with native vegetation, including vegetation in low to moderate condition	• Human-made structures • Habitat connectivity • Water bodies
Pteropus poliocephalus	Grey-headed Flying-fox	The Plan Area supports significant numbers of the species across a number of camps. The location of breeding and roosting camps within the Cumberland subregion has been monitored since 2012 (Geoscience Australia, 2015). There are no known camps in the urban capable lands	• Non-native vegetation • Habitat connectivity
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Records occur within and surrounding the Cumberland subregion. Few records occur in the nominated areas. The species has not been recorded in WSA. Roost requirements are poorly known	• Human-made structures • Non-native vegetation • Habitat connectivity
Scoteanax rueppellii	Greater Broad-nosed Bat	Records occur within and surrounding the Cumberland subregion. Most records for the species in the subregion occur in the eastern part. Few records occur in the nominated areas	• Human-made structures • Non-native vegetation • Habitat connectivity
Marsupials			
Cercartetus nanus	Eastern Pygmy-possum	No records occur in the nominated areas. Records occur to the south and east of Wilton and east of GMAC outside the Cumberland subregion. Suitable habitat for the species is generally restricted to the gorges and gullies on the edges of Wilton, on the edges and through the middle of the southern part of GMAC, along riparian corridors in WSA and GPEC, and associated with larger patches of native vegetation within Wianamatta Regional Park and Orchid Hills	• Habitat connectivity • Vehicle strikes
Dasyurus maculatus	Spotted-tailed Quoll	Several important populations for the species have been identified within the vicinity of the nominated areas. Suitable habitat is generally restricted to the gorges and gullies on the edges of the nominated areas and along waterways	• Non-native vegetation • Habitat connectivity • Vehicle strikes
Petaurus australis	Yellow-bellied Glider	No records occur in the nominated areas. Closest record occurs < 1 km away from Wilton. There are 6 records north of GPEC, 3 records west of Wilton, and one record east of Wilton, all within the Plan Area. The majority of records occur outside the Plan Area to the north-east and south-west	• Habitat connectivity • Vehicles strikes

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Petaurus norfolcensis	Squirrel Glider	Records in the nominated areas are limited. There are 2 records in Wilton and one in GPEC, all of which occur on avoided lands	• Habitat connectivity • Vehicles strikes
Frogs			
Litoria aurea	Green and Golden Bell Frog	Records in the nominated areas are limited. There are 12 records within GPEC and two records within GMAC. Suitable habitat has been mapped along Ropes Creek in GPEC in the vicinity of 6 records made between 1998 and 2012. It has not been confirmed whether this population still exists. However, there are a series of other records from nearby habitat associated with Ropes Creek more broadly and areas of suitable habitat remain along the corridor in the form of a high density of water bodies (Lemckert, 2019)	• Non-native vegetation • Habitat connectivity • Water bodies • Vehicle strikes
Pseudophryne australis	Red-crowned Toadlet	There are no records within the nominated areas. Closest records occur within a few kilometres of the nominated areas. Mapped suitable habitat occurs in scattered patches within the vicinity of gorges and gullies that occur mainly around the edges of the nominated areas	• Rocky areas • Habitat connectivity
Reptiles			
Hoplocephalus bungaroides	Broad-headed Snake	There are no recent records in the nominated areas. There is one historical record from 1970 in the Appin area. Mapped suitable habitat occurs along riparian corridors in gorges and gullies that occur mainly around the edges of the nominated areas	• Karsts, caves, crevices and cliffs • Rocky areas • Vehicle strikes
Varanus rosenbergi	Rosenberg's Monitor	No records occur in the nominated areas and very few records occur in the Cumberland subregion. Records occur at the edges of the subregion near Gordon and Dharawal National Park. The species is associated with sandstone areas, particularly to north-east, south-east and north-west of Sydney (OEH, 2017i) and is considered unlikely to occur in the nominated areas, and is not considered further in this Chapter	N/A
Birds			
Anthochaera phrygia	Regent Honeyeater	There are 78 records in the Plan Area which mostly occur in larger patches of woodland in the Londonderry area. Records in the nominated areas are limited, with one occurring in east Wilton and 3 occurring in north-east GPEC	• Habitat connectivity
Artamus cyanopterus cyanopterus	Dusky Woodswallow	There are 96 records in the nominated areas. The species is abundant in and around the Cumberland subregion	• Non-native vegetation • Habitat connectivity
Botaurus poiciloptilus	Australasian Bittern	Records in the nominated areas are limited to one record in the north of GPEC. Six records occur to the north of GPEC and 4 are scattered between WSA, GMAC and Wilton within the Plan Area	• Habitat connectivity • Water bodies

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Calidris ferruginea	Curlew Sandpiper	The species occurs in and around the Cumberland subregion, most frequently closer to the coast. There are 40 records in the Plan Area, the majority of which are concentrated around Windsor. One record occurs in GMAC, within avoided/excluded lands	• Habitat connectivity
Callocephalon fimbriatum	Gang-gang Cockatoo	The species occurs in and around the Cumberland subregion. Records within the nominated areas are limited. One record occurs in the north of GPEC, 3 in Wilton along the boundary, and 10 in GMAC	• Habitat connectivity
Calyptorhynchus lathami	Glossy Black Cockatoo	The species occurs in and around the Cumberland subregion. Records in the nominated areas are limited. There are 2 records in the north of GPEC, 4 in Wilton, and 3 in GMAC	• Habitat connectivity
Circus assimilis	Spotted Harrier	Records in the nominated areas are limited. One record occurs in GPEC and 2 in GMAC. The majority of records in the Plan Area occur in the north-east around the Richmond area	• Habitat connectivity
Climacteris picumnus victoriae	Brown Treecreeper	This species occurs sparsely in the Cumberland subregion with the highest density of records occurring in the Blue Mountains and Wolgan Valley regions. Records within the nominated areas are limited. There are 2 records in the north-east of GPEC, 3 in the east of Wilton, and 5 throughout GMAC	• Habitat connectivity
Daphoenositta chrysoptera	Varied Sittella	The species occurs in and around the Cumberland subregion. There are 17 records in GPEC, 3 in WSA, 1 in Wilton, and 8 in GMAC	• Habitat connectivity
Ephippiorhynchus asiaticus	Black-necked Stork	Records in the nominated areas are limited. There are 3 records in GPEC and 1 record in GMAC. Outside the nominated areas within the Plan Area there are a further 9 records, the majority of which are located in and around Windsor	• Water bodies
Epthianura albifrons	White-fronted Chat	Records within the nominated areas are limited. There is only 1 record in the nominated areas, located in GMAC. There are a further 3 records outside the nominated areas within the Plan Area, which are located in Liverpool, Windsor, and Scheyville National Park	• Habitat connectivity
Glossopsitta pusilla	Little Lorikeet	The species is abundant and wide-spread in and around the Cumberland subregion. There are 17 records in Wilton, 8 in GPEC, and 22 in GMAC	• Habitat connectivity
Grantiella picta	Painted Honeyeater	The species occurs sparsely in the Cumberland subregion. There are 5 records within the Plan Area, none of which occur in the nominated areas. Four records occur north of GPEC and one east of WSA in Smithfield	• Non-native vegetation • Habitat connectivity

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Haliaeetus leucogaster	White-bellied Sea-eagle	There are several records in the nominated areas. There is one old record in GPEC and two records in the central part of WSA, including a recent (2017) record. There is a cluster of relatively recent records (2013) within or just outside the central part of GPEC, and several other records in the southern part of GPEC. There are several recent (2018) records just outside the northern part of the GPEC to the east. There are no records in Wilton	• Habitat connectivity • Water bodies
Hieraaetus morphnoides	Little Eagle	There are 35 records of the species within the nominated areas or within 5 km of their boundaries. Most records are associated with large patches of open woodland that occur within open grassland areas. Some records are found close to the edges of forests along watercourses. A few records are from woodlands associated with wetlands (Saunders and Debus, 2018a)	• Non-native vegetation • Habitat connectivity
Irediparra gallinacean	Comb-crested Jacana	There are 18 records of the species in the Plan Area, 17 of which occur north of GPEC, with 1 just north of GMAC. There are no records in the nominated areas	• Habitat connectivity • Water bodies
Ixobrychus flavicollis	Black Bittern	The species occurs sparsely in the Cumberland subregion with the majority of records occurring closer to the coast. There are 15 records in the Plan Area, 2 of which occur in GPEC	• Habitat connectivity • Water bodies
Lathamus discolor	Swift Parrot	The species is abundant and wide-spread in and around the Cumberland subregion. There are 135 records in the Plan Area, 25 of which occur in GPEC and 5 in GMAC	• Habitat connectivity
Limicola falcinellus	Broad-billed Sandpiper	There are no records of the species in the Plan Area. The closest record is approximately 9 km east towards the coast	• Habitat connectivity
Limosa limosa	Black-tailed Godwit	There are no records in the nominated areas. Eight records occur in the Plan Area, with the closest approximately 2 km west of GPEC	• Habitat connectivity
Lophoictinia isura	Square-tailed Kite	There are 32 records in the nominated areas, including 12 within Wilton and the southern part of GMAC. Another 15 records occur within 5 km of the nominated areas, with 11 occurring just outside the northern part of GMAC. The majority of records are from January to April, which represents the post-breeding dispersal phase (Saunders and Debus, 2018b)	• Non-native vegetation • Habitat connectivity
Melithreptus gularis gularis	Black-chinned Honeyeater	The species is wide-spread in and around the Cumberland subregion, with a higher abundance further north around Glen Davis and the Hunter. There are 48 records in the Strategic Assessment Area; 1 in Wilton, 2 in GPEC and 2 in GMAC	• Habitat connectivity

Scientific name	Common name	Presence/abundance in nominated areas	Relevant prescribed impact type
Neophema pulchella	Turquoise Parrot	The species occurs in and around the Cumberland subregion with higher densities of records found in Glen Davis, Mellong, and near Yerranderie State Conservation Area. There are 28 records in the Plan Area, 6 of which occur in GMAC and 1 in Wilton	• Habitat connectivity
Ninox connivens	Barking Owl	The species occurs in and around the Cumberland subregion. There are 16 records in the Plan Area, 2 of which occur in Wilton and GMAC	• Non-native vegetation • Habitat connectivity
Ninox strenua	Powerful Owl	The species occurs in and around the Cumberland subregion. There are 121 records in the Plan Area, including 18 records in GMAC, 10 in GPEC and 3 in Wilton	• Non-native vegetation • Habitat connectivity
Pandion cristatus	Eastern Osprey	There are 4 records in the Plan Area, one of which occurs in GPEC. Relatively more records occur to the east of the Plan Area along the coast	• Habitat connectivity • Water bodies
Rostratula australis	Australian painted-snipe	The species is sparsely distributed in and around the Cumberland Plain. There are 19 records in the Plan Area, of which 1 occurs in GPEC and 1 in GMAC	• Water bodies
Stagonopleura guttata	Diamond Firetail	The species occurs in and around the Cumberland subregion. There are 93 records in the Plan Area of which 15 occur in GPEC, 6 in GMAC, and 1 in Wilton	• Habitat connectivity
Stictonetta naevosa	Freckled Duck	The species is sparsely distributed in and around the Cumberland subregion. There are 30 records for the species in the Plan Area, mostly concentrated around Windsor. Of which 7 occur in GPEC and 1 in WSA	• Habitat connectivity • Water bodies
Tyto novaehollandiae	Masked Owl	The species occurs in and around the Cumberland subregion, with higher concentrations occurring around the Central Coast and Nowra. There are 34 records in the Plan Area, of which 3 occur in GMAC and 1 in GPEC	• Non-native vegetation • Habitat connectivity
Snail			
Meridolum corneovirens	Cumberland Plain Land Snail	The species is largely endemic to the Cumberland subregion, with a few records occurring just outside. There are 976 records in the Plan Area, of which 210 occur in GPEC, 66 in GMAC, 13 in WSA and 3 in Wilton. Records are scattered across the subregion. Most records occur outside the nominated areas or on excluded land	• Habitat connectivity

24.6 ASSESSMENT OF KARST, CAVES, CREVICES, CLIFFS

24.6.1 LIST OF RELEVANT SPECIES AND TECS

The list of species associated with karst, caves, crevices and cliffs is shown in Table 24-3.

Table 24-3: Species associated with karst, caves, crevices, cliffs and other geological features

Relevant species	Use and importance of habitat type
Broad-headed Snake	Broad-headed Snake may use rocky areas and crevices for refuge. Adults shelter in rocky outcrops under flat sandstone rocks on exposed cliff edges during autumn, winter and early spring, then move to adjacent woodland within 500 m of rocky areas during late spring and summer. Pregnant females and juveniles remain in rocky habitat, using cooler, shaded rocks and crevices (DoEE, 2018a)
Large Bent-winged Bat	Large Bent-winged Bat mainly roosts in caves with very specific temperature and humidity regimes. It can also use mines, storm water tunnels, buildings and other human-made structures. The species disperses widely from breeding colonies (within 300 km. Interrogation of BioNet records suggests no roost sites occur in the nominated areas
Large-eared Pied Bat	Large-eared Pied Bat roosts in sandstone caves, crevices, cliffs and old mine workings. Habitat within the nominated areas is likely to be used for foraging. Interrogation of BioNet records suggests no roost sites occur in the nominated areas
Little Bentwing-bat	Little Bentwing-bat can roost in the following human-made structures: tunnels, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day. It also roosts in caves and tree hollows. Forages in densely vegetated habitats (OEH, 2019f). Interrogation of BioNet records suggests no roost sites occur in the nominated areas

24.6.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

Locations where karst, caves, crevices, cliffs and other geological features are most likely to occur in the nominated areas are shown in Map 17.

These areas are associated with the gorges and gullies around the edges and northern part of Wilton and the southern part of GMAC, including along the Nepean and Cataract rivers. All these areas occur outside the urban capable land and transport corridors within the nominated areas.

Karst, caves, crevices, cliffs and other geological features were mapped by:

- Manipulation of a bare earth Digital Elevation Model to produce a layer that showed the mean elevation within a 30 m x 30 m grid surrounding each 1 m elevation grid cell
- Creation of a Topographic Position Index to identify the height of each 1 m cell above/below local mean elevation
- Reclassification of the Topographic Position Index to identify only areas that were high enough above the local mean elevation to create a topographic brake that might support cliffs
- Overlay the cliffs layer with a sandstone geology layer to exclude areas outside sandstone geology

The cliffs layer was validated through inspection of aerial photos and knowledge of the topography and landscape of the nominated areas, as well as site observations during surveys.

24.6.3 NATURE, EXTENT AND DURATION OF IMPACTS

Impacts to karsts, caves, crevices and cliffs are unlikely to occur as a result of the urban, industrial, infrastructure, agribusiness or transport development under the Plan within the nominated areas.

Map 17 shows that the areas where karst, caves, crevices, cliffs and other geological features are most likely to occur have been avoided and do not occur within urban capable land or transport corridors within the nominated areas.

The steps taken to avoid and minimise impacts of the development in the nominated areas are set out in Chapter 14.

24.7 ASSESSMENT OF ROCKY AREAS

24.7.1 LIST OF RELEVANT SPECIES AND TECS

The list of species associated with rocky areas is shown in Table 24-4.

Table 24-4: Species associated with rocky areas

Relevant species	Use and importance of habitat type
Broad-headed Snake	Broad-headed Snake may use rocky areas for refuge. Adults shelter in rocky outcrops under flat sandstone rocks on exposed cliff edges during autumn, winter and early spring, then move to adjacent native vegetation (woodland communities) within 500 m of rocky areas during late spring and summer. Pregnant females and juveniles remain in rocky habitat, using cooler, shaded rocks and crevices (DoEE, 2018a)
Red-crowned Toadlet	Red-crowned Toadlet may use rocky areas for breeding and refuge, and is largely restricted to the immediate vicinity of these areas. Breeding habitat comprises dense vegetation and debris beside ephemeral creeks and gutters (OEH, 2019h). The species deposits eggs in terrestrial nests beneath rocks and logs or in leaf litter (NSW Scientific Committee, 2002). Outside the breeding period, the species disperses to refuge areas close to breeding sites, which comprise rocks and masses of dense vegetation or thick piles of leaf litter generally on sandstone ridges (OEH, 2019h)

24.7.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

The potential occurrence of rocky areas in each nominated area is described in Table 24-5.

No obvious rock outcrops were observed during targeted surveys done as part of this project (see Chapter 11). However, some areas were not surveyed due to land access restrictions and rock outcrops have the potential to occur.

Table 24-5: Potential occurrence of rocky areas

Nominated area	Potential occurrence of rocky areas
Wilton	Rocky areas may occur on the edges of the nominated area and in the gully lines where the underlying sandstone is exposed
GMAC	Northern part: A few rocky areas comprising small exposures of shale and lithic sandstone may occur
	Southern part: Rocky areas may occur on the edges of the southern section of the nominated area where the underlying sandstone is exposed. Some exposure may also occur along the main gully lines
WSA	A few rocky areas comprising small exposures of shale and lithic sandstone may occur
GPEC	A few rocky areas comprising small exposures of shale and lithic sandstone may occur. In the Eastern Creek area there are possible outcrops of basalt and other igneous intrusion

24.7.3 NATURE, EXTENT AND DURATION OF IMPACTS

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on rocky areas are set out in Table 24-6.

Table 24-6: Nature, extent and duration of impacts – rocky areas

Species	Nature	Extent	Duration
Broad-headed Snake Red-crowned Toadlet	**Direct impacts:** Rocky areas utilised by these species generally only occur within areas of native vegetation Direct impacts are therefore addressed through impacts to native vegetation and habitat (see Chapter 23) rather than as a prescribed impact	N/A	N/A
	Indirect impacts: The development has the potential to increase bush rock removal in areas of potential habitat for these species as a result of increased human populations in the nominated areas	Risk is highest in publicly accessible habitat areas within and adjacent to the nominated areas	Long-term

24.7.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan will apply environmental conservation zoning to all areas avoided for biodiversity purposes as well as riparian corridors to strengthen the protection of avoided lands from the impacts of development.

This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will reduce the risk, and support the mitigation of, several indirect and prescribed impacts, including:

- Removal of key habitat features, such as trees, firewood and bush rock
- Habitat disturbance from increased public access, including recreational activities

Furthermore, the collection of bush rock is regulated in NSW. For example, the removal of bush rock in national parks and nature reserves, as well as state forests and Crown land reserves, is prohibited. Some councils also regulate bush rock removal in council reserves and other bushland areas (Department of Environment and Climate Change, 2009).

Furthermore, councils or other public authorities prepare management plans for many reserves which typically include measures to control public access within reserves, which may reduce the risk of bush rock removal.

24.7.5 ASSESSMENT OF POTENTIAL IMPACTS

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development on rocky areas is set out in Table 24-7. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-7: Assessment of potential prescribed impacts – rocky areas

Relevant species	Assessment of potential prescribed impacts	Residual risk of impacts?
Broad-headed Snake Red-crowned Toadlet	Impacts are unlikely to cause population decline at a local, regional or state scale because no recent records for the species occur in the nominated areas or nearby, reducing the risk that the species relies to a notable extent on habitat in the vicinity of the nominated areas The Plan will apply environmental conservation zoning to all areas avoided for biodiversity purposes as well as riparian corridors to strengthen the protection of avoided lands from the impacts of development. This will reduce the risk of bush rock removal. Furthermore, the removal of bush rock in many reserves is prohibited and management plans for reserves typically include measures to control public access within reserves, which may also reduce the risk of bush rock removal. The new proposed zoning and these existing arrangements are considered adequate for managing the risk of bush rock removal to these species	Unlikely

24.8 ASSESSMENT OF HUMAN-MADE STRUCTURES

24.8.1 LIST OF RELEVANT SPECIES AND TECS

The list of species associated with human-made structures is shown in Table 24-8.

All relevant species associated with this prescribed impact type are microbat species.

Codes within BioNet records ('observation' and 'microhabitat' codes) were interrogated to identify whether there was data on microbats recorded roosting within the nominated areas (Observation Code 'E'), including under bridges (Microhabitat Code 'BR') or in buildings (Microhabitat Code 'BU').

BioNet records suggest no known roost sites occur for any of the species in the nominated areas except for Southern Myotis within GMAC. The records do not indicate whether these roost sites are associated with human made structures.

Table 24-8: Species associated with human-made structures

Relevant species	Use and importance of habitat type
Large Bent-winged Bat	Large Bent-winged Bat mainly roosts in caves with very specific temperature and humidity regimes. The species can also use mines, storm water tunnels, buildings and other human-made structures. The species disperses widely from breeding colonies (within 300 km) (OEH, 2019d). BioNet records suggest no known roost sites occur in the nominated areas
Eastern False Pipistrelle	Roost requirements for Eastern False Pipistrelle are poorly known. The species is thought to mainly roost in tree hollows, but has also been found under loose bark on trees or in buildings. The species may roost in paddock trees. BioNet records suggest no known roost sites occur in the nominated areas
Eastern Freetail-bat	Eastern Freetail-bat mainly roosts in tree hollows. It can also roost inhuman-made structures, including buildings (OEH, 2017c). The species changes breeding sites every few days, making it very difficult to record sites. Occasionally aggregates in large breeding groups (including in buildings). BioNet records suggest no known roost sites occur in the nominated areas
Greater Broad-nosed Bat	Greater Broad-nosed Bat mainly roosts in tree hollows. It can also roost inhuman-made structures, including buildings. Forages along creek and river corridors (OEH, 2017e). BioNet records suggestsno known roost sites occur in the nominated areas
Little Bentwing-bat	Little Bentwing-bat can roost in the following human-made structures: tunnels, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day. It also roosts in caves and tree hollows. Forages in densely vegetated habitats (OEH, 2019f). BioNet records suggest no known roost sites occur in the nominated areas
Southern Myotis	Southern Myotis can roost in the following human-made structures: mine shafts, storm water tunnels, buildings, and under bridges and in culverts. The species also roosts in caves, hollow-bearing trees and dense foliage, and forages over waterbodies within 200 m of roost sites (OEH, 2019j). BioNet records show roost sites have been recorded in GMAC. The records do not indicate whether these roost sites are associated with human-made structures
Yellow-bellied Sheathtail-bat	Yellow-bellied Sheathtail-bat is thought to mainly roost in tree hollows and buildings, and sometimes mammal burrows (OEH, 2017l). BioNet records suggest no known roost sites occur in the nominated areas

24.8.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

It was not possible to map the location of human made structures at the scale of the nominated areas.

Human-made structures such as mine shafts, storm water channels, old or derelict buildings, bridges and culverts may provide suitable habitat for several species and are likely to occur thoughout each of the nominated areas.

24.8.3 NATURE, EXTENT AND DURATION IMPACTS

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on human made structures are set out in Table 24-9.

Table 24-9: Nature, extent and duration of impacts – human-made structures

Species	Nature	Extent	Duration
All relevant micro-bat species	**Direct impacts:** Direct impacts may occur due to removal or upgrade of bridges, culverts, stormwater channels, old buildings and other human-made structures that contain roost sites	Human-made structures within urban capable lands in each nominated area	Long-term
	Indirect impacts: Indirect impacts may occur due to disturbance to individuals using human-made structures though physical disturbance, lighting or noise due to construction activities, or increased presence of human populations	Human-made structures adjacent to urban capable lands in each nominated area	Temporary or long-term

GREEN AND GOLDEN BELL FROG

Note that an area of approximately 5.8 ha mapped as suitable Green and Golden Bell Frog habitat occurs within an existing urban area comprising buildings and roads in GPEC (near Ropes Creek) and will be directly impacted by the urban, industrial and infrastructure development. The area of habitat was mapped on the basis of:

- The locations of known records
- The riparian corridor joining those records
- A buffer of 1,000 m around the riparian corridor and records that could be used by the species for foraging, shelter, breeding and as migratory habitat as individuals disperse between water bodies and riparian corridors(Lemckert, 2019)

This area occurs within the buffer and is very unlikely to provide notable habitat or connectivity for the species as it currently comprises buildings and roads. As such, the impacts on this area are not considered further.

24.8.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from development on TECs and species habitat to best practice standards (Commitment 5). This commitment will be delivered through preparation of a Development Control Plan (DCP) for each nominated area. A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval. DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

DCPs will include general development controls relevant to managing prescribed impacts on micro-bat species due to the disturbance of human-made structures, including:

- Where noise or light impacts from development may affect wildlife, measures to manage impacts should be implemented, such as managing the timing of activities and/or installing appropriate noise barriers
- High-intensity outdoor lighting should be designed to avoid light spill into adjoining natural areas
- Development within 100 m of known microbat colonies must include street lighting that does not attract insects

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.1.

24.8.5 ASSESSMENT OF POTENTIAL PRESCRIBED IMPACTS

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development on species associated with human-made structures is set out in Table 24-10. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-10: Assessment of potential prescribed impacts – human-made structures

Relevant species	Assessment of potential prescribed impacts	Residual risk of impact
Southern Myotis	Impacts may cause population decline at a local scale because: • Known roost sites occur in the nominated areas (within GMAC) • Many records for the species occur in the nominated areas suggesting the nominated areas are an important area for these species Impacts are unlikely to cause population decline at a regional or State scale because: • Records are widespread across the Cumberland subregion and Sydney Basin bioregion, suggesting the nominated areas are not a stronghold for the species • The species is widely distributed across a coast band (generally within 100 km of the coast) within NSW both north and south of the Cumberland subregion General mitigation measures are likely to reduce but not completely negate the risk that the development may lead to a population decline at a local scale as there is uncertainty about the location of roosting sites within man-made structures within the nominated areas. The Plan includes a species-specific mitigation measures to address this risk	Yes
Large Bent-winged Bat Eastern Freetail-bat	Impacts are unlikely to cause population decline at a local, regional or State scale because: • BioNet records suggest no known roost sites occur in the nominated areas • Species appears to mainly roost in tree hollows and impacts on human-made structures are therefore unlikely to substantially affect roosting habitat While the risk of population decline is low and the general mitigation measures will reduce the risk to these species further, there is uncertainty about the importance of human made structures for microbat species in the subregion. The Plan includes a species-specific mitigation measures to address this risk	Yes
Little Bentwing-bat Yellow-bellied Sheathtail-bat	Impacts are unlikely to cause population decline at a local, regional or State scale because: • BioNet records suggest no known roost sites occur in the nominated areas • Few records occur for the species in the nominated areas compared to other parts of the Cumberland subregion and Sydney Basin bioregion, which suggests the species is less reliant on these areas for persistence in the subregion or region While the risk of population decline is low and the general mitigation measures will reduce the risk to these species further, there is uncertainty about the importance of human made structures for microbat species in the subregion. The Plan includes a species-specific mitigation measures to address this risk	Yes
Eastern False Pipistrelle Greater Broad-nosed Bat	Impacts are unlikely to cause population decline at a local, regional or State scale because: • BioNet records suggest no known roost sites occur in the nominated areas • Species appears to mainly roost in tree hollows and impacts on human-made structures are therefore unlikely to substantially affect roosting habitat • Few records occur in the nominated areas compared to other parts of the Cumberland subregion and Sydney Basin bioregion, which suggests these species is less reliant on these areas for persistence in the subregion or region While the risk of population decline is low and the general mitigation measures will reduce the risk to these species further, there is uncertainty about the importance of human made structures for microbat species in the subregion. The Plan includes a species-specific mitigation measures to address this risk	Unlikely

24.8.6 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

Table 24-11 identifies additional specific mitigation measures under Appendix E of the Plan to address residual risks to microbat species due to the development. These mitigation measures are considered to adequately address residual risks in the context of the risk and significance of the impacts of the development on microbat species.

Table 24-11: Specific mitigation measures – human-made structures

Relevant species	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
All relevant microbat species	Undertake pre-construction surveys prior to removal or disturbance (seasonally dependent, before torpor) to human made structures to ensure any roosting habitat for microbat species including mine shafts, storm water tunnels, old or derelict buildings, bridges and culverts are retained where possible	Urban and industrial, infrastructure, agribusiness development	There is a low risk that pre-construction surveys may not accurately identify roosting sites for various reasons (e.g. because they are undertaken at the wrong time of year)
	Incorporate artificial breeding and roosting habitat (e.g. bat boxes, structural cavities) in the design of bridges associated with the transport corridors in accordance with relevant guidelines or standards	Transport development	While bat boxes are used widely as a conservation measure for micro-bat species, there is some uncertainty about their effectiveness for some species (Smith, 2002) (Rueegger, Goldingay et al., 2019)

Implementation

Urban, industrial and agribusiness

For the urban, industrial, and agribusiness development, these specific mitigation measures will be implemented through DCPs (see above). A detailed description of this process is provided in Chapter 15, Section 15.6.1.

Infrastructure and transport corridors

The Plan includes commitments to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3) and transport development (Commitment 6), as prescribed in Appendix E of the Plan.

These commitments will be delivered through a process of environmental assessment and approval that will be applied to detailed design of each infrastructure and transport project, at the time the project is brought forward for development. These future environmental assessments provide a process through which to implement these specific mitigation measures for microbat species, as prescribed in Appendix E of the Plan.

A detailed description of the assessment and approval process for transport corridors and infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2 and 15.6.3.

24.9 ASSESSMENT OF NON-NATIVE VEGETATION

24.9.1 LIST OF RELEVANT SPECIES AND TECS

The list of species associated with the habitat or prescribed impact type is shown in Table 24-12.

Table 24-12: Species/TECs associated with non-native vegetation

Relevant species/TECs	Use and importance of habitat type
Flora	
Acacia bynoeana	These species can occur in areas of non-native vegetation, such as disturbed or partially cleared land, including roadsides or trail margins. However, they mainly rely on native vegetation as habitat All these species were mapped based on expert reports No areas of suitable habitat were mapped outside native vegetation for: • *Acacia bynoeana* • *Grevillea juniperina* • *Persoonia bargoensis* Very small areas of suitable habitat were mapped within areas of non-native vegetation (within areas mapped as 'urban native/exotic'– see Chapter 19) for the following species: • *Pimelea spicata* • *Hibbertia fumana* • *Hibbertia puberula*
Grevillea juniperina subsp. *Juniperina*	
Hibbertia fumana	
Hibbertia puberula	
Persoonia bargoensis	
Pimelea spicata	
Bats	
Grey-headed Flying-fox	The species may roost in non-native vegetation with a dense canopy. While blossom from *Eucalyptus* and related genera form a large part of the species diet (DoEE, 2018), non-native trees can form an important part of the diet in urban areas (DoEE, 2018)
Yellow-bellied Sheathtail-bat	The species primarily use native vegetation or man-made features for roosting. However, some species may occasionally use crevices in non-native trees or dense non-native vegetation for roosting The species prey, such as small insects, may occur within and rely on non-native vegetation to some extent in some areas
Greater broad-nosed Bat	
Little Bentwing-bat	
Large Bent-winged Bat	
Eastern Freetail-bat	
Eastern False Pipistrelle	
Marsupials	
Spotted-tailed Quoll	The species may use non-native vegetation along waterways for dispersal between areas of suitable habitat. Non-native vegetation may benefit the species by increasing protective vegetation cover along the waterways
Frogs	
Green and Golden Bell Frog	The species may occur in disturbed areas, including non-native vegetation. Habitat comprises water bodies and associated terrestrial habitats with grassy areas and low native or non-native vegetation (DEWHA, 2009a) (Lemckert, 2019). The species may use non-native vegetation to disperse between habitat sites Suitable habitat for the Green and Golden Bell Frog that may contain the species has been mapped around St Mary's in GPEC. The area of suitable habitat covers: • The locations of known records • The riparian corridor joining those records • A buffer of 1,000 m around the riparian corridor and records that could be used by the species for foraging, shelter, breeding and as migratory habitat as individuals move between water bodies and riparian corridors (Lemckert, 2019)

Relevant species/TECs	Use and importance of habitat type
Birds	
Dusky Woodswallow	The species occurs primarily in native vegetation (mainly open eucalypt forests and woodland). However, the species may also occur in farmland, usually at the edges of forest or woodland. The species may use deciduous trees for perching
Painted Honeyeater	The species primarily occurs in woodlands and forages on the fruits of mistletoes growing on eucalypts and acacias. The species may forage on planted Silky-Oaks
Little Eagle	The species' prey, such as mammals, may occur within and rely on non-native vegetation to some extent, particularly in the vicinity of urban areas
Square-tailed Kite	
Barking Owl	
Powerful Owl	
Masked Owl	

24.9.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

Non-native vegetation was mapped as part of the native vegetation mapping for the nominated areas and is defined as:

> *Vegetation that is not consistent with floristic composition and landscape positions for native plant community types as defined by the NSW BioNet Vegetation Classification system; most common communities comprise of very few native species or consist of an assorted mix of planted native or exotic trees*

Non-native vegetation occurs within urban capable land in all nominated areas. The location of non-native vegetation within the nominated areas is shown in Map 18.

24.9.3 NATURE, EXTENT AND DURATION IMPACTS

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on non-native vegetation are set out in Table 24-13.

Table 24-13: Nature, extent and duration of impacts – non-native vegetation

Species/TEC	Nature	Extent	Duration
Flora	**Direct impacts:** Direct impacts will occur to suitable habitat within non-native vegetation for the following species: • *Pimelea spicata* • *Hibbertia fumana* • *Hibbertia puberula* Suitable habitat for the other flora species generally occurs within areas of native vegetation and direct impacts for these species are therefore addressed through impacts to native vegetation and habitat (see Chapter 23)	Following impacts in Wilton: • *Pimelea spicata* – 8.6 ha • *Hibbertia fumana* – 0.06 ha • *Hibbertia puberula* – 0.06 ha	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to suitable habitat within non-native vegetation for these flora species. Key risks are weed invasion, rubbish dumping, and increased risk of fire	Non-native vegetation adjacent to urban capable lands in each nominated area	Temporary or long-term

Species/TEC	Nature	Extent	Duration
Bats	**Direct impacts:** The development may directly impact areas of non-native vegetation that provide foraging habitat for Grey-headed Flying-fox and potential roosting habitat for some microbat species. There are no known Grey-headed Flying-fox camps in the urban capable lands	Non-native vegetation within urban capable lands in each nominated area	Temporary or long-term
	Indirect impacts: There may be a decrease in the abundance of prey for some microbat species due to direct impacts on non-native vegetation potentially impacting prey habitat	Non-native vegetation adjacent to urban capable lands in each nominated area	Temporary or long-term
Marsupials	**Direct impacts:** N/A	N/A	N/A
	Indirect impacts: Removal of non-native vegetation along waterways may reduce vegetation cover that facilitates dispersal of the Spotted-tailed Quoll between areas of suitable habitat	Non-native vegetation within riparian corridors	Temporary or long-term
Green and Golden Bell Frog	**Direct impacts:** The development will directly impact a small amount of non-native vegetation within suitable habitat for this species	0.06 ha in the St Mary's area in GPEC	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to suitable habitat within non-native vegetation for Green and Golden Bell Frog. Key risks are weed invasion, rubbish dumping, and increased risk of fire	Adjacent to urban capable land in the St Mary's area in GPEC	Temporary or long-term
Birds	**Direct impacts:** Direct impacts may occur to non-native vegetation used by Dusky Woodswallow and Painted honeyeater for perching or foraging	Within urban capable land in each nominated area	Long-term
	Indirect impacts: There may be a decrease in the abundance of prey for some bird species due to direct impacts on non-native vegetation potentially impacting prey habitat	Within and adjacent to urban capable land in each nominated area	Temporary or long-term

24.9.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from development on TECs and species habitat to best practice standards (Commitment 5). This commitment will be delivered through preparation of a DCP for each nominated area. A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval.

DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

DCPs will include several general development controls relevant to managing prescribed impacts to species associated with non-native vegetation, including controls to (see Chapter 15, section 15.6.1):

- Manage water cycles and water quality (relevant to Green and Golden Bell Frog)
- Protect riparian corridors (relevant to Spotted-tailed Quoll)
- Control the spread of weeds (relevant to several species above)
- Ensure native trees are planted in open space areas and along major and residential roads as part of the design of new residential areas (relevant to Grey-headed Flying-fox, micro-bat species and birds)

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

24.9.5 ASSESSMENT OF POTENTIAL PRESCRIBED IMPACTS

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development on species associated with non-native vegetation is set out in Table 24-14. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-14: Assessment of potential prescribed impacts – non-native vegetation

Relevant species/TECs	Assessment of potential prescribed impacts	Residual risk of impacts?
Flora	Impacts are unlikely to cause population decline at a local, regional or State scale because: • These species mainly rely on native vegetation as habitat • Only very small areas of potential habitat within non-native vegetation will be impacted for *Pimelea spicata*, *Hibbertia fumana* and *Hibbertia puberula* relative to areas of unimpacted habitat within native vegetation. The 8.6 ha of *Pimelea spicata* habitat appears to occur within an area currently heavily infested with African Olive	Unlikely
Bats	Impacts are unlikely to cause population decline for micro-bat species at a local, regional or State scale because: • These species mainly use caves, crevices, human made structures, or tree hollows within native vegetation for roosting • Substantial areas of native and non-native vegetation will be established in open space areas and along major and residential roads, which is likely to negate any low risk of indirect impacts through reduced prey abundance There is a low risk that impacts may cause population decline for Grey-headed Flying-fox at a local scale due to impacts on foraging habitat. Impacts are unlikely to cause population decline for Grey-headed Flying Fox at a regional or State scale because: • There are no known Grey-headed Flying Fox camps in the urban capable lands that rely on non-native vegetation for roosting • Substantial areas of native and non-native vegetation will be established in open space areas and along major and residential roads • The species can travel large distances for foraging and forage primarily on the nectar and pollen of native trees and fruits of rainforest trees and vines (OEH, 2018f) The Plan includes a species-specific mitigation measures to address this risk	Yes for Grey-headed Flying-fox

Relevant species/TECs	Assessment of potential prescribed impacts	Residual risk of impacts?
Marsupials	Impacts are unlikely to cause population decline for Spotted-tail Quoll at a local, regional or State scale because: • Urban capable lands have avoided riparian corridors consistent with the *Water Management Act 2000* along waterways, comprising: o Strahler stream order 2 - buffer 20 m either side o Strahler stream order 3 - buffer 30 m either side o Strahler stream order 4 and above - buffer 40 m either side • Development controls will be put in place to protect riparian corridors	Unlikely
Green and Golden Bell Frog	Impacts are unlikely to cause population decline for Green and Golden Bell Frog at a local, regional or State scale because only very small areas of potential habitat within non-native vegetation will be impacted. Furthermore, this impact occurs towards the edge of suitable habitat and distant from the riparian corridor of Ropes Creek and is therefore unlikely to significantly contribute to further fragmentation of areas of suitable habitat	Unlikely
Birds	Impacts are unlikely to cause population decline for these species at a local, regional or State scale because: • These species mainly rely on native vegetation as habitat • Only small areas of potential habitat within non-native vegetation will be impacted for these species relative to areas of unimpacted habitat within native vegetation • Substantial areas of native and non-native vegetation will be established in open space areas and along major and residential roads,	Unlikely

24.9.6 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

Table 24-15 identifies additional specific mitigation measures under Appendix E of the Plan to address residual risks to Grey-headed Flying-fox due to the development (these measures will also benefit several other species above, including birds and microbats). These mitigation measures are considered to adequately address residual risks in the context of the risk and significance of the impacts of the development on this species.

Table 24-15: Specific mitigation measures – non-native vegetation

Relevant species	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
Grey-headed Flying-fox	Establish minimum setbacks for urban development around flying fox camps	Urban and industrial, infrastructure, agribusiness development	Set-backs are a well-established mitigation measure for camps
	Retain large trees (including dead trees) (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction		Large trees generally provide the greatest sources of nectar, which is the primary food for the species

IMPLEMENTATION

Urban, industrial and agribusiness

For the urban, industrial, and agribusiness development, these specific mitigation measures will be implemented through DCPs (see above). A detailed description of this process is provided in Chapter 15, Section 15.6.1.

Infrastructure

The Plan includes a commitment to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3), as prescribed in Appendix E of the Plan.

This commitment will be delivered through a process of environmental assessment and approval that will be applied to detailed design of each infrastructure project, at the time the project is brought forward for development. These future environmental assessments provide a process through which to implement these specific mitigation measures for Grey-headed Flying-fox, as prescribed in Appendix E of the Plan.

A detailed description of the assessment and approval process for infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2.

24.10 ASSESSMENT OF HABITAT CONNECTIVITY AND MOVEMENT

Habitat connectivity refers to the degree of connectedness of areas of habitat. Habitat connectivity can include:

- Corridors of vegetation linking other areas of habitat
- Isolated patches of habitat that provide 'stepping stones' between other areas of habitat
- Habitat features (such as large trees with hollows) scattered within areas of non-habitat (e.g. urban land) that provide habtiat connectivity between intact areas of habitat

The urban, industrial, infrastructure, agribusiness and transport development have the potential to lead to changes and disruption to habitat connectivity. Potential habitat connectivity impacts could occur in all four nominated areas.

BIO MAP

The Biodiversity Investment Opportunities Map (BIO Map) is a key deliverable of the NSW Government's $40 million Green Corridors program. The BIO Map project aimed to achieve better biodiversity outcomes by directing biodiversity investment funding to the strategic locations of greatest benefit.

The BIO Map for the Cumberland subregion covers an area of 275,693 ha, including the Cumberland Plain. Mapping criteria were used to identify and map priority investment areas. The priority investment areas comprise of a network of 87 core areas and 27 regional biodiversity corridors within the Cumberland subregion. The 87 core areas include all of the priority conservation lands identified by the Cumberland Plain Recovery Plan (DECCW, 2011).

The total area represented within the mapped priority investment areas is 42,124 ha. This represents approximately 15 per cent of the Cumberland subregion or approximately 61 per cent of all mapped vegetation within the subregion.

BIO Map identifies Priority Investment Areas (PIAs) where the protection and management of native vegetation is likely to maximise benefits to biodiversity within the Cumberland subregion. The PIAs comprise:

- BIO Map core areas: large areas of native vegetation and habitat where management will be of greatest benefit to the conservation of biodiversity values. These areas represent the habitat in the subregion most likely to support species persistence and interactions between species and landscape scale ecological processes
- BIO Map regional corridors: linear areas that link core areas and play a crucial role in maintaining connections between species populations that would otherwise be isolated and at greater risk of local extinction

24.10.1 LIST OF RELEVANT SPECIES AND TECS

Habitat connectivity is relevant to all species to some extent for:

- Movement across home ranges/dispersal between areas of suitable habitat
- Breeding or reproduction
- Foraging
- Other important life cycle events

Species reliant on habitat connectivity have been categorised into five groups:

- Fauna more likely to need large habitat corridors and/or large areas of intact native vegetation
- Fauna able to utilise narrower habitat corridors or riparian corridors or waterways
- Fauna able to utilise scattered and/or degraded patches of native vegetation within an urban or agricultural matrix
- Fauna that are relatively immobile and move only short distances
- TECs that rely on habitat connectivity for effective airborne pollination and the movement of pollinators

Table 24-16 shows the groupings for species predicted to occur in the nominated areas.

Table 24-16: Species/TECs associated with areas of habitat connectivity

Group	Relevant species/TECs	Use and importance of habitat type
Large habitat corridors and/or large areas of intact native vegetation	Most gliders and owls and some birds: • Large-eared Pied Bat • Squirrel Glider • Yellow-bellied Glider • Masked Owl • Barking Owl • Powerful Owl • Gang-gang Cockatoo • Glossy Black Cockatoo • Regent Honeyeater • Black-chinned Honeyeater • Brown Treecreeper	May use large habitat corridors for dispersal between larger patches of suitable habitat, including breeding areas, as well as for foraging
	Raptors: • White-bellied Sea-Eagle • Little Eagle • Square-tailed Kite	
Smaller habitat corridors or riparian corridors or waterways	Smaller marsupials: • Eastern Pygmy-possum • Spotted-tailed Quoll	May use smaller habitat corridors for dispersal between larger patches of suitable habitat, including breeding areas, as well as for foraging Spotted-tailed Quoll relies on habitat connectivity to breed as quolls are solitary and come together to breed
	Birds associated with riparian corridors and/or waterways, including: • Australasian Bittern • Freckled Duck • Comb-crested Jacana • Black Bittern • White-fronted Chat • Eastern Osprey • Curlew Sandpiper • Broad-billed Sandpiper • Black-tailed Godwit	Water birds use waterways and riparian corridors and associated vegetation for shelter, foraging, as well as dispersal between other areas of suitable habitat

Group	Relevant species/TECs	Use and importance of habitat type
Scattered and/or degraded native vegetation within a matrix	• Grey-headed Flying-fox Microbats: • Southern Myotis • Little Bentwing-bat • Large Bent-winged Bat • Eastern Freetail-bat • Eastern False Pipistrelle • Yellow-bellied Sheathtail-bat	Microbats and birds may use scattered native vegetation for roosting or resting, to move within areas of foraging habitat, or to access other larger areas of suitable habitat for foraging
	Birds: • Dusky Woodswallow • Spotted Harrier • Little Lorikeet • Diamond Firetail • Swift Parrot • Turquoise Parrot • Varied Sittella • Painted Honeyeater	
	• Green and Golden Bell Frog	While the species appears to generally be associated with a single water body for general activities, it is highly mobile and can move some distance as part of migrations to and from breeding sites (Lemckert, 2019). Movements of up to 5 km may be common and the species may disperse up to 10 km (DoEE, 2018a)
Relatively immobile and moves only short distances	• Cumberland Plain Land Snail • Red-crowned Toadlet	Little is known about Cumberland Plain Land Snail dispersal patterns or over what distances individuals can move (OEH, 2019c) Most populations are small and isolated. The NSW SoS program identifies several actions to ensure connectivity between population, including implementing 'open structure design' when designing structures such as roads which may isolate patches of habitat (EES, 2020) Red-crowned Toadlets are a localised species that are largely restricted to the immediate vicinity of suitable breeding habitat. The species is usually found as small discrete scattered populations along sandstone ridges
TECs	• All TECs	TECs rely on habitat connectivity for effective airborne pollination and the movement of pollinators

24.10.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

Key areas of habitat connectivity in the nominated areas are shown in Map 19 and described in Table 24-17.

Habitat connectivity was mapped by:

- Identifying BIO Map regional corridors and core areas. These corridors/core areas are likely to be the most important areas of habitat connectivity in the nominated areas for the majority of species. EES had only identified BIO Map corridors within the boundaries of the Cumberland subregion. To undertake the mapping for the small parts of the nominated areas outside the Cumberland subregion the Priority Conservation Lands layer (DECCW, 2010) (EES used this layer as basis for BIO Map) or the native vegetation map (see Chapter 19) was used to extend the BIO Map corridor mapping
- Identifying local corridors using the native vegetation mapping to identify connected patches of native vegetation. This was done visually in GIS, with only contiguous patches identified as being connected
- Identify any remaining native vegetation not within a regional corridor or local corridor as:
  - Connected – within 100 m of another patch of woody vegetation
  - Isolated – greater than 100 m from another patch of woody vegetation

The categories of habitat connectivity identified in Map 19 are:

- BIO Map corridors, categorised as either
  - BIO Map Regional Corridor / BIO Map Regional Corridor and Core Area
  - BIO Map Regional Corridor - extended to match PCLs
  - BIO Map Regional Corridor - extended to match vegetation
- Local corridor
- Connected vegetation
- Isolated vegetation

Table 24-17: Key areas of habitat connectivity in the nominated areas

Nominated area	BIO Map regional corridors/core areas	Local corridors	Connected and isolated vegetation
Wilton	Occur around the edges of the entire nominated area and across the middle of the northern part of the nominated area associated with the Nepean River and the middle of the southern part of the nominated area	One large corridor occurs on the eastern side of the nominated area between the Hume Motorway and Wilton Road connected to the BIO Map regional corridors/core areas to the east of the nominated area. The corridor is a 'dead end' and does not connect to other native vegetation to the south or west of the nominated area	Connected vegetation occurs in scattered areas mainly towards the edges of the nominated area adjacent to BIO Map regional corridors/core areas Isolated vegetation occurs in only a few very small patches in the middle parts of the nominated area
GMAC	Occur around the edges of the entire southern part of the nominated area and across the middle of the southern part in three locations associated with waterways. The corridors/core areas connect native vegetation associated with the Cataract River to the west of the nominated area with large areas of native vegetation to the east of the nominated area	One corridor occurs across the middle of the southern part of the nominated area associated with a waterway. The corridor connects regional corridors/core areas to the east and north within the nominated area with native vegetation to the west of the nominated area	Connected vegetation occurs in scattered areas across the nominated area mainly in the southern part Isolated vegetation occurs in only a few very small patches in the middle parts of the nominated area
WSA	Occur in the eastern part of the nominated area associated with Wianamatta (South Creek) and Kemps Creek. A regional corridor/core area connects Wianamatta (South Creek) and Kemps Creek in the south-eastern corner of the nominated area in the Kemps Creek area	Two corridors occur in the middle part of the nominated area associated with Badgerys Creek and Cosgrove Creek. The Cosgrove Creek corridor is a 'dead end' and does not connect to other native vegetation. The Badgerys Creek corridor continues outside the nominated area as a narrow strip of native vegetation	Connected vegetation occurs in scattered areas mainly in the middle and north-eastern part of the nominated area Isolated vegetation occurs in only a few very small patches in the middle parts of the nominated area
GPEC	Occur in the northern part of the nominated area around Wianamatta Regional Park and the southern part around Orchid Hills. Two corridors connect Wianamatta Regional Park and Orchid Hills associated with Wianamatta (South Creek) and Ropes Creek. A third corridor connects native vegetation at Orchid Hills to native vegetation to the west of the nominated area near Mulgoa Road along a drainage line	No corridors occur within the nominated area	Connected vegetation occurs in scattered areas across the nominated area Isolated vegetation occurs in a few very small patches across the nominated area

24.10.3 NATURE, EXTENT AND DURATION IMPACTS

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on habitat connectivity are set out in Table 24-18.

Table 24-18: Nature, extent and duration of impacts – habitat connectivity

Nominated area	Nature	Extent	Duration
Wilton	**Direct impacts:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impact occurs in the southern part of the nominated area where the development will remove part of a corridor/core area that connects native vegetation either side of the nominated area in this location. The impact reduces the width of the corridor/core area by about half. Connectivity is maintained to the south and east of the impacted area. In all other areas, direct impacts occur only to the edges of corridors/core areas in a few locations and connectivity along these areas is maintained There are very minor direct impacts to the local corridor on the eastern side of the nominated area between the Hume Motorway and Wilton Road The majority of impacts to connected vegetation occur to smaller scattered patches in the middle of the nominated area and to the edge of larger areas of connected vegetation where it occurs adjacent to BIO Map regional corridors/core areas around the nominated area	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 79.5 ha (7.6%) • Local corridor – 5.6 ha (2.9%) • Connected vegetation – 141.3 ha (25.8%) • Isolated vegetation – 1 ha (48%)	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands/transport corridors	Temporary or long-term
GMAC	**Direct impacts:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. Direct impacts occur only to the edges of corridors/core areas in a few locations. There are no locations were direct impacts completely sever or significantly narrow a core area/corridor and connectivity is maintained for these areas of habitat connectivity across all parts of the nominated area The vast majority of the local corridor in the middle of the southern part of the nominated area has been avoided and is not directly impacted. Impacts occur only to the edges of the corridor and connectivity is maintained in this location across the nominated area The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 468.9 ha (3.3%) • Local corridor – 18.6 ha (12.2%) • Connected vegetation – 219.5 ha (21%) • Isolated vegetation – 1.9 ha (15.7%)	Long-term

Nominated area	Nature	Extent	Duration
	vegetation in the southern part of the nominated area. In these cases, the size of the patches will be reduced, but the impacts will not generally sever connectivity between this connected vegetation and other areas of native vegetation, such as BIO Map corridors/core areas		
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands/transport corridors	Temporary or long-term
WSA	**Direct impacts:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impact occurs in the south-eastern part of the nominated area where the development will remove the majority of a corridor/core area that connects Wianamatta (South Creek) and Kemps Creek in the Kemps Creek area. While this area is identified as a regional corridor, connectively has already been completely severed in this location by existing industrial land use. In all other areas, direct impacts occur only to the edges of corridors/core areas in a few locations and connectivity along these areas is maintained The majority of local corridors have been avoided and will not be directly impacted. Direct impacts occur: • At Cosgrove Creek in the middle part of the nominated area where the OSO severs the riparian corridor in two locations • At Badgerys Creek in the middle part of the nominated area where the OSO severs the riparian corridor in one location The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected vegetation in the north-eastern, middle and southern parts of the nominated area. In some cases, the impacts will sever or reduce connectivity between this connected vegetation and other areas of connected vegetation within and outside the nominated area	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 22.3 ha (7.0%) • Local corridor – 34.2 ha (27.4%) • Connected vegetation – 280.5 ha (52.7%) • Isolated vegetation – 9.9 ha (67.1%)	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands/transport corridors	Temporary or long-term

Nominated area	Nature	Extent	Duration
GPEC	**Direct impacts:** The majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impacts occur: • Within Wianamatta Regional Park where the OSO severs the eastern part of the regional park that is connected to Ropes Creek with the western part of the park • Along Wianamatta (South Creek) where the OSO directly impacts the Wianamatta (South Creek) riparian corridor and severs the narrow connection along the corridor that links Wianamatta Regional Park and Orchid Hills In all other areas direct impacts have been avoided, except in the western part of the nominated area near Glenmore Park where there is a small direct impact to the edge of a corridor/core area No local corridors occur within the nominated area The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected vegetation in some parts of the nominated area. In these cases, the size of the patches will be reduced, but the impacts will not generally sever connectivity between this connected vegetation and other areas of native vegetation, such as BIO Map corridors/core areas	**Direct impacts:** The following categorises of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 188.4 ha (5.8%) • Local corridor – 0 ha (0%) • Connected vegetation – 190.6 ha (17.2%) • Isolated vegetation – 0.5 ha (5.9%)	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands/transport corridors	Temporary or long-term

24.10.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from development on TECs and species habitat to best practice standards (Commitment 5). This commitment will be delivered through preparation of a DCP for each nominated area. A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval. DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

DCPs will include several general development controls relevant to managing prescribed impacts associated with habitat connectivity, including (see Chapter 15, section 15.6.1):

- Maintain waterways of Strahler order 2 or higher in a natural state, including riparian corridors
- Design road crossings of waterways to minimise impacts to vegetated riparian corridors and species movements
- Retain large trees (including dead trees) (≥50cm DBH) during precinct planning where possible
- Retain areas of high density proteaceae shrubs where possible, particularly along riparian corridors
- Plant of native trees in open space areas and along major and residential roads as part of the design of new residential areas (particularly relevant to Grey-headed Flying-fox, micro-bat species and birds)
- A range of controls that would mitigate indirect impacts on habitat that forms part of habitat corridors, including water cycle management and water quality and the spread of weeds

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

It is also important to note that the conservation program under the Plan (see Part 2) will result in:

- Protecting a minimum of 5,475 hectares of native vegetation and habitat in the subregion (Commitment 8)
- Securing priority habitat corridors in the subregion (Commitment 12)
- Undertake ecological restoration of up to 25 per cent of the offset target for native vegetation (Commitment 13)
- Managing landscape threats in strategic locations to improve habitat values, including weeds (Commitment 16) and pests (Commitment 17) and fire (Commitment 17)

Importantly, the strategic conservation areas (SCAs) where these commitments will be delivered represent the areas in the Cumberland subregion that are considered most likely to be viable in the long-term and to maximise ecological function and connectivity across the landscape. In determining the location of the SCAs, priority was given to including the largest, best condition and best-connected areas of native vegetation remaining in the subregion (see Part 2).

24.10.5 ASSESSMENT OF POTENTIAL PRESCRIBED IMPACTS

The nominated areas are highly fragmented and key areas of connectivity generally occur along riparian corridors, within steeper land and gully areas, particularly around the edges of Wilton and southern GMAC.

The development will generally reduce habitat connectivity across the nominated areas for species and TECs mainly due to the removal of many smaller connected patches of habitat, which will often generally leave the remaining larger patches along riparian corridors and within steeper land and gully areas more isolated to some extent. This will have a greater impact on the group of species associated with scattered and/or degraded native vegetation within a matrix.

While a reduction in habitat connectivity will occur, the nominated areas are highly fragmented and the majority of key areas of habitat connectivity will be maintained, including the majority of BIO Map core areas and corridors.

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development on species associated with habitat connectivity is set out in Table 24-19. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-19: Assessment of potential prescribed impacts – habitat connectivity

Relevant species	Assessment of potential prescribed impacts	Residual risk of impacts?
Species associated with large habitat corridors and/or large areas of intact native vegetation	Impacts are unlikely to cause population decline at a local, regional or State scale for species associated with large habitat corridors and/or large areas of intact native vegetation (BIO Map corridors/core areas) because: • The vast majority of these areas have been avoided and will not be impacted • Direct impacts generally occur only to the edges of corridors/core areas. There are few locations were direct impacts completely sever or significantly narrow a core area/corridor and connectivity is maintained for these areas The most notable impacts occur: • Within Wianamatta Regional Park • Along Wianamatta (South Creek) where the OSO directly impacts Wianamatta (South Creek) riparian corridor The commitments and general mitigation measures are generally considered adequate to manage the risk of prescribed impacts on these areas of habitat connectivity. The Plan includes a specific mitigation measure to manage the risk from the OSO	Unlikely
Species associated with smaller habitat corridors or riparian corridors or waterways	Impacts are unlikely to cause population decline at a local, regional or State scale for species associated with smaller habitat corridors or riparian corridors (local corridors) because: • The vast majority of these areas have been avoided and will not be impacted • Impacts often occur only to the edges of the local corridors and connectivity is maintained for these areas The most notable impacts occur in WSA: • At Cosgrove Creek in the middle part of the nominated area where the OSO severs the riparian corridor in two locations • At Badgerys Creek in the middle part of the nominated area where the OSO severs the riparian corridor in one location The commitments and general mitigation measures are generally considered adequate to manage the risk of prescribed impacts on these areas of habitat connectivity. The Plan includes a specific mitigation measure to manage the risk from the OSO	Unlikely
Species associated with scattered and/or degraded native vegetation within a matrix	Impacts are unlikely to cause population decline at a local, regional or State scale for species associated with scattered and/or degraded native vegetation (connected vegetation) because impacts generally occur to: • Smaller scattered patches, where patches will be completely cleared • To the edges of larger patches where the size of the patches will be reduced, but the impacts will not generally sever connectivity between this connected vegetation and other areas of native vegetation The most notable impacts occur in WSA, where in some cases, the impacts will sever or reduce connectivity between connected vegetation and other areas of connected vegetation within and outside the nominated area. These impacts may reduce connectivity in this part of the nominated area for microbats and smaller birds The commitments and general mitigation measures are considered adequate to manage the risk of prescribed impacts on these areas of habitat connectivity	Unlikely

Relevant species	Assessment of potential prescribed impacts	Residual risk of impacts?
Species that are relatively immobile and move only short distances	Red-crowned Toadlet: impacts are unlikely to cause population decline at a local, regional or State scale for this species as there are no records within the nominated areas, and mapped suitable habitat occurs in scattered patches within the vicinity of gorges and gullies that occur mainly around the edges of the urban capable land, where habitat connectivity will be maintained Cumberland Plain Land Snail: impacts may potentially cause population decline at a local, regional and State scale for this species. Little is known about Cumberland Plain Land Snail dispersal patterns or over what distances individuals can move (OEH, 2019c). Most populations are small and isolated. Records for the species are scattered across the Cumberland subregion. However, where records occur within the nominated areas, most occur on excluded land and many occur on land avoided for biodiversity, including around the edges of GPEC and along riparian corridors in WSA and GPEC. The development is likely to reduce habitat connectivity for this species, associated particularly with the removal of many smaller connected and more isolated patches of Cumberland Plain Woodland, leaving populations in remaining larger patches more isolated to some extent The commitments and general mitigation measures are generally considered adequate to minimise the risk of prescribed impacts associated with habitat connectivity on Cumberland Plain Land Snail. The Plan includes a specific mitigation measure to manage residual risks to this species	Potentially
TECs/flora species	The development will reduce habitat connectivity across the nominated areas for TECs and flora habitat due to the removal of many smaller connected and more isolated patches of TECs, causing the isolation of more intact, larger patches of TECs. This is due to vegetation removal and associated reduced movement of mobile pollinators such as birds and bats TECs (and associated flora species) within the Plan Area, at a local, regional and State scale, are already highly fragmented with the majority of key areas of habitat connectivity being maintained, including the majority of BIO Map core areas and corridors and riparian corridors The commitments and general mitigation measures are considered adequate to manage the risk of prescribed impacts on these areas of habitat connectivity	Unlikely

24.10.6 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

Table 24-20 identifies additional specific mitigation measures under the Plan to address residual risks.

These mitigation measures are considered to adequately address residual risks in the context of the risk and significance of the impacts of the development on this species.

Table 24-20: Specific mitigation measures – habitat connectivity

Relevant species/TECs	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
• Eastern Pygmy-possum • Spotted-tailed Quoll • Birds associated with riparian corridors	The Plan includes a commitment to ensure transport corridors, including the OSO are designed to avoid and minimise impacts to areas of potential habitat connectivity, particularly vegetation in riparian corridors (Commitment 3)	Transport corridors	Outcome not possible to determine at this stage

Relevant species/TECs	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
• Cumberland Plain Land Snail	The Plan includes a specific mitigation measure to implement 'open structure design' when designing structures such as roads which may isolate patches of habitat, consistent with the critical actions for this species under the Save our Species program (EES, 2020)	Urban, industrial, and agribusiness development	Outcome not possible to determine at this stage. Mitigation measures is consistent with critical actions for this species under the Save our Species program (EES, 2020)

IMPLEMENTATION

Urban, industrial and agribusiness

For the urban, industrial, and agribusiness development, these specific mitigation measures will be implemented through DCPs (see above). A detailed description of this process is provided in Chapter 15, Section 15.6.1.

Transport corridors

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport development (Commitment 6), as prescribed in Appendix E of the Plan.

This commitment will be delivered through a process of environmental assessment and approval that will be applied to detailed design of each transport project, at the time the project is brought forward for development. These future environmental assessments provide a process through which to implement these specific mitigation measures for habitat connectivity, as prescribed in Appendix E of the Plan.

A detailed description of the assessment and approval process for transport corridors and infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2 and 15.6.3.

24.11 ASSESSMENT OF WATER BODIES AND HYDROLOGICAL PROCESSES

24.11.1 LIST OF RELEVANT SPECIES AND TECS

WATER BODIES

The list of species or TECs associated with water bodies is shown in Table 24-21.

Table 24-21: Species/TECs associated with water bodies

Relevant species/TECs	Use and importance of habitat type
Green and Golden Bell Frog	The species uses water bodies for breeding and foraging. While it appears to generally be associated with a single water body for general activities, records suggest the species is highly mobile and can move some distance as part of migrations to and from breeding sites (Lemckert, 2019). Movements of up to 5 km may be common and the frog may disperse up to 10 km (DoEE, 2018a). Breeding occurs after heavy rains or storms and spawn is laid among aquatic vegetation (DEWHA, 2009b)
Southern Myotis	The species uses water bodies for foraging. It forages over streams and pools, including dams, on insects and small fish (OEH, 2019j)
White-bellied Sea-eagle	Occurs near large areas of open water including larger rivers, swamps, lakes, and the ocean, or in the vicinity of freshwater swamps, lakes, reservoirs, billabongs and saltmarsh. Uses waterbodies for foraging. Feeds mainly on fish and freshwater turtles, but also waterbirds, reptiles, and mammals. Breeding habitat is constrained to living or dead mature trees within forests or tall woodland within 1 km of rivers, lakes, large dams or creeks, wetlands and coastlines (OEH, 2017k)

Relevant species/TECs	Use and importance of habitat type
Australasian Bittern	The species uses waterbodies for shelter, foraging and breeding. Inhabits permanent freshwater wetlands with tall, dense vegetation. Shelters during the day amongst dense reeds or rushes and feeds on frogs, fish, yabbies, and insects (OEH, 2018b)
Black-necked Stork	The species uses water bodies for foraging and builds large nests high in tall trees close to water. Primary habitat is floodplain wetlands (swamps, billabongs, watercourses and dams) of major coastal rivers. Secondary habitat includes minor floodplains, coastal sandplain wetlands and estuaries. It usually forages in water 5-30 cm deep for vertebrate and invertebrate prey (OEH, 2017b)
Comb-crested Jacana	The species inhabits permanent freshwater wetlands with a good cover of floating vegetation or fringing vegetation and uses water bodies for breeding and foraging. It feeds primarily on insects and other invertebrates (OEH, 2018d)
Black Bittern	The species inhabits terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation and uses water bodies for breeding and foraging. It feeds on frogs, reptiles, fish and invertebrates. Nests are built on a branch overhanging water (OEH, 2018c)
Eastern Osprey	Inhabits coastal areas, especially the mouths of large rivers, lagoons and lakes and uses water bodies for foraging. Feeds on fish over open water. Nests are made in dead trees or branches, usually within one kilometre of the sea (OEH, 2018e)
Australian Painted-snipe	Inhabits swamps, dams and nearby marshy areas and uses water bodies or fringing habitat for foraging and breeding. Forages on mud flats and in shallow water. Feeds on worms, molluscs, insects and some vegetation. Nests on the ground in tall vegetation, such as grasses, tussocks or reeds (OEH, 2017a)
Freckled Duck	Inhabits freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times, the species inhabits more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. Rests in dense cover, usually in deep water. Nests occur in dense vegetation at or near water level (OEH, 2017d)

HYDROLOGICAL PROCESSES

The list of species or TECs associated with hydrological processes is shown in Table 24-22 and TECs have been grouped based on the potential risk of impacts from changes to hydrological processes associated with the development.

Table 24-22: Species/TECs associated with hydrological processes

Relevant species/TECs	Use and importance of habitat type
Higher Risk TECs	
Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion	Higher risk TECs are those that either: • Directly reliant on hydrological processes for the maintenance of their floristic assemblage, or • Are located in landscape positions where processes such as regular flooding and deposition are key to maintaining the edaphic conditions that support the floristic assemblage, or • Are particularly susceptible to erosion, or are considered particularly susceptible to changes in water quality and nutrient load
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	
River-flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions.	
Shale Gravel Transition Forest in the Sydney Basin Bioregion	

Relevant species/TECs	Use and importance of habitat type
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	
Lower Risk TECs	
Cumberland Plain Woodland in the Sydney Basin Bioregion	Lower risk TECs are those that occur in landscape positions where hydrological processes have a lower level of influence on species assemblage or edaphic conditions
Moist Shale Woodland in the Sydney Basin Bioregion	
Higher Risk threatened flora species	
Allocasuarina glareicola	Higher risk threatened flora species are those that either: • Grow in waterbodies or swampy areas, or • Require regular inundation and deposition to maintain edaphic conditions, or • Are strongly associated with a higher risk TEC, or • Are higher specialised with regards to requirements for soil moisture content and nutrient levels
Dillwynia tenuifolia	
Eucalyptus benthamii Camden White Gum	
Maundia triglochinoides	
Micromyrtus minutiflora	
Persicaria elatior Tall Knotweed	
Pterostylis saxicola Sydney Plains Greenhood	
Lower Risk threatened flora species	
Acacia bynoeana Bynoe's Wattle	Lower risk threatened flora species are those that occur in landscape positions where hydrological processes have a lower level of influence on edaphic conditions
Acacia pubescens Downy Wattle	
Epacris purpurascens var. *purpurascens*	
Grevillea juniperina subsp. *juniperina* Juniper-leaved Grevillea	
Grevillea parviflora subsp. *parviflora* Small-flower Grevillea	
Hibbertia fumana	
Hibbertia puberula	
Marsdenia viridiflora subsp. *viridiflora* Native Pear	
Melaleuca deanei Deane's Paperbark	
Persoonia bargoensis Bargo Geebung	
Persoonia nutans Nodding Geebung	
Pimelea curviflora var. *curviflora*	
Pimelea spicata Spiked Rice-flower	
Pomaderris brunnea Brown Pomaderris	
Pultenaea parviflora	
Pultenaea pedunculata Matted Bush-pea	

Relevant species/TECs	Use and importance of habitat type
Higher Risk threatened fauna species	
Botaurus poiciloptilus Australasian Bittern	Higher risk threatened fauna species are those that are reliant on wetlands, lower Strahler order watercourses and riparian corridors, or soaks and fringing macrophyte vegetation for key aspects of their lifecycle
Ephippiorhynchus asiaticus Black-necked Stork	
Epthianura albifrons White-fronted Chat	
Heleioporus australiacus Giant Burrowing Frog	
Irediparra gallinacean Comb-crested Jacana	
Ixobrychus flavicollis Black Bittern	
Litoria aurea Green and Golden Bell Frog	
Myotis macropus Southern Myotis	
Pseudophryne australis Red-crowned Toadlet	
Rostratula australis Australian Painted Snipe	
Stictonetta naevosa Freckled Duck	
Lower Risk threatened fauna species	
Remaining candidate species and ecosystem credit fauna species	Lower risk threatened fauna species are those not directly reliant on waterbodies or wetlands, those associated with riparian corridors of higher Strahler watercourses, or those species within limited habitat within the nominated areas (such as waders)

24.11.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

WATER BODIES

Water bodies comprise non-vegetated wetlands, ponds, rivers, creeks and other bodies of water, including farm dams, greater than 3 m wide. Water bodies occur in all nominated areas and were identified using the Digital Topographic Database hydro area layer (LPI, 2016).

Direct impacts on Southern Myotis and Green and Golden Bell Frog associated with waterbodies were determined by:

- Intersecting the hydro area layer with the species maps for these three species (see Chapter 11)
- Excluding water bodies that were within native vegetation based on the native vegetation map (see Chapter 11) (direct impacts to these water bodies are assessed through impacts to native vegetation and habitat (see Chapter 23)
- Intersecting water bodies with species habitat that occurs within urban capable lands and transport corridors

The location of water bodies is shown in Map 20.

HYDROLOGICAL PROCESSES

Potential areas of hydrological change were mapped across the nominated areas using topographical features such as watercourses and changes in relief through the landscape to determine catchment areas and floodplains.

A digital elevation model was used to help visualise these catchment areas and floodplains, and highlight those where development is to occur either within the floodplain or near the top of catchments, which were then mapped.

These mapped areas cover the land outside the urban capable land and transport corridors where it is expected that indirect impacts to species and TECs may occur as a result of the development changing the existing hydrological processes that currently support those ecological values.

Table 24-23 provides details of the areas considered to potentially undergo hydrological changes related to development either in the upper reaches of the water catchment area, or development on a floodplain. These mapped areas are shown on Map 20 and are considered to cover the extent of potential hydrological change which may occur as a result of adjacent development within the nominated areas.

Table 24-23: Areas of potential hydrological impacts

Nominated area	Location	Type
Wilton	Allens Creek catchment	Development in catchment area modifying feeder creeks
	Allens Creek tributary catchment	Development in catchment area modifying feeder creeks
	Byrnes Creek catchment	Development in area surrounding catchment
	Nepean River catchment	Development in catchment area modifying feeder creeks
	Stringybark Creek catchment	Development in catchment area modifying feeder creeks
GMAC	Cataract/Elladale/Nepean catchment	Development in upper catchment area modifying feeder creeks
	Cataract/Rocky Ponds catchment	Development in upper catchment area modifying feeder creeks
	Elladale Creek catchment	Development in upper catchment area surrounding watercourses and modifying feeder creeks
	Elladale/Nepean catchment	Development in upper catchment area modifying feeder creeks
	Menangle/Woodhouse/Leafs catchment	Development in upper catchment area modifying feeder creeks
	Nepean River catchment	Development in upper catchment area modifying feeder creeks
	Ousedale Creek catchment	Development in upper catchment area surrounding watercourse and modifying feeder creeks
WSA	Badgerys Creek floodplain	Development on floodplain and within catchment area surrounding watercourse
	Cosgroves Creek floodplain	Development on all sides of floodplain and modification of feeder creeks
	Wianamatta (South Creek) and Kemps Creek floodplains	Development on floodplain and within catchment areas surrounding watercourse
	Wianamatta (South Creek) floodplain	Development on floodplain
GPEC	Wianamatta (South Creek) floodplain	Development on floodplain (major roadway development)
	Surveyors Creek tributary	Development in upper catchment area modifying feeder creeks

24.11.3 NATURE, EXTENT AND DURATION IMPACTS

WATER BODIES

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on water bodies are set out in Table 24-24.

Table 24-24: Nature, extent and duration of impacts –water bodies

Species/TEC	Nature	Extent	Duration
Green and Golden Bell Frog	**Direct impacts:** The development will directly impact two small waterbodies within the know habitat area, with suitable habitat for this species	0.6 ha of water bodies along Ropes Creek in GPEC	Long-term
	Indirect impacts: The development may cause indirect impacts to water bodies within suitable habitat for the species associated with urban run-off and changes to hydrology	Adjacent to urban capable land along Ropes Creek in GPEC	Temporary or long-term
Southern Myotis	**Direct impacts:** The development will directly impact approximately 1,000 waterbodies within suitable habitat for this species	244 ha of water bodies in all nominated areas	Long-term
	Indirect impacts: The development may cause indirect impacts to water bodies within suitable habitat for the species associated with urban run-off and changes to hydrology	Water bodies adjacent to urban capable lands in each nominated area	Temporary or long-term
White-bellied Sea-eagle	**Direct impacts:** The development will directly impact several waterbodies within suitable habitat for this species	Several water bodies within a total of 10 ha of suitable habitat that occurs in each nominated area. An impact of <1 ha will occur	Long-term
	Indirect impacts: The development may cause indirect impacts to water bodies within suitable habitat for the species associated with urban run-off and changes to hydrology	Water bodies adjacent to urban capable lands in each nominated area	Temporary or long-term
Water birds	**Direct impacts:** The development will directly impact many waterbodies within suitable habitat for these species	Many water bodies scattered across each nominated area	Long-term
	Indirect impacts: The development may cause indirect impacts to water bodies within suitable habitat for the species associated with urban run-off and changes to hydrology	Water bodies adjacent to urban capable lands in each nominated area	Temporary or long-term

HYDROLOGICAL PROCESSES

The nature, extent and duration of the impacts of the urban, industrial, infrastructure, agribusiness and transport development on species on hydrological processes are set out in Table 24-25.

The figures presented in the table for the total extent of habitat has been calculated based on the total area of habitat for each group of ecological values (high/low risk species or TECs) within each nominated area. Where habitat overlaps between species in the same group of ecological value (high/low risk species or TECs) the overlaps are 'dissolved' and the habitat area is calculated only once. The total amount equates to an approximate area of habitat that could be utilised by multiple species or TECs within each group.

For lower risk fauna, which includes ecosystem credit species, all native vegetation mapped in the nominated areas was used as a surrogate for species habitat. This is considered suitable as all mapped native vegetation within the nominated areas is potential habitat for at least one ecosystem credit species.

The potential impact areas are those areas of each ecological value that are potentially subject to hydrological changes. These figures have been estimated and represent a worst case. It is unlikely that impacts would occur across all extents in the table, but rather are likely to be more localised within these larger areas.

The largest impact to a higher risk entity is to higher risk TECs in GPEC, where hydrological changes associated with development on floodplain (major roadway development) potentially impacts up to 744 ha (57.9 per cent) of the mapped higher risk TECs. Potential impacts to higher risk flora include 468 ha (49.1 per cent) in Wilton associated with both development modifying feeder creeks and development in surrounding catchments and 504 ha (48.7 per cent) in GPEC associated with development on floodplain (major roadway development). On average the following impacts estimated:

- Higher risk TECs 1,889 ha (17.7 per cent)
- Lower risk TECs 491 ha (7.0 per cent)
- Higher risk flora 2,670 ha (19.4 per cent)
- Lower risk flora 523 ha (4.6 per cent)
- Higher risk fauna 1,767 ha (13.8 per cent)
- Lower risk fauna 2,908 ha (14.2 per cent)

Table 24-25: Nature, extent and duration of impacts – hydrological processes

Location	Nature	Species/TEC	Total extent in Nominated areas (approx.) (ha)	Potential impact (approx.) (ha & %)	Duration
Wilton	Development in catchment area modifying feeder creeks	• Higher risk TECs • Lower risk TECs • Higher risk flora • Lower risk flora • Higher risk fauna • Lower risk fauna	• 1429 • 451 • 954 • 2231 • 932 • 2350	• 442 (30.9%) • 16 (3.5%) • 468 (49.1%) • 83 (3.7%) • 348 (37.3%) • 699 (29.7%)	Long-term
	Development in area surrounding catchment	• Higher risk TECs • Lower risk TECs • Higher risk flora • Lower risk flora • Higher risk fauna • Lower risk fauna	• 1429 • 451 • 954 • 2231 • 932 • 2350	• 57 (4%) • 10 (2.2%) • 72 (7.5%) • 13 (0.6%) • 63 (6.8%) • 93 (4%)	Long-term
GMAC	Development in catchment area modifying feeder creeks	• Higher risk TECs • Lower risk TECs • Higher risk flora • Lower risk flora • Higher risk fauna • Lower risk fauna	• 2084 • 732 • 1877 • 3102 • 1775 • 3284	• 393 (18.9%) • 44 (6%) • 421 (22.4%) • 25 (0.8%) • 355 (20%) • 658 (20%)	Long-term
	Development in upper catchment area surrounding watercourses and modifying feeder creeks	• Higher risk TECs • Higher risk flora • Higher risk fauna • Lower risk fauna	• 2084 • 1877 • 1775 • 3284	• 125 (6%) • 129 (6.9%) • 75 (4.2%) • 163 (5%)	Long-term

Location	Nature	Species/TEC	Total extent in Nominated areas (approx.) (ha)	Potential impact (approx.) (ha & %)	Duration
WSA	Development on floodplain and within catchment area surrounding watercourse	• Higher risk TECs • Lower risk TECs • Higher risk flora • Higher risk fauna • Lower risk fauna	• 366 • 535 • 291 • 1018 • 901	• 103 (28.1%) • 9 (1.7%) • 55 (18.9%) • 129 (12.7%) • 110 (12.2%)	Long-term
	Development on all sides of floodplain and modification of feeder creeks	• Higher risk TECs • Lower risk TECs • Higher risk flora • Higher risk fauna • Lower risk fauna	• 366 • 535 • 291 • 717 • 901	• 15 (4.1%) • 4 (0.7%) • 7 (2.4%) • 11 (1.5%) • 15 (1.7%)	Long-term
	Development on floodplain - avoided areas potentially impacted	• Higher risk TECs • Lower risk TECs • Higher risk flora • Higher risk fauna • Lower risk fauna	• 366 • 535 • 291 • 717 • 901	• 3 (0.8%) • 20 (3.7%) • 8 (2.7%) • 18 (2.5%) • 24 (2.7%)	Long-term
GPEC	Development on floodplain - major roadway development	• Higher risk TECs • Lower risk TECs • Higher risk flora • Lower risk flora • Higher risk fauna • Lower risk fauna	• 1284 • 1877 • 1034 • 3752 • 2469 • 3255	• 744 (57.9%) • 388 (20.7%) • 504 (48.7%) • 402 (10.7%) • 767 (31.1%) • 1139 (35%)	Long-term
	Development in upper catchment area modifying feeder creeks	• Higher risk TECs • Lower risk TECs • Higher risk flora • Higher risk fauna • Lower risk fauna	• 1284 • 1877 • 1034 • 2469 • 3255	• 7 (0.5%) • 0.1 (0%) • 6 (0.6%) • 0.7 (0%) • 7 (0.2%)	Long-term

24.11.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from development on TECs and species habitat to best practice standards (Commitment 5). This commitment will be delivered through preparation of a DCP for each nominated area. A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval. DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

DCPs will include several general development controls relevant to managing prescribed impacts associated with hydrological processes and water quality, including (see Chapter 15, section 15.6.1):

- Waterways: Maintain waterways of Strahler order 2 or higher in a natural state, including riparian corridors
- Water cycle management: Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
- Water quality: Stormwater systems must be constructed and maintained to achieve EES water quality targets

- Soil erosion and sedimentation: Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

24.11.5 ASSESSMENT OF POTENTIAL PRESCRIBED IMPACTS

WATER BODIES

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development in relation to water bodies is set out in Table 24-26. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-26: Assessment of potential prescribed impacts – water bodies

Relevant species/TECs	Assessment of potential prescribed impacts	Residual risk of impacts?
Green and Golden Bell Frog	Development will directly impact a likely population of the Green and Golden Bell Frog associated with Ropes Creek in GPEC. This population comprises 6 BioNet records made between 1998 and 2012. The development will impact an area associated with one of these records made in 1998. It has not been confirmed whether the population at Ropes Creek still exists (Lemckert, 2019). In the absence of targeted surveys, it is considered likely that the population persists in the area The majority of habitat loss within GPEC is associated with the site of the current St Marys Rugby League Club adjacent to the Ropes Creek corridor and includes at least two mapped water bodies. If the population at Ropes Creek is confirmed present, impacts to these areas may be notable at a local level as the aquatic/riparian habitat in that location has the potential to support breeding habitat for the species Impacts are unlikely to cause population decline for this species at a regional or State scale because the majority (greater than 95 %) of records for the species occur in the eastern third of the Cumberland subregion outside the nominated areas (Lemckert, 2019) and the nominated areas are unlikely to be important for species persistence	Likely
Southern Myotis	There is a low risk direct impacts may cause population decline at a local level. The development will remove 246 ha of a total of 785 ha of water bodies within suitable habitat for this species in the nominated areas (approximately 60 % of water bodies within suitable habitat in the nominated areas). However, inspection of aerial photos suggests many of these water bodies are farm dams that are likely to provide more marginal foraging habitat for the species. Urban capable lands have avoided riparian corridors along waterways (see Chapter 14) that are likely to be preferred foraging habitat for the species. Furthermore, riparian corridors across the nominated areas have been avoided (see Chapter 14) and general mitigation measures will be put in place to further protect riparian corridors. It is also likely that urban landform water bodies will be created within developed lands, potentially providing some habitat Impacts are unlikely to cause population decline for this species at a regional or State scale because records for the species are widespread across the bioregion and NSW and the species does not appear to be highly reliant on the Cumberland subregion	Unlikely

Relevant species/TECs	Assessment of potential prescribed impacts	Residual risk of impacts?
White-bellied Sea Eagle	There is a low risk direct impacts may cause population decline at a local, regional or State scale because: • Most water bodies impacted by the development across the nominated areas are farm dams that do not provide suitable foraging habitat for the species • Only very small amounts of potential habitat for the species containing water bodies is being impacted relative to suitable habitat remaining in the subregion Furthermore, riparian corridors across the nominated areas have been avoided (see Chapter 14) and general mitigation measures will be put in place to further protect riparian corridors	Unlikely
Water birds	There is a low risk direct impacts may cause population decline at a local, regional or State scale because most water bodies impacted by the development across the nominated areas are farm dams that are likely to provide more marginal foraging habitat for most of these species, as they are generally associated with vegetated waterbodies Furthermore, riparian corridors across the nominated areas have been avoided (see Chapter 14) and generic mitigation measures will be put in place to further protect riparian corridors	Unlikely

HYDROLOGICAL PROCESSES

The risk and consequences of the impacts of the urban, industrial, infrastructure, agribusiness and transport development in relation to hydrological processes are set out in Table 24-27. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-27: Assessment of potential prescribed impacts – hydrological processes

Assessment of potential prescribed impacts	Relevant species/TECs	Residual risk of impacts?
Risks associated with development in upper catchment areas include: • An increase in impermeable areas may result in higher levels of fluctuation in overland flow patterns reaching downstream areas. Following rain events downstream areas are more likely to receive higher volumes of water at higher velocities, over a shorter period of time, leading to higher potential for erosion, changes in deposition and sedimentation patterns and changes to water quality and type and volume of nutrient load. Conversely, as less water is being absorbed by vegetated areas there is less water in the soil during drier times leading to longer periods with lower levels of water availability between rain events • Changes to overland flow patterns through channelisation of stormwater into creeks and stormwater management systems may directly impact upon populations of higher risk flora and fauna species and/or TECs downstream that are reliant on current hydrological patterns for survival • Increases in, or changes to, nutrients and pollutants in stormwater and run-off as a result of anthropogenic inputs such fertilisers, herbicides, soil conditioners, and petrol/oil Risks associated with development on floodplains include: • Changes in flooding regimes and patterns resulting from construction and earthworks may alter the relief of floodplains. This can confine streamlines to channels and reduce the width of those channels, which results in increased water velocities and impacts on groundcover. Increased water velocity may also impact nutrient deposition reducing the nutrient input for floodplain dependent species and TECs • Changes to flooding regimes and patterns may directly impact populations	Higher risk species and TEC	Potentially
	Lower risk species and TECs	Unlikely

Assessment of potential prescribed impacts	Relevant species/TECs	Residual risk of impacts?
of higher risk flora and fauna species and/or TECs downstream that are reliant on current hydrological patterns for survival. Changes may result in periodically wet areas being reduced or lost, or formerly drier areas becoming periodically inundated. This could substantially impact upon the vegetation present within the floodplain The general mitigation measures are considered adequate to manage these risks to lower risk species/TECs. The Plan includes specific mitigation measures to manage this risk for higher risk species and TECs		

24.11.6 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

Table 24-28 identifies additional specific mitigation measures under the Plan to address residual risks to Green and Golden Bell Frog associated with impacts to water bodies. These mitigation measures are considered to adequately address residual risks in the context of the risk and significance of the impacts of the development on this species.

There are no specific mitigation measures under the Plan to address residual risks to Southern Myotis in addition to the measures put in place to avoid riparian corridors and the generic measures to further protect riparian corridors. This is because the risk to this species is considered low and the generic measures are considered adequate in this context.

Table 24-28: Specific mitigation measures – water bodies and hydrological processes

Relevant species	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
Green and Golden Bell Frog	• Actions under Commitment 5 specify the Department will conduct a survey to confirm the presence of the Green and Golden Bell Frog along Ropes Creek. If confirmed present along Ropes Creek, consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced	Urban, industrial and infrastructure development Transport corridors	Not possible to predict at this stage
Higher risk species and TECs	• An action under Commitment 5 specifies that, in finalising the evaluation program for the Plan, ensure the program monitors impacts of hydrological changes to high risk species and TECs, and evaluations consider feasible adaptive management responses if necessary • The Plan includes an action under commitment to ensure transport corridors are designed to avoid and minimise impacts to vegetation in riparian corridors (Commitment 3). As part of this commitment, the Plan will ensure OSO waterway crossings minimise structures within riparian corridors, waterway re-alignments, and bulk earthworks on adjacent floodplain areas		There is a risk that development in water catchments and on floodplains may result in residual localised impacts to high risk species and TECs. Monitoring and adaptive management in key locations will reduce this risk

IMPLEMENTATION

<u>Transport corridors</u>

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport development (Commitment 5.3), as prescribed in Appendix E of the Plan.

This commitment will be delivered through a process of environmental assessment and approval that will be applied to detailed design of each transport project, at the time the project is brought forward for development. These future environmental assessments provide a process through which to implement these specific mitigation measures for hydrological processes as prescribed in Appendix E of the Plan.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2.

24.12 ASSESSMENT OF VEHICLE STRIKES

24.12.1 LIST OF RELEVANT SPECIES

Vehicle strikes have been identified as a key threat to several species known or predicted to occur in the nominated areas.

The list of species susceptible to vehicle strikes is shown in Table 24-2.

Note that a detailed assessment of the impacts of vehicle strikes on Koala is provided in Chapter 30.

24.12.2 OCCURRENCE OF HABITAT OR PRESCRIBED IMPACT TYPE

The development will lead to new roads and an increase in the volume of vehicles on existing roads. The main risks areas associated with these impacts occur in areas of suitable habitat of species vulnerable to vehicle strikes where:

- New roads are built within areas of suitable habitat
- Existing roads occur within areas of suitable habitat, assuming that vehicle volumes will increase on these roads

Risk areas area described for each relevant species in Table 24-29.

24.12.3 LIKELIHOOD OF VEHICLE STRIKES WITHIN RISK AREAS

An analysis of the likelihood of vehicle strikes from traffic associated with the urban, industrial, infrastructure, agribusiness and transport development is set out in Table 24-29. The analysis was undertaken on the basis of:

- Likelihood of occurrence of species vulnerable to vehicle strikes, based on records
- Evidence of previous roadkill in the area for those species
- Consideration of relevant life history traits

Observation codes within BioNet records were interrogated to identify whether species records were associated with vehicle strikes (Observation Code R – Roadkill).

Table 24-29: Key risk areas and likelihood of vehicle strikes

Relevant species/TECs	Key risk areas	Likelihood of vehicle strikes in key risk areas
Green and Golden Bell Frog	The key risk area occurs in the northern part of the GPEC, where many existing roads occur across a large patch of suitable habitat associated with a riparian corridor and the OSO intersects the edge of that habitat in Wianamatta Regional Park	The likelihood of vehicle strikes is difficult to predict but is considered to be low to moderate because: • Where the OSO intersects suitable habitat, this only occurs on the edges of suitable habitat and does not disrupt any existing movement corridors. This reduces the likelihood the species needs to cross the OSO to move between areas of suitable habitat • Many existing roads occur within areas of suitable habitat. Despite this, there have been no recorded vehicle strikes on this species. This suggests this species may not be regularly needing to move across existing roads to disperse between areas of suitable habitat, or is able to pass under existing roads where road crossings provide suitable conditions
Eastern Pygmy Possum	The key risk areas occur: • Northern part of Wilton and southern part of GMAC where urban capable lands and associated roads occur adjacent to suitable habitat • Central part of WSA where the OSO impacts small areas of suitable habitat mainly associated with riparian corridors • Northern and central part of GPEC where the OSO intersects suitable habitat in Wianamatta Regional Park and several riparian corridors	The likelihood of vehicle strikes is considered to be low because: • Few records occur within or in the vicinity of the nominated areas, which suggests this species may not occur in the area or occurs only in small numbers • The vast majority of suitable habitat for this species in Wilton and GMAC is restricted to the gorges and gullies mainly on the edges of the nominated areas. The urban capable lands generally occur outside these areas and no major roads directly cross these areas as part of the development
Spotted-tailed Quoll	The key risk areas occur: • Northern part of Wilton and southern part of GMAC where urban capable lands and associated roads occur adjacent to suitable habitat • Central part of WSA where the OSO impacts small areas of suitable habitat mainly associated with riparian corridors • Northern and central part of GPEC	The likelihood of vehicle strikes on the important population of the species near Wilton is difficult to predict but is considered low to moderate as: • The vast majority of suitable habitat for this species is restricted to the gorges and gullies of the edges of Wilton. These areas are outside the urban capable lands and there will be no new roads intersecting these areas as part of the development • Several existing roads occur within areas of suitable habitat. Despite this, there have been no recorded vehicle strikes on this species. This suggests this species may not be regularly needing to move across existing roads to disperse between areas of suitable habitat, or is able to pass under existing roads where road crossings provide suitable conditions The likelihood of vehicle strikes in the other nominated areas is considered to be low because:

Relevant species/TECs	Key risk areas	Likelihood of vehicle strikes in key risk areas
	where the OSO intersects suitable habitat in Wianamatta Regional Park and several riparian corridors	• Few records occur within or in the vicinity of the nominated areas, which suggests this species may not occur in the area or occurs only in small numbers • Many existing roads occur within areas of suitable habitat. Despite this, there have been no recorded vehicle strikes on these species in the nominated areas
Yellow-bellied Glider Squirrel Glider Broad-headed Snake	The key risk areas occur in the northern part of Wilton and southern part of GMAC where urban capable lands and associated roads occur adjacent to suitable habitat	The likelihood of vehicle strikes is considered to be low because: • No records for these species occur in the nominated areas, except for two recent records of Squirrel Glider in the gorge areas in Wilton, which suggests these species may occur only in small numbers • The vast majority of suitable habitat for these species in Wilton and GMAC is restricted to the gorges and gullies mainly on the edges of the nominated areas. The urban capable lands generally occur outside these areas and no major roads directly cross these areas as part of the development
Broad-headed Snake	The key risk areas occur in the northern part of Wilton where urban capable lands and associated roads occur adjacent to suitable habitat	The likelihood of vehicle strikes is considered to be low because: • No records for this species occur in Wilton, which suggests this species may not occur • Suitable habitat for this species in Wilton is likely to be restricted to the gorges and gullies on the edges of the nominated area. The urban capable lands generally occur outside these areas and no major roads directly cross these areas as part of the development
Koala	See Chapter 30	See Chapter 30

24.12.4 COMMITMENTS AND GENERAL MITIGATION MEASURES TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from development on TECs and species habitat to best practice standards (Commitment 5). This commitment will be delivered through preparation of a DCP for each nominated area. A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval. DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

DCPs will include several general development controls relevant to managing prescribed impacts to species associated with vehicle strikes, including (see Chapter 15, section 15.6.1):

- Implement traffic calming measures in development areas not subject to Koala exclusion fencing, including speed limit restrictions for areas adjacent to land with biodiversity values, and installation of wildlife signposting and speed humps and audible surfacing in accordance with relevant standards
- Install and maintain fauna-friendly road design structures in appropriate areas adjacent to fauna habitat, such as underpasses, fauna bridges and overpasses

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

The Plan also includes a range of commitments and actions to reduce vehicle strike on Koala, including:

- Install Koala exclusion fencing between important Koala habitat and urban capable land within GMAC and Wilton, except where exclusion fencing is not feasible due to slope, heritage or water courses
- Install Koala exclusion fencing on both sides of Appin Road between Rosemeadow and Appin to mitigate Koala vehicle strikes at roadkill hotspots

Many areas of suitable habitat for Koala overlap with suitable habitat for other species susceptible to vehicle strikes, such as Spotted-tailed Quoll, Eastern Pygmy Possum, and Yellow-bellied Glider, and these mitigation measures for Koala are likely to benefit these other species in many cases.

24.12.5 ASSESSMENT OF POTENTIAL PRESCRIBED IMPACTS

An assessment of the potential prescribed impacts of the urban, industrial, infrastructure, agribusiness and transport development in relation to vehicle strikes is set out in Table 24-30. This assessment takes into account any general mitigation measures under the Plan to manage impacts.

Table 24-30: Risks and consequences of impacts – vehicles strikes

Relevant species/TECs	Assessment of the potential prescribed impacts	Residual risk of impact
Green and Golden Bell Frog	There is a low risk impacts may cause population decline at a local level. The species may occur in GPEC, and while the development will only intersect the edges of suitable habitat and existing roads already occur in the vicinity of suitable habitat, the development will lead to increased traffic levels on existing roads Impacts are unlikely to cause population decline for this species at a regional or State scale because the majority (greater than 95 %) of records for the species occur in the eastern third of the Cumberland subregion outside the nominated areas (Lemckert, 2019) and the nominated areas are unlikely to be important for species persistence The general mitigation measures are considered adequate to reduce this risk The Plan also includes a specific mitigation measure for the transport corridors that may also benefit this species in the northern part of GPEC	Unlikely

Relevant species/TECs	Assessment of the potential prescribed impacts	Residual risk of impact
Eastern Pygmy Possum	Impacts are unlikely to cause population decline for this species at a local, regional or State scale because: • The likelihood of vehicle strikes in key risk areas is considered to be low • Few records occur within or in the vicinity of the nominated areas, which suggests this species may not occur in the area or occurs only in small numbers While risks are considered unlikely, the Plan includes: • General mitigation measures to reduce any actual risk • A specific mitigation measure for the transport corridors that may benefit this species in WSA and GPEC	Unlikely
Spotted-tailed Quoll	There is a low to moderate risk impacts may cause population decline at a local level. An important population of the species occurs immediately to the south of Wilton. While no new major roads will intersect suitable habitat in this area, the development will lead to increased traffic levels on existing roads. Impacts are unlikely to cause population decline for this species at a regional or State scale because: • The vast majority of suitable habitat for this species, including in Wilton and the other nominated areas, are outside the urban capable lands • Few records occur within or in the vicinity of the other nominated areas, which suggests this species may not occur in the area or occurs only in small numbers • There have been no recorded vehicle strikes on this species in the nominated areas suggesting this species may not be regularly needing to move across existing roads to disperse between areas of suitable habitat The general mitigation measures are considered adequate to reduce this risk The Plan also includes a specific mitigation measure for the transport corridors that may also benefit this species in WSA and GPEC	Unlikely
Yellow-bellied Glider Squirrel Glider	Impacts are unlikely to cause population decline for this species at a local, regional or State scale because: • The risk of vehicle strike in key risk areas is considered to be low • Few records occur within or in the vicinity of the nominated areas, which suggests this species may not occur in the area or occurs only in small numbers While risks are considered unlikely, the Plan includes: • General mitigation measures to reduce any actual risk • A specific mitigation measure for the transport corridors that may benefit this species in WSA and GPEC	Unlikely
Broad-headed Snake	Impacts are unlikely to cause population decline for this species at a local, regional or State scale because: • The risk of vehicle strike in key risk areas is considered to be low • No records occur within or in the vicinity of the Wilton (and the other nominated areas), which suggests this species may not occur in the area	Unlikely

24.12.6 ADDITIONAL SPECIFIC MITIGATION TO ADDRESS RESIDUAL RISKS

Table 24-31 identifies additional specific mitigation measures under the Plan to address residual risks to Green and Golden Bell Frog and any actual risks to other species due to the direct and indirect impacts of the development.

These mitigation measures are considered to adequately address residual risks in the context of the risk and significance of the impacts of the development on these species, and the mitigation measures put in place for Koala.

Table 24-31: Specific mitigation measures – vehicle strikes

Relevant species/TECs	Specific mitigation measure	Applicable development	Uncertainty or risks of failure
Green and Golden Bell Frog Yellow-bellied Glider Squirrel Glider Eastern Pygmy Possum Spotted-tailed Quoll	The Plan includes a commitment to ensure transport corridors are designed to avoid and minimise impacts to areas of potential habitat connectivity, particularly vegetation in riparian corridors for these species (Commitment 3)	Transport development	Not possible to predict at this stage

IMPLEMENTATION

Transport corridors

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport development (Commitment 5.3), as prescribed in Appendix E of the Plan.

This commitment will be delivered through a process of environmental assessment and approval that will be applied to detailed design of each transport project, at the time the project is brought forward for development. These future environmental assessments provide a process through which to implement these specific mitigation measures for vehicle strikes as prescribed in Appendix E of the Plan.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2.

25 Serious and irreversible impacts

25.1 INTRODUCTION

Section 10.2 of the BAM requires the BCAR to assess whether the urban, industrial, infrastructure, agribusiness and transport development in the nominated areas will result in SAII to any NSW listed TECs or species. As outlined in the *Guidance to assist a decision-maker to determine a serious and irreversible impact* (OEH, 2017f), an SAII is one that:

- *Will cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or*
- *Will further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or*
- *Impact on the habitat of a species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or*
- *Impact on a species or ecological community that is unlikely to respond to measures to improve habitat and vegetation integrity and is therefore irreplaceable*

This section:

- Sets out the approach and results for identifying relevant TECs and species that are potentially subject to serious and irreversible impacts due to the development (SAII entities)
- Provides a detailed assessment for each relevant SAII entity

Impacts to SAII entities were assessed in accordance with the requirements of Section 10.2 of the BAM and Appendix 4 of the EES guidelines (OEH, 2017f). The structure of the assessment for each SAII entity in sections 25.3 to 25.11 reflects these requirements.

25.2 IDENTIFYING SAII ENTITIES

25.2.1 APPROACH

The approach to identify SAII entities impacted by the development is described in Chapter 12 and involved:

- Comparing the list of NSW listed TECs and ECS and candidate SCS that occurs within the nominated areas and are potentially impacted by the development with the:
  - List of SAII entities in the *Guidance to assist a decision-maker to determine a serious and irreversible impact* (DPIE, 2019)
  - Threatened Biodiversity Data Collection (TBDC) that indicates whether a TEC or species is an SAII entity
- Determining whether any other NSW listed TECs or ECS and candidate SCS that occur within the nominated areas have the potential to become an SAII in accordance with the requirement of section 10.2.1.4 of the BAM. This section of the BAM requires an assessment against the above EES guidance document (DPIE, 2019) that includes four principles under the BC Regulation (see Table 25-1) that determine whether a species or TEC should be considered an SAII entity. This was undertaken by senior ecologists at Biosis by:
  - Undertaking a literature review to ascertain:
    - Distribution, including geographic extent and area of occupancy
    - Known or inferred reductions in geographic extent or area of occupancy
    - Population sizes and current knowledge of declining populations
    - Susceptibility to known threats, such as invasive weeds and pests, disease or pathogens
    - Life history traits that may make the species particularly vulnerable
  - Investigating existing records and new records found during targeted surveys for this project and the updated native vegetation mapping (see Chapter 11), and using aerial imagery interpretation, to consider likely impacts in areas approved or planned for other future development in the region

- o Considering risk weightings in the TBDC
- o Considering levels of existing protection
- o Consultation with senior Department biodiversity officers

Table 25-1 summarises the principles under the BC Regulation that determine whether a species or TEC should be considered an SAII entity.

Table 25-1: Summary of serious and irreversible impact principles

Principle	Description (DPIE, 2019)
Principle 1	**Species or ecological community currently in a rapid rate of decline** Entities listed as critically endangered under the BC Act • The principle would generally capture entities listed as critically endangered under the BC Act where the reason for that listing is a very large reduction in population size Rapid rate of decline for species considered to be critically endangered by IUCN • The species has an observed, estimated, inferred, suspected or projected population reduction of ≥80% in 10 years or three generations (whichever is longer). Rapid rate of decline for an ecological community considered to be critically endangered by IUCN • To be considered under this principle, the ecological community should have been observed, estimated, inferred, or reasonably suspected to have undergone, or be projected to undergo, a very large reduction in distribution, being: o ≥90% reduction where the reduction is measured since 1750 (historical decline), or o ≥80% reduction where the reduction is over a 50-year period, either in the past, future, or any part of the past, present and future
Principle 2	**Species or ecological communities with a very small population size** Entities listed as critically endangered under the BC Act • The principle would generally capture species or ecological communities listed as critically endangered under the BC Act where the reason for that listing is a very small size or very high environmental degradation and/or a very large disruption of biotic processes or interactions, respectively Very small population size for species considered to be critically endangered by IUCN • Species that have a very small population size are species with a known population size that is either: o fewer than 50 mature individuals independent of whether there are any threats, or o fewer than 250 mature individuals and the species has an observed, estimated or projected continuing decline: ▪ of at least 25% in three years or one generation (whichever is longer) OR ▪ where the number of mature individuals in each subpopulation is <50 OR ▪ the percentage of mature individuals in one subpopulation is 90–100% OR ▪ the population is subject to extreme fluctuations in the number of individuals (IUCN 2017) Very high environmental degradation or disruption of biotic processes or interactions for an ecological community considered to be critically endangered by IUCN • Ecological communities that are considered to have a very large degree of environmental degradation or disruption of biotic processes or interactions are those with: o ≥90% extent and severity where the disruption or impacts are measured since 1970 o ≥80% extent and severity where the disruption or impacts are over a 50-year period, either in the past, future, or any part of the past, present and future (as per Bland et al. 2016).

Principle	Description (DPIE, 2019)
Principle 3	**Species or area of ecological community with very limited geographic distribution** Entities listed as critically endangered under the BC Act • The principle would generally capture entities that are listed as critically endangered under the BC Act where the reason for that listing is their very highly restricted geographic distribution Very limited geographic distribution for species considered to be critically endangered by IUCN • Species that have a very limited geographic distribution are generally known to: o have an area of occupancy (sensu IUCN 2017) of ≤10 km2 o have an extent of occurrence (sensu IUCN 2017) of ≤100 km2 o have at least two of the following three conditions: ▪ are severely fragmented or only known from one location ▪ continuing decline ▪ extreme fluctuations o inhabit less than or equal to three locations in NSW Very limited geographic distribution for an ecological community considered to be critically endangered by IUCN • The geographical distribution of ecological communities is defined by the area of occupancy (sensu Bland et al. 2016). Ecological communities with a very limited geographic distribution have an area of occupancy of less than or equal to two 10 x 10 km grid cells or an extent of occurrence of ≤1000 km2 (sensu Bland et al. 2016) and one of the following: o an observed or inferred continuing decline in: ▪ a measure of spatial extent appropriate to the ecological community ▪ a measure of environmental quality appropriate to characteristic biota of the ecological community ▪ a measure of disruption to biotic interactions appropriate to the characteristic biota of the ecological community o observed or inferred threatening processes that are likely to cause continuing declines in geographic distribution, environmental quality or biotic interactions within the next 20 years o an ecological community exists at one location
Principle 4	**Species or ecological community that is unlikely to respond to management and is therefore irreplaceable** • These are species or ecological communities with: 1. Life history traits and/or ecology which is known, but the ability to control key threats at the site scale is negligible. In general, these are species significantly threatened by uncontrollable disease (e.g. frogs highly threatened by chytrid fungus) 2. Known reproductive characteristics that severely limit their ability to increase the existing population on, or occupy new habitat at, a stewardship site. In general, these are plants that are sterile or largely clonal with no or very limited capacity to increase in number through seed production and recruitment • Irreplaceable o Whether an impact on an entity is considered irreplaceable takes into account two factors. The first factor is the likely success in achieving gain in condition, abundance or habitat area. For potential species that are identified in criteria 1 and 2 above, the likelihood of achieving an offset gain is extremely low or highly uncertain

25.2.2 RESULTS

Table 25-2 and Table 25-3 identify the NSW listed TECs and ECS and candidate SCS species that are SAII entities and that are potentially directly or indirectly impacted by the development (highlighted in blue). These are:

- Cooks River/Castlereagh Ironbark Forest
- Cumberland Plain Woodland
- Shale Sandstone Transition Forest
- *Allocasuarina glareicola*
- *Chalinolobus dwyeri (*Large-eared Pied Bat)
- *Hibbertia fumana*
- *Litoria aurea* (Green and Golden Bell Frog)
- *Micromyrtus minutiflora*
- Three raptor species - *Haliaeetus leucogaster* (White-bellied Sea-Eagle), *Hieraaetus morphnoides* (Little Eagle), and *Lophoictinia isura* (Square-tailed Kite)
- *Pseudophryne australis* (Red-crowned Toadlet)

A TEC or species is an SAII entity either because:

- It is identified in the EES guidelines or TBDC as an SAII entity, or
- It has been assessed as meeting one or more of the four SAII principles in the BC Regulation (section 10.2.1.4 of BAM)

The species assessed as meeting one or more of the four SAII principles in the BC Regulation were:

- Green and Golden Bell Frog and Red-crown Toadlet – these species are likely to meet SAII Principle 4 because of their very high susceptibility to the disease Chytrid fungus
- *Micromyrtus minutiflora –* this species is likely to meet SAII Principle 3 because of its very highly restricted distribution and the development directly impacting potential habitat
- Three raptor species – White-bellied Sea-Eagle, Little Eagle, and Square-tailed Kite – these species are likely to meet SAII Principle 4 because there is potential for the development to impact breeding habitat for the species (hollows of very old trees) that cannot readily be created at a stewardship site

TECs and species were identified as unlikely to trigger SAII principles generally on the basis that the development will not have significant impacts on the TEC or species, and:

- The TEC or species has a relatively broad distribution across the Cumberland subregion or NSW
- Known populations for species are relatively large (> 250 individuals)

In considering the impacts to each TEC and species, both direct impacts on potential habitat for TECs and species (see Chapter 23) and existing and new records based on targeted surveys for this project, were taken into account.

SAII entities that are not mapped as occurring within the nominated areas were not considered to be impacted by the development within the nominated areas and are not considered further. This includes, for example:

- Agnes Banks Woodland
- Elderslie Banksia Scrub Forest
- Western Sydney Dry Rainforest

Each SAII entity impacted by the development is assessed below in accordance with Section 10.2 of the BAM.

Table 25-2: Identification of TEC SAII entities and assessment against SAII principles

TEC name	NSW status	Cth status	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Castlereagh Scribbly Gum Woodland	V	E	No	No – unlikely to trigger SAII principles	N/A	No
Cooks River/Castlereagh Ironbark Forest	E	CE	SAII advice on EES website	N/A	Yes – directly impacted	Yes
Cumberland Plain Woodland	CE	CE	SAII advice on EES website	N/A	Yes – directly impacted	Yes
Freshwater Wetlands on Coastal Floodplains	E	-	No	No – unlikely to trigger SAII principles	N/A	No
Moist Shale Woodland	E	CE	No	No – unlikely to trigger SAII principles	N/A	No
River-flat Eucalypt Forest on Coastal Floodplains	E	-	No	No – unlikely to trigger SAII principles	N/A	No
Shale Gravel Transition Forest	E	CE	No	No – unlikely to trigger SAII principles	N/A	No
Shale Sandstone Transition Forest	CE	CE	SAII advice on EES website	N/A	Yes – directly impacted	Yes
Swamp Oak Floodplain Forest	E	E	No	No – unlikely to trigger SAII principles	N/A	No

Table 25-3: Identification of species SAII entities and assessment against SAII principles

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Acacia bynoeana	E	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Acacia pubescens	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Allocasuarina glareicola	E	E	SCS	3	SAII advice on EES website	N/A	Yes – potential habitat directly impacted	Yes
Anthochaera Phrygia^	CE	CE	ECS	3	No	No – unlikely to trigger SAII principles	No. This species is an SAII entity for mapped Important Areas. EES advised that no mapped Important Areas occur in the nominated areas	No
Artamus cyanopterus cyanopterus	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Botaurus poiciloptilus	E	E	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Burhinus grallarius	E	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Calidris ferruginea^	E	CE	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Callocephalon fimbriatum**	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Callocephalon fimbriatum^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Calyptorhynchus lathami**	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Calyptorhynchus lathami^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Cercartetus nanus	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Chalinolobus dwyeri	V	V	SCS	3	SAII advice on EES website	N/A	Yes – Habitat within 100 metres of potential breeding habitat (sandstone cliffs) will be directly impacted	Yes
Chthonicola sagittata	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Circus assimilis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Climacteris picumnus victoriae	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Daphoenositta chrysoptera	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Dasyurus maculatus	V	E	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Dillwynia tenuifolia	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Epacris purpurascens var. *purpurascens*	V	-	SCS	1.5	No	No – unlikely to trigger SAII principles	N/A	No
Ephippiorhynchus asiaticus	E	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Epthianura albifrons	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Eucalyptus benthamii	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Falsistrellus tasmaniensis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Glossopsitta pusilla	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Grantiella picta	V	V	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Grevillea juniperina subsp. *juniperina*	V	-	SCS	1.5	No	No – unlikely to trigger SAII principles	N/A	No
Grevillea parviflora subsp. *parviflora*	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
*Haliaeetus leucogaster**	V	-	SCS	2	No	Yes – likely to trigger SAII principle 4	Yes – potential breeding habitat directly impacted	Yes
*Haliaeetus leucogaster^*	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Heleioporus australiacus	V	V	SCS	1.5	No	No – unlikely to trigger SAII principles	N/A	No
Hibbertia fumana	CE	-	SCS	3	SAII advice on EES website	N/A	Yes – potential habitat directly impacted	Yes
Hibbertia puberula	E	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
*Hieraaetus morphnoides**	V	-	SCS	1.5	No	Yes – likely to trigger SAII principle 4	Yes – potential breeding habitat directly impacted	Yes
*Hieraaetus morphnoides^*	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Hoplocephalus bungaroides**	E	V	SCS	3	Yes	N/A	No – breeding habitat will not be impacted by development	No
*Hoplocephalus bungaroides^*	E	V	ECS		No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Irediparra gallinacea	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Ixobrychus flavicollis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Lathamus discolor^	E	CE	ECS		No	Yes – likely to trigger SAII principle 1	No. This species is an SAII entity for mapped Important Areas. EES advised that no mapped Important Areas occur in the nominated areas	No
Limicola falcinellus^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Limosa limosa^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Litoria aurea	E	V	SCS	2	No	Yes – likely to trigger SAII principles 1 and 4	Yes – potential habitat directly impacted	Yes
*Lophoictinia isura**	V	-	SCS	1.5	No	No – unlikely to trigger SAII principles	Yes – potential breeding habitat directly impacted	Yes
Lophoictinia isura^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Marsdenia viridiflora subsp. *viridiflora*	E	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Maundia triglochinoides	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Melaleuca deanei	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Melanodryas cucullata cucullata	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Melithreptus gularis gularis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Meridolum corneovirens	E	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Micromyrtus minutiflora	E	V	SCS	2	No	Yes – likely to trigger SAII principle 3	Yes – potential habitat directly impacted	Yes
Miniopterus australis^	V	-	SCS	3	Yes	N/A	No – breeding habitat will not be impacted by development	No
Miniopterus australis^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Miniopterus orianae oceanensis^	V	-	SCS	3	Yes	N/A	No – breeding habitat will not be impacted by development	No
Miniopterus orianae oceanensis^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Mormopterus norfolkensis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Myotis macropus	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Neophema pulchella	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Ninox connivens (breeding)	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Ninox connivens^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Ninox strenua**	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
*Ninox strenua^*	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Pandion cristatus^*	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Persicaria elatior	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Persoonia bargoensis	E	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Persoonia nutans	E	E	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Petaurus australis	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Petaurus norfolcensis	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Petroica boodang	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Petroica phoenicea	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Phascolarctos cinereus**	V	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
*Phascolarctos cinereus^*	V	V	ECS	2	No	No – unlikely to trigger SAII principles	N/A	No
Pilularia novae-hollandiae	E	-	SCS		SAII advice on EES website	N/A	No – determined not to be a candidate SCS (see Chapter 21)	No
Pimelea curviflora var. *curviflora*	E	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Pimelea spicata	E	E	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Pomaderris brunnea	E	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Pseudophryne australis	V	-	SCS	1.5	No	Yes – likely to trigger SAII principle 4	Yes – potential habitat directly impacted	Yes
Pteropus poliocephalus^	V	V	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Pterostylis saxicola	E	E	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Pultenaea parviflora	E	V	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Pultenaea pedunculata	E	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No
Rostratula australis	E	E	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Saccolaimus flaviventris	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Scoteanax rueppellii	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Stagonopleura guttata	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Stictonetta naevosa	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
*Tyto novaehollandiae**	V	-	SCS	2	No	No – unlikely to trigger SAII principles	N/A	No

Species name	NSW status	Cth status	Species type	Bio. risk weight.	Identified by EES as SAII entity	Potential to become SAII entity (Section 10.2.1.4 of BAM)	Is the SAII entity potentially directly or indirectly impacted?	SAII assessment needed
Tyto novaehollandiae^	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No
Varanus rosenbergi	V	-	ECS		No	No – unlikely to trigger SAII principles	N/A	No

* These species are SCS in relation to breeding / important habitat only ^ These species are ECS in relation to foraging habitat only

25.3 COOKS RIVER/CASTLEREAGH IRONBARK FOREST

25.3.1 TEC BACKGROUND

Cooks River Castlereagh Ironbark Forest in the Sydney Basin Bioregion (CRCIF) is a dry sclerophyll open forest to low woodland community with an overstorey dominated by *Eucalyptus fibrosa* and *Melaleuca decora*, with *Eucalyptus longifolia* often present. The midstorey is usually moderate to dense, commonly including *Melaleuca nodosa* and *Lissanthe strigosa*, and to a lesser extent *Melaleuca decora*. The ground layer is generally sparse (OEH, 2019b).

The TEC is equivalent to the ecological community with the same name listed under the EPBC Act (DoE, 2015c).

CRCIF primarily occurs in elevations below 100 m above sea level with mean annual rainfall of approximately 700-1,000 mm. It generally occurs on clay soils derived from Tertiary alluvium and on Wianamatta Shale soils found next to Tertiary alluvium. In the eastern areas of its distribution, the TEC can be found on soils with a sandstone influence (DoE, 2015c). The TEC can intergrade into Shale-Gravel Transition Forest (where the alluvium is shallow), Castlereagh Swamp Woodland (in moist depressions) and Castlereagh Scribbly Gum Woodland (on sandier soils) (OEH, 2019b).

A range of fauna species occur in CRCIF, including reptiles, amphibians, birds, micro-bats, and marsupials. Most of these species also rely on other native vegetation in the Cumberland subregion (DoE, 2015c). Most plant species in the TEC are able to regenerate after fire from lignotubers and buds beneath the bark and seeds stored in the soil (DoE, 2015c).

CRCIF is confined to the Sydney Basin Bioregion and mostly restricted to the Cumberland subregion. The majority of the TEC is found in larger patches in the north-west part of the subregion in the Castlereagh area between Penrith and Richmond. Other significant patches occur in the Kemps Creek and Holsworthy areas. Smaller patches of the ecological community occur in the eastern part of the subregion, such as the upper Cooks River Valley (OEH, 2019b).

25.3.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

CRCIF has been identified as a potential serious and irreversible impacts entity based on advice from EES to accredited assessors in January 2019 as it has a very highly restricted geographic distribution (Principle 3 of the BC Regulation) (OEH, 2017f).

CRCIF is associated with PCT 725 – 'Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion'. The TEC has been mapped within the nominated areas and the Cumberland subregion on the basis of the extent and condition of this PCT (see Chapter 11).

25.3.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of CRCIF in relation to the subject land is shown in Map 21.

The majority of CRCIF within the Cumberland subregion occurs outside the nominated areas within the Londonderry and Castlereagh areas in the northern part of the subregion.

The TEC has been mapped as occurring in the following nominated areas:

- GPEC
- WSA

The main occurrences of the TEC within these nominated areas are located:

- Within Wianamatta Regional Park in the northern part of GPEC
- In the south-eastern part of WSA

25.3.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.2 of the BAM.

10.2.2.1(A) THE ACTION AND MEASURES TAKEN TO AVOID THE DIRECT AND INDIRECT IMPACT ON THE POTENTIAL ENTITY FOR AN SAII

Avoidance and minimisation of impacts to biodiversity values, including CRCIF, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The baseline mapping for this assessment has mapped 65 ha of CRCIF within the nominated areas (not including excluded lands). Approximately 28 ha (43 per cent) of this was avoided within the nominated areas as part of the design of the urban capable land and transport corridors (not including excluded lands). Almost all of this was avoided for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 25-4.

The table shows that the majority of the total avoidance that has occurred (71 per cent) has been of CRCIF in intact condition, and that of the 35 ha of intact condition CRCIF (without excluded lands), the majority (19.4 ha or 55 per cent) has been avoided.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-4 shows the amounts of habitat within excluded lands for context only.

Table 25-4: Avoidance outcomes for Cooks River Castlereagh Ironbark Forest (PCT 725)

Condition	Total area in nominated areas (ha)	Area in excluded lands (ha)	Area without excluded lands (ha)	Directly impacted (ha)	Avoided for biodiversity purposes (ha)	Avoided for other purposes (ha)	Total avoidance (ha)
Intact condition	107.4	72.4	35	15.6	19.4	0	19.4
Thinned condition	50.3	24.1	26.3	18.4	0.2	0.1	7.9
Scattered trees	9.6	6.4	3.2	3	7.8	0	0.2
Total	**167.4**	**102.9**	**64.5**	**36.9**	**27.4**	**0.1**	**27.5**

Avoidance of indirect impacts

Potential indirect impacts to CRCIF due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(B) THE AREA (HA) AND CONDITION OF THE TEC TO BE IMPACTED DIRECTLY AND INDIRECTLY BY THE DEVELOPMENT

Direct impacts

A total of 37 ha of CRCIF will be directly impacted by the development. This is approximately half of the TEC in the nominated areas (without excluded lands). The direct impacts of the development are mainly associated with the transport corridors.

The main direct impacts occur:

- In the northern part of GPEC within Wianamatta Regional Park associated with the OSO
- In the south-eastern part of WSA associated with urban development

Scattered smaller patches of the TEC will also be directly impacted in the central part of GPEC.

The direct impacts of the development on CRCIF are provided in Table 25-5.

Table 25-5: Direct impacts on Cooks River Castlereagh Ironbark Forest (PCT 725)

PCT	Condition	Direct impacts (ha)						Vegetation integrity score
		Wilton*	GMAC*	WSA*	GPEC*	Transport#	Total	
725	Intact	0	0	0.4	0	15.2	15.6	49.2
725	Thinned	0	0	8.2	6.4	3.7	18.3	43.3
725	Scattered Trees	0	0	3.0	0	0.0	3.00	19.6
Total		**0**	**0**	**11.6**	**6.4**	**18.9**	**36.9**	

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

Indirect impacts

Potential indirect impacts to CRCIF due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS THE THRESHOLD FOR THE POTENTIAL ENTITY

No threshold has been established for CRCIF.

10.2.2.1(D) THE EXTENT AND OVERALL CONDITION OF THE POTENTIAL TEC WITHIN AN AREA OF 1,000 HA, AND THEN 10,000 HA, SURROUNDING THE URBAN CAPABLE LANDS

The extent and condition of CRCIF surrounding the urban capable lands are provided in Table 25-6. Due to the scale of the development, calculations were also presented based on a 1 km buffer and a 10 km buffer from the outer edge of the urban capable lands, as well as buffers of 1,000 ha or 10,000 ha as per the BAM.

Table 25-6: Extent and condition of Cooks River Castlereagh Ironbark Forest (PCT 725) surrounding the urban capable lands

PCT	Condition	Area in 1,000 ha buffer	Area in 10,000 ha buffer	Area in 1,000 m buffer	Area in 10,000 m buffer
725	Intact	18.5	82.3	162.5	769.3
725	Thinned	20.2	31.2	47.2	117.7
725	Scattered Trees	3.7	6.7	17.7	267.3
Total		**42.4**	**120.2**	**227.4**	**1,154.2**

10.2.2.1(E) AN ESTIMATE OF THE EXTANT AREA AND OVERALL CONDITION OF THE POTENTIAL TEC REMAINING IN THE IBRA SUBREGION BEFORE AND AFTER THE IMPACT OF THE DEVELOPMENT HAS BEEN TAKEN INTO CONSIDERATION

The development will result in a loss of 2.7 per cent of the remaining area of CRCIF in the Cumberland subregion.

The extent and condition of CRCIF remaining in the subregion before and after the impact of the development is provided in Table 25-7. The largest percentage change relates to the TEC in thinned condition. Only very small changes occur to the TEC in intact condition (-1.8 per cent change).

Table 25-7: Extent and condition of Cooks River Castlereagh Ironbark Forest (PCT 725) before and after development

PCT	Condition	Current area in Cumberland subregion (ha)	Area in Cumberland subregion after the direct impacts of the development (ha)	Per cent loss of current area in Cumberland subregion (%)
725	Intact	851.4	835.9	-1.8
725	Thinned	189.5	171.2	-9.7
725	Scattered Trees	327.5	324.5	-0.9
Total		**1,368.5**	**1,331.6**	**-2.7**

10.2.2.1(F) AN ESTIMATE OF THE AREA OF THE POTENTIAL TEC THAT IS IN THE RESERVE SYSTEM WITHIN THE IBRA REGION AND THE IBRA SUBREGION

The area of CRCIF occurring within protected lands (land reserved under NPW Act) within the Cumberland subregion is 412 ha. This represents 30 per cent of the total area of the remaining TEC in the subregion.

The extent and condition of CRCIF within protected lands is provided in Table 25-8.

Table 25-8: Extent and condition of Cooks River Castlereagh Ironbark Forest (PCT 725) in protected lands

PCT	Condition	Area in protected lands within the Cumberland subregion (ha)
725	Intact	402.4
725	Thinned	5.9
725	Scattered Trees	4.0
	Total	**412.3**

10.2.2.1(G) THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION PROPOSAL'S IMPACT ON:

(I) ABIOTIC FACTORS CRITICAL TO THE LONG-TERM SURVIVAL OF THE POTENTIAL TEC

(II) CHARACTERISTIC AND FUNCTIONALLY IMPORTANT SPECIES

(III) THE QUALITY AND INTEGRITY OF AN OCCURRENCE OF THE POTENTIAL TEC THROUGH THREATS AND INDIRECT IMPACTS

The Final Determination (NSW Scientific Committee, 2011) and BioNet profile (OEH, 2019b) for CRCIF identifies a range of threats to the TEC. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

These threats and indirect impacts have the potential to degrade the condition of the TEC and reduce the long-term viability of the patches of the TEC, particularly in the following locations:

- Northern part of GPEC where the OSO corridor fragments TEC patches
- South-eastern part of WSA where urban development occurs immediately adjacent to several TEC patches

To help address these potential indirect impacts, the Plan includes a requirement to undertake mitigation in accordance with the *Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest* (DECC, 2008) within and adjacent to the TEC. These are discussed further below in relation to specific indirect impacts.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC by altering the mid and ground layers (NSW Scientific Committee, 2011). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

The diversity and composition of species will change with time since fire, and may also change in response to changes in fire frequency (NSW Scientific Committee, 2011). This is despite most plant species in the TEC being able to regenerate after fire from lignotubers and buds beneath the bark, as well as seeds stored in the soil (OEH, 2019b).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in the north of GPEC, and the south east of WSA.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes
- A specific requirement in relation to two commitments (Commitments 5 and 6) to apply the best practice guidelines for managing the TEC (DECC, 2008). This includes specifics around fire management for the TEC.

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands in WSA where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

- The fire management requirements for the TEC specified in the best practice guidelines will be applied

WEED INVASION

The TEC is threatened with invasion and competition by weeds. It typically occurs on soils that are richer in nutrients compared to other soil types in the Sydney Basin bioregion, which means it is particularly susceptible to threats from weeds (DECC, 2008). The most serious threats are African Lovegrass, scramblers and vines, and urban weeds such as Mother of Millions (OEH, 2019b).

These weeds are already present within the nominated areas and pose a threat to the TEC. However, urban and transport development in the vicinity of the TEC has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds. The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development or transport corridors occur adjacent to the TEC and/or fragments patches of the TEC into smaller patches and introduces edge effects. Key risk areas include the northern part of GPEC and south-eastern part of WSA.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas
- A specific requirement in relation to two commitments (Commitments 5 and 6) to apply the best practice guidelines for managing the TEC (DECC, 2008). This includes specifics around weed management

Importantly for the TEC, weeds will be actively managed within the 110 ha to be added to conservation as part of the conservation program under the Plan.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management

- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction
- The weed management requirements for the TEC specified in the best practice guidelines will be applied

INAPPROPRIATE HABITAT DISTURBANCE

Damage caused by human disturbance, such as motorbikes, bicycles, 4WD vehicles, rubbish dumping, trampling, and erosion is identified in the BioNet profile as a threat to the TEC (OEH, 2019b).

These activities have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the nominated areas may increase due to the urban development. Occurrences of the TEC considered most at risk are those in the northern part of GPEC and the south-eastern part of WSA.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 110 ha offset for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

CHANGES TO HYDROLOGY

The main threat to the TEC is associated with altered hydrology is increased runoff into patches of the TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause siltation and erosion (OEH, 2019b).

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are those in the northern part of GPEC and the south-eastern part of WSA.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

DISEASES, PATHOGENS AND DIEBACK

The TEC is potentially susceptible to dieback caused by the root-rot fungus *Phytophthora cinnamomi* (OEH, 2019b).

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora*

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion

- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species, including CRCIF (DECC, 2008). These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the introduced Indian Myna, and native species such as the Sulphur-crested Cockatoo

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the nominated areas and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

10.2.2.1(H) DIRECT OR INDIRECT FRAGMENTATION AND ISOLATION OF AN IMPORTANT AREA OF THE POTENTIAL TEC

Direct loss of CRCIF may cause fragmentation and isolation of remaining patches of the TEC, which may increase the susceptibility of the TEC to weed invasion and other edge effects and reduce its long-term viability.

Fragmentation and isolation of CRCIF will mainly occur in the following areas:

- In the northern part of GPEC within Wianamatta Regional Park associated with the OSO

- In the south-eastern part of WSA associated with urban development

The small area of scattered patches of the TEC in the central part of GPEC will be completed removed.

The most notable impact to CRCIF occurs within Wianamatta Regional Park. The patches of the TEC in this location form part of a larger, well-connected patch of native vegetation, and large parts of the patch are in intact condition. These impacts will lead to fragmentation of the TEC in this location, reducing the size and increasing the isolation of the areas that remain. This will increase the susceptibility of CRCIF in this location to weed invasion and other edge effects and reduce its long-term viability. The patch that is directly impacted is only marginally connected to the second occurrence of the TEC within Wianamatta Regional Park (to the east of Ropes Crossing) and as such, the development is not expected to increase the level of fragmentation to the TEC in this locality more broadly.

The patches of the TEC in the south-eastern part of WSA are already relatively fragmented and isolated as a result of existing industrial land use and farming. The urban development in this location is not considered to greatly increase the level of fragmentation and isolation in this location.

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE POTENTIAL TEC IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of CRCIF in the Cumberland subregion. Several commitments are described in more detail the sections above.

Key commitments relevant to the TEC are:

- TEC-specific commitments or mitigation measures to:
  - Secure an offset target of 110 ha of CRCIF (Commitment 8.1) in conservation lands within Strategic Conservation Areas (SCAs). This would increase the area of TEC protected within the Cumberland subregion by approximately 27 per cent
  - Undertake management of fire, weeds and pest animals and disease control consistent with the *Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest* (DECC, 2008) (as part of Commitment 5.1)
- As part of securing a minimum of 5,475 ha of native vegetation in SCAs:
  - Undertake ecological restoration of priority areas secured for conservation within the Cumberland subregion (Commitment 13). This includes restoring up to 1,365 ha of native vegetation, including targeting CRCIF
  - Secure priority habitat corridors within the Cumberland subregion to support habitat connectivity (Commitment 12)
- Manage weeds (Commitment 16) and pest animals(Commitment 17) in strategic locations in the Cumberland subregion to reduce threats to conservation lands secured within SCAs. This includes preparing:
  - A Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program
  - A Pest Animal Control Implementation Strategy to guide and co-ordinate delivery of a pest control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
  - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
  - Preparing a Fire Management Strategy to guide and co-ordinate fire management

25.4 CUMBERLAND PLAIN WOODLAND

25.4.1 TEC BACKGROUND

Cumberland Plain Woodland in the Sydney Basin Bioregion (CPW) is a woodland or forest with an overstorey dominated by Grey Box (*Eucalyptus moluccana*) and Forest Red Gum (*E. tereticornis*), with Narrow-leaved Ironbark (*E. crebra*), Spotted Gum (*Corymbia maculata*) and Thin-leaved Stringybark (*E. eugenioides*) occurring less frequently. The TEC typically comprises an open tree canopy, a near-continuous groundcover dominated by grasses and herbs, sometimes with layers of shrubs and/or small trees (NSW Scientific Committee, 2009).

The TEC is listed under the EPBC Act as part of *Cumberland Plain Shale Woodlands and Shale Gravel Transition Forest in the Sydney Basin Bioregion* (DEWHA, 2009a).

CPW generally occurs on flat to undulating or hilly terrain up to about 350 m elevation but may also occur on locally steep sites and at slightly higher elevations, and on clay soils derived from Wianamatta Group geology, or more rarely alluvial substrates, on the Cumberland Plain (NSW Scientific Committee, 2009).

Several other TECs may intergrade with CPW, including CRCIF, *Shale Gravel Transition Forest in the Sydney Basin Bioregion (SGTF)* and *Moist Shale Woodland and Shale Sandstone Transition Forest* (SSTF) (NSW Scientific Committee, 2009).

CPW is restricted to the Sydney Basin Bioregion. It is known to occur in the Auburn, Bankstown, Baulkham Hills, Blacktown, Camden, Campbelltown, Fairfield, Hawkesbury, Holroyd, Liverpool, Parramatta, Penrith and Wollondilly LGAs (NSW Scientific Committee, 2009). The remaining area of the TEC is severely fragmented, with more than half of the remaining area occurring in patches of less than 80 ha in 2009 (NSW Scientific Committee, 2009).

25.4.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

CPW has been identified as a potential serious and irreversible impacts entity under the EES guidelines because it is currently in a rapid rate of decline (Principle 1 of the BC Regulation) and is subject to high levels of degradation or disruption of biotic processes (Principle 2 of the BC Regulation) (EES, 2019).

CPW is associated with the following PCTs:

- PCT 849 – Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain
- PCT 850 – Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain

The TEC has been mapped within the nominated areas and the Cumberland subregion on the basis of the extent and condition of these PCTs (see Chapter 11).

25.4.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of CPW in relation to the subject land is shown in Map 22.

CPW is relatively evenly distributed in scattered patches across the Cumberland subregion generally west of Parramatta and Liverpool, with the majority of large patches occurring in the centre and northern parts of the subregion.

The TEC has been mapped as occurring in all nominated areas.

25.4.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.2 of the BAM.

10.2.2.1(A) THE ACTION AND MEASURES TAKEN TO AVOID THE DIRECT AND INDIRECT IMPACT ON THE POTENTIAL ENTITY FOR AN SAII

Avoidance and minimisation of impacts to biodiversity values, including CPW, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The baseline mapping for this assessment has mapped 1,488 ha of CPW within the nominated areas (not including excluded lands). Approximately 473 ha (32 per cent) of this was avoided within the nominated areas as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 393 ha was avoided for biodiversity purposes
- 80 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-9.

The table shows that of the 147 ha of intact condition CPW (without excluded lands), the majority (109 ha or 74 per cent) has been avoided.

It is important to note that the avoidance calculations in the table including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands. Table 25-9 shows the amounts of habitat within excluded lands for context only.

Table 25-9: Avoidance outcomes for Cumberland Plain Woodland (PCT 849 and 850)

Condition	Total area in nominated areas (ha)	Area in excluded lands (ha)	Area without excluded lands (ha)	Directly impacted (ha)	Avoided for biodiversity purposes (ha)	Avoided for other purposes (ha)	Total avoidance (ha)
Intact condition	646	499	147	38	92	17	109
Thinned condition	1,979	1,276	703	402	249	53	302
Scattered trees	356	192	164	148	12	4	17
DNG	592	117	474	428	41	6	47
Total	**3,573**	**2,084**	**1,488**	**1,015**	**394**	**80**	**474**

<u>Avoidance of indirect impacts</u>

Potential indirect impacts to CPW due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(B) THE AREA (HA) AND CONDITION OF THE TEC TO BE IMPACTED DIRECTLY AND INDIRECTLY BY THE DEVELOPMENT. THE CONDITION OF THE TEC IS TO BE REPRESENTED BY THE VEGETATION INTEGRITY SCORE FOR EACH VEGETATION ZONE

<u>Direct impacts</u>

A total of 1,015 ha of CPW will be directly impacted by the development. This is approximately 68 per cent of the TEC in the nominated areas (without excluded lands). The direct impacts of the development are mainly associated with urban development. The direct impacts mainly occur:

- Wilton: to most remaining patches of the TEC, including several large patches. These patches are mainly low condition (DNG or scattered trees) and occur primarily in the northern and central parts of the nominated area. Many of these patches are relatively isolated, although some occur adjacent to other native vegetation associated with the gorges and gullies along the edges of the nominated area
- GMAC: to many small to moderate scattered patches of mainly low to moderate condition (DNG, scattered trees or thinned) throughout the nominated area. Most of these patches are isolated, particularly in the northern section of the nominated area, although some occur adjacent to other native vegetation associated with the gorges and gullies along the edges of the southern part of the nominated area. Development will impact some intact patches in the southern part of the nominated area. These patches are generally small and narrow
- WSA: to several moderate to large patches of mainly low to moderate condition TEC (DNG, scattered trees or thinned) in two main areas – the southern arm of the nominated area, and the northern part of the nominated area near Luddenham Road, which will be impacted by the transport corridors (Outer Sydney Orbital (OSO)). Most patches are relatively isolated and surrounded by either farmland or existing urban development
- GPEC: to many scattered mostly small patches in moderate condition that are generally isolated from larger patches of native vegetation and surrounded by farmland or existing urban development. Two large areas of CPW occur in this nominated area around Jordan Springs west of Wianamatta Regional Park, and at Orchard Hills.

The direct impacts of the development on CPW are provided in Table 25-10.

Table 25-10: Direct impacts on Cumberland Plain Woodland (PCT 849 and 850)

PCT	Condition	Direct impacts (ha)						Vegetation integrity score
		Wilton*	GMAC*	WSA*	GPEC*	Transport#	Total	
849	Intact	1.6	13.5	5.6	0.1	9.0	29.7	53.9
849	Thinned	22.4	31.7	149.3	68.2	64.1	335.6	42.3
849	Scattered trees	24.1	31.4	56.3	3.6	9.8	125.3	18.3
849	DNG	139.5	32.3	33.0	8.8	25.6	239.2	24.1
850	Intact	0.0	8.1	0.0	0.0	0.0	8.1	58.1
850	Thinned	0.0	44.5	5.7	15.9	0.0	66.1	41.9
850	Scattered trees	0.9	17.2	2.1	2.1	0.0	22.2	38.1
850	DNG	151.1	14.2	0.2	23.0	0.0	188.5	25.7
Total		**339.6**	**192.8**	**252.1**	**121.5**	**108.6**	**1,014.5**	

* Impacts from urban development only within each nominated area
# Impacts from transport corridors across all nominated areas

Indirect impacts

Potential indirect impacts to CPW due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(C) A DESCRIPTION OF THE EXTENT TO WHICH THE IMPACT EXCEEDS THE THRESHOLD FOR THE POTENTIAL ENTITY

No threshold has been established for CPW.

10.2.2.1(D) THE EXTENT AND OVERALL CONDITION OF THE POTENTIAL TEC WITHIN AN AREA OF 1,000 HA, AND THEN 10,000 HA, SURROUNDING THE URBAN CAPABLE LANDS

The extent and condition of CPW surrounding the urban capable lands are provided in Table 25-11. Due to the scale of the development, calculations were also presented based on a 1 km buffer and a 10 km buffer from the outer edge of the urban capable lands, as well as buffers of 1,000 ha or 10,000 ha as per the BAM.

Table 25-11: Extent and condition of Cumberland Plain Woodland (PCT 849 and 850) surrounding the urban capable lands

PCT	Condition	Area in 1,000 ha buffer	Area in 10,000 ha buffer	Area in 1,000 m buffer	Area in 10,000 m buffer
849	Intact	37.3	203.1	656.8	3,039.6
849	Thinned	384.8	776.6	1,315.2	3,358.3
849	Scattered trees	137.1	237.2	671.2	4,196.0
849	DNG	251.0	329.9	344.8	380.7
850	Intact	13.6	98.1	277.5	1,883.2
850	Thinned	78.1	157.7	268.0	1,031.0
850	Scattered trees	25.2	100.9	410.8	4,067.8
850	DNG	198.5	210.1	210.8	211.4
Total		**1,125.5**	**2,113.7**	**4,155.1**	**18,168.0**

10.2.2.1(E) AN ESTIMATE OF THE EXTANT AREA AND OVERALL CONDITION OF THE POTENTIAL TEC REMAINING IN THE IBRA SUBREGION BEFORE AND AFTER THE IMPACT OF THE DEVELOPMENT HAS BEEN TAKEN INTO CONSIDERATION

The development will result in a loss of 4.4 per cent of the remaining area of CPW in the Cumberland subregion.

The extent and condition of CPW remaining in the subregion before and after the impact of the development is provided in Table 25-12. The largest percentage changes relate to the TEC in very low condition (DNG). Only very small changes occur to the TEC in intact condition (-0.7 per cent change for PCT 849, and -0.3 per cent change for PCT 850).

Table 25-12: Extent and condition of Cumberland Plain Woodland (PCT 849 and 850) before and after the development

PCT	Condition	Current area in Cumberland subregion (ha)	Area in Cumberland subregion after the direct impacts of the development (ha)	Per cent loss of current area in Cumberland subregion (%)
849	Intact	4,309.6	4,280.0	-0.7
849	Thinned	3,659.0	3,323.4	-9.2
849	Scattered trees	5,949.0	5,823.7	-2.1
849	DNG	380.7	141.5	-62.8
850	Intact	2,668.6	2,660.5	-0.3
850	Thinned	1,137.1	1,071.0	-5.8
850	Scattered trees	4,900.3	4,878.1	-0.5
850	DNG	211.4	23.0	-89.1
Total		**23,221.9**	**22,201.1**	**-4.4**

Trend analysis for PCT 849

As part of the EPBC Act strategic assessment process for the nominated areas and transport corridors, a trend analysis looking at the extent and condition of PCT 849 over the life of the Plan was undertaken by RMIT University (Gordon & Peterson, 2019) (see Supporting Document D). The project (while only looking at one of the two PCTs that make up CPW) has direct relevance to the assessment of CPW as an SAII entity.

The trend analysis examined the potential impacts of development and offsetting under various scenarios on PCT 849 in the Cumberland subregion. It considered a summed score across the landscape for the PCT of extent and ecological condition (the latter being based on an approximation of the BAM vegetation integrity score).

The project involved two major components:

- A formal expert elicitation to gather quantitative knowledge regarding how the condition of PCT 849 will change over time under:
  - High or low intensity management
  - The case where the PCT is exposed to typical ongoing private land activities
- Quantitative modelling to simulate the urban development within the designated nominated areas and compensation via managing areas as biodiversity offsets in a strategically defined offset region and the ecological response of the PCT. The modelling included eight scenarios exploring different options for implementing biodiversity offsets which varied:
  - The timing of when offsets are implemented
  - The total area of offsets implemented
  - The type of management implemented for the offsets (low or high intensity)

The analysis found that:

- Existing landscape scale threats (e.g. weed invasion, grazing, rubbish dumping, disturbance from recreational activities) across the Cumberland subregion are significant and will result in an approximate 5.8% decline in the extent and condition of the PCT over the life of the Plan unless additional areas are managed
- The proposed impacts of development under the Plan will lead to approximately the same magnitude of losses (~5.8%) to the PCT that will result due to existing landscape threats
- High intensity management and early offsetting will provide the greatest benefits to the outcomes of the PCT over the life of the Plan
- Securing approximately 1,600 ha of offsets for the PCT:
  - Will compensate for the impacts of development where earlier offsetting and higher intensity management is preferential by improving the extent and condition of the PCT over the life of the Plan
  - Has the potential to also contribute significantly to addressing the declines across the subregion due to existing landscape scale threats

Subsection (i) below sets out the actual offsets that are proposed under the Plan for CPW. These include a commitment to protect 2,803 ha of PCT 849 which is significantly greater than the modelled amount of 1,600 ha used in the trend analysis. The results of the trend analysis when considered in the context of the actual commitments of the Plan strongly indicate that PCT 849 will be substantially better off due to implementation of the Plan.

10.2.2.1(F) AN ESTIMATE OF THE AREA OF THE POTENTIAL TEC THAT IS IN THE RESERVE SYSTEM WITHIN THE IBRA REGION AND THE IBRA SUBREGION

The area of CPW occurring within protected lands (land reserved under NPW Act) within the Cumberland subregion is 1,289 ha. This represents 6 per cent of the total area of the remaining TEC in the subregion.

The extent and condition of CPW within protected lands is provided in Table 25-13.

Table 25-13: Extent and condition of Cumberland Plain Woodland (PCT 849 and 850) in protected lands

PCT	Condition	Area in protected lands within the Cumberland subregion (ha)
849	Intact	920.7
849	Thinned	71.9
849	Scattered trees	110.7
849	DNG*	N/A
850	Intact	152.1
850	Thinned	8.2
850	Scattered trees	25.3
850	DNG*	N/A
Total		**1,288.9**

* DNG mapping is not available outside of the nominated areas

10.2.2.1(G) THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION PROPOSAL'S IMPACT ON:

(I) ABIOTIC FACTORS CRITICAL TO THE LONG-TERM SURVIVAL OF THE POTENTIAL TEC

(II) CHARACTERISTIC AND FUNCTIONALLY IMPORTANT SPECIES THROUGH IMPACTS

(III) THE QUALITY AND INTEGRITY OF AN OCCURRENCE OF THE POTENTIAL TEC THROUGH THREATS AND INDIRECT IMPACTS

The Final Determination (NSW Scientific Committee, 2009) and BioNet profile (OEH, 2009) for CPW identifies a range of threats to the TEC. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15

(Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

The greatest risk areas within GPEC and WSA for these relevant threats are:

- Wilton: along the edges of the urban capable lands mainly around the outer edges of the nominated area, particularly in the northern part of the area
- GMAC: along the edges of the urban capable lands within the southern part of the nominated area
- WSA: along the edges of the urban capable lands
- GPEC: along the edges of the urban capable lands, in particular in the west and north of the nominated area

Impacts from inappropriate livestock grazing regimes were also identified in the Conservation Advice as a key threat. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate this risk across the nominated areas.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC (OEH, 2009). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Fire regimes influence the plant species composition and vegetation structure of the TEC and are also likely to influence other components of the community (NSW Scientific Committee, 2009). Fire intervals of 4 to 12 years are likely to maintain most understorey species within the TEC. Fire intervals which are too short are associated with reduced native plant diversity (NSW Scientific Committee, 2009). Disruption of ecological processes associated with altered fire regimes contributes to a very large reduction in the ecological function of the TEC (NSW Scientific Committee, 2009).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC, this includes areas in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton, where the TEC is much less extensive.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Plan Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are

permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

- o Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

WEED INVASION

Weed invasion also poses a major threat to the TEC ((NSW Scientific Committee, 2009). Weeds can displace native plants and reduce the diversity and regenerative capacity of the TEC. The Final Determination lists a wide range of weed species that threaten the TEC, including African Olive (O*lea europa* subsp. *cuspidata*), Bridal Creeper (*Asparagus asparagoides*) and a range of exotic grasses (NSW Scientific Committee, 2009).

These weeds are already present within the nominated areas and pose a threat to the TEC. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to the TEC and introduces edge effects. Key risk areas include in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - o Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - o Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - o Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - o Require proponents to undertake the following when applying for/undertaking development:
    - ▪ Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction

    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Importantly for the TEC, weeds will be actively managed within the 3,170 ha to be added to conservation as part of the conservation program.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified as a threat to the TEC (OEH, 2009). This relates to a wide range of different mechanisms for disturbance including:

- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as cause weed invasion
- Inappropriate recreational activities such as 4WD and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of woody debris and firewood collection which changes the structure and habitat features of the TEC

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the nominated areas may increase due to the urban development. Occurrences of the TEC considered most at risk are those in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 3,170 ha for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand

and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules (OEH, 2009). This can both encourage weed invasion and cause erosion and sedimentation.

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas include in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. CPW at a Commonwealth level is recognised as being susceptible to dieback caused by the root-rot fungus *Phytophthora cinnamomi* (DoEE, 2018b).

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
    - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
    - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora*

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. Predation of native fauna by cats and foxes is specifically identified as a threat to the TEC (OEH, 2009). Pest animals can lead to declines in biodiversity through:

- Predation on native fauna
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the nominated areas and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and foxes are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats in the local area, which, in turn, may lead to an increase in feral cat numbers.

The Plan incorporates a range of measures to manage these risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
    - Preparation of a Pest Animal Control Implementation Strategy
    - A process to enter into written agreements with delivery partners to implement the pest animal control program

    - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
    - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
    - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
    - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

10.2.2.1(H) DIRECT OR INDIRECT FRAGMENTATION AND ISOLATION OF AN IMPORTANT AREA OF THE POTENTIAL TEC

Direct loss of CPW may cause fragmentation and isolation of remaining patches of the TEC, which may increase the susceptibility of the TEC to weed invasion and other edge effects and reduce its long-term viability.

Fragmentation and isolation of patches of CPW will mainly occur in the following areas:

- Wilton: Development will remove most remaining patches of the TEC. Three larger patches of mostly moderate condition TEC will be reduced in size. These patches will not be isolated by the development and will remain contiguous with larger areas of native vegetation associated with the gorges and gullies on the edges of the nominated area, which will reduce the effects of fragmentation
- GMAC: Development will mostly remove scattered patches of mainly low to moderate condition TEC. Patches of the TEC that will remain are already generally isolated and surrounded by farm land or existing urban development, particularly in the southern part of the nominated area and the development will not generally result in further isolation of remaining patches. In some areas, remaining patches will remain contiguous with larger areas of native vegetation associated with the gorges and gullies on the edges and middle of the southern part of the nominated area, which will reduce the effects of fragmentation
- WSA: In the northern part of the nominated area near Luddenham Road, the OSO will fragment a large patch of mainly low to moderate condition TEC. In the southern part of the nominated area, an area of relatively well-connected patches of the TEC will be mostly removed and the TEC will only remain along a narrow riparian corridor. In both these cases, the development will reduce the size of the patch and increase the susceptibility of the TEC to weed invasion and other edge effects, which may reduce its long-term viability
- GPEC: In the northern part of the nominated area, a relatively narrow patch of the TEC that occurs within Wianamatta Regional Park will be fragmented by the OSO. This will reduce the size of the patch and increase the susceptibility of the TEC within the Regional Park to weed invasion and other edge effects. This is not expected to reduce the long-term viability of the TEC in this locality as the remaining patches will be managed for conservation in the Regional Park. In other parts of the nominated area, the development usually removes entire patches of the TEC and will not generally result in increased fragmentation or increased isolation of patches

10.2.2.1(I) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE POTENTIAL TEC IN THE IBRA SUBREGION

The Plan includes a range of commitments and actions that will contribute to the recovery of CPW in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments relevant to the TEC are:

- TEC-specific commitments to secure an offset target of 3,170 ha of CPW (Commitment 8.1) in conservation lands within SCAs. This includes a target of 2,325 ha of PCT 849 and a target of 845 ha of PCT 850. This would increase the area of TEC protected within the Cumberland subregion by approximately 245 per cent
- As part of securing a minimum of 5,475 ha of native vegetation in SCAs:
    - Undertake ecological restoration of priority areas secured for conservation within the Cumberland subregion (Commitment 13). This includes restoring up to 1,365 ha of native vegetation, including targeting CPW
    - Secure priority habitat corridors within the Cumberland subregion to support habitat connectivity (Commitment 12)

- Manage weeds (Commitment 16) and pest animals (Commitment 17) in strategic locations in the Cumberland subregion to reduce threats to conservation lands secured within SCAs. This includes preparing:
  - A Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program
  - A Pest Animal Control Implementation Strategy to guide and co-ordinate delivery of a pest control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
  - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
  - Preparing a Fire Management Strategy to guide and co-ordinate fire management

As outlined previously in subsection (e), the trend analysis (Gordon & Peterson, 2019) when considered in the context of the commitments of the Plan, strongly indicates that PCT 849 will be substantially better off due to implementation of the Plan under scenarios of high intensity management and early offsetting. While care needs to be taken in extrapolating the results of the analysis to PCT 850, it is considered highly likely that the commitments in the Plan will also provide substantial benefits to that PCT over the life of the Plan.

25.5 SHALE SANDSTONE TRANSITION FOREST

25.5.1 TEC BACKGROUND

Shale Sandstone Transition Forest in the Sydney Basin Bioregion (SSTF) is a forest or woodland with an overstorey that may include *Eucalyptus punctata*, *Eucalyptus resinifera*, one of the stringybarks (*Eucalyptus globoidea, Eucalyptus eugenioides, Eucalyptus sparsifolia, Eucalyptus agglomerata*). One or more ironbark species may be locally important. The understorey may be either grassy and herbaceous or shrubby with a notable amount of grass cover (although the presence of some shrubs, such as *Banksia* and *Persoonia* species, indicate the site may not be SSTF). In areas that have not been burnt for long periods the understorey may be dense. Species composition varies between sites depending on geographical location and local conditions (e.g. topography, relative influence of sandstone or shale) (NSW Scientific Committee, 1995).

The TEC is equivalent to the ecological community with the same name listed under the EPBC Act, although it is important to note that condition thresholds apply to the EPBC listed community (DoE, 2014b).

SSTF generally occurs on soils derived from a shallow shale or clay material overlying sandstone, or where shale-derived materials have washed down over sandstone-derived substrate. Such sites are generally close to the geological boundary between the Wianamatta Shale and the Hawkesbury Sandstone (NSW Scientific Committee, 1995). The contributing shale has to come from the Wianamatta group. Shale lenses that occur in the Hawkesbury Sandstone provide a different chemistry and may relate to a different TEC (O'Hares Creek Shale Forest).

The TEC is confined to the Sydney Basin Bioregion and mostly restricted to areas transitional between clay soils derived from Wianamatta Shale and sandy soils derived from Hawkesbury Sandstone on the margins of the Cumberland Plain (NSW Scientific Committee, 1995). The main occurrences of the TEC are in the Hawkesbury, The Hills, Liverpool, Parramatta, Penrith, Campbelltown and Wollondilly LGAs (OEH, 2019i) and it extends west into the lower Blue Mountains. Many occurrences are linear s, which may be as narrow as 20 m wide (NSW Scientific Committee, 1995).

25.5.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

SSTF has been identified as a potential SAII entity under the OEH guidelines because it is it subject to high levels of degradation or disruption of biotic processes (Principle 2 of the BC Regulation) and a very highly restricted geographic distribution (Principle 3 of the BC Regulation) (OEH, 2017f).

SSTF is associated with PCT 1395 – 'Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion'. The TEC has been mapped within the nominated areas and the Cumberland subregion on the basis of the extent and condition of this PCT (see Chapter 11)

25.5.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of SSTF in relation to the subject land is shown in Map 23.

The majority of SSTF within the Cumberland subregion occurs on the edges of the subregion outside the nominated areas north-west of Richmond, west of the Nepean River around Gulguer Nature Reserve, and in the southern part of the subregion around Tahmoor, Wilton and Appin.

The TEC has been mapped as occurring in the following nominated areas:

- Wilton
- GMAC, mainly in the southern part of the nominated area
- A small area in far western GPEC

25.5.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.2 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID THE DIRECT AND INDIRECT IMPACT ON THE POTENTIAL ENTITY FOR AN SAII

Avoidance and minimisation of impacts to biodiversity values, including SSTF, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The baseline mapping for this assessment has mapped 2,623 ha of SSTF within the nominated areas (not including excluded lands). Approximately 2,135 ha (82 per cent) of this was avoided within the nominated areas as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,865 ha was avoided for biodiversity purposes
- 270 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-14.

The table shows that the majority of the total avoidance that has occurred (69 per cent) has been of SSTF in intact condition, and that of the 1,511 ha of intact condition SSTF (without excluded lands), the vast majority (1,466 ha or 97 per cent) has been avoided.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-14 shows the amounts of habitat within excluded lands for context only.

Table 25-14: Avoidance outcomes for Shale Sandstone Transition Forest (PCT 1395)

Condition	Total area in nominated areas (ha)	Area in excluded lands (ha)	Area without excluded lands (ha)	Directly impacted (ha)	Avoided for biodiversity purposes (ha)	Avoided for other purposes (ha)	Total avoidance (ha)
Intact condition	1,836	325	1,511	45	1,231	235	1,466
Thinned condition	972	262	711	155	523	32	556
Scattered trees	140	52	88	51	36	2	38
DNG	377	64	314	237	75	2	76
Total	**3,326**	**703**	**2,623**	**488**	**1865**	**270**	**2,135**

Avoidance of indirect impacts

Potential indirect impacts to SSTF due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(B) THE AREA (HA) AND CONDITION OF THE TEC TO BE IMPACTED DIRECTLY AND INDIRECTLY BY THE DEVELOPMENT. THE CONDITION OF THE TEC IS TO BE REPRESENTED BY THE VEGETATION INTEGRITY SCORE FOR EACH VEGETATION ZONE

Direct impacts

A total of 488 ha of SSTF will be directly impacted by the development. This is approximately 19 per cent of the TEC in the nominated areas (without excluded lands). The direct impacts of the development are mainly associated with urban development. The direct impacts mainly occur:

- Wilton: along the edges of the urban capable lands mainly around the outer edges of the nominated area, particularly in the northern part of the area
- GMAC: along the edges of the urban capable lands within the southern part of the nominated area

The direct impacts of the development on SSTF are provided in Table 25-15.

Table 25-15: Direct impacts on Shale Sandstone Transition Forest (PCT 1395)

PCT	Condition	Direct impacts (ha)						Vegetation integrity score
		Wilton*	GMAC*	WSA*	GPEC*	Transport#	Total	
1395	Intact	13.3	31.6	0	0	0	44.9	72.9
1395	Thinned	84.7	70.3	0	0	0	155.1	64
1395	Scattered trees	20.2	30.4	0	0	0	50.5	30
1395	DNG	205.8	31.5	0	0	0	237.3	28.4
Total		**324.0**	**163.8**	**0**	**0**	**0**	**488**	

* Impacts from urban development only within each nominated area

\# Impacts from transport corridors across all nominated areas

Indirect impacts

Potential indirect impacts to SSTF due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (g).

10.2.2.1(C) A DESCRIPTION OF THE EXTENT TO WHICH THE IMPACT EXCEEDS THE THRESHOLD FOR THE POTENTIAL ENTITY THAT IS SPECIFIED IN THE GUIDANCE TO ASSIST A DECISION-MAKER TO DETERMINE A SERIOUS AND IRREVERSIBLE IMPACT

No threshold has been established for SSTF.

10.2.2.1(D) THE EXTENT AND OVERALL CONDITION OF THE POTENTIAL TEC WITHIN AN AREA OF 1000HA, AND THEN 10,000HA, SURROUNDING THE URBAN CAPABLE LANDS

The extent and condition of SSTF surrounding the urban capable lands are provided in Table 25-16. Due to the scale of the development, calculations were also presented based on a 1 km buffer and a 10 km buffer from the outer edge of the urban capable lands, as well as buffers of 1,000 ha or 10,000 ha as per the BAM.

Table 25-16: Extent and condition of Shale Sandstone Transition Forest (PCT 1395) surrounding the urban capable lands

PCT	Condition	Area in 1,000 ha buffer	Area in 10,000 ha buffer	Area in 1,000 m buffer	Area in 10,000 m buffer
1395	Intact	76.6	1,107.9	2,367.6	5,404.4
1395	Thinned	200.2	637.5	928.5	1,635.4
1395	Scattered trees	55.6	113.5	453.6	2,691.5
1395	DNG	255.9	346.2	358.1	377.4
Total		**588.3**	**2,205.1**	**4,086.9**	**6,005.3**

10.2.2.1(E) AN ESTIMATE OF THE EXTANT AREA AND OVERALL CONDITION OF THE POTENTIAL TEC REMAINING IN THE IBRA SUBREGION BEFORE AND AFTER THE IMPACT OF THE DEVELOPMENT HAS BEEN TAKEN INTO CONSIDERATION

The development will result in a loss of 3.9 per cent of the remaining area of SSTF in the Cumberland subregion.

The extent and condition of SSTF remaining in the subregion before and after the impact of the development is provided in Table 25-17. The largest percentage change relates to the TEC in very low condition (DNG). Only very small changes occur to the TEC in intact condition (-0.7 per cent change).

Table 25-17: Extent and condition of Shale Sandstone Transition Forest (PCT 1395) before and after the development

PCT	Condition	Current area in Cumberland subregion (ha)	Area in Cumberland subregion after the direct impacts of the development (ha)	Per cent loss of current area in Cumberland subregion (%)
1395	Intact	6,618.6	6,573.7	-0.7
1395	Thinned	1,759.7	1,604.7	-8.8
1395	Scattered trees	4,186.6	4,136.1	-1.2
1395	DNG	377.4	140.1	-62.9
Total		**12,501.9**	**12,014.1**	**-3.9**

10.2.2.1(F) AN ESTIMATE OF THE AREA OF THE POTENTIAL TEC THAT IS IN THE RESERVE SYSTEM WITHIN THE IBRA REGION AND THE IBRA SUBREGION

The area of SSTF occurring within protected lands (land reserved under NPW Act) within the Cumberland subregion is 509 ha. This represents 4 per cent of the total area of the remaining TEC in the subregion.

The extent and condition of SSTF within protected lands is provided in Table 25-18.

Table 25-18: Extent and condition of Shale Sandstone Transition Forest (PCT 1395) in protected lands

PCT	Condition	Area in protected lands within the Cumberland subregion (ha)
1395	Intact	422.6
1395	Thinned	27.6
1395	Scattered trees	58.8
1395	DNG*	N/A
Total		**509.1**

* DNG mapping is not available outside of the nominated areas

10.2.2.1(G) THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION PROPOSAL'S IMPACT ON:

(I) ABIOTIC FACTORS CRITICAL TO THE LONG-TERM SURVIVAL OF THE POTENTIAL TEC

(II) CHARACTERISTIC AND FUNCTIONALLY IMPORTANT SPECIES THROUGH IMPACTS

(III) THE QUALITY AND INTEGRITY OF AN OCCURRENCE OF THE POTENTIAL TEC THROUGH THREATS AND INDIRECT IMPACTS

The Final Determination (NSW Scientific Committee, 1995) and BioNet profile (OEH, 2019i) for SSTF identify a range of threats to the TEC. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology

The greatest risk areas within Wilton and GMAC for these relevant threats are:

- Wilton: along the edges of the urban capable land mainly around the outer edges of the nominated area, particularly in the northern part of the area
- GMAC: along the edges of the urban capable land within the southern part of the nominated area

Inappropriate fire regimes

Inappropriate fire regimes can affect the structure and species composition of the TEC (OEH, 2019i). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in and around Wilton and the southern part of GMAC where significant areas of the TEC are present.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Plan Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are

designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

Also relevant for the TEC is the fact that it largely overlaps with Koala habitat which is a key focus of the Plan in terms of protection and management. Significant areas of Koala habitat will be managed which will include the application of the fire management strategy and a set of measures to control access to bushland which will help minimise risks around arson and accidental fires.

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas
- The measures in the Plan for Koalas in terms of protecting and managing habitat, and constraining access to bushland will help protect the TEC

Weed invasion

The TEC is threatened with invasion of weeds. Weeds can displace native plants and reduce the diversity and regenerative capacity of the TEC. Weeds that are a particular threat are invasive exotic grasses like African love grass (*Eragrostis curvula*) and Chilean needle grass (*Nassella neesiana*), as well as Lantana (*Lantana camara*), Broad-leafed and Small-leaf Privet (*Ligustrum lucidum* and *L. Sinense*), African olive (*Olea europaea* subsp. *cuspidate*), and Bridal Creeper (*Myrsiphyllum asparagoides*), and environmental weeds such as Sweet Pittosporum (*Pittosporum undulatum*) (OEH, 2019i).

These weeds are already present within the nominated areas and pose a threat to the TEC. However, development within the nominated areas has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to the TEC and introduces edge effects. Key risk areas include:

- In north and north west of Wilton, where the urban capable land impacts the edges of patches of the TEC connected to gorges and gullies on the edge of the nominated area
- In the southern part of GMAC, where the urban capable land impacts the edges of patches of the TEC connected to gorges and gullies on the edge and middle of the nominated area

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to

provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16

- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Importantly for the TEC, weeds will be actively managed within the 1,540 ha to be added to conservation as part of the conservation program.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

Inappropriate habitat disturbance

Inappropriate habitat disturbance is identified in the Final Determination and BioNet profile as a threat to the TEC. Disturbance can relate to a wide range of different mechanisms for disturbance including:

- Inappropriate mowing, slashing or scrubbing of the understorey for reasons such as bushfire fuel reduction, grazing and perceived aesthetics
- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as mountain bike use and 4WDs which can directly impact areas of the TEC and facilitate processes such as erosion

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those that occur in close proximity to development within Wilton and GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values

- A commitment (Commitment 7) to mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on Koalas. This is relevant to the TEC because large areas of the TEC are identified as important Koala habitat. Of particular relevance to habitat disturbance are associated actions around the use of exclusion fencing which will assist in controlling access to Koala habitat. These measures will help minimise inappropriate habitat disturbance to the TEC within both Wilton and GMAC
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 1,540 ha for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas.

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- The measures in the Plan for Koalas in terms of protecting and managing habitat, and constraining access to bushland will help protect the TEC
- A program of education for the community will be run to help them understand the biodiversity values they live near

Changes to hydrology

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules (OEH, 2019i). This can both encourage weed invasion and cause erosion.

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are:

- In north and north west of Wilton
- In the southern part of GMAC

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets

    - Soil erosion and sedimentation. For example:
        - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
        - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

10.2.2.1(H) DIRECT OR INDIRECT FRAGMENTATION AND ISOLATION OF AN IMPORTANT AREA OF THE POTENTIAL TEC

Direct loss of SSTF may cause fragmentation and isolation of remaining patches of the TEC, which may increase the susceptibility of the TEC to weed invasion and other edge effects and reduce its long-term viability.

Fragmentation and isolation of patches of SSTF will mainly occur in the following areas:

- Wilton: along the edges of the urban capable lands mainly around the outer edges of the nominated area, particularly in the northern part of the area
- GMAC: along the edges of the urban capable lands within the southern part of the nominated area

Within both nominated areas, patches of the TEC are relatively well connected around the edges of the urban capable lands. In Wilton, this occurs mainly around the outer edges of the nominated area, particularly in the northern part. In GMAC, this occurs around the outer edges as well as through the middle of the southern part of the nominated area.

Urban development in these nominated areas mainly directly impacts the edges of the TEC and does not generally impact this connectivity. While direct impacts will reduce the size and width of some patches around the edges of the urban capable lands, it does not generally result in isolation of these patches.

Where direct impacts will impact connectivity between patches of the TEC, these areas are generally already only marginally connected as a result of existing urban development or farming, and as such, the development is not expected to increase the level of fragmentation to the TEC in the locality more broadly.

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE POTENTIAL TEC IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of SSTF in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments relevant to the TEC are:

- TEC-specific commitments to secure an offset target of 1,540 ha of SSTF (Commitment 8.1) in conservation lands within SCAs. This would increase the area of TEC protected within the Cumberland subregion by approximately 300 per cent
- As part of securing a minimum of 5,475 ha of native vegetation in SCAs:
    - Undertake ecological restoration of priority areas secured for conservation within the Cumberland subregion (Commitment 13). This includes restoring up to 1, 365 ha of native vegetation, including targeting SSTF
    - Secure priority habitat corridors within the Cumberland subregion to support habitat connectivity (Commitment 12)
- Manage weeds (Commitment 16) and pest animals (Commitment 17) in strategic locations in the Cumberland subregion to reduce threats to conservation lands secured within SCAs. This includes preparing:
    - A Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program

- A Pest Animal Control Implementation Strategy to guide and co-ordinate delivery of a pest control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
  - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
  - Preparing a Fire Management Strategy to guide and co-ordinate fire management

25.6 ALLOCASUARINA GLAREICOLA

25.6.1 SPECIES BACKGROUND

Allocasuarina glareicola is an erect, smooth-barked shrub with cones that grows to approximately 2 m tall (DoEE, 2018a; OEH, 2018a). The species is monoecious or dioecious and flowers around October each year. The time taken for the plants to flower and set seed is not known. Regeneration is commonly by suckers. Root suckers can appear up to 3 m from the parent plant, where clumps of hundreds of stems may be a single individual. Seedling recruitment has only been observed at one site. The species is wind pollinated which means the distance between individuals may be a critical factor in enabling pollination and seed set (DoEE, 2018a; OEH, 2018a).

A. glareicola inhabits Castlereagh woodland and open woodland (with *Eucalyptus parramattensis, Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla and Melaleuca decora*). It occurs on strongly acidic soils with low fertility (DoEE, 2018a; OEH, 2018a).

Records are primarily restricted to the Castlereagh and Londonderry areas of the Cumberland Plain where there are 36 known occurrences of the species, with an outlier population found in Liverpool (Holsworthy Military Area). The total range of the species is approximately 36 km^2.

25.6.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

A. glareicola is being assessed as a candidate species credit species for GPEC. The species has been also identified as a potential SAII entity under the EES guidelines (Principle 3 of the BC Regulation) (OEH, 2017f), as it has a very highly restricted geographic distribution.

25.6.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of *A. glareicola* in relation to the subject land is shown in Map 24.

GPEC occurs within the southern extent of *A. glareicola's* stronghold in the Castlereagh and Londonderry areas.

There is one known population of *A. glareicola* within the nominated areas. This occurs in GPEC, located within a rail corridor along Hobart St in St Marys. This population is disjunct from the majority of known records which occur approximately 8 km to the north and are generally associated with larger, more intact remnants of native vegetation. The population in St Marys is located approximately 1.2 km from the nearest urban capable land.

Approximately 186 ha of potential habitat for the species has been identified in the nominated areas. This occurs in GPEC. The majority of potential habitat occurs within the Wianamatta Regional Park in the northern part of GPEC. A smaller patch of potential habitat has been mapped in Orchard Hills towards the middle of GPEC. The remaining habitat areas exist as scattered and isolated remnants across the eastern half of GPEC.

25.6.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including *A. glareicola*, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The population of *A. glareicola* within GPEC occurs outside the urban capable land and has been avoided.

The baseline mapping for this assessment has mapped 22 ha of potential habitat for *A. glareicola* within GPEC (not including excluded lands). Approximately 10 ha (46 per cent) of this was avoided within GPEC as part of the design of the urban capable land and transport corridors (not including excluded lands). All of this was avoided for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 25-19.

Table 25-19: Avoidance outcomes for *A. glareicola*

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential habitat (ha)	186	164	22	11.9	10	0	10

Avoidance of indirect impacts

Potential indirect impacts to *A. glareicola* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Development within the nominated areas will not directly impact on any records or known populations of *A. glareicola.*

Potential indirect impacts to *A. glareicola* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

No threshold has been established for *A. glareicola.*

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

A total of 11.9 ha of potential habitat will be directly impacted by the development. This is 54.1 per cent of the potential habitat in the nominated areas (not including excluded lands). The direct impacts of the development are associated with urban development and a transport corridor (the M7/Ropes Crossing Link Road). The main direct impacts occur:

- Along the northern boundary of GPEC within the alignment of the M7/Ropes Crossing Link Road
- Two scattered patches of potential habitat at Orchard Hills, which will be impacted by urban development

Although survey confirmed the species is absent from the OSO, the OSO alignment does bisect two areas of mapped potential habitat to the east of west of the OSO alignment.

The direct impacts of the development on *A. glareicola* are provided in Table 25-20.

Table 25-20: Direct impacts on *A. glareicola*

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential habitat (ha)	0	0	0	7.4	4.5	11.9

Impacts to habitat within northern GPEC

The M7/Ropes Crossing Link Road impacts on 4.5 ha of potential habitat along the northern boundary of GPEC. The habitat impacted is contiguous with mapped habitat in Shanes Park.

Although not directly impacting on mapped habitat, the OSO corridor will lead to fragmentation of potential habitat within Wianamatta Regional Park, leading to a number of smaller, isolated patches of vegetation. This fragmentation may increase impacts associated with edge effects (primarily weeds) and this has the potential to compromise the suitability of remaining habitat areas directly adjacent to development.

The species was confirmed absent within the OSO corridor during project surveys, and the likelihood that the species actually occurs within lands adjacent to the corridor is considered low given:

- The area forms part of a Regional Park which is managed by the NSW NPWS and would be well traversed
- The species is a conspicuous shrub which can be surveyed for throughout the year

This low likelihood of occurrence considerably reduces the risk of impacts to *A. glareicola* on key life-cycle processes. Furthermore, the species primarily regenerates through suckers and occasionally via wind pollination and neither of these processes are likely to be affected by fragmentation of potential habitat in this location.

Impacts to habitat at Orchard Hills

The loss of potential habitat for *A. glareicola* at Orchard Hills is associated with small remnants of scattered vegetation surrounded by houses and farmland. The extent of cleared land in the area means that impacts are unlikely to increase edge effects to retained habitat areas or further reduce their viability.

A section of potential habitat within the urban capable land which could be accessed as part of this biodiversity certification process was surveyed and the species was not observed. It is generally considered unlikely that potential habitat in this area contributes to the ongoing survival or viability of the species more broadly.

Indirect impacts

Potential indirect impacts to *A. glareicola* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential habitat areas within GPEC is unlikely to affect the ecology of *A. glareicola* in the locality because:

- There is a low likelihood the species occurs within this habitat
- The loss and extent of fragmentation of potential habitat will not affect the key life-cycle processes of the species, which primarily regenerates through suckers and occasional seed production via wind pollination

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential habitat areas within GPEC is unlikely to fragment or isolate any local populations of *A. glareicola.* There will be fragmentation of potential habitat from impacts caused by the M7/Ropes Crossing Link Road. Further fragmentation may occur within Wianamatta Regional Park as a result of the OSO corridor bisecting two areas of potential habitat. However, this is considered to have limited implications for the species in the region given the low likelihood of occurrence within this habitat.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

Potential habitat within GPEC occurs within the southern extent of the *A. glareicola* stronghold in the Castlereagh and Londonderry areas, and is within the geographic extent of the species.

There is one known population within the nominated area in St Marys. This population is disjunct from the majority of known records which occur approximately 8 km to the north and are generally associated with larger, more intact remnants of native vegetation and will not be directly or indirectly impacted by development.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profile and additional available information for *A. glareicola* identifies a range of threats to the species (DoEE, 2018a; OEH, 2018a). Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Habitat degradation from rubbish dumping and unrestricted access
- Weed invasion
- Inappropriate fire regimes

The greatest risk areas within GPEC for these relevant threats are:

- The southern end of Shanes Park where M7/Ropes Crossing Link Road occurs adjacent to potential habitat areas
- The north-eastern section of Wianamatta Regional Park, where the OSO corridor bisects two areas of potential habitat

HABITAT DEGRADATION

Habitat degradation through unrestricted public access and rubbish dumping have been identified as a key threat to *A. glareicola* (OEH, 2018a). Development within GPEC may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

The Plan incorporates a range of broader measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

WEED INVASION

A. glareicola is threatened with invasion and competition by weeds, with African lovegrass *(Eragrostis curvula)*, Whisky grass (*Andropogon virginicus*), *Pennisetum clandestinum*, *Ricinus communis* and Asparagus fern considered to be the main competitors (OEH, 2018a). These weeds are already present within the Strategic Assessment Area. However, urban and transport development within GPEC has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area (SCA). This includes a number of actions, of which the following are the most relevant to the outcome the species:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program

  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

INAPPROPRIATE FIRE REGIMES

A. glareicola can regenerate following fire. However, plants may be damaged and fruit production and seed set prevented by too frequent fires (OEH, 2018a). Increased human activity within GPEC increases the risk of fire to habitat areas supporting the species.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

There is currently approximately 1,160 ha of potential habitat mapped within protected areas. This includes potential habitat within:

- Wianamatta Regional Park
- Wianamatta Nature Reserve
- Castlereagh Nature Reserve
- Agnes Banks Nature Reserve
- Windsor Downs Nature Reserve

Eleven records (likely to comprise a single biological population) occur within the Castlereagh Nature Reserve. No other occurrences of the species are currently protected.

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of *A. glareicola* in the Cumberland subregion. Several commitments are described in more detail the sections above.

Key commitments relevant to the species are:

- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential habitat for *A. glareicola* in the SCAs, as there is approximately 572 ha of mapped potential habitat in the SCAs for this species
- Manage weeds (Commitment 16) in strategic locations in the Cumberland subregion to reduce threats to conservation lands secured within SCAs. This includes preparing a Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
    - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
    - Preparing a Fire Management Strategy to guide and co-ordinate fire management

25.7 CHALINOLOBUS DWYERI

25.7.1 SPECIES BACKGROUND

Large-eared Pied Bat (*Chalinolobus Dwyeri*) is a small to medium insectivorous bat with shiny, black fur (DoEE, 2018).

The species appears to roost predominantly in caves and crevices in sandstone cliffs and forage in nearby high-fertility forest or woodland near watercourses and in gullies (DERM, 2011). Roosting areas can also include old mines and disused mud nests. The species is generally constrained to 'areas within two kilometres of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within two kilometres of old mines or tunnels' (OEH, 2019a).

Large-eared Pied Bat has specific requirements in relation to the structure of breeding roosts. Caves need to be high and deep enough to allow juvenile bats to learn to fly and have indentations in the roof to allow the capture of heat. These physical characteristics are very uncommon in the landscape (OEH, 2018). The species is not known to roost in tree hollows (DERM, 2011). The species breeds in early winter and young are born in early summer. The species uses the same maternity roosting sites over many years (OEH, 2018).

Almost all records of the Large-eared Pied Bat are within several kilometres of cliff lines or rocky terrain. Evidence suggests the species does not usually forage in sandstone habitat and prefers fertile valleys and plains, as well as areas with moderately-tall to taller trees along waterways (DERM, 2011).

Habitat critical to the survival of the species comprises:

- Breeding sites
- Sandstone cliffs and fertile wooded valley habitat within close proximity of each other (DERM, 2011)

Large-eared Pied Bat occurs from Shoalwater Bay in central Queensland to Ulladulla in south-eastern NSW. In NSW, the species is generally rare with a very patchy distribution. It is found in the north east at Coolah Tops, Mt Kaputar and Warrumbungle National Park and in sandstone areas of the Sydney Basin and the western slopes and plains including Pilliga Nature Reserve (DERM, 2011). The area of occupancy is estimated to be 9,120 km^2 (DoEE, 2018a).

The species is known to breed in very few locations across NSW and the distance bats move from the maternity roost to over-wintering roosts has not been established, but is likely to be less than 100 km (DoEE, 2018a). As such all records within the Cumberland subregion are considered likely to be from the same breeding population.

Records for the Large-eared Pied Bat are widespread surrounding the Cumberland subregion and some records occur within the subregion. Records occur within Wilton and GMAC and adjacent to GPEC.

25.7.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

The Large-eared Pied Bat is being assessed as a candidate Species Credit Species for all four nominated areas.

The species has been identified as a potential SAII entity under the TBDC because it has a very highly restricted geographic distribution (Principle 3 of the BC Regulation) (EES, 2019). The species is also likely to be a potential entity because of Principle 4 of the BC Regulation as breeding habitat is likely to be irreplaceable.

The species has been identified as a potential SAII entity in relation to potential breeding habitat and the presence of breeding individuals. Potential breeding habitat comprises:

> *PCTs associated with the species within 100 m of rocky areas containing caves, or overhangs or crevices, cliffs or escarpments, or old mines, tunnels, culverts, derelict concrete buildings*

For the purposes of this BCAR, potential breeding habitat was mapped on the basis of:

- Associated PCTs as defined in TBDC in 'intact', 'thinned' and 'scattered trees' condition, and that are:
  - Within areas of Hawkesbury Sandstone and Minchinbury Sandstone geology, and
  - Within 200 m of locations where caves, crevices and cliffs are more likely to occur

Locations where caves, crevices and cliffs are more likely to occur were mapped by:

- Manipulation of a bare earth Digital Elevation Model to produce a layer that showed the mean elevation within a 30 m x 30 m grid surrounding each 1 m elevation grid cell
- Creation of a Topographic Position Index to identify the height of each 1 m cell above/below local mean elevation
- Reclassification of the Topographic Position Index to identify only areas that were high enough above the local mean elevation to create a topographic brake that might support cliffs
- Overlay the cliffs layer with a sandstone geology layer to exclude areas outside sandstone geology

The cliffs layer was validated through inspection of aerial photos and knowledge of the topography and landscape of the nominated areas, as well as site observations during surveys.

The potential breeding habitat was not able to be confirmed as actual breeding habitat. While Anabat surveys were undertaken for the species within a part of the northern section of Wilton, the surveys did not confirm the presence of breeding habitat or breeding individuals. The species was not detected during surveys.

25.7.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of Large-eared Pied Bat in relation to the subject land is shown in Map 25.

Records for the Large-eared Pied Bat are widespread surrounding the Cumberland subregion and some records occur within the subregion. A population of Large-eared Pied Bat occurs within Wilton and the southern part of GMAC associated with several records. Within Wilton, a cluster of recent records (as recent as 2016) occur in the vicinity of existing development in the central-eastern section of the nominated area. Within GMAC, a few recent records (as recent as 2014) occur in the Gilead area around the centre of the southern section of the nominated area.

Interrogation of the observation codes of records for the species indicate there are no known roost or breeding sites for the species within the nominated areas (OEH, 2019a).

Approximately 1,105 ha of potential breeding habitat for the Large-eared Pied Bat has been identified in the nominated areas. This occurs within Wilton and the southern section of GMAC.

25.7.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including Large-eared Pied Bat, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

Records associated with a population of Large-eared Pied Bat have been avoided within the nominated areas, although one record in GMAC occurs on the very edge of the urban capable land.

The baseline mapping for this assessment has mapped 888 ha of potential breeding habitat for Large-eared Pied Bat within Wilton and GPEC (not including excluded lands). Approximately 882 ha (99 per cent) of this was avoided as part of the design of the urban capable land and transport corridors (not including excluded lands). Of this:

- 452 ha was avoided for biodiversity purposes
- 429 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-21.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-21 shows the amounts of habitat within excluded lands for context only.

Table 25-21: Avoidance outcomes for Large-eared Pied Bat

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential breeding habitat (ha)	1,105	216	889	7.5	452	429	882

Avoidance of indirect impacts

Potential indirect impacts to Large-eared Pied Bat due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Development in the nominated areas will not directly impact on records or known populations of Large-eared Pied Bat.

Potential indirect impacts to Large-eared Pied Bat potential breeding habitat due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

Breeding habitat has been identified as an impact threshold for Large-eared Pied Bat.

While Anabat surveys were undertaken for the species within a part of the northern section of Wilton, the surveys did not confirm the presence of breeding habitat or breeding individuals.

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

A total of 7.5 ha of potential breeding habitat will be directly impacted by the development. This is 0.8 per cent of the potential habitat in the nominated areas (without excluded lands). The direct impacts of the development are associated with urban development. The main direct impacts occur at the edges of Wilton and the southern part of GMAC.

The direct impacts of the development on Large-eared Pied Bat are provided in Table 25-22.

Table 25-22: Direct impacts on Large-eared Pied Bat

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential breeding habitat (ha)	4.6	2.9	0	0	0	7.5

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

The impacts to potential breeding habitat within Wilton and GMAC are unlikely to affect life cycle processes or impact the viability of any local population of Large-eared Pied Bat because:

- While roosting or breeding sites may occur, there are no known roosting or breeding sites for the species in the area
- Only a very small proportion of potential breeding habitat is directly impacted. The vast majority of potential breeding habitat has been avoided for biodiversity or other purposes
- The impacts are unlikely to cause fragmentation or isolation of potential breeding habitat because only the fringes of potential breeding habitat that occurs on the edges of gorges and gullies are impacted
- The corridors of potential breeding habitat that exist along the gorges and gullies are maintained
- Potential breeding habitat in the nominated areas forms a relatively small part of much broader and intact areas of habitat to the north and west of the Plan Area and to the south of Sydney

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential breeding habitat within the Wilton and GMAC is unlikely to affect the ecology of any local population of Large-eared Pied Bat in the area, including because:

- Only a very small proportion of potential breeding habitat is directly impacted
- The impacts are unlikely to cause fragmentation or isolation of potential breeding habitat and the corridors of potential breeding habitat that exist along the gorges and gullies are maintained

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential breeding habitat within Wilton and GMAC is unlikely to cause fragmentation or isolation of habitat because only the edges of potential breeding habitat are impacted and the corridors of habitat that exist along the gorges and gullies are maintained.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

All records within the Cumberland subregion are considered likely to be from the same breeding population.

While roosting or breeding sites may occur, development within Wilton and GMAC will not directly impact any known roosting or breeding sites for Large-eared Pied Bat, and will only impact a very small proportion of potential breeding habitat for the species in the nominated areas around the edges of this habitat.

The development is therefore not considered likely to affect the broader population in the Cumberland subregion.

Potential breeding habitat within Wilton and GMAC is not at the limit of the species range. Records for the species are widespread surrounding the Cumberland subregion.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profile (OEH, 2017g) and Recovery Plan (DERM, 2011) for the Large-eared Pied Bat identifies a range of threats to the species Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Use of pesticides
- Disturbance of roosts from human recreational activities
- Fire in the proximity of roosts

The greatest risk areas within Wilton and GMAC for these relevant threats are around the edges of the nominated areas along gorges and gullies associated with waterways, including the Nepean River.

USE OF PESTICIDES

Use of pesticides has been identified as a threat to the Large-eared Pied Bat. Poisoning of pest animals may occur during implementation of the Plan as part of the Pest Animal Control Implementation Strategy (Commitment 17, Action 1).

The Plan includes Action 4 under Commitment 17.1, as follows: "*Ensure that the Pest Animal Control Implementation Strategy specifies the use of pest control techniques that will reduce the risk of secondary poisoning from Pindone or second-generation rodenticides*"

This measure is considered to be sufficient to address the threat posed to the Large-eared Pied Bat.

DISTURBANCE OF ROOSTS FROM HUMAN RECREATIONAL ACTIVITIES

Disturbance of roosts from recreational activities such as bushwalking, caving and abseiling is identified as a threat to the Large-eared Pied Bat. Regular disturbance can lead to bats abandoning roosts or depleting essential fat reserves (DERM, 2011).

Areas considered most at risk from increased disturbance due to recreational activities are those that occur in close proximity to development within Wilton and GMAC. Roosting and maternity caves are most likely to be located within the sandstone areas adjacent to and surrounding the Strategic Assessment Area. Much of this land is protected for conservation or as part of Sydney's drinking water catchment and should have existing management frameworks to prevent inappropriate access and use.

The Plan incorporates a range of measures to mitigate the risks associated with recreational disturbance within the Strategic Assessment Area, including:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- A commitment (Commitment 7) to mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on Koalas. This is relevant to the species because a lot of the mapped habitat for the Large-eared Pied Bat is identified as important Koala habitat. Of particular relevance to habitat disturbance are associated actions around the use of exclusion fencing which will assist in controlling access to Koala habitat. These measures will help minimise inappropriate habitat disturbance to potential habitat within both Wilton and GMAC
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate access and use

- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor issues such as illegal access and use
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan, combined with existing management of protected areas adjacent to the Plan Area is expected to adequately manage the risk to the species from inappropriate recreational use.

FIRE IN THE PROXIMITY OF ROOSTS

Bushfires and prescribed burning are identified as a key threat to the Large-eared Pied Bat as they are potentially susceptible to direct mortality from heat and smoke if the fire is close to their relatively shallow cave roosts (DERM, 2011). Changes in foraging resources and prey species as a result of altered fire regimes may also impact the species (DERM, 2011).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

There is currently approximately 25 ha of potential breeding habitat for the Large-eared Pied Bat mapped within protected areas in the nominated areas. The number of known breeding sites in NSW is very limited. However, other protected areas in NSW where the species is known to occur include (DERM, 2011):

- Bouddi National Park
- Big Scrub Flora Reserve
- Blue Mountains National Park
- Bungonia Nature Reserve
- Coolah Tops National Park
- Goulburn River National Park
- Mt Kaputar National Park
- Morton National Park
- Munghorn Gap Nature Reserve
- Pilliga Scrub Nature Reserve
- Richmond Range National Park
- Royal National Park
- Warrumbungle National Park
- Wollemi National Park
- Yengo National Park

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of Large-eared Pied Bat in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments relevant to the species are:

- Manage pest animals in strategic locations in the Cumberland subregion (Commitment 17) to reduce threats to conservation lands secured within SCAs. This includes preparing a Pest Animal Control Implementation Strategy to guide and co-ordinate delivery of a pest control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
  - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
  - Preparing a Fire Management Strategy to guide and co-ordinate fire management

Due to the low risk of direct impacts on Large-eared Pied Bat potential breeding habitat, the Plan does not include any specific commitment to secure any known or potential breeding habitat in conservation lands.

However, the Plan includes a commitment to secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs. Given that several records of Large-eared Pied Bat occur within and immediately adjacent to SCAs, some of this land may contain potential breeding habitat for this species.

25.8 HIBBERTIA FUMANA

25.8.1 SPECIES BACKGROUND

Hibbertia fumana is a small low shrub or sub-shrub (OEH, 2020).

Little is known about the life history and ecology of the species. Regeneration can occur through suckers, suggesting it may be able to resprout from rootstock following fire (TSSC, 2016). Peak flowering times are spring to early summer, although the species appears to be capable of minor sporadic flowering at other times of the year as a response to suitable climatic conditions (Miller, 2018b).

H. fumana inhabits areas of woodland generally with an open understorey. Within the nominated areas, the species is associated with the following PCTs and transition zones between these (Miller, 2018a):

- PCT 724 - Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain
- PCT 725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain
- PCT 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain
- PCT 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain
- PCT 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain

The species has a highly restricted range and until very recently was only known from only two populations:

- Moorebank (population size of approximately 370 individuals)
- Bankstown Airport (population size unknown) (Miller, 2018b)

However, it appears that as a result of recent surveys "populations of this species have been detected over a wider range within greater Sydney stretching from Richmond to Mittagong" (OEH, 2020). These records are not available to inform the assessment at this stage. If available, they will be integrated into the assessment after public comment.

At Moorebank, the population mainly occurs within a transition zone between Castlereagh Scribbly Gum Woodland and Castlereagh Ironbark Forest, and in soils of fine sandy clay loam. It has the potential to occur in similar intergrade alluvial habitats rich in sands and laterite in other parts of Western Sydney (OEH, 2020).

The population at Moorebank is surrounded by existing development, including urban development, particularly to the north, east and west of the site. A rail line occurs along the boundary of southern end of the site. Habitat at the site is disturbed, and the population is traversed by a disused railway line. Proposed infrastructure in the area will result in further habitat loss and disturbance (TSSC, 2016). Habitat at the site at Bankstown Airport is heavily disturbed – the site is managed and is routinely slashed to a height of about 10 cm (Miller, 2018b).

It should be noted that *H. fumana* is difficult to survey and may have been overlooked in past surveys as it:

- Has only recently been described
- Is extremely cryptic
- Is easily misidentified and/or overlooked as a depauperate version of other species

25.8.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

Hibbertia fumana is being assessed as a candidate species credit species in all four nominated areas.

The species has been identified as a potential SAII entity under the EES guidelines because it has a very highly restricted geographic distribution (Principle 3 of the BC Regulation) (OEH, 2017f).

Two expert reports have been prepared for *H. fumana* by Cumberland Flora & Fauna Interpretive Services. One for GPEC and WSA (Miller, 2018a) and one for Wilton and GMAC (Miller, 2018b).

25.8.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of *H. fumana* in relation to the subject land is shown in Map 26.

There are no records of *H. fumana* in the nominated areas.

Targeted surveys for the species were undertaken as part of the expert report for *H. fumana* within some areas of habitat similar to the sites that support the populations of the species. Areas targeted for survey are shown in the expert report (see Supporting Document C). Targeted surveys were also undertaken in small areas of the nominated areas by ecological consultants as part of the biodiversity certification process. The species was not recorded during any of these surveys.

The two known populations of *H. fumana* occur outside the nominated areas. The population at Moorebank occurs 1.2 km to the north-east of GMAC, and the population at Bankstown Airport occurs about 9 km from GMAC.

Approximately 1,650 ha of potential habitat for *H. fumana* has been identified within the nominated areas.

25.8.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including *H. fumana*, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The only known populations of *H. fumana* occur outside the nominated areas. Avoidance of impacts to these populations were therefore not a relevant consideration.

The baseline mapping for this assessment has mapped 1,245 ha of potential habitat for *H. fumana* within the nominated areas (not including excluded lands). Approximately 1,207 ha (97 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,064 ha was avoided for biodiversity purposes
- 143 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-23.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-23 shows the amounts of habitat within excluded lands for context only.

Table 25-23: Avoidance outcomes for *H. fumana*

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential habitat (ha)	1,650	405	1,245	37.5	1,064	143	1,207

Avoidance of indirect impacts

Potential indirect impacts to *H. fumana* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Development within the nominated areas will not directly impact on any records or known populations of *H. fumana*.

Potential indirect impacts to *H. fumana* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

There are currently no impact thresholds for *H. fumana*.

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

A total of 37.5 ha of potential habitat will be directly impacted by the development. This is 3.0 per cent of the potential habitat in the nominated areas (without excluded lands). The direct impacts of the development are associated with urban development. The direct impacts mainly occur:

- WSA: habitat mapped in the south-east corner of WSA
- GMAC: within the areas mapped as 'likely habitat' by the expert in the south west corner of GMAC (see Supporting Document C)
- Wilton: along the edges of the urban capable land in the northern part of the nominated area

Surveys confirmed *H. fumana* as absent within the OSO corridor, however mapped potential habitat remains present within the Wianamatta Regional Park in the northern part of GPEC. The OSO alignment bisects two areas of 'low probability' habitat for the species.

The direct impacts of the development on *H. fumana* are provided in Table 25-24.

Table 25-24: Direct impacts on *H. fumana*

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential habitat (ha)	25.9	8.4	3.1	0	0	37.5

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

Impacts to potential habitat within GPEC

Surveys for the species confirmed that the species was not present within the OSO alignment, however the OSO does bisect potential habitat for *H. fumana* within the north-eastern part of Wianamatta Regional Park. This will lead to loss and fragmentation of potential habitat at this location, leading to a number of smaller, isolated patches of habitat. This fragmentation may increase impacts associated with edge effects and weed invasion and this has the potential to compromise the suitability of remaining habitat areas directly adjacent to the development.

Surveys for *H. fumana* were undertaken within Wianamatta Regional Park (see Supporting Document C). The species was not recorded during surveys and the expert report concluded that the potential for the species to occur was low. This reduces the risk of impacts to life-cycle processes and viability of any local population.

Impacts to potential habitat within WSA

Urban capable land impacts on potential habitat for *H. fumana* in the south-east corner of WSA. The impacts are generally around the edges of larger potential habitat polygons, with a total impact of 3.1 ha recorded across WSA. The likelihood that the species occurs within the urban capable footprint is low as:

- The likelihood the species occurred within the potential habitat mapped in the Kemps Creek area was assessed as moderate to low potential
- The species was not recorded during surveys of the area undertaken as part of the strategic biodiversity certification by either the expert (see Supporting Document C) or the ecological consultants

Impacts to potential habitat within GMAC

The urban capable land directly impacts potential habitat for *H. fumana* along the edges of a corridor of habitat that occurs along the outer perimeter of the southern part of GMAC.

This potential habitat currently occurs adjacent to farmland, which means that the impacts of urban development are unlikely to greatly increase edge effects to retained habitat areas or further reduce their viability. Furthermore, the likelihood that the species occurs within the urban capable land is considered low for the following reasons:

- The expert report for *H. fumana* concluded that the species has low potential to occur in GMAC because areas of potential habitat with similar attributes to known sites are highly modified and of limited extent (Miller, 2018b)
- The species was not recorded during surveys of the area undertaken as part of the strategic biodiversity certification by either the expert (see Supporting Document C) or the ecological consultants

The expert identified mostly small areas of 'likely habitat' for the species in the centre and north of GMAC, including at Menangle Park, Milton Part, Kayess Park and Bunbury Curran Creek. These areas are not directly impacted by the urban capable lands. The indirect impacts of the development are considered unlikely to further reduce the viability these areas because these areas are distant from the urban capable lands.

Impacts to potential habitat within Wilton

The urban capable land directly impacts potential habitat for *H. fumana* along the edges of a corridor of habitat that occurs along the outer edge of the northern section of Wilton.

This potential habitat currently occurs adjacent to farmland, which means that the impacts of urban development are unlikely to greatly increase edge effects to retained habitat areas or further reduce their viability. Furthermore, the likelihood that the species occurs within the urban capable land is considered low for the following reasons:

- The expert report concluded that while the species could possibly occur within Wilton, the species is unlikely to occur within the urban capable land because the majority of this area is confined to the Wianamatta Shale-derived soils which, based on current knowledge, is not potential habitat for the species
- The species was not recorded during surveys of the area undertaken as part of the strategic biodiversity certification by either the expert (see Supporting Document C) or the ecological consultants

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential habitat within the nominated areas is unlikely to affect the ecology of any local population of *H. fumana* because the potential for the species to occur is low.

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential habitat within the nominated areas is unlikely to fragment or isolate any local population of *H. fumana* because the potential for the species to occur is low.

Two areas of potential habitat will be fragmented within Wianamatta Regional Park as a result of the OSO corridor. The low likelihood of occurrence of *H. fumana* in the area considerably reduces the risk of these impacts.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

H. fumana is currently only known from two populations at Moorebank and Bankstown outside the nominated areas. The distance between the populations suggest they are unlikely to interact.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The Final Determination and BioNet profile for *H. fumana* identify a range of threats to the species. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Habitat disturbance

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are recognised as a threat to the species (OEH, 2020). This can relate to fire that is either:

- Too frequent which has the potential to limit recruitment, or
- Too rare which may allow the midstorey to thicken

Inappropriate fire regimes can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

WEED INVASION

Weeds are recognised as a threat to the species. In particular low shrubs, dense shrubs and smothering grasses (OEH, 2020). Weeds are present in the Strategic Assessment Area and are unlikely to pose a novel threat to *H. fumana*. However, development within the nominated has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area (SCA). This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program

  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

HABITAT DISTURBANCE

Habitat disturbance is a recognised as a threat to the species (OEH, 2020). This relates to mechanisms such as land management practices (e.g. mowing) and uncontrolled vehicle movements.

The Plan incorporates a range of measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

The two known populations of *H. fumana* are not within reserves, but are managed for conservation – the site at Moorebank is a BioBank/stewardship site, and the site at Bankstown is managed within the airport complex.

There is currently approximately 92 ha of potential habitat for the species mapped within protected areas in the Plan Area. This comprises potential habitat within Wianamatta Regional Park.

Potential habitat also occurs within several Council reserves.

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments and actions that will contribute to the recovery of *H. fumana* in the Cumberland subregion. The key commitments and actions relevant to the species are:

- A species-specific commitment to secure 1 offset location of *H. fumana* in conservation lands within the SCAs (Commitment 9.1)
- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential habitat for *H. fumana* in the SCAs, as there is approximately 1,779 ha of mapped potential habitat in the SCAs for this species
- Manage weeds in strategic locations in the Cumberland subregion (Commitment 16) to reduce threats to conservation lands secured within SCAs. This includes preparing a Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
    - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
    - Preparing a Fire Management Strategy to guide and co-ordinate fire management

25.9 LITORIA AUREA

25.9.1 SPECIES BACKGROUND

Green and Golden Bell Frog (*Litoria aurea*) is a relatively large, dull, olive to bright emerald-green frog.

The species requires different habitats for foraging, breeding, over-wintering and dispersal. The species also uses certain habitats on a periodic or seasonal basis (DEWHA, 2009b). Habitat comprises one or more water bodies, and associated terrestrial habitats with grassy areas and low vegetation, although the species tends not to disperse far from waterbodies into more terrestrial non-breeding habitats (DEWHA, 2009; Lemckert, 2019). The species has been found in a wide range of water bodies except those that are fast flowing and the species can occur in disturbed habitats (DEWHA, 2009b).

Breeding habitat includes water bodies that are still, shallow, temporary, unshaded, with aquatic plants and free of mosquito fish. Ephemeral water bodies are important habitat for the species as they can provide habitat stepping stones between otherwise disconnected areas and they are less likely to contain mosquito fish (DEWHA, 2009b).

Records suggest that Green and Golden Bell Frog is highly mobile and moves between breeding sites. Movements of up to 5 km may be common and the frog may disperse up to 10 km (DoEE, 2018c). Connectivity between habitat sites is vital as the species exhibits a 'metapopulation structure', which relies on dispersal between 'local' populations within a larger 'metapopulation'. The species is more likely to be present, and habitat more likely to be important, where:

- Multiple suitable breeding sites are within a close enough proximity for individuals to migrate between them
- Multiple non-breeding water bodies are present in an area and within close enough proximity to allow migration between them (and breeding sites) with relative ease
- The connectivity of breeding and non- breeding habitat contains vegetation and shelter that facilitates migration
- There are other individuals occupying waterbodies in close proximity (Lemckert, 2019)

Breeding of the Green and Golden Bell Frog occurs generally between September and February after heavy rains or storms, and spawn is laid among aquatic vegetation (DEWHA, 2009a). The species has high fecundity and clutch sizes have been known to contain between over 2000 to 11,000 eggs (DEWHA, 2009a).

Records of the species in NSW are widely separated and isolated (OEH, 2019e). Approximately 30 populations are known. The largest populations of the species are located in Sydney and the Shoalhaven and mid north coast areas (OEH, 2019e). Most populations have fewer than 20 adults. Over 1,000 individuals have been recorded at Homebush, Kooragang Island and Broughton Island (DoEE, 2018c).

Nearly all known populations of Green and Golden Bell Frog are located with 10 km of the coast or saline waterways. This is likely due to the species being susceptible to the amphibian chytrid fungus, as the fungus is intolerant of salt. These locations therefore provide some refuge from the impacts of chytrid (Lemckert, 2019).

25.9.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

Green and Golden Bell Frog is being assessed as a candidate species credit species for all four nominated areas.

The species has been identified as a potential SAII entity in accordance with the requirement of section 10.2.1.4 of the BAM because of its very high susceptibility to the disease Chytrid fungus (Principle 4 of the BC Regulation).

An expert report has been prepared for the Green and Golden Bell Frog (Lemckert, 2019).

The expert report involved:

- Targeted surveys within the most likely areas of potential habitat for this species
- Identification of potential habitat within the nominated areas

25.9.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of Green and Golden Bell Frog in relation to the subject land is shown in Map 27.

A total of 13,146 records for the Green and Golden Bell Frog occur within the Cumberland subregion. The majority (greater than 95 per cent) occur in the eastern third of the subregion outside the nominated areas (Lemckert, 2019).

In relation to the records in the subregion, the expert report concluded that:

- Few records occur in the Cumberland subregion and it appears the species has never been common in this area, reflecting the fact that the region is over 10 km from the coast where chytrid fungus is more likely to be present
- The majority of records are from prior to 1990, indicating that most populations are likely to now be extinct. This is consistent with the pattern of declines noted for the species by Mahony et al (2013), who noted that populations rarely persist more than 10 kilometres from the coast (i.e. east of the nominated areas)

Records of the species within the nominated areas are limited. There are 12 records within GPEC and two records within GMAC. The records primarily occur around St Marys and Ropes Creek in GPEC and Blair Athol in GMAC. There are no records in Wilton and WSA and the expert report concluded that the species is unlikely to be present in those nominated areas (Lemckert, 2019). The expert report concluded that the population around St Marys and Ropes Creek is likely to be present. However, the records at Blair Athol are likely to be from individuals that escaped a captive colony and the population is no longer likely to persist in that location (Lemckert, 2019).

As part of the EPBC assessment for the development, two important populations of Green and Golden Bell Frog were identified in proximity to the nominated areas:

- A population at Gow Park in Mulgoa, approximately 2.4 km south of the nearest urban capable land within GPEC. This population was recorded in 1999 in a non-permanent creek
- A population along the eastern boundary of the Strategic Assessment Area, approximately 17 km east of WSA

The population around St Marys and Ropes Creek occurs within the urban capable land.

Approximately 1,655 ha of potential habitat for Green and Golden Bell Frog has been identified within the nominated areas. This occurs GPEC and GMAC. The majority of potential habitat occurs around St Marys between Ropes Crossing in the north and Minchinbury in the south. A smaller area occurs around Blair Athol.

25.9.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM:

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including Green and Golden Bell Frog, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

A likely population of Green and Golden Bell Frog occurs within the urban capable land in GPEC around St. Marys. No other known populations of the species occur within urban capable lands.

The baseline mapping for this assessment has mapped 25 ha of potential habitat for Green and Golden Bell Frog within GPEC and GMAC (not including excluded lands). Approximately 11 ha (46 per cent) of this was avoided as part of the design of the urban capable land and transport corridors (not including excluded lands). All of this was avoided for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 25-25.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-25 shows the amounts of habitat within excluded lands for context only.

Table 25-25: Avoidance outcomes for Green and Golden Bell Frog

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential habitat (ha)	1,655	1,630	25	13.3	11	0	11

Avoidance of indirect impacts

Potential indirect impacts to Green and Golden Bell Frog due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Direct impacts

Development within GPEC will directly impact a likely population of the Green and Golden Bell Frog associated with Ropes Creek. This population comprises 6 BioNet records made between 1998 and 2012. The development will impact an area associated with one of these records made in 1998. The impact is associated with urban development.

It has not been confirmed whether the population at Ropes Creek still exists. However, there are a series of other records for this population from nearby habitat associated with Ropes Creek and areas of potential habitat remain along the corridor in the form of a high density of water bodies within undeveloped lands (Lemckert, 2019). In the absence of targeted surveys, it is considered likely that the population persists in the area.

If the population at Ropes Creek is confirmed present, the population would be important. Nearly all populations in Australia occur within 10 km of the coast or saline waterways. This population is located almost 60 km from the coast, placing it on the edge of the western range for the species and outside of the area of refuge potentially provided by elevated salinity levels (Lemckert, 2019).

A smaller area of potential habitat occurs around Blair Athol between the Hume Motorway and Campbelltown in GMAC. The species is unlikely to occur in GMAC and the records at Blair Athol are likely to be from individuals that escaped a captive colony and the population no longer appears to persist in that location (Lemckert, 2019)

Indirect impacts

Potential indirect impacts to Green and Golden Bell Frog due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

There are currently no impact thresholds for Green and Golden Bell Frog.

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

The area of potential habitat within and around the Ropes Creek corridor at St Marys in GPEC covers:

- The locations of known records
- The riparian corridor joining those records
- A buffer of 1,000 m around the riparian corridor and records that could be used by the species for foraging, shelter, breeding and as migratory habitat as individuals move between water bodies and riparian corridors (Lemckert, 2019)

Approximately 13.4 ha of potential habitat will be directly impacted by the development within GPEC along Ropes Creek. This is about half of the potential habitat in the nominated areas (without excluded lands). This includes:

- 1.9 ha of aquatic/riparian habitat
- 7.1 ha of terrestrial habitat less than 200 m from aquatic habitat
- 4.4 ha of terrestrial habitat greater than 200 m from aquatic habitat

The direct impacts of the development on Green and Golden Bell Frog are provided in Table 25-26.

Table 25-26: Direct impacts on Green and Golden Bell Frog^

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential habitat (ha)	0	0	0	11	2.3	13.3

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

^ Note that this total impact of 13.3 ha is comprised of:

- 7.58 ha of impact on native vegetation
- 0.06 ha of impact on non-native vegetation (see Chapter 24)
- 0.6 ha of impact on a non-vegetated waterbodies (see Chapter 24)
- Approximately 5 ha of impact on within an existing urban area comprising buildings and roads (see Chapter 24)

The majority of habitat loss within GPEC is associated with the site of the current St Marys Rugby League Club adjacent to the Ropes Creek corridor and includes at least two mapped water bodies. A smaller impact occurs to the north-west of St Marys Rugby League Club associated with the OSO.

If the population at Ropes Creek is confirmed present, impacts to these areas may be notable as the aquatic/riparian habitat in that location has the potential to support breeding habitat for the species.

The development is unlikely to cause fragmentation or isolation of potential habitat at Ropes Creek because the area impacted occurs at the edge of the area of potential habitat (excluding areas that are already developed) and distant from the riparian corridor of Ropes Creek, as well as being adjacent to existing urban development, including two major roads. The corridor of habitat along the riparian corridor at Ropes Creek will therefore be maintained.

Indirect impacts

Potential indirect impacts to Green and Golden Bell Frog due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, if the population at Ropes Creek is confirmed present, the aquatic/riparian habitat in that location may support breeding habitat and impacts to these areas may be notable.

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the development is unlikely to cause fragmentation or isolation of any local population because impacts occur at the edge of the area of potential habitat and distant from the riparian corridor of Ropes Creek. The corridor of habitat along the riparian corridor at Ropes Creek will be maintained.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

Potential habitat for the Green and Golden Bell Frog within GPEC and GMAC occurs towards the western edge of the distribution of the species in the Cumberland subregion. The potential population at Ropes Creek is disjunct from the majority of known records which generally occur over 20 km to the east.

If the population at Ropes Creek is confirmed present, the population would be important. Despite nearly all populations occurring within 10 km of the coast, this population is located almost 60 km from the coast, placing it on the edge of the western range for the species and outside of the area of refuge potentially provided by elevated salinity levels.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profile and Conservation Advice for the Green and Golden Bell Frog identifies a range of threats to the species. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Changes to the structure and diversity of aquatic vegetation
- Changes to hydrology and water quality
- Intensification of public access to habitat
- Predation by foxes, cats, dogs and rats
- Inappropriate fire regimes
- Infection with amphibian chytrid fungus
- Road mortality

Predation of eggs and tadpoles, predation by exotic fish, interaction with cane toads and grazing are also identified as potential threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

The greatest risk areas for these relevant threats are at Ropes Creek near St Marys, in GPEC.

CHANGES TO THE STRUCTURE AND DIVERSITY OF AQUATIC VEGETATION

Changes to the structure and diversity of aquatic vegetation from weed invasion is a key threat to the Green and Golden Bell Frog. Weeds are already present within the Strategic Assessment Area. However, urban and transport development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occurs adjacent to known populations or habitat, in particular adjacent to the OSO and close to North St Marys along Ropes Creek in GPEC.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of key actions:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk posed to the Green and Golden Bell Frog from invasive weeds. This is because:

- Avoided lands will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

CHANGES TO HYDROLOGY AND WATER QUALITY

A reduction in water quality and changes to hydrology are recognised as a principal threat to the species (DEWHA, 2009c). Key issues relate to changes to drainage patterns and stormwater runoff, soil erosion and sedimentation and increased pollutants.

Development under the Plan has the potential to alter water quality and hydrology in areas of known and potential habitat for the Green and Golden Bell Frog. The areas at risk include the population associated with Ropes Creek where development of the Western Sydney Freight Line (transport corridor to the east of WSA) intersects an upstream section of the creek.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:

        - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
        - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
    - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
    - Soil erosion and sedimentation. For example:
        - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
        - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to habitat for the species
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

INTENSIFICATION OF PUBLIC ACCESS TO HABITAT

Intensification of public access to habitat is identified as a threat to the species. However, populations of the Green and Golden Bell Frog adjacent to or within proximity of proposed development are already subject to this threat as they are located within highly urbanised areas. Implementation of the Plan is unlikely to change the current level of disturbance.

The Plan also incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the species. In summary, these include:

- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate access and use by the public
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal activities
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas.
- A specific measure in relation to Commitment 5 to ensure key habitat features are protected and enhanced if the Green and Golden Bell Frog is confirmed present along Ropes Creek following targeted surveys

The package of measures in the Plan is expected to adequately manage the risk to the species from increased public access to habitat areas as a result of development. This is because:

- The Ropes Creek corridor will be protected and managed if the species is confirmed to occur there
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

PREDATION BY CATS AND OTHER PEST ANIMALS

Predation by cats and other pest animals is recognised as a threat to the Green and Golden Bell Frog. New urban development under the Plan is likely to increase the number of domestic cats in the local area. However, areas of habitat within proximity of proposed development already occur within highly urbanised areas. Any increase in the risk of predation from cats on populations of the Green and Golden Bell Frog as a result of the Plan is expected to be minimal.

The Plan also incorporates a range of measures to manage this issue across throughout the nominated areas. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the strategic conservation areas. This includes a number of actions with the most relevant to the outcome for the species being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are identified as a potential threat to the Green and Golden Bell Frog (DoE, 2014a).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity across the Strategic Assessment Area. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are

permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

- Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

INFECTION WITH AMPHIBIAN CHYTRID FUNGUS

Amphibian chytrid fungus, which causes the infection known as chytridiomycosis, is likely to impact on populations of the Green and Golden Bell Frog. The threat to the species from chytrid fungus is not well understood, with the risk of extinction from the disease categorised as low to moderate (DEWHA, 2009b; DoEE, 2016). However, the suitability of habitat is influenced by the presence of chytrid fungus.

Chytrid fungus is already present in the Cumberland subregion, although there may be pockets of disease free areas that are inhospitable to the growth of the disease (for example, due to salinity levels or elevated concentrations of trace metals). The potential for dispersing chytridiomycosis in wild frog populations increases with urbanisation around streams. This comes from growing potential for human interaction, more water flow (urban run-off) and reduced optimal habitat. Increased risks associated with development under the Plan are minimal, however, as habitat areas are already highly urbanised.

The Plan also incorporates a range of measures to manage the risks associated with this issue. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion (this measure specifically relates to chytrid fungus)
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures to protect the environment during construction, including best practice site hygiene protocols to minimise the spread of disease
- A specific measure in relation to Commitments 5 and 6 to incorporate best practice site hygiene protocols to manage the potential spread of chytrid fungus within construction environmental management plans, if the Green and Golden Bell Frog is confirmed present along Ropes Creek. This measure is consistent with the following priority action in the Conservation Advice (DoE, 2014a): “develop and implement suitable hygiene protocols to protect known sites from further outbreaks of chytrid fungus”

The package of measures in the Plan is expected to adequately manage the risk associated with chytrid fungus because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction, including a species specific measure for the Ropes Creek corridor

ROAD MORTALITY

Road mortality is identified as a potential threat to the Green and Golden Bell Frog (DoE, 2014d). This is not a novel threat to the species within the Strategic Assessment Area as roads have already been developed in proximity to habitat areas. However, implementation of the Plan will lead to new roads and an increase in the volume of cars on existing roads within nominated areas. The main area of concern is the development of the Outer Sydney Orbital downstream of habitat associated with the Ropes Creek corridor

The Plan incorporates a range of measures to manage the increased threat from road mortality. In summary, these include:

- Development controls that will require fauna-friendly road design structures to be installed and maintained in appropriate areas adjacent to fauna habitat, such as underpasses, fauna bridges and overpasses
- A commitment (Commitment 6) to mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat. This includes an action to identify potential design options for major watercourse crossings to reduce disruption to connectivity and the risk of vehicle strikes, with specific reference to the Green and Golden Bell Frog

These measures are considered to adequately address any potential increased threat from road mortality due to implementation of the Plan.

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

There is currently approximately 340 ha of potential habitat mapped within protected areas within the area covered by the Plan. This includes potential habitat within:

- Wianamatta Regional Park
- Agnes Banks Nature Reserve

Populations are known to occur in several conservation reserves outside the Cumberland subregion.

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of Green and Golden Bell Frog in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments and actions relevant to the species are:

- A species-specific commitment (under Commitment 5) to:
  - Undertake targeted surveys along the Ropes Creek corridor to determine the presence of the species
  - If confirmed present:
    - Consult with land managers of the riparian corridor to ensure key habitat features are protected from development impacts and enhanced
    - Incorporate site hygiene protocols to manage the potential spread of chytrid fungus
- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential habitat for Green and Golden Bell Frog in the SCAs, as there is approximately 660 ha of mapped potential habitat in the SCAs for this species
- Manage pest animals in strategic locations in the Cumberland subregion (Commitment 17) to reduce threats to conservation lands secured within SCAs. This includes preparing a Pest Animal Control Implementation Strategy to guide and co-ordinate delivery of a pest control program
- Support new or existing programs to control key diseases affecting TECs and species in the Cumberland subregion (Commitment 19)

25.10 MICROMYRTUS MINUTIFLORA

25.10.1 SPECIES BACKGROUND

Micromyrtus minutiflora is a slender spreading shrub that grows to 2 m high with solitary flowers and white petals (DEWHA, 2008).

The species flowers sporadically from June to March. Response to disturbance (such as fire or mechanical) is uncertain. Regeneration may occur as a result of re-sprouting, or germination of seeds stored within the soil (OEH, 2019g).

M. minutiflora inhabits Scribbly Gum Woodland, Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest, open forest on tertiary alluvium and consolidated river sediments (DEWHA, 2008; OEH, 2019g).

The species is endemic to the western parts of the Cumberland subregion in the Richmond-Castlereagh area and has a highly restricted distribution. The distribution overlaps with CRCIF and Castlereagh Scribbly Gum Woodland.

In 2002 there were 11 known populations with approximately 1,800 individuals across the Blacktown, Hawkesbury and Penrith Local Government Areas. In 1997, there were over 1,160 individuals in the Australian Defence Industries site and 500 individuals at Marsden Park site. Populations range from fewer than 50 plants to over 1,000 (DEWHA, 2008).

25.10.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

Micromyrtus minutiflora is being assessed as a candidate species credit species for GPEC and WSA nominated areas.

The species has been identified as a SAII entity in accordance with the requirement of section 10.2.1.4 of the BAM because it has a very highly restricted geographic distribution, which triggers Principle 3 of the BC Regulation.

25.10.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of *M. minutiflora* in relation to the subject land is shown in Map 28.

The majority of records and potential habitat for *M. minutiflora* occur to the north of the nominated areas. GPEC and WSA occur within the southern extent of the species stronghold in the Castlereagh and Londonderry areas.

There are several records of the species within GPEC located in the vicinity of Wianamatta Regional Park in the Ropes Crossing area, including one important population identified as part of the strategic assessment process under the EPBC Act. There are no records of the species within WSA.

There are no records of *M. minutiflora* within the urban capable lands of GPEC and WSA. The important population on the edge of Wianamatta Regional Park in the Ropes Crossing area occurs approximately 1.5 km from the nearest urban capable land.

The species was targeted during surveys within the nominated areas, but was not recorded.

Approximately 232 ha of potential habitat for *M. minutiflora* has been identified within GPEC and WSA. The majority of potential habitat occurs within the Wianamatta Regional Park in the northern part of GPEC, however surveys confirmed the species was not present within the OSO alignment. A smaller patch of potential habitat has been mapped in Orchard Hills in the middle part of GPEC and around Kemps Creek in WSA. The remaining habitat areas exists mainly as scattered and isolated habitat patches across the eastern half of GPEC.

25.10.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including *M. minutiflora*, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

The population of *M. minutiflora* within GPEC occurs outside the urban capable land and has been avoided.

The baseline mapping for this assessment has mapped 50 ha of potential habitat for *M. minutiflora* within the nominated areas (not including excluded lands). Approximately 28 ha (56 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 28 ha was avoided for biodiversity purposes
- <1 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-27.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-27 shows the amounts of habitat within excluded lands for context only.

Table 25-27: Avoidance outcomes for *M. minutiflora*

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential habitat (ha)	231	181	50	22	28	< 1	28

Avoidance of indirect impacts

Potential indirect impacts to *M. minutiflora* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Development within GPEC and WSA will not directly impact on any records or known populations of *M. minutiflora.*

Potential indirect impacts to *M. minutiflora* potential habitat due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

There are currently no impact thresholds for *M. minutiflora.*

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

A total of 22 ha of potential habitat for *M. minutiflora* will be directly impacted by the development. This is 42 per cent of the potential habitat in the nominated areas (without excluded lands). The direct impacts of the development are associated with urban development. The direct impacts mainly occur:

- To scattered patches of potential habitat at Orchard Hills in the central part of GPEC, which will be impacted by urban development
- To potential habitat within the alignment of the M7/Ropes Crossing Link Road in northern GPEC
- To potential habitat within the Kemps Creek area in WSA associated with urban development

An area of potential habitat within the Wianamatta Regional Park in the northern part of GPEC is bisected by the corridor for the Outer Sydney Orbital (OSO). Survey confirmed the species was absent with the road corridor, however potential habitat is mapped either side of the OSO and would be fragmented by the proposed development.

The direct impacts of the development on *M. minutiflora* are provided in Table 25-28.

Table 25-28: Direct impacts on *M. minutiflora*

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential habitat (ha)	0	0	10.9	6.6	4.5	22

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

Impacts to habitat in northern GPEC

The M7/Ropes Crossing Link Road impacts on 4.5 ha of potential habitat along the northern boundary of GPEC. Although not directly impacting on mapped habitat, the OSO corridor will lead to fragmentation of potential habitat within Wianamatta Regional Park, leading to a number of smaller, isolated patches of vegetation. This fragmentation may increase impacts associated with edge effects (primarily weeds) and this has the potential to compromise the suitability of remaining habitat areas directly adjacent to development.

The species was confirmed absent within the OSO corridor during project surveys, and the likelihood that the species occurs within lands adjacent to the corridor is considered low given:

- The area forms part of a Regional Park which is managed by the NSW NPWS and would be well traversed
- The species is relatively easy to identify when it is in flower

This low likelihood of occurrence considerably reduces the risk of impacts to *M. minutiflora* on key life-cycle processes.

Impacts to habitat at Orchard Hills

The loss of potential habitat at Orchard Hills is associated with small scattered patches of habitat that are currently surrounded by houses and farmland. The extent of cleared land in the area means that impacts are unlikely to increase edge effects to retained habitat areas or further reduce their viability. It is generally considered unlikely that potential habitat in this area contributes to the ongoing survival or viability of the species more broadly.

Impacts to habitat in WSA

Impacts to potential habitat within WSA are restricted to the Kemps Creek area and are associated with urban capable development. The impacts generally occur on the edges of larger potential habitat polygons, with the habitat surrounded by rural residential development and farmland. The extent of cleared land in the area means that impacts are unlikely to increase edge effects to retained habitat areas or further reduce their viability. It is generally considered unlikely that potential habitat in this area contributes to the ongoing survival or viability of the species more broadly.

Indirect impacts

Potential indirect impacts to *M. minutiflora* due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential habitat within GPEC and WSA is unlikely to affect the ecology of any local population of *M. minutiflora* because the potential for the species to occur is low.

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential habitat within the nominated areas is unlikely to fragment or isolate any local population of *M. minutiflora* because the potential for the species to occur is low.

Surveys of the OSO did not detect *M. minutiflora*, but potential habitat remains either side of the OSO corridor in Wianamatta Regional Park. This mapped potential habitat will be fragmented by the OSO. However, the low likelihood of occurrence of *M. minutiflora* in the area considerably reduces the risk of these impacts.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

Potential habitat for *M. minutiflora* within GPEC and WSA occurs within the southern extent of the species stronghold in the Castlereagh and Londonderry areas.

There is one known population within GPEC on the edge of Wianamatta Regional Park near Ropes Crossing. This population is disjunct from the majority of known records which occur approximately 7 km to the north-west and are generally associated with larger, more intact remnants of native vegetation and will not be directly or indirectly impacted by development. This population is generally within the southern geographic extent of the species range, although there are two relatively recent (2014) records of the species further south near Mulgoa.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profile for *M. minutiflora* (OEH, 2019g) identifies a range of threats to the species. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Habitat degradation

The greatest risk areas for these relevant threats are

- Within the alignment of the M7/Ropes Crossing Link Road in northern GPEC
- Within Wianamatta Regional Park, where the OSO corridor fragments potential habitat
- At Orchard Hills, where urban development fragments potential habitat

INAPPROPRIATE FIRE REGIMES

The response of *M. minutiflora* to fire is unknown. However, altered fire regimes are an identified threat (OEH, 2019g) and a 2016 fire in the Wianamatta Nature Reserve (outside of the nominated areas to the north of GPEC) may have substantially affected the species. Increased human activity within the nominated areas increases the risk of fire to habitat areas supporting the species.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the

sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

WEED INVASION

M. minutiflora is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban and transport development within GPEC has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

M. minutiflora is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include population 108 that occurs within GPEC.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area (SCA). This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

HABITAT DEGRADATION

Habitat degradation through unrestricted public access and rubbish dumping have been identified as a key threat to *M. minutiflora* (OEH, 2019g). Development within GPEC may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

The Plan incorporates a range of measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

There is currently approximately 2,036 ha of potential habitat mapped within protected areas within the area covered by the Plan. This includes potential habitat within:

- Castlereagh Nature Reserve
- Wianamatta Regional Park
- Wianamatta Nature Reserve
- Agnes Banks Nature Reserve
- Windsor Downs Nature Reserve

Four populations occur on public land managed for conservation. They are:

- Castlereagh Nature Reserve – two populations
- Wianamatta Regional Park – one population
- Wianamatta Nature Reserve – one population
- Agnes Banks Nature Reserve – one population

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments and actions that will contribute to the recovery of *M. minutiflora* in the Cumberland subregion. The key commitments and actions relevant to the species are:

- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential habitat for *M. minutiflora* in the SCAs, as there is approximately 3,818 ha of mapped potential habitat in the SCAs for this species
- Manage weeds in strategic locations in the Cumberland subregion (Commitment 16) to reduce threats to conservation lands secured within SCAs. This includes preparing a Weed Control Implementation Strategy to guide and co-ordinate delivery of a weed control program
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
    - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
    - Preparing a Fire Management Strategy to guide and co-ordinate fire management

25.11 RAPTORS

This assessment addresses three raptor species together – White-bellied Sea-Eagle (*Haliaeetus leucogaster*), Little Eagle (*Hieraaetus morphnoides*) and Square-tailed Kite (*Lophoictinia isura*).

25.11.1 SPECIES BACKGROUND

LITTLE EAGLE

Little Eagle is a medium-sized bird of prey that occurs throughout the Australian mainland except the most densely forested parts of the Dividing Range escarpment (OEH, 2017h). The species is found throughout NSW, but is more common in the western two-thirds of the state (Saunders and Debus, 2018a).

The species inhabits open eucalypt forest, woodland or open woodland. It also occurs in Sheoak or Acacia woodlands and riparian woodlands of interior NSW (OEH, 2017h).

Little Eagle generally nests in tall living eucalypts (between 5 and 30 m) in open forest, woodland, and remnant woodland within farmland. Nests are generally between 13 and 20 m above ground. They prefer to nest in dense woodland adjacent to open habitat (e.g. grassy woodland) for foraging. Nests are typically:

- In an emergent eucalypt, the tallest in the stand and often with the largest girth
- In woodland patches at least 4.8 ha in size (average 85 ha)
- Mostly within 200 m of the edge of habitat
- More distant from sealed roads (average 838 m) than gravel roads (average 546 m) than tracks (average 304 m)
- At least 38 m from the nearest dwelling (average 457 m)
- At least 1 km from urban development (Saunders and Debus, 2018a)

Little Eagle will forage up to 3 km from the nest, which gives a maximum breeding/foraging territory of 2,800 hectares. Banding data suggest that birds occupy a home range for at least 6-10 years (Saunders and Debus, 2018a).

The species occurs as a single population throughout NSW (OEH, 2017h).

SQUARE-TAILED KITE

Square-tailed Kite is a reddish, medium-sized raptor that occurs along coastal and subcoastal areas from south-western to northern Australia, NSW, Queensland, and Victoria. There are scattered records across NSW (OEH, 2017j).

The species inhabits a variety of forests, including dry woodlands and open forests (OEH, 2017j). Square-tailed Kite prefers timbered watercourses through open or cleared land and the margins between open and timbered country, and can tolerant human disturbance and urban bushland (Saunders and Debus, 2018b).

Nests are generally located along or near watercourses and on the edge of habitat areas, in a fork or on horizontal limbs of a large living trees, and mostly between 15 and 28 m above ground (Saunders and Debus, 2018b).

The species appears to be monogamous as breeding pairs, as they are intolerant of other adults within their breeding territory, and they occupy the same nest site for many years (Saunders and Debus, 2018b).

The species migrates in the summer to south-east NSW to breed, arriving in September and leaving by March (OEH, 2017j). In the Cumberland subregion, breeding has been recorded from July to February (Saunders and Debus, 2018b).

The species occupies large hunting ranges of more than 100 km^2.

WHITE-BELLIED SEA-EAGLE

The White-bellied Sea-Eagle is a large eagle that has long, broad wings and a short, wedge-shaped tail that occurs around the Australian coastline and inland along rivers and wetlands of the Murray Darling Basin. In NSW, it is widespread along the east coast, and along all major inland rivers and waterways (OEH, 2017k).

The species occurs in a variety of habitats, including coastal dunes, tidal flats, grassland, heathland, woodland, and forest close to large bodies of open water including larger rivers, swamps, lakes, and the ocean (OEH, 2017k).

Breeding habitat is constrained to living or dead mature trees within forests or tall woodland within 1 km of rivers, lakes, large dams or creeks, wetlands and coastlines. Nest are generally located in large emergent eucalypts, often with emergent dead branches or large dead trees nearby, which are used as 'guard roosts' (OEH, 2017k).

25.11.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

The raptors are being assessed as candidate species credit species in terms of breeding habitat for all nominated areas.

The raptors have been identified as potential SAII entities in accordance with the requirement of section 10.2.1.4 of the BAM because of the potential for the development to impact breeding habitat that cannot readily be created at a stewardship site. This SAII assessment addresses direct and indirect impacts on breeding habitat only.

An expert report was prepared for Little Eagle and Square-tailed Kite. Potential breeding habitat for the raptors was mapped on the basis of the expert reports, as well as a KBM, as follows:

- Little Eagle:
    - An expert report for Wilton and GMAC (Saunders and Debus, 2018a) and addendum letter (Saunders, 2020)
    - A KBM for WSA and GPEC
- Square-tailed Kite:
    - An expert report for Wilton and GMAC (Saunders and Debus, 2018b) and addendum letter (Saunders, 2020)
    - A KBM for WSA and GPEC
- White-bellied Sea-Eagle: A KBM for all four nominated areas

The expert reports involved:

- Targeted surveys within the most likely areas of potential breeding and foraging habitat for these species
- Identification of potential breeding and foraging habitat within the nominated areas
- Targeted surveys in potential habitat by the expert as part of preparing the expert report as well as Biosis as part of other targeted surveys for this project (the Biosis surveys were taken into account in preparing the expert report)

The addendum refined the mapping of potential breeding and foraging habitat and clarified the location of such habitat.

25.11.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of the raptors in relation to the subject land is shown in Map 29.

Records

Little Eagle

The majority of records of the Little Eagle within the Cumberland subregion are recorded on the Cumberland Plain. This includes 35 records within the nominated areas, or within 5 km of the nominated area boundaries.

Most records are associated with large patches of open woodland that occur within open grassland areas. Some records are found close to the edges of forests along watercourses. A few records were from woodlands associated with wetlands. The records support the conclusion that a mosaic of open woodland and open grassland with scattered trees provides important foraging habitat for the Little Eagle (Saunders and Debus, 2018a).

The expert report concluded that there is a very high likelihood that Little Eagle occurs in the nominated areas at any time of the year and that the nominated areas provide good foraging habitat for the species. There are likely to be 4 to 6 resident pairs resident in Wilton and GMAC, including (Saunders and Debus, 2018a):

- 1 pair in the northern part of GMAC
- 2 pairs in the middle part of GMAC
- 1 pair in the southern part of GMAC
- 1 pair in Wilton

Square-tailed Kite

Square-tailed Kite was seldom recorded in the Cumberland subregion prior to 1990, but the number of records has increased over the last two decades. All records for the Liverpool, Campbelltown and Wollondilly Local Government Areas are more recent than 2000. There are breeding records within the subregion, from near Asquith in 2012, Lane Cove National Park in 2015, and more recently near Penrith, Asquith and South Turramurra (Saunders and Debus, 2018b).

There are 32 records in the nominated areas, including 12 within Wilton and the southern part of GMAC. Another 15 records occur within 5 km of the nominated areas, with 11 occurring just outside the northern part of GMAC. The majority of records are from January to April, which represents the post-breeding dispersal phase (Saunders and Debus, 2018b).

The expert report concluded that there is a very high likelihood that Square-tailed Kite occurs in the nominated areas during the breeding season, and that the nominated areas provide good foraging habitat for the species. There are likely to be 2 to 3 breeding pairs of Square-tailed Kite resident in Wilton and GMAC, including:

- 1 pair centred along the Georges River along the eastern edge of the northern part of GMAC
- 1 pair in the Appin Road area that extends into contiguous forest to the east of the southern part of GMAC
- Possibly 1 pair in the southern part of Wilton

White-bellied Sea-Eagle

There are many records of the White-bellied Sea-Eagle in the Cumberland subregion, although the majority in the Sydney Basin bioregion occur to the east of the subregion along the coast, to the north and south of Sydney.

There are several records of the species in the nominated areas. There is one old record in GPEC and two records in the central part of WSA, including a recent (2017) record. There is a cluster of relatively recent records (2013) within or just outside the central part of GPEC, and several other records in the southern part of GPEC. There are several recent (2018) records just outside the northern part of the GPEC to the east. There are no records in Wilton.

POTENTIAL BREEDING HABITAT

Potential breeding habitat for the raptors has been mapped in all nominated areas.

Potential breeding habitat for Little Eagle and Square-tailed Kite occurs in the urban capable lands of GPEC, GMAC and WSA, and for White-bellied Sea-Eagle, occurs in the urban capable lands of all nominated areas.

Little Eagle

No nests have been recorded in the nominated areas and no evidence of breeding was observed during surveys by ecological consultants or by the authors of the expert report. As the Little Eagle is considered to be resident for at least several consecutive years while nesting, it is likely that if nesting has occurred within the nominated areas it would have been detected. However, suitable nesting habitat is still considered to occur within the nominated areas (Saunders and Debus 2018a). This view is supported by the occurrence of species records within and around the nominated areas in the breeding season (e.g. a mating pair was observed by Starr et al. (2004) near Camden (Saunders and Debus 2018a)).

Square-tailed Kite

There is a very high likelihood that Square-tailed Kite occurs within the nominated areas during the breeding season. However, no nests have been recorded in the nominated areas. Breeding was not observed during surveys by the ecological consultants or by the authors of the expert report. As other bird species build similar stick nests it is difficult to identify a Square-tailed Kite nest without the bird being in attendance, which would be required to confirm breeding habitat. The breeding habitat areas indicated in the expert reports (Saunders and Debus 2018b) are based on the minimum criteria presented in Tables 1 and 2 of the report.

Note that the conclusions in the expert reports are supported by mapping showing 'Breeding and foraging habitat' for Little Eagle and Square-tailed Kite. This habitat is generally restricted to areas outside urban capable lands. Further clarification was sought from the experts and additional refinement of the mapping was completed in June 2020 (Saunders, 2020). The refined mapping was used to define breeding habitat for the species in GMAC and Wilton and calculate impacts consistent with the BAM. KBM mapping was used to identify potential breeding habitat in GPEC and WSA

25.11.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including the raptors, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

Little Eagle

The baseline mapping for this assessment has mapped 4,163 ha of potential breeding habitat for Little Eagle within the nominated areas (not including excluded lands). Approximately 3,006 ha (99 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,311 ha was avoided for biodiversity purposes
- 696 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-29.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-29 shows the amounts of habitat within excluded lands for context only.

Table 25-29: Avoidance outcomes for Little Eagle

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential breeding habitat (ha)	4,163	1,137	3,026	18.9	2,311	696	3,006

Square-tailed Kite

The baseline mapping for this assessment has mapped 4,246 ha of potential breeding habitat for White-bellied Sea-Eagle within the nominated areas (not including excluded lands). Approximately 2,955 ha (99 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,279 ha was avoided for biodiversity purposes
- 676 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-30.

Table 25-30: Avoidance outcomes for Square-tailed Kite

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential breeding habitat (ha)	4,246	1,264	2,983	27.8	2,279	676	2,955

White-bellied Sea-Eagle

The baseline mapping for this assessment has mapped 2,485 ha of potential breeding habitat for White-bellied Sea-Eagle within the nominated areas (not including excluded lands). Approximately 1,661 ha (99 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,066 ha was avoided for biodiversity purposes
- 596 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-31.

Table 25-31: Avoidance outcomes for White-bellied Sea-Eagle in all four nominated areas

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential breeding habitat (ha)	2,485	806	1,679	16.6	1,066	596	1,661

Avoidance of indirect impacts

Potential indirect impacts to the raptors due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Little Eagle and Square-tailed Kite

There are likely to be 4 to 6 resident pairs of Little Eagle, and 2 to 3 breeding pairs of Square-tailed Kite (that will use the areas for foraging during the breeding season), in Wilton and GMAC.

The expert report found no evidence of breeding of Little Eagle of Square-tailed Kite, as defined by the presence of a bird on a nest, or the presence of pairs of birds in potential habitat, in Wilton or GMAC. Refined mapping completed in June 2020 did map areas of potential breeding habitat in both Wilton and GMAC (Saunders, 2020).

It is uncertain whether Little Eagle or Square-Tailed Kite resides in GPEC or WSA, or the number of resident individuals. Potential breeding habitat occurs in these nominated areas, and relatively recent records occur within or in close proximity to the nominated areas. It is considered likely that the species uses the nominated areas at least for foraging.

White-bellied Sea-Eagle

It is uncertain whether White-bellied Sea-Eagle resides in any of the nominated areas, and if it does occur, the number of potential resident individuals. Potential breeding habitat occurs in each of the nominated areas, particularly Wilton and GMAC, and recent records occur in WSA and particularly within or just outside the central part of GPEC. It is considered likely that the species uses the nominated areas at least for foraging.

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

There are currently no impact thresholds for the raptors.

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

The direct impacts of the development on the raptors are provided in Table 25-32. The direct impacts are mainly associated with the transport corridors. For all raptors, the impacts mainly occur:

- In Wianamatta Regional Park where the OSO intersects an area of habitat, which will fragment this habitat into two patches and lead to the isolation of one of the patches from the remainder of habitat in the regional park
- In the central part of the nominated area where the OSO mostly removes habitat associated with riparian corridors
- To the edges of smaller scattered patches of habitat in WSA that are mainly associated with riparian corridors

For Little Eagle and Square-tailed Kite potential breeding habitat is impacted in the central southern area of GMAC by urban development.

It is important to note that potential foraging habitat was also mapped within GMAC and Wilton for Little Eagle and Square-tailed Kite (Saunders, 2020). The potential foraging habitat is generally represented by grassed paddocks adjacent to mapped potential breeding habitat and are not considered to be impacts to breeding habitat requiring credit calculations under the BAM. In total 2,838 ha of Little Eagle potential foraging habitat is mapped across GMAC and Wilton, with 1,323 ha impacted. For Square-tailed Kite 1,623 ha of potential foraging habitat is mapped across GMAC and Wilton, with 511 ha impacted.

For White-bellied Sea-Eagle in Wilton and GMAC, impacts also occur to the edges of potential breeding habitat that is associated with gullies and gorges that run down to the Nepean River.

Table 25-32: Direct impacts on potential breeding habitat (ha) for raptors

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Little Eagle	0	14.7	0.5	0.5	3.2	18.9
Square-tailed Kite	0	14.7	0.2	0.3	12.6	27.8
White-bellied Sea-Eagle	2	8.5	0.2	0.3	5.5	16.6

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

Direct impacts to potential breeding habitat for the raptors are unlikely to affect life cycle processes or impact the viability of any local populations of raptors because:

- While there are likely to be resident pairs of Little Eagle and Square-tailed Kite in Wilton and GMAC, there are no direct impacts on potential breeding habitat for these species in Wilton and only relatively minor impacts on potential breeding habitat in GMAC
- In GPEC and WSA, and in relation to White-bellied Sea-Eagle, in Wilton and GMAC, direct impacts to potential breeding habitat for raptors are very small relative to the amount of potential breeding habitat remaining
- Impacts generally occur to the edges of potential breeding habitat that in most cases remains connected to larger patches of habitat associated with gullies and gorges that run down to the Nepean River or along riparian corridors. This reduces the risk that potential breeding habitat becomes isolated from foraging habitat

The development will lead to some fragmentation of potential breeding habitat. This mainly occurs:

- GPEC:
  - In Wianamatta Regional Park where the OSO will fragment habitat into two patches
  - In the central part of the nominated area where the OSO will reduce the size of some habitat patches
- WSA: Along some riparian corridors where the development will reduce the size of patches to some extent
- GMAC and Wilton: Along the edges of habitat associated with waterways, gullies and gorges and, for Little Eagle and Square-tailed Kite, some fragmentation of habitat within the southern area of GMAC

In most cases, this fragmentation will lead to a small reduction in the size of some potential breeding habitat patches as impacts mainly occur only to the edges of patches. Particularly in Wilton and the southern part of GMAC, potential breeding habitat usually remains connected to large areas of habitat associated with waterways, gullies and gorges in the nominated areas, as well as large patches of habitat outside the nominated areas. In WSA, impacts mainly occur to the edges of riparian corridors which generally remain connected along their length.

It is also important to note that in Wilton, the development will not impact potential breeding habitat for Little Eagle and Square-tailed Kite and therefore no fragmentation or isolation of habitat will occur.

As a result, it is not considered that the development is likely to significantly fragment or isolate the likely resident pairs of Little Eagle and Square-tailed Kite and any population of White-bellied Sea-Eagle in Wilton and GMAC, or fragment or isolate any populations of these species in the WSA or GPEC.

Indirect impacts

Potential indirect impacts to the raptors due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential breeding habitat is unlikely to affect the ecology of any local populations of raptors because:

- While there are likely to be resident pairs of Little Eagle and Square-tailed Kite in Wilton and GMAC, there are no direct impacts on potential breeding habitat for these species in Wilton and only relatively minor impacts on potential breeding habitat in GMAC
- Direct impacts to potential breeding habitat for raptors are very small relative to the amount of habitat remaining

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential breeding habitat is unlikely to fragment or isolate any local populations of raptors because in most cases, impacts mainly occur only to the edges of patches and potential breeding habitat usually remains connected to large areas of habitat or along riparian corridors. Furthermore, in Wilton, the development will not impact potential breeding habitat for Little Eagle and Square-tailed Kite and therefore no fragmentation or isolation of habitat for these species will occur.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

There are likely to be 4 to 6 resident pairs of Little Eagle, and 2 to 3 breeding pairs of Square-tailed Kite (that will use the areas for foraging during the breeding season), in Wilton and GMAC. It is uncertain whether White-bellied Sea-Eagle resides in any of the nominated areas, and if it does occur, the number of potential resident individuals.

The importance of these resident pairs to other populations outside the nominated areas is uncertain.

Little Eagle occurs as a single population throughout NSW (OEH, 2017h), while Square-tailed Kite appears to be monogamous as breeding pairs, as they are intolerant of other adults within their breeding territory, and they occupy the same nest site for many years (Saunders and Debus, 2018b).

The expert report found no evidence of breeding of Little Eagle or Square-tailed Kite, as defined by the presence of a bird on a nest, or the presence of pairs of birds in potential habitat, in Wilton or GMAC. If breeding does not occur within the nominated areas, it is likely that these species breed outside the nominated areas and use the nominated areas for foraging.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profiles for the three species identify a range of threats. Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Non-target poisoning during pest animal control
- Habitat disturbance

Non-target poisoning during pest animal control

Accidental poisoning during pest animal control is recognised as a threat to the species. Poisoning of pest animals may occur during implementation of the Plan as part of the Pest Animal Control Implementation Strategy (Commitment 17, Action 1).

To mitigate the risk to the three raptor species, the Plan includes a specific commitment and a specific action to address the threat. These are:

- Commitment 17.1 – "*Reduce the risk of secondary poisoning from pesticides for the following threatened raptor species:*
  - *Little Eagle*
  - *Spotted Harrier*
  - *Square-tailed Kite*
  - *White-bellied Sea-Eagle"*
- Commitment 17.1, Action 4 – "*Ensure that the Pest Animal Control Implementation Strategy specifies the use of pest control techniques that will reduce the risk of secondary poisoning from Pindone or second-generation rodenticides"*

These measures are considered adequate to address the threat to the species.

Habitat disturbance

Habitat disturbance (particularly to nest sites) is recognised as a threat to the species. Habitat disturbance can occur due to a range of mechanisms including:

- Uncontrolled access to areas of high biodiversity
- Inappropriate land management practices

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance which are considered adequate for protecting the species. In summary, these include:

- Retaining large trees (including dead trees) (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction (under Commitment 5)
- Establishing ecological setbacks for raptor nests to provide a buffer to adjacent development
- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about the TEC

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

An estimate of the potential breeding habitat for raptors in protected lands in the area covered by the Plan is:

- Little Eagle: 197 ha
- Square-tailed Kite: 232 ha
- White-bellied Sea-Eagle: 249 ha

Each of the raptors has been recorded within several of the following protected lands within and outside the Cumberland subregion, including:

- Wianamatta Nature Reserve
- Dharawal National Park
- Dharug National Park
- Scheyville National Park
- Cattai National Park
- Yengo National Park
- Blue Mountains National Park
- Dharawal National Park
- Royal National Park
- Castlereagh Nature Reserve
- Windsor Downs Nature Reserve

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of the raptors in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments and actions relevant to the species are:

- Species-specific commitments under Commitment 5 to retain large trees (including dead trees) (≥50cm DBH) during precinct planning where possible and establish ecological setbacks for raptor nests to provide a buffer to adjacent development
- Ensuring that the Pest Animal Control Implementation Strategy specifies the use of pest control techniques that will reduce the risk of secondary poisoning from Pindone or second-generation rodenticides (Commitment 17.1)
- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential breeding habitat for raptors in the SCAs, as there is approximately 15,000 ha of mapped potential breeding habitat in the SCAs for these species

25.12 PSEUDOPHRYNE AUSTRALIS

25.12.1 SPECIES BACKGROUND

Red-crowned Toadlet (*Pseudophryne australis*) is a small frog that is dark brown to black, with distinctive reddish-orange patches. It is a relatively long-lived species (up to 8 to 10 years) (OEH, 2019h).

The species inhabits periodically wet drainage lines below sandstone ridges within open forests, mostly at the interface of Hawkesbury sandstone and Wianamatta and Narrabeen shale (OEH, 2019h).

The Red-crowned Toadlet appears to be largely restricted to the immediate vicinity of suitable breeding habitat. Breeding habitat comprises dense vegetation and debris beside ephemeral creeks and gutters (OEH, 2019h). The species deposits eggs in terrestrial nests beneath rocks and logs or in leaf litter, and relies on rainfall to wash the partially developed tadpoles into ephemeral creeks for completion of the reproductive cycle (NSW Scientific Committee, 2002).

Outside the breeding period, the species disperses to refuge areas close to breeding sites, under rocks and amongst masses of dense vegetation or thick piles of leaf litter generally on sandstone ridges (OEH, 2019h).

The Red-crowned Toadlet has a restricted distribution. It is confined to the Sydney Basin, from Pokolbin in the north, the Nowra area to the south, and west to Mt Victoria in the Blue Mountains (OEH, 2019h).

Records for the species are widespread surrounding the Cumberland subregion, but few records occur in the subregion.

25.12.2 ASSESSMENT UNDER THE STRATEGIC BIODIVERSITY CERTIFICATION

The Red-crowned Toadlet is being assessed as a candidate species credit species for GPEC, GMAC and Wilton.

The species has been identified as a potential SAII entity in accordance with the requirement of section 10.2.1.4 of the BAM because of its very high susceptibility to the disease chytrid fungus, which triggers Principle 4 of the BC Regulation.

25.12.3 OCCURRENCE IN RELATION TO THE SUBJECT LAND

The occurrence of Red-crowned Toadlet in relation to the subject land is shown in Map 30.

There are no records for the Red-crowned Toadlet within the nominated areas. The closest records occur within a few kilometres of GPEC, GMAC and Wilton.

Approximately 1,090 hectares of potential habitat for Red-crowned Toadlet has been identified within the nominated areas. This occurs in Wilton and GMAC. No potential habitat was mapped within GPEC.

Potential habitat in Wilton and GMAC generally occurs in scattered patches within the vicinity of gorges and gullies that occur mainly around the edges of the nominated areas. The vast majority of potential habitat in GMAC is restricted to the southern part of the nominated area, with only one small patch of habitat occurring in the northern part.

25.12.4 IMPACT ASSESSMENT

The following assessment addresses the provisions set out in section 10.2.3 of the BAM.

10.2.3.1(A) THE ACTION AND MEASURES TAKEN TO AVOID DIRECT AND INDIRECT IMPACTS

Avoidance and minimisation of impacts to biodiversity values, including Red-crowned Toadlet, was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of direct impacts

No known populations of Red-crowned Toadlet occur within GMAC and Wilton. Avoidance of impacts to populations was therefore not a relevant consideration for this species.

The baseline mapping for this assessment has mapped 884 ha of potential habitat for Red-crowned Toadlet within the nominated areas (not including excluded lands). Approximately 875 ha (99 per cent) of this was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 652 ha was avoided for biodiversity purposes
- 223 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 25-33.

It is important to note that the avoidance calculations in the table including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands. Table 25-33 shows the amounts of habitat within excluded lands for context only.

Table 25-33: Avoidance outcomes for Red-crowned Toadlet

Avoidance of:	Total in nominated areas	Total in excluded lands	Total without excluded lands	Directly impacted	Avoided for biodiversity purposes	Avoided for other purposes	Total avoidance
Potential habitat (ha)	1,090	206	884	9.0	652	223	875

Avoidance of indirect impacts

Potential indirect impacts to Red-crowned Toadlet due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(B) THE SIZE OF THE LOCAL POPULATION DIRECTLY AND INDIRECTLY IMPACTED BY THE DEVELOPMENT

Development within GMAC and Wilton will not directly impact any known populations of Red-crowned Toadlet.

10.2.3.1(C) THE EXTENT TO WHICH THE IMPACT EXCEEDS ANY THRESHOLD FOR THE POTENTIAL ENTITY

There are currently no impact thresholds for Red-crowned Toadlet.

10.2.3.1(D) THE LIKELY IMPACT (INCLUDING DIRECT AND INDIRECT) THAT THE DEVELOPMENT, CLEARING OR BIODIVERSITY CERTIFICATION WILL HAVE ON THE HABITAT OF THE LOCAL POPULATION

Direct impacts

A total of 9 ha of potential habitat for Red-crowned Toadlet will be directly impacted by the development. This is 1.0 per cent of the potential habitat in the nominated areas (without excluded lands). The direct impacts of the development are associated with urban development. The direct impacts mainly occur at the very edges of potential habitat associated with gorges and gullies that run down to the Nepean River, in the following locations:

- Scattered areas of Wilton
- Southern part of GMAC

The direct impacts of the development on Red-crowned Toadlet are provided in Table 25-34.

Table 25-34: Direct impacts on Red-crowned Toadlet

Impacts to:	Wilton*	GMAC*	WSA*	GPEC*	Transport corridors#	Total
Potential habitat (ha)	3.3	5.8	0	0	0	9.0

* Impacts from urban development only within each nominated area

Impacts from transport corridors across all nominated areas

The impacts to the areas of potential habitat within Wilton and GMAC are unlikely to impact the ongoing survival or viability of the Red-crowned Toadlet in the local area because:

- Only a very small proportion (1.0 per cent) of this potential habitat is directly impacted. The vast majority of potential habitat has been avoided for biodiversity or other purposes
- There are no records or known populations of the species in the area. While many records of the species occur surrounding the Cumberland subregion, the species is generally not known from the subregion
- The impacts are unlikely to cause fragmentation or isolation of habitat because, where impacts occur, only the edges of potential habitat at the tops of gorges and gullies are impacted
- The corridors of potential habitat that exist along gorges and gullies are maintained

Indirect impacts

Potential indirect impacts to Red-crowned Toadlet due to the development, including mitigation measures under the Plan to avoid and manage these impacts, are assessed in subsection (h).

10.2.3.1(E) THE LIKELY IMPACT ON THE ECOLOGY OF THE LOCAL POPULATION

As discussed in response to subsection (d) above, the loss of potential habitat within Wilton and GMAC is unlikely to affect the ecology of any local population of Red-crowned Toadlet because:

- Only a very small proportion (1.0 per cent) of this potential habitat is directly impacted
- There are no records or known populations of the species in the locality and the species is generally not known from the subregion, reducing the risk that breeding habitat occurs in the locality

10.2.3.1(F) A DESCRIPTION OF THE EXTENT TO WHICH THE LOCAL POPULATION WILL BECOME FRAGMENTED OR ISOLATED

As discussed in response to subsection (d) above, the loss of potential habitat within Wilton and GMAC is unlikely to fragment and isolate any local population because impacts occur only to the very edges of potential habitat and the corridors of potential habitat that exist along gorges and gullies are maintained.

10.2.3.1(G) THE RELATIONSHIP OF THE LOCAL POPULATION TO OTHER POPULATION/POPULATIONS OF THE SPECIES

Development within Wilton and GMAC will not directly impact any records or known populations of Red-crowned Toadlet. No populations are known from these nominated areas.

Potential habitat within Wilton and GMAC is not at the limit of the species range. Records for the species are widespread surrounding the Cumberland subregion.

10.2.3.1(H) THE EXTENT TO WHICH THE DEVELOPMENT WILL LEAD TO AN INCREASE IN THREATS AND INDIRECT IMPACTS, INCLUDING IMPACTS FROM INVASIVE FLORA AND FAUNA, THAT MAY IN TURN LEAD TO A DECREASE IN THE VIABILITY OF THE LOCAL POPULATION

The BioNet profile for the Red-crowned Toadlet identifies a range of threats to the species (OEH, 2019h). Where these threats are present in the nominated areas and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential threats or indirect impacts are considered relevant to implementation of the Plan:

- Reduction in water quality
- Inappropriate fire regimes
- Habitat disturbance including collection of bush rock and recreational activities
- Infection with amphibian chytrid fungus

The greatest risk areas for these relevant threats are at the edges of potential habitat associated with gorges and gullies that run down to the Nepean River in the northern part of Wilton, and the western part of GMAC.

REDUCTION IN WATER QUALITY

A reduction in water quality and changes to hydrology are recognised as a principal threat to the species (OEH, 2019h). Key issues relate to increased pollutants in runoff from developed areas.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council’s requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to habitat for the species
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

INAPPROPRIATE FIRE REGIMES

High frequency fire is identified as a potential threat to the Red-crowned Toadlet (OEH, 2019h).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

HABITAT DISTURBANCE INCLUDING COLLECTION OF BUSH ROCK AND RECREATIONAL ACTIVITIES

Inappropriate habitat disturbance has been identified as a threat to the Red-crowned Toadlet (OEH, 2019h).

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the Red-crowned Toadlet. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about the Red-crowned Toadlet

The package of measures in the Plan is expected to adequately manage the risk to the Red-crowned Toadlet from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of mapped habitat for Red-crowned Toadlet occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

INFECTION WITH AMPHIBIAN CHYTRID FUNGUS

Amphibian chytrid fungus, which causes the infection known as chytridiomycosis, is recognised as a threat to the Red-crowned Toadlet (OEH, 2019h).

Chytrid fungus is already present in the Cumberland subregion, although there may be pockets of disease free areas that are inhospitable to the growth of the disease (for example, due to salinity levels or elevated concentrations of trace metals).

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise the spread of disease

The package of measures in the Plan is expected to adequately manage the risk to potential habitat from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

10.3.2.1(I) AN ESTIMATE OF THE AREA, OR NUMBER OF POPULATIONS AND SIZE OF POPULATIONS THAT IS IN THE RESERVE SYSTEM IN NSW, THE IBRA REGION AND THE IBRA SUBREGION

There is currently approximately 27 ha of potential habitat for the Red-crowned Toadlet mapped within protected areas in the area covered by the Plan. This comprises potential habitat within the Upper Nepean State Conservation Area.

Populations are known from many reserves managed for conservation outside the Cumberland subregion, including:

- Nattai National Park
- Blue Mountains National Park
- Wollemi National Park
- Dharawal National Park
- Royal National Park
- Berowra Valley National Park

10.3.2.1(J) THE MEASURES PROPOSED TO CONTRIBUTE TO THE RECOVERY OF THE SPECIES IN THE IBRA SUBREGION

The Plan includes a range of commitments that will contribute to the recovery of Red-crowned Toadlet in the Cumberland subregion. Several commitments are described in more detail the sections above.

The key commitments and actions relevant to the species are:

- Secure a minimum of 5,475 ha of native vegetation in conservation lands within SCAs (Commitment 8). Offset targets to secure PCTs (see Chapter 8) are likely to result in securing of additional potential habitat for Red-crowned Toadlet in the SCAs, as there is approximately 8,593 ha of mapped potential habitat in the SCAs for this species
- Support new or existing programs to control key diseases affecting TECs and species in the Cumberland subregion (Commitment 19)
- Manage fire in strategic locations in the Cumberland subregion (Commitment 18) to support the maintenance of biodiversity values on land secured within SCAs. This includes:
  - Consulting with Rural Fire Service, NSW NPWS, and EES to identify fire management priorities, including fire sensitive species and ecological communities
  - Preparing a Fire Management Strategy to guide and co-ordinate fire management

26 Impact summary

The BCAR must include the number and classes of biodiversity credits that would be required to be retired if the offset rules under the BC Act applied (clause 6.9(c) BC Regulation).

This Chapter identifies:

- Impacts on native vegetation (PCTs) and species requiring offsets and the native vegetation not requiring offsets
- Areas not requiring assessment in accordance with section 10 of the BAM
- Biodiversity credits that would be required to be retired if the offset rules under the BC Act applied

It is important to note that the number and classes of biodiversity credits needed to offset the impacts of the development are not required to be retired under a strategic biodiversity certification (see Part 1). However, the NSW Environment Minister must be satisfied that the 'approved conservation measures' under the Plan adequately address the likely impacts on biodiversity values. The Minister will have regard to the BCAR in making this decision.

The Plan has had regard to the credit output of the BAM in determining the commitments under the conservation program. The adequacy of the commitments in offsetting the impacts of the development are evaluated in Part 7.

26.1 IMPACTS REQUIRING OFFSET

Table 26-1 and Table 26-3 identify the impacts on native vegetation and species that require offsets.

Map 31 and Map 32 provide maps of impacts on native vegetation and species that require offsets and impacts on native vegetation and species that do not require offsets.

26.1.1 NATIVE VEGETATION REQUIRING OFFSETS

Section 10.3.1 of the BAM specifies that an offset is required for impacts on native vegetation where the vegetation integrity score is:

- ≥15 where the PCT is representative of an endangered or critically endangered ecological community
- ≥17 where the PCT is associated with threatened species habitat (as represented by ecosystem credits), or is representative of a vulnerable ecological community
- ≥20 where the PCT is not representative of a TEC or associated with threatened species habitat

The PCTs/vegetation zones requiring offsets are provided in Table 26-1.

The PCT/vegetation zones not requiring offsets are provided in Table 26-2.

Table 26-1: PCTs/vegetation zones requiring offsets

PCT	Condition
724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
781 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Thinned

PCT	Condition
830 - Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Thinned
835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
	DNG
850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
	DNG
1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Intact
	Thinned
	Scattered Trees
	DNG
1800 - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Intact
	Thinned
	Scattered Trees

Table 26-2: PCTs/vegetation zones not requiring offsets

PCT	Condition
835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Non-offsettable grassland
849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Non-offsettable grassland
850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Non-offsettable grassland
1395 - Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Non-offsettable grassland

26.1.2 SPECIES REQUIRING OFFSETS

The species credit species requiring offsets are provided in Table 26-3.

Table 26-3: Species credit species requiring offsets

Species	Common Name
Acacia bynoeana	Bynoe's Wattle
Acacia pubescens	Downy Wattle
Allocasuarina glareicola	-
Callocephalon fimbriatum	Gang-gang Cockatoo
Calyptorhynchus lathami	Glossy Black Cockatoo
Cercartetus nanus	Eastern Pygmy-possum
Chalinolobus dwyeri	Large-eared Pied Bat
Dillwynia tenuifolia	-
Epacris purpurascens var. *purpurascens*	-
Grevillea juniperina subsp. *juniperina*	-
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea
Haliaeetus leucogaster	White-bellied Sea-Eagle
Heleioporus australiacus	Giant Burrowing Frog
Hibbertia fumana	-
Hibbertia puberula	-
Hieraaetus morphnoides	Little Eagle
Litoria aurea	Green and Golden Bell Frog
Lophoictinia isura	Square-tailed Kite
Marsdenia viridiflora subsp. *viridiflora* - endangered population	*Marsdenia viridiflora* R. Br. subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas
Maundia triglochinoides	-
Melaleuca deanei	Deane's Paperbark
Meridolum corneovirens	Cumberland Plain Land Snail
Micromyrtus minutiflora	*Micromyrtus minutiflora*
Myotis macropus	Southern Myotis
Ninox strenua	Powerful Owl
Persicaria elatior	Tall Knotweed
Persoonia bargoensis	Bargo Geebung
Persoonia nutans	Nodding Geebung
Petaurus norfolcensis	Squirrel Glider
Phascolarctos cinereus	Koala

Species	Common Name
Pimelea curviflora var. *curviflora*	-
Pimelea spicata	Spiked Rice-flower
Pomaderris brunnea	Brown Pomaderris
Pseudophryne australis	Red-crowned Toadlet
Pterostylis saxicola	Sydney Plains Greenhood
Pultenaea parviflora	-
Pultenaea pedunculata	Matted Bush-pea
Tyto novaehollandiae	Masked Owl

26.2 IMPACTS NOT REQUIRING FURTHER ASSESSMENT

Areas that do not require assessment in accordance with section 10. 4 of the BAM include:

- Urban native/exotic vegetation
- Non-offsettable grassland
- Cleared land and existing building

26.3 BIODIVERSITY CREDIT CALCULATIONS

The biodiversity credit reports are provided at Supporting Document E.

26.3.1 ECOSYSTEM CREDITS

Table 26-4 to Table 26-7 identify the area of impact and associated number of biodiversity credits for each impacted PCT within each nominated area that would be required to be retired if the offset rules applied under the BC Act.

The total number of ecosystem credits that would be required to be retired to offset the impact of the proposed development on PCTs is 41,347 credits.

As noted, the number and classes of biodiversity credits needed to offset the impacts of the development are not required to be retired under a strategic biodiversity certification (see Part 1). The adequacy of the commitments in offsetting the impacts of the development are evaluated in Part 7.

Table 26-4: Ecosystem credits - Wilton

Vegetation zone	Vegetation integrity loss	Area (ha)	Ecosystem credits
849_Intact	53.9	1.6	53
849_Thinned	42.3	22.4	592
849_Scattered_trees	18.3	24.1	275
849_DNG	24.1	139.5	2,098
850_Scattered_trees	38.1	0.9	22
850_DNG	25.7	151.1	2,423
1395_Intact	72.9	13.3	605
1395_Thinned	63.9	84.7	3,385
1395_Scattered_trees	30.0	20.1	378
1395_DNG	28.4	205.8	3,647
	Total	**663.5**	**13,478**

Table 26-5: Ecosystem credits - GMAC

Vegetation zone name	Vegetation integrity loss	Area (ha)	Ecosystem credits
830_Thinned	20.1	0.1	1
835_Intact	76.6	0.2	8
835_Thinned	57.1	5.0	143
835_Scattered_trees	68.7	0.1	4
849_Intact	53.9	13.5	453
849_Thinned	42.3	31.7	838
849_Scattered_trees	18.3	31.4	359
849_DNG	24.1	32.3	486
850_Intact	58.1	8.1	292
850_Thinned	41.9	44.5	1,166
850_Scattered_trees	38.1	17.2	409
850_DNG	25.7	14.2	228
1395_Intact	72.9	31.6	1,441
1395_Thinned	63.9	70.3	2,810
1395_Scattered_trees	30.0	30.4	570
1395_DNG	28.4	31.5	557
	Total	**362.0**	**9,765**

Table 26-6: Ecosystem credits - WSA

Vegetation zone name	Vegetation integrity loss	Area (ha)	Ecosystem credits
724_Thinned	44.1	19.3	424
724_Scattered_trees	17.8	0.1	1
725_Intact	49.2	0.4	10
725_Thinned	43.3	8.2	178
725_Scattered_trees	19.6	3.0	29
781_Thinned	62.5	0.1	2
835_Intact	76.6	0.4	15
835_Thinned	57.1	18.6	532
835_Scattered_trees	68.7	15.1	518
849_Intact	53.9	10.4	351
849_Thinned	42.3	170.7	4,511
849_Scattered_trees	18.3	65.4	747
849_DNG	24.1	58.6	882
850_Intact	58.1	0.01	1
850_Thinned	41.9	5.7	149

Vegetation zone name	Vegetation integrity loss	Area (ha)	Ecosystem credits
850_Scattered_trees	38.1	2.1	49
850_DNG	25.7	0.2	3
1800_Intact	43.2	0.2	5
1800_Thinned	46.6	10.4	242
1800_Scattered_trees	41.2	0.4	8
	Total	**389.1**	**8,657**

Table 26-7: Ecosystem credits – GPEC

Vegetation zone name	Vegetation integrity loss	Area (ha)	Ecosystem credits
724_Intact	61.7	8.0	247
724_Thinned	44.1	24.8	545
724_Scattered_trees	17.8	0.1	1
725_Intact	49.2	15.2	373
725_Thinned	43.3	10.1	219
781_Thinned	62.5	2.0	63
835_Intact	76.6	11.6	444
835_Thinned	57.1	111.5	3,185
835_Scattered_trees	68.7	2.6	90
849_Intact	53.9	4.3	144
849_Thinned	42.3	110.9	2,930
849_Scattered_trees	18.3	4.3	50
849_DNG	24.1	8.8	132
850_Thinned	41.9	15.9	416
850_Scattered_trees	38.1	2.1	49
850_DNG	25.7	23.0	368
1800_Thinned	46.6	8.2	191
	Total	**363.2**	**9,447**

26.3.2 SPECIES CREDITS

As noted, the number and classes of biodiversity credits needed to offset the impacts of the development are not required to be retired under a strategic biodiversity certification (see Part 1). The adequacy of the commitments in offsetting the impacts of the development are evaluated in Part 7.

Table 26-8 to Table 26-11 identifies the area of impact and associated number of biodiversity credits for each impacted species credit species within each nominated area that would be required to be retired if the offset rules applied under the BC Act.

The total number of species credits that would be required to be retired to offset the impact of the proposed development on species credit species is 145,014 credits.

As noted, the number and classes of biodiversity credits needed to offset the impacts of the development are not required to be retired under a strategic biodiversity certification (see Part 1). The adequacy of the commitments in offsetting the impacts of the development are evaluated in Part 7.

Table 26-8: Species credits - Wilton

Species	Area (ha)	No. of species credits
Bynoe's Wattle (*Acacia bynoeana*)	122.19	2,366
Downy Wattle (*Acacia pubescens*)	167.48	3,004
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	0.66	24
Glossy Black Cockatoo (*Calyptorhynchus lathami*)	1.50	55
Eastern Pygmy-possum (*Cercartetus nanus*)	7.96	277
Large-eared Pied Bat (*Chalinolobus dwyeri*)	123.47	5,576
Epacris purpurascens var. *purpurascens*	696^	1,044
Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)	3.94	130
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	2.04	74
Giant Burrowing Frog (*Heleioporus australiacus*)	0.30	8
Hibbertia fumana	25.90	976
Hibbertia puberula	25.36	634
Deane's Paperbark (*Melaleuca deanei*)	46.29	1,303
Cumberland Plain Land Snail (*Meridolum corneovirens*)	102.99	3,148
Southern Myotis (*Myotis macropus*)	92.7	2,392
Bargo Geebung (*Persoonia bargoensis*)	39.38	1,231
Squirrel Glider (*Petaurus norfolcensis*)	64.26	1,860
Koala (*Phascolarctos cinereus*)	116.66	3,534
Spiked Rice-flower (*Pimelea spicata*)	397.08	4,190
Brown Pomaderris (*Pomaderris brunnea*)	16.32	534
Red-crowned Toadlet (*Pseudophryne australis*)	3.27	89
Sydney Plains Greenhood (*Pterostylis saxicola*)	14.33	502
Matted Bush-pea (*Pultenaea pedunculata*)	30.69	867
Masked Owl (*Tyto novaehollandiae*)	0.01	0
Total	**1,404.78**	**33,818**

^ Count of individuals – not included in area total

Table 26-9: Species credits – GMAC

Species	Area (ha)	No. of species credits
Bynoe's Wattle (*Acacia bynoeana*)	63.04	1,784
Downy Wattle (*Acacia pubescens*)	121.73	2,837
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	2.80	91
Glossy Black Cockatoo (*Calyptorhynchus lathami*)	7.20	262

Species	Area (ha)	No. of species credits
Eastern Pygmy-possum (*Cercartetus nanus*)	33.52	1,147
Large-eared Pied Bat (*Chalinolobus dwyeri*)	188.42	8,101
Epacris purpurascens var. *purpurascens*	893^	1,340
Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)	1.06	34
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	8.73	310
Giant Burrowing Frog (*Heleioporus australiacus*)	0.29	8
Hibbertia fumana	8.44	408
Hibbertia puberula	8.44	272
Little Eagle (*Hieraaetus morphnoides*)	14.40	332
Square-tailed Kite (*Lophoictinia isura*)	14.40	332
Marsdenia viridiflora subsp. *viridiflora* - endangered population	27.86	698
Deane's Paperbark (*Melaleuca deanei*)	56.17	1,695
Cumberland Plain Land Snail (*Meridolum corneovirens*)	162.17	4,520
Southern Myotis (*Myotis macropus*)	148.02	3,325
Powerful Owl (*Ninox strenua*)	0.25	7
Bargo Geebung (*Persoonia bargoensis*)	41.99	1,343
Squirrel Glider (*Petaurus norfolcensis*)	118.46	3,251
Koala (*Phascolarctos cinereus*)	143.92	4,223
Spiked Rice-flower (*Pimelea spicata*)	56.25	799
Brown Pomaderris (*Pomaderris brunnea*)	18.27	602
Red-crowned Toadlet (*Pseudophryne australis*)	5.75	157
Sydney Plains Greenhood (*Pterostylis saxicola*)	31.34	1,062
Matted Bush-pea (*Pultenaea pedunculata*)	27.74	729
Masked Owl (*Tyto novaehollandiae*)	0.36	10
Total	**1,311.02**	**39,679**

^ Count of individuals – not included in area total

Table 26-10: Species credits – WSA

Species	Area (ha)	No. of species credits
Bynoe's Wattle (*Acacia bynoeana*)	8.31	150
Downy Wattle (*Acacia pubescens*)	283.63	5,182
Eastern Pygmy-possum (*Cercartetus nanus*)	10.59	290
Dillwynia tenuifolia	74.29	1,179
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	280.53	3,838
Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)	7.02	154
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	0.62	20

Species	Area (ha)	No. of species credits
Hibbertia fumana	3.11	82
Hibbertia puberula	3.11	56
Little Eagle (*Hieraaetus morphnoides*)	1.14	23
Square-tailed Kite (*Lophoictinia isura*)	0.62	15
Marsdenia viridiflora subsp. *viridiflora* - endangered population	197.92	4,372
Maundia triglochinoides	9.13	213
Cumberland Plain Land Snail (*Meridolum corneovirens*)	212.44	4,712
Micromyrtus minutiflora	10.91	240
Southern Myotis (*Myotis macropus*)	292.45	5,930
Powerful Owl (*Ninox strenua*)	0.06	2
Tall Knotweed (*Persicaria elatior*)	0.13	3
Nodding Geebung (*Persoonia nutans*)	25.43	527
Spiked Rice-flower (*Pimelea spicata*)	275.14	3,702
Pultenaea parviflora	22.81	502
Matted Bush-pea (*Pultenaea pedunculata*)	78.51	1,400
Total	**1,797.90**	**32,592**

Table 26-11: Species credits – GPEC

Species	Area (ha)	No. of species credits
Bynoe's Wattle (*Acacia bynoeana*))	1.69	37
Downy Wattle (*Acacia pubescens*)	162.05	3,777
Allocasuarina glareicola	11.87	403
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	0.04	0
Eastern Pygmy-possum (*Cercartetus nanus*)	13.34	466
Large-eared Pied Bat (*Chalinolobus dwyeri*)	0.93	29
Dillwynia tenuifolia	101.32	2,228
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	177.22	3,013
Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)	4.00	89
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	5.17	198
Hibbertia puberula	4.67	77
Little Eagle (*Hieraaetus morphnoides*)	3.05	65
Green and Golden Bell Frog (*Litoria aurea*)	7.58	112
Square-tailed Kite (*Lophoictinia isura*)	12.51	296
Marsdenia viridiflora subsp. *viridiflora* - endangered population	186.56	4,494
Maundia triglochinoides	8.33	201
Cumberland Plain Land Snail (*Meridolum corneovirens*)	258.80	6,439

Species	Area (ha)	No. of species credits
Micromyrtus minutiflora (*Micromyrtus minutiflora*)	11.12	253
Southern Myotis (*Myotis macropus*)	212.00	5,321
Tall Knotweed (*Persicaria elatior*)	47.01	1,318
Nodding Geebung *(Persoonia nutans)*	15.28	343
Squirrel Glider (*Petaurus norfolcensis*)	139.34	3,490
Pimelea curviflora var. *curviflora*	72.97	1,648
Spiked Rice-flower (*Pimelea spicata*)	110.71	1,865
Sydney Plains Greenhood (*Pterostylis saxicola*)	0.93	20
Pultenaea parviflora	51.51	1,242
Matted Bush-pea (*Pultenaea pedunculata*)	70.79	1,486
Masked Owl (*Tyto novaehollandiae*)	0.52	15
Total	**1,691.31**	**38,925**

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AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 6A: STRATEGIC ASSESSMENT REPORT

CHAPTER 27 – INTRODUCTION

CHAPTER 28 – DESCRIPTION OF THE PROTECTED MATTERS AFFECTED BY THE PLAN

CHAPTER 29 – THREATENED FLORA IMPACT ASSESSMENT

CHAPTER 30 – THREATENED FAUNA IMPACT ASSESSMENT

CHAPTER 31 – THREATENED ECOLOGICAL COMMUNITIES IMPACT ASSESSMENT

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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27 Introduction

Parts 6a and 6b of the Cumberland Plain Assessment Report present the impact assessment for relevant matters protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

27.1 SCOPE OF THE EPBC ACT ASSESSMENT

As outlined in Chapter 1, the scope of the EPBC Act assessment includes:

- Urban and industrial development within urban capable land in nominated areas
- Infrastructure within urban capable land in nominated areas, as well as 'essential' infrastructure in limited cases within avoided lands in the nominated areas
- Agribusiness within agribusiness lands in the Western Sydney Aerotropolis (WSA)
- Western Sydney Major Infrastructure Corridors (transport corridors) within and outside nominated areas

Chapter 7 in Part 2 of the report provides details about these development types and locations.

27.2 STRUCTURE AND APPROACH TO PARTS 6A AND 6B

Part 6a (this document) includes:

- Chapter 27: Introduction (this chapter)
- Chapter 28: Description of the protected matters affected by the Plan
- Chapter 29: Listed threatened flora species
- Chapter 30: Listed threatened fauna species
- Chapter 31: Listed threatened ecological communities

Part 6b includes:

- Chapter 32: Listed migratory species
- Chapter 33: Ramsar wetlands
- Chapter 34: World and National Heritage
- Chapter 35: Areas of Commonwealth land
- Chapter 36: Analysis of the transport program
- Chapter 37: Analysis of the urban and industrial program
- Chapter 38: Cumulative impact assessment

Chapters in these Parts address the Terms of Reference for the assessment as they relate to specific protected matters. Parts 1, 2, 3, 4 and 7 of the report also address components of the Terms of Reference and must be read in conjunction with Parts 6a and 6b for a complete understanding of the project. Section 4.2.2 (in Chapter 4 of Part 1) sets out the Terms of Reference in full and identifies where they have been addressed throughout the report.

Given the size and complexity of the assessment report, each chapter in Parts 6a and 6b attempts to provide a stand-alone analysis of the relevant issues. However, to avoid excessive repetition each chapter includes cross references to other relevant sections of the report and supporting documents where it is appropriate to do so. For example, details about the baseline data used in the assessment are provided in Part 3 of the report.

Each chapter provides:

- An introduction that sets out the assessment approach for those protected matters
- Descriptions of the relevant protected matters
- Analysis of:
    - How impacts have been avoided

  - Any direct impacts and offsets
  - Potential indirect impacts and mitigation measures
  - An evaluation of the outcomes for each protected matter against the relevant requirements of the EPBC Act and Terms of Reference
- Where appropriate, detailed attachments for any specific technical information that is best presented separately and out of the main text
- Maps of the protected matters (e.g. habitat and records for threatened species). In some cases these are presented within chapters and in others are presented as separate files which can be viewed as layered PDFs. Layered PDFs enable more information to be presented on maps and allow viewers to turn layers on and off as they interrogate the information

Reference lists are provided at the end of both Part 6a and 6b.

28 Description of the protected matters affected by the Plan

This Chapter describes the protected matters likely to be affected by the Plan by:

- Providing a high-level description of the existing environment within the Strategic Assessment Area
- Identifying the relevant matters for assessment under the EPBC Act

28.1 EXISTING ENVIRONMENT

As required by Clause 3.1 of the Terms of Reference:

> *The Report must describe the nature of the environment within the Strategic Assessment Area, and other areas outside the Strategic Assessment Area that may be impacted by actions taken under the Plan. This must include (at a minimum):*
>
> 1. *A description of historical and current land use*
> 2. *The extent and quality of native vegetation present including detailed mapping of ecological communities and habitat for threatened species listed under the EPBC Act*
> 3. *The nature of the environment, including ecosystem processes and threatening processes*
> 4. *A description of the landscape context for key environmental matters, including connectivity, habitat fragmentation and ecological processes*
> 5. *A spatial map of areas that are already protected for environmental purposes, including Bio-banking and Biodiversity Stewardship sites*

This section broadly addresses these requirements. For the Strategic Assessment Area, it provides:

- A discussion of historical and existing land uses
- An overview of native vegetation
- A description of ecological processes
- A description of threatening processes
- Information about currently protected areas

Detailed information about threatened ecological communities (TECs) and species (e.g. mapping of individual species habitat) as well as relevant protected matters that sit outside the Strategic Assessment Area is provided elsewhere in this report.

28.1.1 HISTORICAL AND EXISTING LAND USES

The Strategic Assessment Area occurs primarily within the Cumberland IBRA subregion of Western Sydney (Cumberland subregion). The Cumberland subregion is a broad geographic basin that is bounded by the Hornsby Plateau in the north, the base of the Blue Mountains in the west, the Woronora plateau in the south, and the centre of Sydney to the east. It has an area of approximately 275,000 hectares, rising gradually from the flat low-lying areas at sea level in the east to an altitude of around 350 metres on the margins to the north and south.

The Strategic Assessment Area has been greatly affected by historical and ongoing land use pressures. Its gentle undulating plains and fertile soils mean it has been a focus of agriculture and occupation both before and after European settlement (DECCW, 2011).

Before European settlement it had extensive grassy woodlands and abundant fauna. Hundreds of records of Aboriginal sites have been found across the subregion, suggesting it was an important area for Aboriginal people. Records indicate Aboriginal occupation of the Sydney region for at least 20,000 years, and possibly 40,000 years (Nanson, Young et al., 1987; Stockton, 2009; Stockton & Holland, 1974). There also is evidence of Aborigines using fire to manage the landscape to establish mosaics of forest and grassland in a way that facilitated hunting of kangaroos (Gammage, 2011).

Since European settlement the Strategic Assessment Area has been used for agriculture and more recently for urban development. Agriculture was established by European settlers in 1792, and since the mid-1900s most of the area has been subject to grazing or cultivation (Tozer, 2003). Fire and clearing have been used extensively to support this.

In the second half of 1900s, Sydney's growth accelerated and residential, commercial and industrial areas expanded further into the Cumberland subregion (Benson & Howell, 1990). At 2019, the Cumberland subregion is expected to support 44 per cent of Sydney's population (DECCW, 2011). The need to accommodate and provide services for the increasing urban population has put pressure on existing agriculture. The Sydney Metropolitan Area is predicted to reach 6 million by 2036. (DECCW, 2011). One recent study projected that on the current trajectory, by 2031 total food production in the Basin may reduce by 60 per cent, including 90 per cent of fresh vegetable production (Institute for Sustainable Futures, 2016).

28.1.2 NATIVE VEGETATION

The native vegetation in the Cumberland subregion is diverse and very different to the surrounding areas. It supports a variety of flora and fauna, including a range of migratory and threatened species. As a result of historical and ongoing patterns of use, the Cumberland subregion and its biodiversity have suffered significant disturbance and it is thought to be one of the most threatened regions in NSW (DEC, 2005b). Many of the ecological communities and the fauna and flora they support are listed as threatened under both NSW and Commonwealth environmental legislation. Approximately 8 per cent of the remaining bushland is protected in reserves (DECCW, 2011).

Areas of remaining native vegetation (see Figure 28-1) are often of high conservation value as they may contain the only remaining habitat for ecological communities and species that rely on the Cumberland subregion for survival.

Native vegetation remaining in the Strategic Assessment Area comprises 39 different PCTs which represent 19 vegetation classes within 10 vegetation formations.

In 2010 only 13 per cent of the pre-1750 extent of the region's vegetation remained as intact, with an additional 12 per cent occurring as scattered trees in disturbed areas (DECCW, 2011). What remains is often highly fragmented. An estimated 2,446 individual native vegetation remnants remain, and the 81 largest patches (containing >50ha) represent 51 per cent of the remaining native vegetation across the Cumberland subregion (DECCW, 2011).

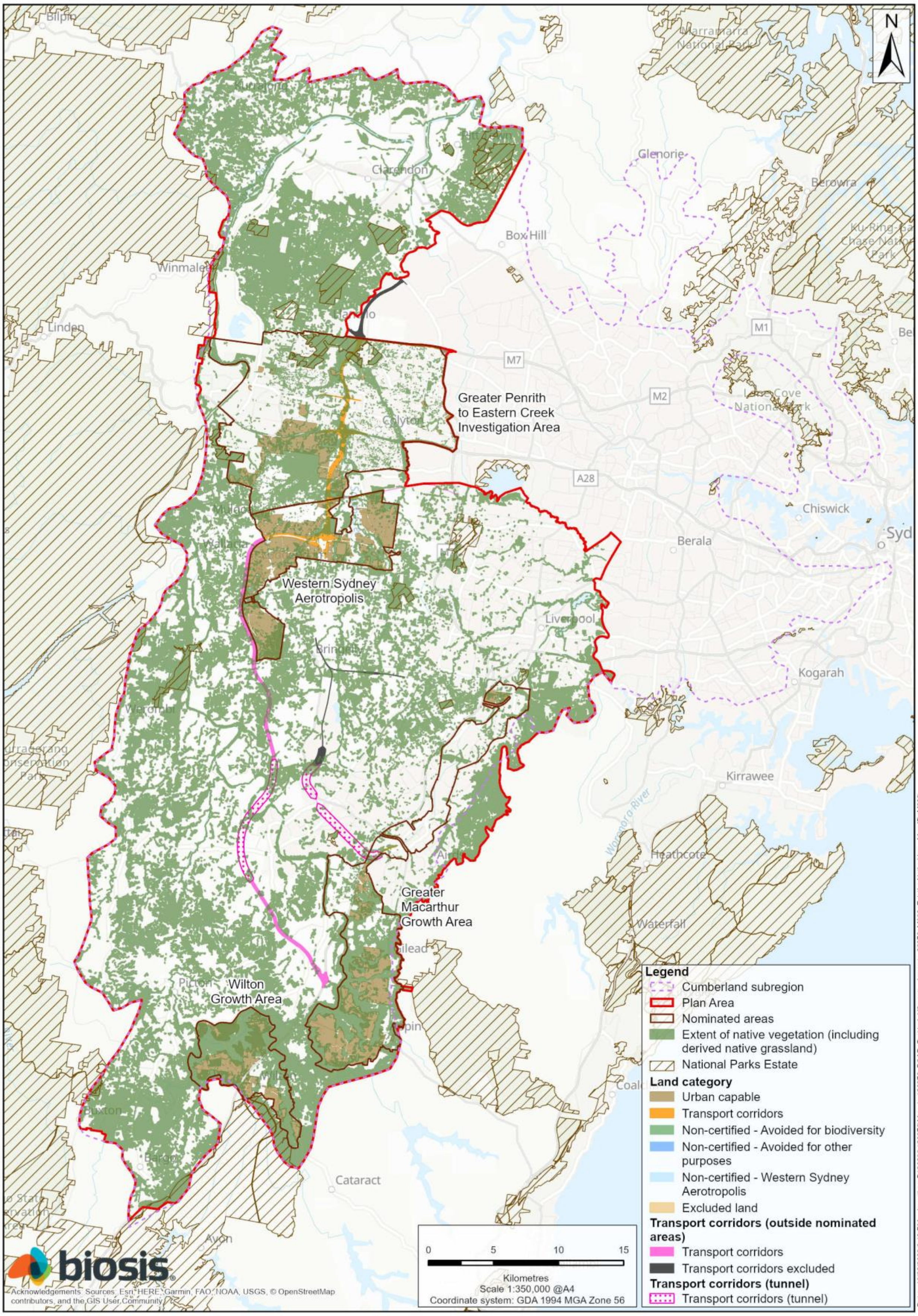

Figure 28-1: Extent of native vegetation in the Strategic Assessment Area

28.1.3 ECOLOGICAL PROCESSES

The ecological processes in an area determine the species composition, habitat structure, and ecological health of sites and landscapes. They include biological, physical, and chemical processes such as natural disturbance, hydrology, nutrient cycling, flora and fauna interactions, population dynamics, and evolution (US EPA, 1999).

There are several ecological processes that are particularly relevant to consideration of the Plan and its contribution to the Cumberland subregion. They are:

- Landscape connectivity and fragmentation
- Fire regimes
- Soil nutrient cycling
- Hydrology

LANDSCAPE CONNECTIVITY AND FRAGMENTATION

Landscape connectivity is important for biodiversity as it allows the linkage of habitats, species, communities and ecological processes. In undisturbed areas connectivity is high, and as development increases, fragmentation occurs.

Larger patches of vegetation are often more diverse and less susceptible to 'edge effects'. Edge effects are an indirect impact of habitat fragmentation. New environmental conditions at edges can promote growth of invasive species and weeds which can compete with native flora and fauna. Altered conditions can also reduce the health of important habitat features such as hollow-bearing trees. Changes in connectivity can allow invasion of pest fauna specialising in edge habitats which may alter the behaviour of resident animals and make them at risk of higher levels of predation.

The Cumberland subregion is highly fragmented, and connectivity is already compromised to the point that many of the species that previously occurred there are no longer present (DECCW, 2011). However, it is still very important for species such as Koalas, woodland birds, and a range of flora. Once clearing levels exceed 70 per cent of the landscape, biodiversity loss from fragmentation increases (DECCW, 2011). This threshold has been passed already in the Cumberland subregion (DECCW, 2011).

Significant conservation planning has occurred in the Cumberland subregion over the last decade which has examined landscape connectivity. Following the Cumberland Plain Recovery Plan (DECCW, 2011), EES prepared the Biodiversity Investment Opportunities Map (BIO Map) (OEH, 2015), to ensure that conservation funding within the subregion is targeted towards areas of greatest strategic benefit.

BIO Map identifies Priority Investment Areas (PIAs) where the protection and management of native vegetation is likely to maximise benefits to biodiversity within the subregion. The PIAs comprise:

- Core areas: large areas of native vegetation and habitat where management will be of greatest benefit to the conservation of biodiversity values. These areas represent the habitat in the Cumberland subregion most likely to support species persistence and interactions between species and landscape-scale ecological processes
- Regional biodiversity corridors: linear areas that link core areas and play a crucial role in maintaining connections between species populations that would otherwise be isolated and at greater risk of local extinction

BIO Map identifies a total of 87 core areas and 27 regional biodiversity corridors within the Cumberland subregion. The core areas comprise a total of 20,175 ha of native vegetation and the corridors a total of 11,672 ha of native vegetation.

The combination of core and corridor areas is considered suitable for use as a surrogate measure of habitat connectivity. See Figure 28-2 for the Cumberland subregion BIO Map.

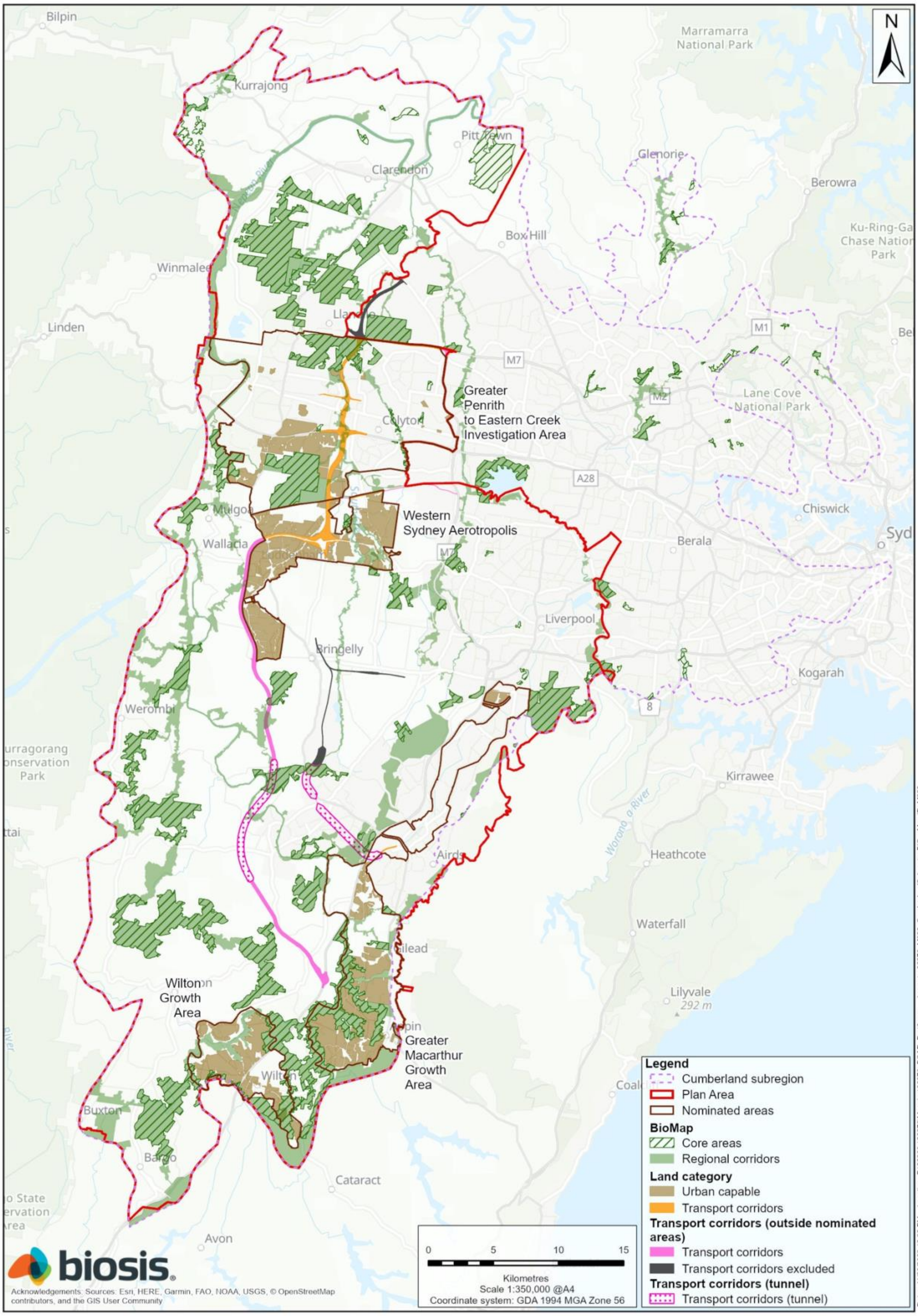

Figure 28-2: Cumberland subregion BIO Map

FIRE

Fire has been shown to be important in maintaining native species richness in remnant grasslands in south-eastern Australia (Lunt & Morgan, 2002; Lunt, Prober et al., 2012).

Fire regimes in the Cumberland subregion were established over hundreds of years and fire plays an important role in shaping the landscape and vegetation. The fire regimes of the subregion have been significantly altered over time due to urbanisation. In and around urban areas, fire is primarily used to manage fire risk to property from surrounding vegetation. This results in either more frequent fires than would occur naturally (through hazard reduction burns), or alternatively the total exclusion of fire. Both of these situations represent a deviation from natural fire patterns and this impacts fire-dependent vegetation communities.

Fire regimes are characterised by their frequency, seasonality, and intensity. Different ecological communities have different recommended fire intervals. For example, the suggested minimum fire interval for Cumberland Plain Woodland is five years and the maximum fire interval is 12 years (DECCW, 2011). For other communities, including Moist Shale Woodland and Western Sydney Dry Rainforest, burning is not recommended at all (DECCW, 2011). In general, grassy woodlands require a higher fire frequency than shrubby woodlands (DECCW, 2011).

Particularly relevant to restoration efforts, fire can be used to increase the native species richness in previously cleared Cumberland Plain Woodland derived grasslands (Morris, de Barse et al., 2016).

SOIL NUTRIENT CYCLING

Soil nutrient cycling is another important ecological process that contributes to the healthy functioning of vegetation communities and species habitats on the Cumberland subregion. It does this through storing water and carbon and transforming waste and nutrients.

Natural soil nutrient cycling processes have been negatively affected in several ways through urbanisation and agricultural practices. Grazing has led to soil compaction, which hinders the re-establishment of a diverse native understorey, and makes soil more susceptible to erosion.

The soils of Cumberland Plain woodland communities have been shown to be subject to nutrient loading from fertilisers from previous agricultural use, deposition of livestock dung, rubbish dumping and stormwater runoff from urban areas (NSW Scientific Committee, 2009). The soils of other vegetation communities within the Cumberland subregion would have likely also been subject to similar nutrient loading.

The effects of agriculture and urbanisation on soils of the Cumberland subregion have promoted invasion by exotic species, displacing native species (Hill, Tung et al., 2005). Areas that have been cleared and grazed are now dominated by exotics (mainly perennial grasses), which make up two thirds of the canopy cover and up to half of species richness (Hill, Tung et al., 2005). This is partly due to elevated levels of soil nitrogen (which is found in fertilisers) that creates conditions which favour that exotic species over native species.

Understanding soil nutrient cycling is relevant for restoration efforts. A study examining barriers to restoring Cumberland Plain Woodland on previously cleared areas found that adding carbon to the soil and/or fire, when combined with native seed addition, increased the abundance and species richness of native species relative to exotic species (Morris & de Barse, 2013). Adding carbon to the soil reduces the nitrate levels in the soil and increases soil microbes, creating conditions that allow natives to be more competitive with exotic species.

HYDROLOGY

The Strategic Assessment Area occurs within two catchments and is traversed by a number of major rivers and a wide range of smaller waterways (see Figure 28-3). The two catchments are:

- Botany Bay
- Hawkesbury-Nepean

Development and agricultural practices over the years have reduced riparian vegetation and impacted the hydrology of the catchments. During heavy rain water moves more quickly off surfaces which leads to flooding, erosion, and sedimentation and can contribute to reduced water quality (DEC, 2005b). For plants and animals dependent on flood flows to trigger critical life cycle events, changes to hydrology could impact their viability.

Botany Bay catchment

Parts of Greater Macarthur Growth Area (GMAC) occur within the Georges River sub-catchment of the Botany Bay catchment. The Georges River ultimately flows directly into Botany Bay and the waters surrounding Towra Point Ramsar site (outside the Strategic Assessment Area).

The water quality of the Georges River varies depending upon the degree of development within each sub-catchment of the river. The water quality in the vicinity of GMAC ranges from poor (within the Bunbury-Curran Creek sub-catchment) to good (the Mid Georges River sub-catchment) (GRCCC, 2016). Large areas of the upper reaches of the catchment are vegetated, which provides protection from activities that reduce water quality.

Hawkesbury-Nepean catchment

The majority of the Strategic Assessment Area occurs within the Hawkesbury-Nepean catchment. The catchment is one of the longest coastal catchments in NSW, stretching from Broken Bay in the north to Goulburn in the south with the Hawkesbury-Nepean river flowing for 470 km and draining more than 22,000 km^2 of land (Western Sydney University, 2016).

The Nepean River flows south to north through the Strategic Assessment Area to near the point that it becomes the Hawkesbury River where it junctions to the Grose River. Wianamatta (South Creek) is another major waterway running through Western Sydney Aerotropolis (WSA) and Greater Penrith to Eastern Creek Investigation Area (GPEC). Many of the waterways in the Strategic Assessment Area have extensive floodplains (GES, 2018).

Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by the negative effects of historical land uses (e.g. clearing, urbanisation) (GES, 2018).

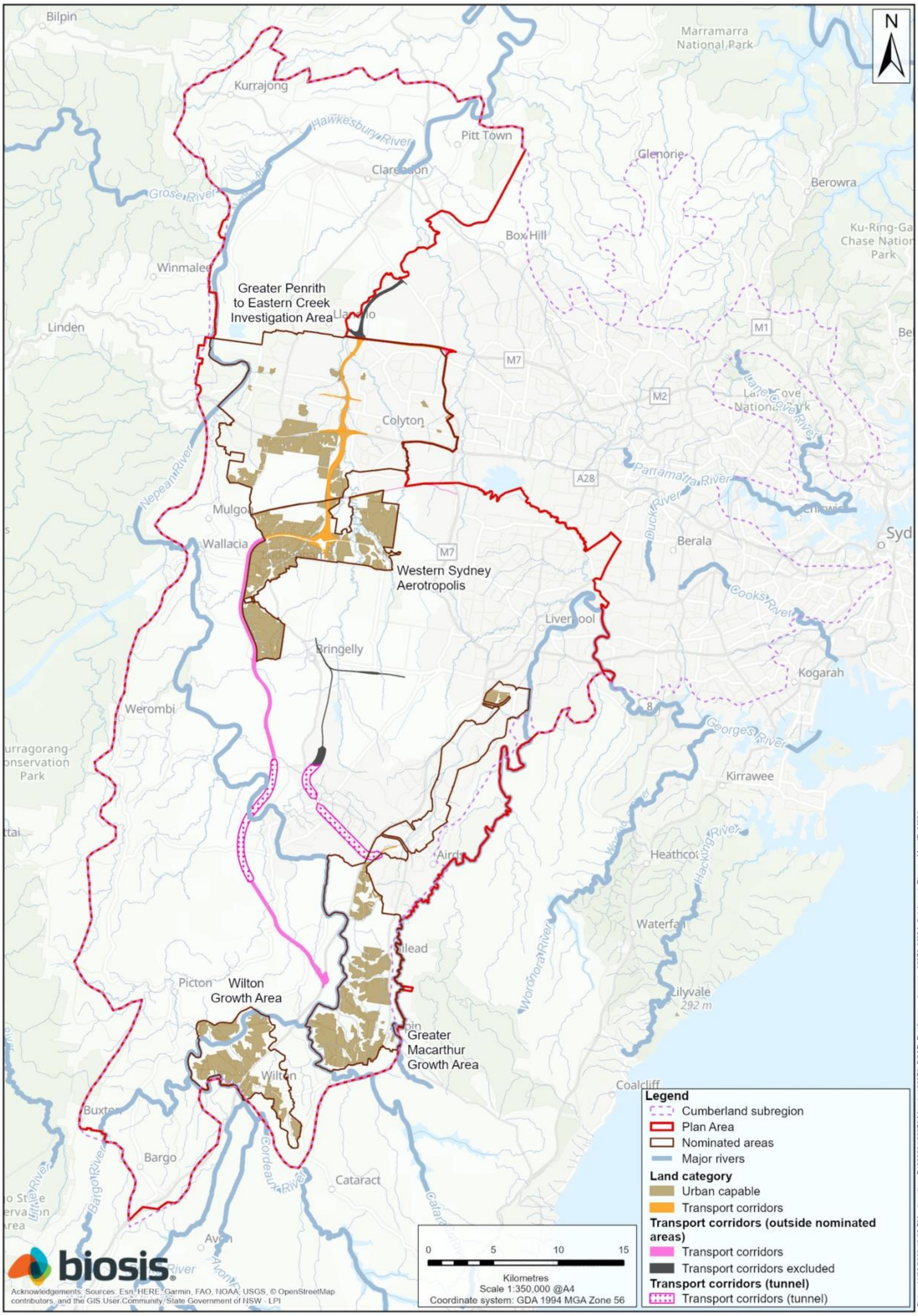

Figure 28-3: Major rivers of the Strategic Assessment Area

28.1.4 THREATENING PROCESSES

A process is defined as a threatening process under the EPBC Act if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

The EPBC Act enables the listing of key threatening processes. A threatening process may be added to the list of key threatening processes in several circumstances, including where it could cause a native species or an ecological community to become eligible for listing under the EPBC Act as threatened.

The key threatening processes in the Cumberland subregion fall into the following categories:

- Habitat loss
- Climate change
- Weeds
- Pest animals
- Fire
- Disease

HABITAT LOSS

Habitat loss is one of the key threats to the biodiversity of the Cumberland subregion (DECCW, 2011). Further clearing of native vegetation places more pressure on already over-cleared landscapes and leads to increasingly isolated and small remnants that are more susceptible to degradation, provide less habitat and support fewer species (DECCW, 2011).

The EPBC Act lists 'Land clearance' under this category.

CLIMATE CHANGE

Climate change is a key threat to the biodiversity of the Cumberland subregion (DECCW, 2011). The nature and extent of the threat is difficult to quantify, but may include (DECCW, 2010):

- Reductions in the geographic range of species
- Changes to the timing of species' lifecycle events
- Changes in population dynamics and survival
- Changes in the location of species' habitats
- Increases in the risk of extinction for species that are already vulnerable
- Increased opportunity for range expansion of invasive species
- Changes in the structure and composition of ecosystems and communities
- Increased likelihood of extreme weather events and fire
- Changes in coastal and estuarine habitat due to rising sea levels

The EPBC Act lists 'Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases' under this category.

WEED INVASION

Weed invasion is an ongoing threat to the remaining vegetation in the Cumberland subregion. In particular, African Olive, African Lovegrass and Bridal Creeper have established themselves widely, are very competitive and can dominate native understory species (DECCW, 2011; Tozer, 2003).

Key threatening processes listed under the EPBC Act in this category include:

- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
- Novel biota and their impact on biodiversity

Several threatening processes relevant to the subregion are also listed under the *Biodiversity Conservation Act 2016* (BC Act) in this category, including:

- Invasion of native plant communities by African Olive
- Invasion, establishment and spread of Lantana
- Invasion of native plant communities by exotic perennial grasses

PEST ANIMALS

Pest animals are a key threat to native fauna species and native vegetation in the Cumberland subregion, including threatened ecological communities such as Cumberland Plain Woodland (DIPNR, 2003). Grazing by pest animals has prevented the recovery and regeneration of native species (DIPNR, 2003).

KTPs listed under the EPBC Act in this category include:

- Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)
- Competition and land degradation by rabbits
- Competition and land degradation by unmanaged goats
- Predation by European red fox
- Predation by feral cats
- Predation, habitat degradation, competition and disease transmission by feral pigs
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*)

FIRE

Inappropriate fire regimes are a key issue for biodiversity, particularly ecological communities, in the Cumberland subregion. Frequent fire from arson is a major problem and has resulted in a significant change to ecological communities in the subregion, which have evolved and been selected by pre-European practices to be dependent on a certain fire regime (DECCW, 2011).

High frequency fire and inappropriate fire regimes have been identified as threats to a number of species and ecological communities in the Cumberland subregion, including Cumberland Plain Woodland (NSW Scientific Committee, 2000).

No key threatening processes listed under the EPBC Act are included in this category.

The BC Act lists 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' as a threatening process under this category.

DISEASE

KTPs listed under the EPBC Act in this category include:

- Dieback caused by the root-rot fungus *Phytophthora cinnamomi*
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis
- Novel biota and their impact on biodiversity
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species

Phytophthora has the potential to affect several ecological communities in the Cumberland subregion, including Castlereagh Scribbly Gum and Agnes Banks Woodland, Cumberland Plain Woodland and Shale Sandstone Transition Forest (DoEE, 2018d).

Several frog species are under threat from the impacts of chytrid fungus in the subregion, including Green and Golden Bell Frog and Giant Burrowing Frog (DoEE, 2016b).

Although not listed under the EBPC Act, psyllid-induced dieback of grey box in the Cumberland subregion has been observed. Specifically a native lace lerp species, or psyllid (*Cardiaspina* sp.) has been found to cause defoliation, canopy dieback and tree mortality on *E. moluccana* (NSW Environmental Trust & NSW Environmental Trust, 2016). The canopy loss removes patches from being within the EPBC-listed state as it is dependent on the presence of a minimum foliage density.

28.1.5 CURRENTLY PROTECTED AREAS

There are a range of currently protected lands within the Strategic Assessment Area (see Figure 28-4). These comprise:

- Land within the National Parks estate
- Land that is in the process of being incorporated into the National Parks estate
- Existing offset sites
- Existing Biobank and Biodiversity Stewardship sites

The total area of protected lands within the Strategic Assessment Area is 9,063 hectares.

Existing offset sites, BioBank and Biodiversity Stewardship sites have not been shown in Figure 28-4 due to privacy reasons.

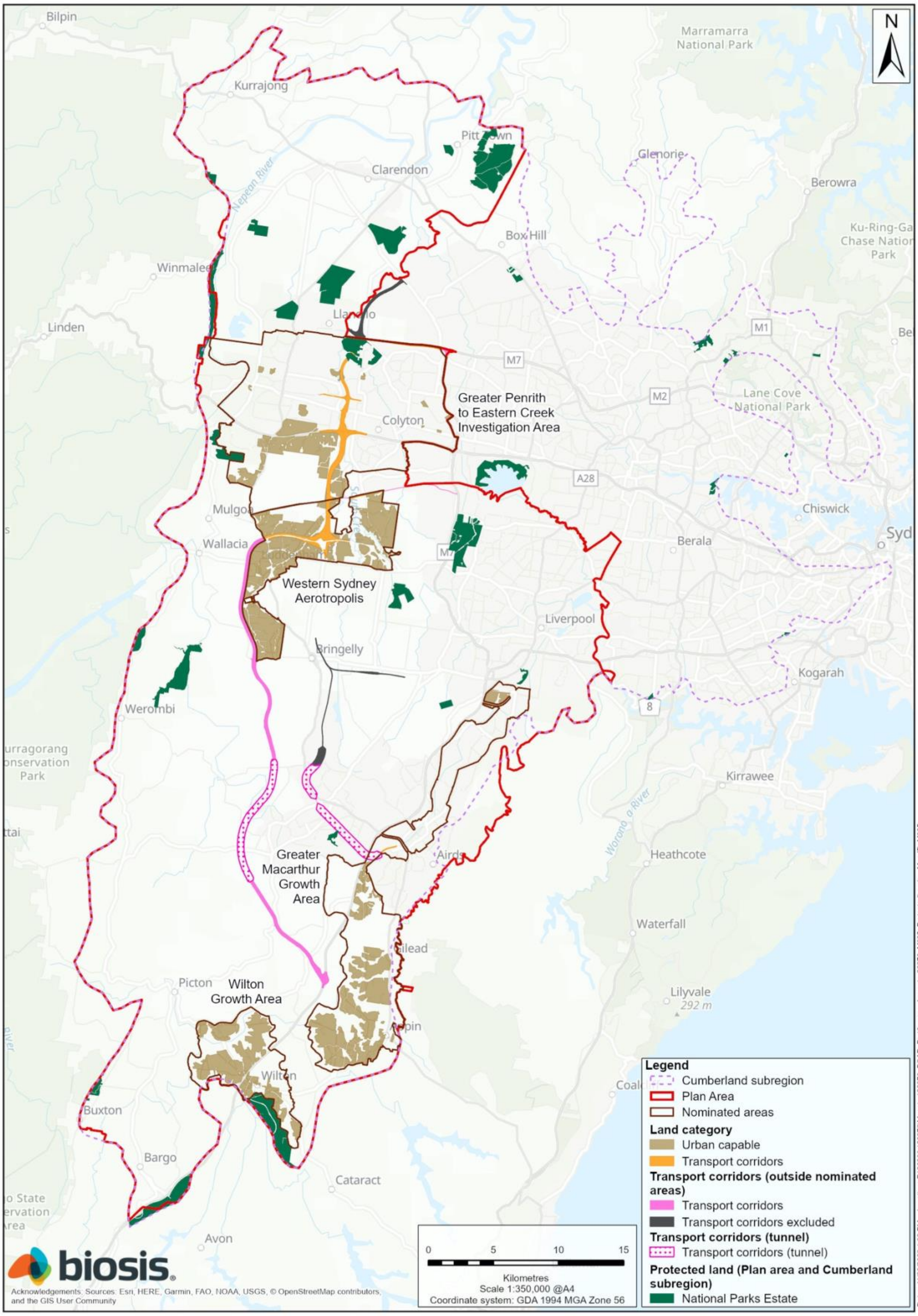

Figure 28-4: Currently protected lands within the Strategic Assessment Area

28.2 RELEVANT PROTECTED MATTERS

As required by Clause 3.2 of the Terms of Reference:

> *The Report must identify and describe each protected matter that may be impacted directly, indirectly and cumulatively by actions taken under the Plan…*

A method to identify these matters was applied (see Section 11.1.2 in Part 3 of the report). This was based on applying a set of criteria and using expert input to assign the full list of potential matters for the Strategic Assessment Area into one of two categories:

- Category 1: matter needs detailed assessment. These matters are reliant on the Cumberland subregion, have some potential to be impacted (directly, indirectly or cumulatively), and are addressed in detail in the SAR
- Category 2: assessment of the matter is completed and no further analysis is required. These matters are not reliant on the Cumberland subregion, are subject to no or very low risk of impacts (directly, indirectly or cumulatively), and are not addressed further in the SAR

This work identified the following groups of protected matters as being relevant to the assessment:

- Listed threatened species (see Section 28.2.1)
- Listed threatened ecological communities (see Section 28.2.2)
- Listed migratory species (see Section 28.2.3)
- Finalised Priority Assessment List (FPAL) (see Section 28.2.4)
- Wetlands of international importance (Ramsar wetlands) (see Section 28.2.5)
- World and National Heritage (see Section 28.2.6)
- Commonwealth land (see Section 28.2.7)

Detailed impact assessments have been undertaken for Category 1 protected matters which are highlighted in blue in the following tables.

28.2.1 THREATENED SPECIES

The following threatened species were assigned to Category 1 for detailed assessment in the report:

- 20 threatened fauna species (see Table 28-1)
- 23 threatened flora species (see Table 28-2)

Detailed impact assessments for Category 1 threatened species are presented in Chapter 29 (flora species), Chapter 30 (threatened species) and Chapter 32 (migratory species).

Table 28-1: Threatened fauna

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
BIRDS						
Anthochaera phrygia	Regent Honeyeater	Critically Endangered	Critically Endangered	1, 1.36%, 0.63%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Botaurus poiciloptilus	Australasian Bittern	Endangered	Endangered	1, 3.97%, 0.42%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Calidris canutus	Red Knot, Knot	Endangered; Migratory	Not Listed	1, 0.34%, 0	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Calidris ferruginea	Curlew Sandpiper	Critically Endangered; Migratory	Not Listed	1, 0.08%, 0.03%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Calidris tenuirostris	Great Knot	Critically Endangered; Migratory;	Vulnerable	0, 0, 0.08%	Category 2	The species has a broad Australian distribution and NSW does not contain any important sites for the species. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Vulnerable; Migratory	Vulnerable	1, 0.63%, 0.11%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Charadrius mongolus	Lesser Sand Plover, Mongolian Plover	Endangered; Migratory	Not Listed	0, 0, 0.06%	Category 2	The species has a widespread Australian distribution and no records occur in the Strategic Assessment Area. It is unlikely to occur in the Strategic Assessment Area
Dasyornis brachypterus	Eastern Bristlebird	Endangered	Endangered	0, 0, 1.3%	Category 2	The species does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Diomedea antipodensis	Antipodean Albatross	Vulnerable	Vulnerable	0, 0, 0	Category 2	The species is endemic to New Zealand and forages in open water off the coast of NSW. It is unlikely to occur in the Strategic Assessment Area
Diomedea antipodensis gibsoni	Gibson's Albatross	Vulnerable	Vulnerable	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Diomedea epomophora	Southern Royal Albatross	Vulnerable; Migratory	Not Listed	0, 0, 0	Category 2	The species forages in open water off the east, west and south Australian coast. It is unlikely to occur in the Strategic Assessment Area
Diomedea exulans	Wandering Albatross	Vulnerable; Migratory	Endangered	0, 0, 0	Category 2	The species forages in open water from Fremantle in WA around southern Australia to the Whitsunday Islands in Queensland. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Diomedea sanfordi	Northern Royal Albatross	Endangered	Not Listed	0, 0, 0	Category 2	The species has a broad distribution across the Southern Ocean. It forages in waters off Tasmania and South Australia, and less frequently in NSW waters. It is unlikely to occur in the Strategic Assessment Area
Grantiella picta	Painted Honeyeater	Vulnerable	Vulnerable	0, 0.18%, 0.16%	Category 2	The species has a broad but sparse distribution from south-east Australia to the Northern Territory that is associated with the fruiting of mistletoe. It is unlikely to be reliant on the Strategic Assessment Area
Hirundapus caudacutus	White-throated Needletail	Vulnerable; Migratory	Not Listed	0, 2.43%, 0.38	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Lathamus discolor	Swift Parrot	Critically Endangered	Endangered	1, 9.49%, 0.41%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Limosa lapponica baueri	Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit	Vulnerable; Migratory	Not Listed	1, 0, 0.06%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)	Critically Endangered; Migratory	Not Listed	0, 0, 0.06%	Category 2	The species occurs predominately in Western Australia and is not considered likely to occur in the Strategic Assessment Area
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel	Endangered; Migratory	Endangered	0, 0, 0	Category 2	The species is a pelagic bird with a range as far as northern Queensland. It does not occur in the Strategic Assessment Area and is unlikely to be reliant on the area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Macronectes halli	Northern Giant Petrel	Vulnerable; Migratory	Vulnerable	0, 0, 0	Category 2	The species is a pelagic bird with an Australian distribution from Freemantle in WA to Sydney in NSW. No records occur in the Strategic Assessment Area and it is unlikely to be reliant on the area
Neophema chrysogaster	Orange-bellied Parrot	Critically Endangered	Critically Endangered	0, 0, 0.09%	Category 2	The species is associated with saltmarsh and foredune vegetation communities either on coastlines or coastal lagoons. No records occur in the Strategic Assessment Area and it is unlikely to be reliant on the area
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Critically Endangered; Migratory	Not Listed	1, 0, 0.05%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Pachyptila turtur	Fairy Prion	Vulnerable	Not Listed	0, 0, 0	Category 2	The species has a circumpolar distribution and is known from areas in the vicinity to Macquarie Island, and Bishop and Clerk Island. No records occur in the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area due to the lack of suitable habitat
Pachyptila turtur subantarctica	Fairy Prion (southern)	Vulnerable	Not Listed	0, 0, 0	Category 2	The species has a circumpolar distribution and is known from areas in the vicinity to Macquarie Island, and Bishop and Clerk Island. No records occur in the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area due to the lack of suitable habitat
Rostratula australis	Australian Painted Snipe	Endangered	Endangered	1, 6.38%, 0.07%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Rostratula benghalensis (sensu lato)	Painted Snipe	Endangered	Not Listed	0, 0, 0.07%	Category 2	The species is generally accepted as *Rostratula australis*. The Australian painted snipe is now accepted as a full species rather than a sub species of *Rostratula benghalensis*, based on morphological differences (listing advice). This does not need assessment because *Rostratula australis* is being assessed
Sternula nereis nereis	Australian Fairy Tern	Vulnerable	Not Listed	0, 0, 0	Category 2	The species' extent occurs along the coast from NSW to Western Australia, including Tasmania. It is associated with offshore estuarine or lake islands, wetlands, beaches and spits. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche bulleri	Buller's Albatross, Pacific Albatross	Vulnerable; Migratory	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters with a broad distribution. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche bulleri platei	Northern Buller's Albatross, Pacific Albatross	Vulnerable	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters with a broad distribution. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche cauta	Tasmanian Shy Albatross	Vulnerable; Migratory	Vulnerable	0, 0, 0	Category 2	The species is accepted as being the same as *Thalassarche cauta cauta*. It is a non-breeding visitor to Australian waters and does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Thalassarche cauta cauta	Shy Albatross, Tasmanian Shy Albatross	Vulnerable	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters with a broad distribution. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Thalassarche cauta steadi	White-capped Albatross	Vulnerable	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters, particularly off the coast of south-east Australia. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche eremita	Chatham Albatross	Endangered	Not Listed	0, 0, 0	Category 2	The species' principle foraging range occurs in waters off the coast off eastern and southern New Zealand, and Tasmania. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	Vulnerable	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters. Its Australian distribution occurs over the oceanic continental slope off the coast of Tasmania, Victoria and NSW. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche melanophris	Black-browed Albatross	Vulnerable; Migratory	Vulnerable	0, 0, 0	Category 2	The species breeds on Heard Island, Macquarie Island, McDonald Islands, and Bishop and Clerk Islets and has a broad Australian oceanic distribution. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Thalassarche salvini	Salvin's Albatross	Vulnerable	Not Listed	0, 0, 0	Category 2	The species is a non-breeding visitor to Australian waters, with a broad distribution. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
MAMMALS						
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	Vulnerable	Vulnerable	0, 3.19%, 0.61%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (south eastern mainland population)	Endangered	Vulnerable	1, 0.4%, 0.98%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern)	Endangered	Endangered	0, 0, 0.59%	Category 2	The species distribution extends from the Hawkesbury River in NSW to Kangaroo Island in South Australia. In NSW it occurs in two populations located in Ku-ring-gai Chase and Garigal National Parks, and far south east NSW around Ben Boyd National Park. It is unlikely to occur in the Strategic Assessment Area
Megaptera novaeangliae	Humpback Whale	Vulnerable	Vulnerable	0, 0, 0	Category 2	The species occurs in marine areas. It is unlikely to occur in the Strategic Assessment Area
Petauroides volans	Greater Glider	Vulnerable	Not Listed	3, 0.15%, 0.37%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Petrogale penicillata	Brush-tailed Rock-wallaby	Vulnerable	Endangered	0, 0, 0.87%	Category 2	The species' distribution occurs along the Great Dividing Range from Queensland to Victoria. No records occur in the Strategic Assessment Area and it is unlikely to be reliant on the area
Phascolarctos cinereus	Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory)	Vulnerable	Vulnerable	1, 0.89%, 0.22%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Potorous longipes	Long-footed potoroo	Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs in Victoria and south eastern NSW. No records occur in the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Potorous tridactylus tridactylus	Long-nosed Potoroo (SE mainland)	Vulnerable	Vulnerable	0, 0, 0	Category 2	The species' distribution occurs from Queensland to eastern Victoria and Tasmania. No records occur on the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Pseudomys fumeus	Smoky mouse	Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs in south-east NSW in the vicinity of Kosciuszko National Park. No records occur on the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Pseudomys novaehollandiae	New Holland Mouse, Pookila	Vulnerable	Not Listed	0, 0, 2.09%	Category 2	The species has a fragmented distribution from Queensland down to Tasmania. No records occur in the Strategic Assessment Area and it is unlikely to occur in the area
Pseudomys oralis	Hastings River mouse	Endangered	Endangered	0, 0, 0	Category 2	The species' range extends from Mount Royal National Park in NSW to Main Range National Park in Queensland. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Pteropus poliocephalus	Grey-headed Flying-fox	Vulnerable	Vulnerable	4, N/A, 0.42%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
REPTILES						
Caretta caretta	Loggerhead Turtle	Endangered; Migratory	Endangered	0, 0, 0	Category 2	The species is a marine animal. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Chelonia mydas	Green Turtle	Vulnerable; Migratory	Vulnerable	0, 0, 0	Category 2	The species is a marine animal. It is unlikely to occur in the Strategic Assessment Area
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle, Luth	Endangered; Migratory	Endangered	0, 0, 0	Category 2	The species is a marine animal. It is unlikely to occur in the Strategic Assessment Area
Eretmochelys imbricata	Hawksbill Turtle	Vulnerable; Migratory	Not Listed	0, 0, 0	Category 2	The species is a marine animal. It is unlikely to occur in the Strategic Assessment Area
Hoplocephalus bungaroides	Broad-headed Snake	Vulnerable	Endangered	0, 0.87%, 4.34%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Natator depressus	Flatback Turtle	Vulnerable; Migratory	Not Listed	0, 0, 0	Category 2	The species is a marine animal. It is unlikely to occur in the Strategic Assessment Area
AMPHIBIANS						
Heleioporus australiacus	Giant Burrowing Frog	Vulnerable	Vulnerable	0, 0.84%, 1.54%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Litoria aurea	Green and Golden Bell Frog	Vulnerable	Endangered	6, 63.09%, 5.48%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Litoria castanea	Yellow-spotted tree frog	Endangered	Critically Endangered	0, 0, 0	Category 2	The species' distribution occurs within the New England Tablelands and the South Eastern Highlands Bioregions. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Litoria littlejohni	Littlejohn's Tree Frog, Heath Frog	Vulnerable	Vulnerable	0, 0, 0.74%	Category 2	The species does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Litoria raniformis	Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog	Vulnerable	Endangered	0, 0, 0.15%	Category 2	The species occurs along the Murray and Murrumbidgee Rivers. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Mixophyes balbus	Stuttering Frog, Southern Barred Frog (in Victoria)	Vulnerable	Endangered	0, 0, 0.87%	Category 2	The species occurs along the east coast from southern Queensland to north-eastern Victoria. No records occur in the Strategic Assessment Area and it is unlikely to be reliant on the area
INVERTEBRATES						
Pommerhelix duralensis	Dural Land Snail	Endangered	Endangered	4, 16.36%, 55.37%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
FISH						
Epinephelus daemelii	Black Rockcod, Black Cod, Saddled Rockcod	Vulnerable	Not Listed	0, 0, 0.13%	Category 2	The species occurs in marine areas. It is unlikely to occur in the Strategic Assessment Area
Macquaria australasica	Macquarie Perch	Endangered	Not Listed	1, 3.45%, 0.97%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30
Prototroctes maraena	Australian Grayling	Vulnerable	Not Listed	0, 0, 0.55%	Category 2	There are no records of the species in the Strategic Assessment Area. It is unlikely to be reliant on the area
Thunnus maccoyii	Southern Bluefin Tuna	Conservation Dependent	Not Listed	0, 0, 0	Category 2	The species is associated with marine areas. It is unlikely to occur in the Strategic Assessment Area

Table 28-2: Threatened flora

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	Vulnerable	Endangered	25, 10.12%, 9.54%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Acacia gordonii	Gordon's Wattle	Endangered	Endangered	0, 2.5%, 4.83%	Category 2	The species only occurs in the lower Blue Mountains and Glenorie areas, and is associated with sandstone. It is unlikely to occur in Strategic Assessment Area
Acacia meiantha		Endangered; FPAL	Endangered	0, 0, 0	Category 2	The species is endemic to NSW and occurs in the Central Tablelands, west of the Great Dividing Range. It is unlikely to occur in the Strategic Assessment Area
Acacia pubescens	Downy Wattle, Hairy-stemmed Wattle	Vulnerable	Vulnerable	90, 96.05%, 61.16%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Acacia terminalis subsp. *terminalis MS*	Sunshine Wattle (Sydney region)	Endangered	Endangered	0, 0, 8.61%	Category 2	The species is associated with sandstone and is restricted to Sydney's eastern suburbs, northern suburbs and northern beaches. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Allocasuarina glareicola		Endangered	Endangered	10, 88.89%, 30.69%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Asterolasia elegans		Endangered	Endangered	0, 0, 3.53%	Category 2	The species occurs in Baulkham Hills, Hawkesbury and Hornsby LGAs. It is unlikely to occur in the Strategic Assessment Area
Bossiaea fragrans		Critically Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs only in Abercrombie Karst reserve in NSW. It is unlikely to occur in the Strategic Assessment Area
Caladenia attenuata	Duramana fingers	Critically Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs only in the Duramana area, north of Bathurst. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Caladenia tessellata	Thick-lipped Spider-orchid, Daddy Long-legs	Vulnerable	Endangered	0, 10%, 3.28%	Category 2	The species is primarily associated with sandstone derived communities in coastal areas. It is unlikely to occur in the Strategic Assessment Area
Callistemon purpurascens		Critically Endangered	Not Listed	0, 0, 0	Category 2	The species occurs only in the far west of the Blue Mountains. It is unlikely to occur in the Strategic Assessment Area
Commersonia prostrata	Dwarf Kerrawang	Endangered	Endangered	1, 0.96%, 13.45%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Cryptostylis hunteriana	Leafless Tongue-orchid	Vulnerable	Vulnerable	0, 0, 1.4%	Category 2	The species does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Cynanchum elegans	White-flowered Wax Plant	Endangered	Endangered	9, 4.87%, 4.7%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Darwinia biflora		Vulnerable	Vulnerable	0, 1.46%, 30.61%	Category 2	This species met the criteria for a Category 1 species. However, in preparing the Assessment Report it was found that no records or potential habitat occurs for the species in the Strategic Assessment Area. As a result, the species was changed to Category 2 and was not assessed further
Deyeuxia appressa		Endangered	Endangered	0, 81.63%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Diuris eborensis		Endangered	Endangered	0, 0, 0	Category 2	The species is not known or predicted on the Cumberland subregion. Its distribution is contained within the New England Plateau. It is unlikely to occur in the Strategic Assessment Area
Eucalyptus aggregata	Black Gum	Vulnerable	Vulnerable	0, 0, 0.35%	Category 2	The species does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	Vulnerable	Vulnerable	8, 84.19%, 54.41%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Eucalyptus camfieldii	Camfield's Stringybark	Vulnerable	Vulnerable	0, 0.08%, 6.49%	Category 2	The species is restricted to sandstone and shale-capped ridges to the north-east of the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Eucalyptus largeana	Craven Grey Box	Endangered	Endangered	0, 0, 0	Category 2	The species occurs between Dungog and Taree; and does not occur on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Eucalyptus sp. Cattai (NSW 318983)	Cattai Stringybark	Critically Endangered	Critically Endangered	0, 0, 0	Category 2	The species is found on sandstone ridges in the north-east of the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Genoplesium baueri	Yellow Gnat-orchid	Endangered	Endangered	1, 3.13%, 16.1%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Grevillea caleyi	Caley's Grevillea	Critically Endangered	Critically Endangered	0, 0, 0.6%	Category 2	The species is highly restricted to the Ingleside area of north-east Sydney. It is unlikely to occur in the Strategic Assessment Area
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	Vulnerable	Vulnerable	10, 4.66%, 13.98%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Haloragis exalata subsp. *exalata*	Wingless Raspwort, Square Raspwort	Vulnerable	Vulnerable	0, 0, 8.13%	Category 2	The species favours sandstone gullies. It is unlikely to occur on the Cumberland subregion or be reliant on the Strategic Assessment Area
Haloragodendron lucasii	Hal	Endangered	Endangered	0, 3.45%, 2.12%	Category 2	The species occurs on Hawkesbury Sandstone and is restricted to Turramurra and Pymble in northern Sydney. It is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Hibbertia puberula subsp. *glabrescens*		Critically Endangered	Not Listed	1, 3.77%, 100%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Hibbertia spanantha	Julian's Hibbertia	Critically Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs mainly in Turramurra and Pymble. It is unlikely to occur in the Strategic Assessment Area
Lasiopetalum joyceae		Vulnerable	Vulnerable	0, 1.52%, 2.21%	Category 2	The species is found in the sandstone country to the north-east and north of the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Leptospermum deanei	Deane's Tea-tree	Vulnerable	Vulnerable	0, 25%, 14.42%	Category 2	The species is known only from the Lane Cove Valley area. It is unlikely to occur in the Strategic Assessment Area
Leucopogon exolasius	Woronora Beard-heath	Vulnerable	Vulnerable	2, 8.2%, 16.18%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Melaleuca biconvexa	Biconvex Paperbark	Vulnerable	Vulnerable	0, 0, 1.29%	Category 2	The species distribution is limited to coastal districts and adjacent tablelands in NSW, from Jervis Bay to Port Macquarie. There are no records in the Strategic Assessment Area and it is considered unlikely to occur
Melaleuca deanei	Deane's Melaleuca	Vulnerable	Vulnerable	2, 16.35%, 10.35%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Micromyrtus minutiflora		Vulnerable	Endangered	14, 98.41%, 94.62%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Olearia cordata		Vulnerable	Vulnerable	0, 0, 0.3%	Category 2	The species is associated with woodland on exposed Hawkesbury Sandstone ridges. No records occur in the Strategic Assessment Area it is unlikely to be reliant on the area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Pelargonium sp. *striatellum (G.W.Carr 10345)*	Omeo Stork's-bill	Endangered	Endangered	0, 0, 1.77%	Category 2	The species occurs in the South Eastern Highlands and South East Corner IBRA bioregions as well as the Hawkesbury-Nepean, Murrumbidgee, Southern Rivers and North East Natural Resource Management Regions. No records occur in the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Persicaria elatior	Tall Knotweed	Vulnerable	Vulnerable	N/A	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Persoonia acerosa	Needle Geebung	Vulnerable	Vulnerable	0, 0, 3.26%	Category 2	The species' distribution is restricted to the central coast and Blue Mountains. No records occur on the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Persoonia bargoensis	Bargo Geebung	Vulnerable	Endangered	1, 69.7%, 62.77%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Persoonia glaucescens	Mittagong Geebung	Vulnerable	Endangered	10, 8.02%, 8.92%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Persoonia hirsuta	Hairy Geebung, Hairy Persoonia	Endangered	Endangered	6, 6.27%, 12.51%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Persoonia mollis subsp. *maxima*		Endangered	Endangered	0, 2.68%, 25.72%	Category 2	The species occurs in the sandstone surrounding northern Sydney and beyond the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Persoonia nutans	Nodding Geebung	Endangered	Endangered	9, 96.66%, 88.45%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Pimelea curviflora var. *curviflora*		Vulnerable	Vulnerable	3, 6.79%, 26.75%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Pimelea spicata	Spiked Rice-flower	Endangered	Endangered	26, 98.06%, 74.42%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Pomaderris brunnea	Rufous Pomaderris	Vulnerable	Endangered	3, 67.12%, 16.02%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Pomaderris cocoparrana		Endangered	Endangered	0, 0, 0	Category 2	The species is endemic to NSW and mainly occurs in and around the Cocoparra Range, northeast of Griffith. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Pomaderris delicata		Critically Endangered	Critically Endangered	0, 0, 0	Category 2	The species occurs between Goulburn and Bungonia. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Prostanthera marifolia	Seaforth Mintbush	Critically Endangered	Critically Endangered	0, 0.61%, 4.29%	Category 2	The species is endemic to NSW. It only occurs in the Manly area in northern Sydney, in the Duffy's Forest ecological community. It is unlikely to occur in the Strategic Assessment Area
Pterostylis gibbosa	Illawarra Greenhood, Rufa Greenhood, Pouched Greenhood	Endangered	Endangered	0, 0, 7.1%	Category 2	The species only occurs in the Illawarra and middle Hunter Valley. It is closely related to *Pterostylis saxicola*. It does not occur in the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Pterostylis pulchella	Pretty Greenhood	Vulnerable	Vulnerable	0, 0, 4.78%	Category 2	The species is restricted to the Illawarra escarpment and Southern Highlands of NSW. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Pterostylis saxicola	Sydney Plains Greenhood	Endangered	Endangered	8, 88%, 59.69%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Pultenaea aristata		Vulnerable	Vulnerable	0, 0, 2.23%	Category 2	The species occurs from Heathcote to Port Kembla in NSW and is associated with low nutrient sandstone soils. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Pultenaea glabra	Smooth Bush-pea, Swamp Bush-pea	Vulnerable	Vulnerable	0, 0, 2.46%	Category 2	The species occurs in disjunct populations in Queensland, NSW, and Victoria. In NSW it is restricted to the higher Blue Mountains. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Pultenaea parviflora		Vulnerable	Endangered	15, 98.96%, 92.95%	Category 1	A detailed impact analysis has been carried out for this species in Chapter 29
Rhizanthella slateri	Eastern Underground Orchid	Endangered	Vulnerable	0, 0, 4.4%	Category 2	The species is endemic to NSW and occurs from the mid-north coast to the south coast. It does not occur in the Strategic Assessment Area and is unlikely to be reliant on the area
Syzygium paniculatum	Magenta Lilly Pilly, Magenta Cherry, Daguba, Scrub Cherry, Creek Lilly Pilly, Brush Cherry	Vulnerable	Endangered	0, 7.28%, 5.7%	Category 2	The species is only found in NSW and occurs from Upper Lansdowne on the north coast to Conjola National Park on the south coast. Six records occur in the Strategic Assessment Area, but it is unlikely to be reliant on the area and likely results from records of planted individuals as the species is popular in cultivation
Thelymitra kangaloonica	Kangaloon Sun Orchid	Critically Endangered	Critically Endangered	0, 0, 11.77%	Category 2	The species only occurs in Wingecarribee, NSW. It does not occur in the Cumberland subregion or the Strategic Assessment Area

Scientific name	Common name	Commonwealth status (EPBC Act)	NSW status	No. of important populations, Post 1990 Cumberland records as % of NSW records, % of total C'wealth distribution	Category	Comment
Thesium australe	Austral Toadflax, Toadflax	Vulnerable	Vulnerable	0, 0, 0.84%	Category 2	The species is considered to be extinct on the Cumberland as no records have been recorded since the original specimen was collected. It is unlikely to rely on the Cumberland subregion as it is distributed across NSW, ACT and parts of Queensland and Victoria
Wollemia nobilis	Wollemi pine	Critically Endangered	Critically Endangered	N/A	Category 2	The species is found naturally only in western Wollemi National Park. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Zieria involucrata		Vulnerable	Endangered	0, 0, 1.54%	Category 2	The species has a restricted distribution between Yengo National Park and Marramarra National Park adjacent to the Blue Mountains National Park. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area
Zieria parrisiae		Critically Endangered	Critically Endangered	N/A	Category 2	The species is highly restricted to one site on a private property west of Pambula, NSW. It does not occur on the Cumberland subregion and is unlikely to occur in the Strategic Assessment Area

28.2.2 THREATENED ECOLOGICAL COMMUNITIES

All TECs identified as potentially occurring in the Strategic Assessment Area were assigned to Category 1 (see Table 28-1).

There are eight Category 1 TECs in total. The assessments of each TEC are contained in Chapter 31.

Table 28-3: Threatened ecological communities

Commonwealth-listed TEC	Commonwealth status
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	Endangered
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Endangered
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered
Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion	Critically Endangered
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	Critically Endangered
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered
Western Sydney Dry Rainforest and Moist Woodland on Shale	Critically Endangered

28.2.3 MIGRATORY SPECIES

The following listed migratory species were assigned to Category 1:

- 21 species of migratory shorebirds (see Table 28-4)
- 8 other migratory birds (see Table 28-5)

Table 28-4: Migratory shorebirds

Scientific name	Common name	Commonwealth status (EPBC Act)	Species recorded in the Cumberland subregion	Category	Comment
Actitis hypoleucos	Common Sandpiper	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Arenaria interpres	Ruddy Turnstone	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Calidris acuminata	Sharp-tailed Sandpiper	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Calidris canutus	Red Knot	Migratory; Endangered	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Calidris ferruginea	Curlew Sandpiper	Migratory; Critically Endangered	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Calidris melanotos	Pectoral Sandpiper	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Calidris ruficollis	Red-necked Stint	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Calidris subminuta	Long-toed Stint	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Charadrius bicinctus	Double-banded Plover	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Charadrius leschenaultii	Greater Sand-plover	Migratory; Vulnerable	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Gallinago hardwickii	Latham's Snipe	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32

Scientific name	Common name	Commonwealth status (EPBC Act)	Species recorded in the Cumberland subregion	Category	Comment
Limosa lapponica	Bar-tailed Godwit	Migratory; Vulnerable	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Limosa limosa	Black-tailed Godwit	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Numenius madagascariensis	Eastern Curlew	Migratory; Critically Endangered	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 30 in relation to its listing as a threatened species, and Chapter 32 in relation to its listing as a migratory species
Numenius minutus	Little Curlew	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Philomachus pugnax	Ruff	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Pluvialis fulva	Pacific Golden Plover	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Pluvialis squatarola	Grey Plover	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Tringa glareola	Wood Sandpiper	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Tringa nebularia	Common Greenshank	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Tringa stagnatilis	Marsh Sandpiper	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32

Table 28-5: Other migratory species*

Scientific name	Common name	Commonwealth status (EPBC Act)	Species recorded in the Strategic Assessment Area	Category	Comment
BIRDS					
Anous stolidus	Common Noddy	Migratory	No	Category 2	The species has a broad distribution and mainly occurs in the ocean off the coast of Queensland. It is unlikely to occur in the Strategic Assessment Area
Apus pacificus	Fork-tailed Swift	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Calonectris leucomelas	Streaked Shearwater	Migratory	No	Category 2	The species is migratory and occurs in waters off the coast of northern and eastern Australia. It is unlikely to occur in the Strategic Assessment Area
Cuculus optatus	Oriental Cuckoo, Horsfield's Cuckoo	Migratory	No	Category 2	The species is the same as *Cuculus saturates* (IUCN, 2018)
Cuculus saturatus	Oriental Cuckoo, Himalayan Cuckoo	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Fregata ariel	Lesser Frigatebird, Least Frigatebird	Migratory	No	Category 2	The species has a broad oceanic distribution in Australia with no records on the Cumberland subregion. It is unlikely to occur in the Strategic Assessment Area
Fregata minor	Great Frigatebird, Greater Frigatebird	Migratory	No	Category 2	The species is a pelagic bird with a broad Australian oceanic distribution. No records occur on the Cumberland subregion and it is unlikely to occur in the Strategic Assessment Area
Monarcha melanopsis	Black-faced Monarch	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Motacilla flava	Yellow Wagtail	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Myiagra cyanoleuca	Satin Flycatcher	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Pandion haliaetus	Osprey	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Rhipidura rufifrons	Rufous Fantail	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32
Symposiachrus trivirgatus	Spectacled Monarch	Migratory	Yes	Category 1	A detailed impact analysis has been carried out for this species in Chapter 32

Scientific name	Common name	Commonwealth status (EPBC Act)	Species recorded in the Strategic Assessment Area	Category	Comment
FISH					
Lamna nasus	Porbeagle, Mackerel Shark	Migratory	No	Category 2	The species occurs in marine areas. It is unlikely to occur in the Strategic Assessment Area
Manta alfredi	Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory	No	Category 2	The species occurs in marine areas. It is unlikely to occur in the Strategic Assessment Area
Manta birostris	Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory	No	Category 2	The species occurs in marine areas. It is unlikely to occur in the Strategic Assessment Area.

* This table does not include migratory species that are also listed as threatened under the EPBC Act. These species are dealt with in Section 28.2.1

28.2.4 FINALISED PRIORITY ASSESSMENT LIST (FPAL)

All relevant species, ecological communities or key threatening processes on FPAL lists up to and including the assessment period commencing 1 October 2019 were assigned to Category 1 (see Table 28-6). There is one ecological community which has been assessed in Chapter 31.

Table 28-6: Matters on the FPAL list

Species, ecological community or key threatening process	Assessment completion date	Category	Comment
Coastal floodplain eucalypt forest of eastern Australia (previously referred to as river-flat eucalypt forest on coastal floodplains of New South Wales)	31/07/2020	Category 1	A detailed impact analysis has been carried out for this ecological community in Chapter 31

28.2.5 RAMSAR

Towra Point Nature Reserve is the only wetland of international importance (Ramsar Wetland) that was identified as being relevant to the strategic assessment. It occurs outside and downstream of the Strategic Assessment Area. It has been assigned to Category 1 and a detailed impact assessment is presented in Chapter 33.

28.2.6 WORLD AND NATIONAL HERITAGE

Four World and/or National Heritage Places were identified as being present within, or within 10 km of the Strategic Assessment Area (see Chapter 34). These include:

- The Greater Blue Mountains World Heritage Area which is listed as both a World and National Heritage Place
- Parramatta Female Factory and Institutions Precinct which is listed as a National Heritage Place
- Old Government House and Government Domain which is listed as both a World and National Heritage Place
- Ku-ring-gai Chase National Park which is listed as a National Heritage Place

A detailed impact assessment for each place is presented in Chapter 34.

28.2.7 COMMONWEALTH LAND

Commonwealth land is a protected matter under the EPBC Act. It has been assigned to Category 1 and an impact assessment is provided in Chapter 35.

29 Threatened flora impact assessment

29.1 INTRODUCTION

There are 23 Category 1 threatened flora species that are assessed in this Chapter. These species were identified as needing detailed assessment (see Part 3 for the approach, and Chapter 28 for the results) as they are reliant on the Cumberland subregion and have some potential to be impacted (directly, indirectly or cumulatively).

The Chapter is structured around the level of risk of residual adverse direct impacts (prior to the application of offsets) occurring to each species (see Table 29-1). Species most at risk from development under the Plan are discussed first, with species at lower levels of risk discussed subsequently.

The overall assessment approach for threatened flora is presented below in Section 29.2, and the methodology for the risk assessment is set out in Section 29.3.

The analysis in this Chapter concludes that the avoidance, mitigation and offset measures in the Plan will ensure that the long-term viability of all 23 threatened flora species will not be adversely influenced.

Table 29-1: Species assessed in the threatened flora chapter categorised according to the risk of residual adverse direct impacts

Level of risk of residual adverse direct impacts to species	Number of species	Species names
High risk	2	• *Pimelea spicata* • *Pultenaea parviflora*
Medium risk	2	• *Cynanchum elegans* • *Persoonia nutans*
Low risk	4	• *Eucalyptus benthamii* • *Grevillea parviflora* subsp. *parviflora* • *Persoonia bargoensis* • *Pomaderris brunnea*
Very low risk	9	• *Acacia bynoeana* • *Acacia pubescens* • *Allocasuarina glareicola* • *Melaleuca deanei* • *Micromyrtus minutiflora* • *Persicaria elatior* • *Persoonia hirsuta* • *Pimelea curviflora* var. *curviflora* • *Pterostylis saxicola*
No risk	6	• *Commersonia prostrata* • *Deyeuxia appressa* • *Genoplesium baueri* • *Hibbertia puberula* subsp. *glabrescens* • *Leucopogon exolasius* • *Persoonia glaucescens*

29.2 THREATENED FLORA ASSESSMENT APPROACH

The assessments for threatened flora follow a standard format. However, the content is tailored for the specific context of each species.

There are eight sections to the assessments. They are described below and include:

- Species background
- Approach to baseline data
- Occurrence in the Strategic Assessment Area
- Avoidance of impacts
- Direct impacts and offsets
- Potential indirect impacts and mitigation
- Potential additional impacts from essential infrastructure and tunnels
- Likely effects of implementation of the Plan on the long-term viability of the species
- Data tables

To assist the reader, standard explanatory text about the purpose and content of each section is provided throughout the assessments in *blue italics text*. The text is repeated for each species. It enables the reader to quickly understand the content of each section and where in the broader report more detailed information is available about a particular issue.

29.2.1 SPECIES BACKGROUND

Sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

29.2.2 APPROACH TO BASELINE DATA

Provides a summary of the baseline information used in the assessment. It sets out:

- If the species is a candidate species under the Biodiversity Certification Assessment Report (BCAR) process. A candidate species is a species that has been determined through the BCAR assessment as needing to be assessed because suitable habitat occurs in the nominated areas. A candidate species can be either an ecosystem credit species (ECS) (one that can be reasonably predicted to occur within a nominated area based on the habitat that occurs there - surveys are not required to determine the presence of these species); or a species credit species (SCS) (one that cannot be reasonably predicted to occur within a nominated areas based on habitat – species in these areas may either be assumed present, or their presence needs to be determined through surveys or a report prepared by an expert on that species). Understanding whether a species has been categorised as a candidate species is useful to know for the EPBC Act assessments as it is based on the application of a systematic method under the BCAR process and provides an initial indication of how development in the nominated areas might interact with the species. This helps to shape the assessment narrative
- If an expert report was prepared for the species under the BCAR process. Expert reports were prepared as part of the BCAR process for a subset of species that: could not be sufficiently surveyed for within the nominated areas due to either access restrictions, seasonality or their cryptic nature; or had highly specific habitat requirements and restrictions for which expert advice was required. It is relevant to note that the expert reports were prepared as a requirement of the BCAR process and were not specifically prepared to support the EPBC assessments. As a result, the expert reports are not relied on heavily in these assessments and instead, information (particularly relating to species ecology and distribution) has been identified and drawn on as relevant
- An overview of the habitat mapping for the species within and outside the nominated areas. Habitat maps were generated using either species distribution models (SDMs), knowledge-based maps (KBMs) reflecting broad habitat associations (for instance, with mapped PCTs) and expert polygons defined through the expert reports under the BCAR process
- An overview of the population mapping for the species. This includes:
  - Any filters applied to the use of species (BioNet) records
  - Assumptions made in identifying biological populations from the species records. It is relevant to note that the method used to define populations for this assessment was tailored to the available data and purpose of the

baseline mapping. While the definition used is based on the theoretical definition of a biological population used elsewhere in the literature, it is confounding to try to match or relabel these populations to corresponding populations in other publications, such as recovery plans or species profiles, which will be based on a different dataset, often with a different purpose, set of criteria and level of resolution. The population mapping presented in this report therefore needs to be considered as standalone and fit for purpose

    - Any criteria met in determining the importance of populations

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

29.2.3 OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

Describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file (layered PDF). The map provides critical context for the assessment and should be viewed in conjunction with the text presented in the assessments. This section also provides a qualitative description of where records and habitat occur.

29.2.4 AVOIDANCE OF IMPACTS

Provides an overview of the area of potential habitat that was avoided for each species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan.

The definition of what constitutes avoidance has been adopted from the BCAR process. Under the BAM, avoidance refers to land that is suitable for development and included in the area proposed for development or biodiversity certification, but has been avoided because of its biodiversity value. This is referred to as avoided for 'biodiversity purposes' in this assessment.

Land not impacted because it is not suitable for development or biodiversity certification, or land that has been excluded from the area proposed for development is not considered to have been avoided under the BAM. This land is referred to as avoided for 'other purposes' and includes:

- Riparian corridors consistent with the *Water Management Act 2000*:
    - Strahler stream order 2 - buffer 20 m either side
    - Strahler stream order 3 - buffer 30 m either side
    - Strahler stream order 4 and above - buffer 40 m either side
- State protected land (>18 degrees slope, considered too steep for urban development)

Some land within the nominated areas was not considered for inclusion in the area proposed for development and has therefore been identified as 'excluded' land. These lands include:

- Existing protected land, including reserves and established offset sites
- Council owned land which is zoned for environmental conservation, environmental management or recreation
- Commonwealth land, such as Defence Establishment Orchard Hills
- Lands within the nominated areas already assessed as part of another development approval (Bingara Gorge), or lands progressing through an alternate assessment (Mount Gilead, Menangle Park, Sydney Metro Stage 1)
- Lands already developed (existing urban areas, urban land zones and roads)

A further, detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.2.5 DIRECT IMPACTS AND OFFSETS

Provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat.

Direct impacts were determined based on an intersect of the urban capable lands and transport corridors with the baseline mapping generated for each threatened flora species. It has been assumed that total permanent clearing will occur within the urban capable lands and transport corridors for the purposes of the assessment. However, it is important to note that in reality:

- Further avoidance will be undertaken within the transport corridors (see Chapter 7)
- Direct impacts will occur progressively over the life of the Plan, which reduces the severity of impacts

The extent or scale of loss is presented in terms of:

- Number and size of populations/important populations
- Hectares of potential habitat

The analysis also considers the likelihood of direct impacts leading to fragmentation of populations and areas of potential habitat.

To provide a sense of the magnitude and importance of direct impacts, the risk of residual adverse impacts to each species occurring as a result of any direct impacts was characterised as per the methodology set out in Section 29.3 below.

The Plan provides offsets for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.2.6 POTENTIAL INDIRECT IMPACTS AND MITIGATION

Identifies the potential indirect impacts to each species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to a species if:

- The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, *and*
- The threat is present in the Cumberland subregion, *and*
- The Plan has the potential to exacerbate the threat

Relevant indirect impacts were identified by drawing on ecological and life history information in species profiles, conservation advices and recovery plans, and species records and habitat maps prepared for this Assessment Report.

The indirect impacts section then goes on to determine if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary. Species-specific commitments were generally considered necessary where a species was found to have a particular vulnerability or susceptibility to a potential indirect impact in a discrete location.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.1.1 POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

Considers the potential additional impacts to species due to essential infrastructure projects that are needed to support development within the nominated areas. These might include projects such as water and electricity utilities, communications facilities, stormwater management systems, and waste or resource management systems. The assessment covers projects that may need to be located outside urban capable lands and on areas that are identified as avoided lands within the nominated areas.

This section also assesses the likelihood of potential additional impacts to species due to the tunnel sections of the transport corridors. The impacts of tunnels were assessed separately to the rest of the transport corridors as only small areas of the footprints will be disturbed and it is not possible to determine at this stage the nature and extent of those impacts.

Please refer to the following chapters for details about these development types:

- Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels

- Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)

29.2.7 LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

Considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.2.8 DATA TABLES

Sets out the data tables for occurrence, avoidance and direct impacts for each species.

29.3 RISK ASSESSMENT APPROACH FOR THREATENED FLORA

This section sets out:

- The purpose of the risk assessment approach
- The risk assessment framework
- A description of the risk ratings
- The likelihood and consequence definitions for direct impacts to populations and/or potential habitat
- The likelihood and consequence definitions for direct impacts leading to fragmentation

29.3.1 PURPOSE

The purpose of the risk assessment for threatened flora was to determine the level of risk of residual adverse impacts occurring to a species as a result of direct impacts. Indirect impacts were assessed differently (see Chapter 15) and were not subject to the same risk assessment process.

The term "residual adverse impacts" was used as it forms part of the EPBC Act Environmental Offsets Policy (DSEWPC, 2012c). Offsets are typically required under the EPBC Act when residual adverse impacts remain after avoidance and mitigation measures have been applied. In this case, the Plan provides offsets for species which are considered to be at high or medium risk of residual adverse impacts. Offsets are not provided for species which are considered to be at low or very low risk. As outlined above, the rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

A risk based approach to considering residual adverse impacts is appropriate for the strategic assessment. The Terms of Reference (Clause 4.2) identify the need for the impact assessment to consider the "level of likely risk to each protected matter". The spatial and temporal scale of the Plan means that there is an inherent level of uncertainty in the baseline data (both for habitat and records). In particular, the potential habitat mapping for the majority of species is highly precautionary and does not necessarily indicate with great certainty if a species will occur in an impact area. It is critical therefore to understand the level of risk to each species rather than take a simplistic view of direct impacts as presented in the impact numbers.

29.3.2 RISK ASSESSMENT FRAMEWORK

Risk is generally considered to be the combination of the likelihood and consequence of an event occurring. The methodology used in the assessment is based on an adapted version of the Australian Standard on Risk Management (Standards Australia, 2018).

The assessment for threatened flora was based on:

- The risk ratings table shown in Table 29-2

- Understanding the risk of residual adverse impacts due to direct impacts to populations and/or potential habitat based on:
  - The likelihood definitions in Table 29-3
  - The consequence definitions in Table 29-4, Table 29-5, Table 29-6, and Table 29-7
- Understanding the risk of residual adverse impacts due to fragmentation based on:
  - The likelihood definitions in Table 29-8
  - The consequence definitions in Table 29-11

The final level of risk for a species was determined on a precautionary basis. The highest level of risk based on the consideration of impacts to populations, potential habitat, or due to fragmentation was taken.

29.3.3 RISK RATINGS

Four levels of risk were defined through the process (see Table 29-2). They were:

- Very low risk = very low risk that residual adverse impacts to a species will occur. Offsets for residual impacts were not considered necessary
- Low risk = low risk that residual adverse impacts to a species will occur. Offsets for residual impacts were not considered necessary
- Medium risk = medium risk that residual adverse impacts to a species will occur. Offsets were considered necessary
- High risk = high risk that residual adverse impacts to a species will occur. Offsets were considered necessary

Where there were no direct impacts to a species, there was considered to be no risk of residual adverse impacts.

Table 29-2: Risk ratings table

	CONSEQUENCE				
LIKELIHOOD	**Negligible**	**Minor**	**Moderate**	**Major**	**Extreme**
Almost certain	Low	Medium	Medium	High	High
Likely	Low	Low	Medium	Medium	High
Possible	Very low	Low	Low	Medium	Medium
Unlikely	Very low	Very low	Low	Low	Medium

29.3.4 LIKELIHOOD AND CONSEQUENCE DEFINITIONS FOR DIRECT IMPACTS TO POPULATIONS AND/OR POTENTIAL HABITAT

LIKELIHOOD

Table 29-3 sets out the definitions for the likelihood that a threatened flora species will be directly impacted due to impacts to populations and/or potential habitat. These definitions:

- Draw on the baseline data for the species in terms of records and potential habitat mapping
- Consider the level of confidence in the records and potential habitat mapping. Strict definitions of “high”, “moderate” and “low” confidence are not provided as they are species specific in relation to the baseline data. Judgements about the level of confidence in the data were instead determined based on the expert judgement of the assessment team who created the baseline data

Table 29-3: Likelihood definitions for direct impacts to populations and/or potential habitat

Likelihood	Definition
Almost certain	• Direct impacts to a known population with high confidence in the accuracy of the records
Likely	• Direct impacts to a known population with some uncertainty in the accuracy of the records OR • Direct impacts to potential habitat with high confidence that the species occurs in the impact area
Possible	• No direct impacts to a known population • Direct impacts to potential habitat with moderate confidence that the species occurs in the impact area
Unlikely	• No direct impacts to a known population • Direct impacts to potential habitat with low confidence that the species occurs in the impact area

CONSEQUENCES

Consequence was determined by separately considering impacts to potential habitat as well as any impacts to known populations. The highest ranking of consequence was then taken for a species.

The criteria for determining consequence were based on a range of factors including:

- Conservation status. Impact thresholds for consequence were smaller for critically endangered species than for endangered species, and smaller for endangered species than for vulnerable species
- If the species is considered to be an SAII entity under the BCAR process or is endemic (>90 per cent of records in the subregion) to the Cumberland subregion. Species that met either of these criteria were treated under the consequence thresholds for critically endangered species even if they had a lower conservation status
- The application of both population impact thresholds and potential habitat impact thresholds. It should be noted that like all threshold approaches the numbers are arbitrary to a degree. However, the thresholds are considered to be appropriate because they:
  - Reflect the nature of the baseline data. In particular the potential habitat mapping which has been generated across the Strategic Assessment Area is precautionary in many cases and over-maps habitat
  - Are structured around conservation status
  - Reflect the expert view of the assessment team about the level of risk to species

The consequence definitions for direct impacts due to impacts to populations and/or potential habitat are set out in:

- Table 29-4 – habitat for vulnerable species
- Table 29-5 – habitat for endangered species
- Table 29-6 – habitat for critically endangered, SAII, and/or endemic species
- Table 29-7 - populations

Table 29-4: Consequence definitions for direct impacts to potential habitat for vulnerable species

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >15% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 10-15% of mapped potential habitat	Extreme	Major	Minor
Loss of 6-10% of mapped potential habitat	Major	Moderate	Negligible
Loss of 2-6% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <2% of mapped potential habitat	Minor	Negligible	Negligible

Table 29-5: Consequence definitions for direct impacts to potential habitat for endangered species

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >10% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 7-10% of mapped potential habitat	Extreme	Major	Minor
Loss of 3-7% of mapped potential habitat	Major	Moderate	Negligible
Loss of 1-3% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <1% of mapped potential habitat	Minor	Negligible	Negligible

Table 29-6: Consequence definitions for direct impacts to potential habitat for critically endangered, SAII* and/or endemic species**

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >5% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 2-5% of mapped potential habitat	Extreme	Major	Minor
Loss of 1-2% of mapped potential habitat	Major	Moderate	Negligible
Loss of 0.5-1% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <0.5% of mapped potential habitat	Minor	Negligible	Negligible

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90 per cent of records of the species occur within the subregion

Table 29-7: Consequence definitions for direct impacts to populations

Consequence	TYPE OF IMPACT	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
Extreme	• Impacts to known population, OR	• Loss of 2 or more important populations	• Loss of 2 or more populations	• Loss of 1 or more populations
	• Impacts to population at edge of occurrence, OR	• Loss of 1 important population at edge of occurrence	• Loss of 1 population at edge of occurrence	• Loss of records within a population at the edge of occurrence
Major	• Impacts to known population, OR	• Loss of 1 important population	• Loss of 1 population	• Loss of records within a population
	• Impacts to population at edge of occurrence	• Loss of records within an important population at the edge of occurrence	• Loss of records within a population at the edge of occurrence	• N/A
Moderate	• Impacts to known population, OR	• Loss of records within an important population, or the loss of a non-important population	• Loss of records within a population	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A
Minor	• Impacts to known population, OR	• Loss of records within a non-important population	• N/A	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A
Negligible	• Impacts to known population, OR	• N/A	• N/A	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90 per cent of records of the species occur within the subregion

29.3.5 LIKELIHOOD AND CONSEQUENCE DEFINITIONS FOR FRAGMENTATION IMPACTS

Likelihood

Table 29-8 sets out a matrix for determining the likelihood that a threatened flora species will be impacted by fragmentation. The two axes of the matrix are:

- Barrier likelihood which represents a judgement about how likely a particular development will disrupt connectivity for a species. Table 29-9 provides examples of different barrier likelihoods
- Fragmentation type which sets out how a species may be impacted. Table 29-10 provides criteria for fragmentation types

Table 29-8: Likelihood definitions for fragmentation

	FRAGMENTATION TYPE (see Table 29-10**)**			
BARRIER LIKELIHOOD (see Table 29-9**)**	**Certain impact within population**	**Likely impact within population OR certain impact between populations**	**Possible impact between populations OR likely impact to habitat connected to a population**	**Impact to mapped habitat only**
Certain barrier	Almost certain	Almost certain	Likely	Possible
Likely barrier	Almost certain	Likely	Possible	Possible
Possible barrier	Likely	Likely	Possible	Unlikely
Unlikely barrier	Possible	Possible	Unlikely	Unlikely

Table 29-9: Examples of barrier likelihood

Barrier likelihood	**Examples**
Certain barrier	• If a species is thought to be unable to cross barriers >100 m, a barrier of 120 m or more is inconsistent with dispersal requirements • If a species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with little to no vegetation (such as high density urban and/or commercial areas) are inconsistent with dispersal requirements • If a species is highly susceptible to being impacted by major roads with high traffic density (either through high roadkill rates, through aversion to noise and light, or through aversion to crossing open spaces) a major road is inconsistent with dispersal requirements
Likely barrier	• If a species is thought to be unable to cross barriers >100 m, a 100-120 m barrier is likely to be inconsistent with dispersal requirements • If a species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with sparse vegetation (such as low to moderate density urban areas with gardens) are likely to be inconsistent with dispersal requirements • If a species is thought to be susceptible to being impacted by major roads with high traffic density (either through moderate roadkill rates, through moderate aversion to noise and light, or through moderate aversion to crossing open spaces) a major road is likely to be inconsistent with dispersal requirements
Possible barrier	• If a species is thought to be unable to cross barriers >100 m, an 80-100 m barrier may be inconsistent with dispersal requirements

Barrier likelihood	Examples
	• If a species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with sparse vegetation (such as rural residential areas and agricultural areas) may be inconsistent with dispersal requirements • If a species is thought to have potential to be impacted by major roads with high traffic density (either through possible roadkill occurrences, possible aversion to noise and light, or through possible aversion to crossing open spaces), a major road may be inconsistent with dispersal requirements
Unlikely barrier	• If a species is thought to be unable to cross barriers >100 m, barrier of <80 m is unlikely to be inconsistent with dispersal requirements • If a species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with moderate vegetation density (such as parks, nature reserves and vegetated areas) are unlikely to be inconsistent with dispersal requirements • If a species is not known to be impacted by major roads with high traffic density (the species is not known to be susceptible to roadkill, noise or light aversion, or aversion to open spaces), then a major road is unlikely to be inconsistent with dispersal requirements

Table 29-10: Criteria for fragmentation types

Fragmentation type	Criteria
Certain impact within population	• Barrier is placed between records of a single population, with high confidence in the accuracy of the records
Likely impact within population **OR** **Certain impact between populations**	• Barrier is placed between records of a single population, with some uncertainty in the accuracy of the records OR • Barrier is placed in mapped potential habitat between records of two or more different populations, with high confidence in the accuracy of the records
Possible impact between populations **OR** **Likely impact to habitat connected to a population**	• Barrier is placed in mapped potential habitat between records of two or more different populations, with some uncertainty in the accuracy of the records OR • Barrier is placed in mapped potential habitat, where the mapped habitat is in the vicinity of, or connected to, only one known population of the species
Impact to mapped habitat only	• Barrier is placed in mapped potential habitat, where the mapped habitat is not connected to any known populations of the species

CONSEQUENCES

Consequence was determined by considering fragmentation type and applying different criteria depending on the conservation status of the species.

Table 29-11: Consequence definitions for fragmentation

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
Extreme	Internal fragmentation	• Internal fragmentation of two or more important populations, OR • Internal fragmentation of an important population at edge of occurrence	• Internal fragmentation of two or more populations, OR • Internal fragmentation of a population at edge of occurrence	• Internal fragmentation of one population
	Fragmentation between populations	• Fragmentation between populations, which impacts an important population at the edge of occurrence	• Fragmentation between populations, which impacts a population at the edge of occurrence	• Fragmentation between populations, which impacts a population at the edge of occurrence, OR • Fragmentation between populations, which impacts two or more populations which are not at the edge of occurrence
	Fragmentation between a population and potential habitat	• N/A	• N/A	• N/A
	Fragmentation of potential habitat	• N/A	• N/A	• N/A
Major	Internal fragmentation	• Internal fragmentation of one important population	• Internal fragmentation of one population	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts two or more important populations which are not at the edge of occurrence	• Fragmentation between populations, which impacts two or more populations which are not at the edge of occurrence	• N/A

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a large area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a large area of connected mapped potential habitat, OR • Fragmentation of two or more populations, where each population is connected to either a moderate or small area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a large area of connected mapped potential habitat, OR • Fragmentation of two or more populations, where each population is connected to either a moderate or small area of connected mapped potential habitat
	Fragmentation of potential habitat	• N/A	• N/A	• Fragmentation of a large area of potential habitat with no associated records
Moderate	Internal fragmentation	• Internal fragmentation of two or more non-important populations	• N/A	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts one important population and one or more non-important populations not at the edge of occurrence	• N/A	• N/A
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a moderate area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a moderate area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a moderate area of connected mapped potential habitat
	Fragmentation of potential habitat	• Fragmentation of a large area of potential habitat with no associated records	• Fragmentation of a large area of potential habitat with no associated records	• Fragmentation of a moderate area of potential habitat with no associated records
Minor	Internal fragmentation	• Internal fragmentation of one non-important populations	• N/A	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts two or more non-	• N/A	• N/A

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
		important populations not at the edge of occurrence		
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a small area of connected mapped potential habitat, OR • Fragmentation of one or more non-important population, where the population is separated from a large area of connected mapped potential habitat	• Fragmentation of one or more populations, where the population is separated from a small area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a small area of connected mapped potential habitat
	Fragmentation of potential habitat	• Fragmentation of a moderate area of potential habitat with no associated records	• Fragmentation of a moderate area of potential habitat with no associated records	• Fragmentation of a small area of potential habitat with no associated records
Negligible	Internal fragmentation	• N/A	• N/A	• N/A
	Fragmentation between populations	• N/A	• N/A	• N/A
	Fragmentation between a population and potential habitat	• Fragmentation of one or more non-important populations, where the population is separated from a moderate or small area of connected mapped potential habitat	• N/A	• N/A
	Fragmentation of potential habitat	• Fragmentation of a small area of potential habitat with no associated records, OR • Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species	• Fragmentation of a small area of potential habitat with no associated records, OR • Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species	• Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90 per cent of records of the species occur within the subregion

SPECIES AT HIGH RISK OF DIRECT IMPACTS

29.4 *PIMELEA SPICATA* (SPIKED RICE-FLOWER)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	A slender, low growing shrub with narrow elliptical leaves, pink tinged white flowers and green fruit. It grows up to 50 cm tall. (DoEE, 2018c)
ECOLOGY	Flowers and fruits throughout the year, although flowering is more common in summer, particularly following rainfall. The species is known to be pollinated by native bees and may also be capable of self-pollination (James, 2018b). While reproduction is the primary means of recruitment, established plants can re-sprout from a taproot after defoliation due to disturbance (James, 2018b). It is estimated that the species requires over three years to develop a sufficient tap root to enable this process to occur. Regrowing from a taproot significantly depletes energy reserves and reduces the plant's capacity to re-sprout from subsequent disturbances. The species maintains a long-lived, persistent soil seed bank. Sites which have been undisturbed for a long period of time, or sites that are subject to a high level of weed infestation, may exhibit strong recruitment following a disturbance event. Optimum disturbance frequencies are unknown for this species. It is estimated that disturbance should not occur at less than 10-year intervals. Seed dispersal is highly localised (within 30 cm of adult plants). The life span of the species could be 20-30 years or more. (DoEE, 2018c; TSSC, 2016f)
DISTRIBUTION AND HABITAT	The species occurs in the Sydney Basin IBRA: in the Cumberland Plain in the west, and Illawarra region on the coast, south of Sydney. Current known distribution in the Cumberland Plain extends from Marayong and Prospect Reservoir south to Narellan Vale and Douglas Park. In Illawarra it exists from Lansdowne past Shellharbour to northern Kiama. Habitat is associated with: • Cumberland Plain Shale Woodlands and Shale Gravel Transition Forest

	• Western Sydney Dry Rainforest and Moist Woodland on Shale Woodland In both vegetation types it occurs on well-structured clay soils derived from Wianamatta shales, in areas of undulating topography. As of 2005, the species had a known area of occupancy of 17 ha. In 2006, 80 per cent of populations had a small area of occupancy of less than 0.5 ha. (DEC, 2005a; TSSC, 2016f)
POPULATIONS	In 2006 the total population was 4,300 individual plants across 30 known populations. Of these populations, 25 were on the Cumberland Plain. They varied in size from a few individuals to more than 500 plants. Over half were populations of less than 50 individuals. (DEC, 2005a; DoEE, 2018c) Since 2006, the species has been shown to respond well to recovery actions, leading to a significant increase in abundance and area of occupancy of some populations, with examples numbering in the thousands (TSSC, 2016f). Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *P. spicata* is considered to be an endemic species to the region.
SOS SITES	The following SOS sites for the species have been identified: • Prospect Nature Reserve • Narellan
RELEVANT PLANS AND POLICIES	Conservation Advice for *Pimelea spicata* (Spiked Rice-Flower) (TSSC, 2016f) *Pimelea spicata R. Br.* Recovery Plan (DEC, 2005a) Threat abatement plan for competition and land degradation by rabbits (DoEE, 2016a)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=20834

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	Yes	Yes	Yes	Yes
EXPERT REPORT (BCAR PROCESS)	Yes, (James, 2018b) and (James, 2018a). Available at Supporting Document C				

	WITHIN THE NOMINATED AREAS

HABITAT MAPPING	**Expert report and expert report polygons:**
	Overview of available information
	Two expert reports have been produced which separately map habitat polygons within GPEC and WSA, and in GMAC and Wilton. Both reports were authored by the same expert, T. James (2018b, 2018a).
	As part of the expert report preparation process, James produced:
	• Expert reports which outline:
	  o The ecological characteristics of *P. spicata*
	  o An overview of available data for *P. spicata* within the region
	  o The method used to map habitat polygons in each nominated area
	  o An overview of the habitat mapped in each nominated area
	• Expert report polygons, which are shapefiles which indicate the areas of potential habitat of *P. spicata* in each of the nominated areas. Note that the expert report polygons were provided to the consulting team in association with the expert reports to enable habitat analysis
	The expert report polygons provided by James have been used directly by the consulting team to conduct assessments of *P. spicata*. These uses include:
	• Calculating the amount of habitat available in each nominated area
	• Calculating the amount of habitat that will be impacted by urban capable and/or transport development
	• Calculating the amount of habitat within avoided and/or excluded land
	It is recognised that *P. spicata* is a cryptic species, which is often difficult to detect when not flowering, and may not be visible above ground during dry periods where it may persist in the soil as rootstock and/or seeds. The species flowers in response to rainfall, and therefore survey following rain is recommended. While surveys were undertaken by the consulting team for the strategic assessment during 2017-18, and then again in 2019 (during which the species was not found), it is noted that field conditions at the time of survey were hot and dry, and therefore the surveys undertaken by the consulting team are not considered to constitute proof of absence for the species. Subsequently, survey results were not used to modify the habitat polygons produced in association with the expert report.
	Overview of discrepancies between expert reports and expert report polygons
	It is noted that the expert report polygons used by the consulting team match the maps of potential habitat included in the two expert reports (Figures 4, 5, 5a, 6, 6a, 7, 8, 9, 10 and 12 in the expert report for GMAC and Wilton, and Figures 5 and 6 in the expert report for GPEC and WSA (James, 2018b, 2018a)).
	However, for all nominated areas, there are some details within the written expert reports which are at odds with the expert report polygons provided by James. Differences include:
	• Differences in the total area of habitat mapped within each nominated area
	• Differences in the identified PCTs which have been mapped to contain habitat for *P. spicata*
	• Differences in the vegetation condition states of vegetation used to identify habitat for *P. spicata*
	Unfortunately, the expert author is unavailable to provide comment or clarification on the discrepancies between the written reports and the expert report polygons. The consulting team have therefore based this assessment upon the data contained within the expert report polygons, where discrepancies with the written reports exist.

Habitat mapped in GPEC and WSA

In the written report, James (2018a) notes that *P. spicata* is known to occur in the following vegetation communities: PCT 849, 850, 806, 807, 830, 835, 1395. James (2018a) then identifies habitat mapped for *P. spicata* within the following vegetation communities: PCT 850, 849, 835, 724, 1395 (as per Table 11 of the expert report). It is noted that the expert report polygons map habitat for *P. spicata* within the following PCTs: 724, 725, 781, 835, 849, 850, 1395 and 1800, in addition to urban native/exotic vegetation with no associated PCT number.

James (2018a) further states that, as *P. spicata* is tolerant of disturbance and may re-appear in disturbed habitat, the following condition states were considered when determining suitable habitat: intact, thinned, scattered trees, derived shrubland and grassland. It is noted that the expert report polygons for *P. spicata* map habitat in vegetation of the following conditions: intact, thinned, scattered trees, derived native grassland, non-offsettable grassland and urban native/exotic.

The characteristics of the physical environment were also used to identify suitable habitat, where suitable sites include slopes in undulating low hilly terrain on Wianamatta Group shales, on moist soils, often on protected south or east facing slopes (James, 2018a).

It is recognised that the expert report identifies a total of 2,168 ha of habitat in GPEC and 564 ha of habitat in WSA (James, 2018a), whilst the associated expert report polygons indicate a total of 2,164 ha of habitat in GPEC and 512 ha of habitat in WSA.

Habitat mapped in GMAC and Wilton

In the written report for GMAC and Wilton, James (2018b) notes that *P. spicata* is known to occur in the following vegetation communities: PCT 849, 850, 806, 807, 830, 1395. James (2018b) then identifies habitat mapped for *P. spicata* within the following vegetation communities: PCT 850, 849, 608, 609, 830, 835, 1395 (as per Table 14 of the expert report). It is noted that the expert report polygons map habitat for *P. spicata* within the following PCTs: 830, 835, 849, 850, 1181, 1395, in addition to urban native/exotic vegetation with no associated PCT number.

James (2018b) further states that, as *P. spicata* is tolerant of disturbance and may re-appear in disturbed habitat, the following condition states were considered when determining suitable habitat: intact, thinned, scattered trees, derived shrubland and grassland. It is noted that the expert report polygons for *P. spicata* map habitat in vegetation of the following conditions: intact, thinned, scattered trees, derived native grassland, non-offsettable grassland and urban native/exotic.

The characteristics of the physical environment were also used to identify suitable habitat, where suitable sites include slopes in undulating low hilly terrain on Wianamatta Group shales, on moist soils, often on protected south or east facing slopes (James, 2018b).

It is recognised that the expert report identifies a total of 542 ha of habitat in GMAC and 405 ha of habitat in Wilton (James, 2018b), whilst the associated expert report polygons indicate a total of 475 ha of habitat in GMAC and 664 ha of habitat in Wilton.

Characteristics of *P. spicata* occurrence with respect to interpretation of mapped habitat

The ideal habitat of *P. spicata* is intact woodland with open, grassy understorey. However, it is recognised that *P. spicata* may persist in disturbed areas (often surviving as a long-lived seedbank), and may re-occur after disturbance to that environment has ceased and vegetation is permitted to regenerate (e.g. after mowing or grazing of a site ceases) (James, 2018b, 2018a)

Habitat that has been mapped within the four nominated areas occurs across a variety of vegetation condition states, from intact vegetation through to non-offsettable grasslands. While *P. spicata* has the potential to be present within vegetation of very low condition, such as heavily grazed paddocks, it is recognised that the species is less likely to be present in these environments than in higher condition, more intact vegetation communities with fewer threatening processes such as livestock grazing.

While it is suitable to map low condition vegetation as potential habitat for *P. spicata* (as the species does have a real potential to be present in these areas), it is recognised that the quality of habitat for the species in these areas is likely to be significantly degraded and therefore, the likelihood that the species persists in these environments is low. The habitat mapping for *P. spicata* is therefore considered to be precautionary, and it is considered unlikely that *P. spicata*, if present, would be present in high densities in degraded areas of vegetation.

	OUTSIDE THE NOMINATED AREAS
	Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The report for this process (Supporting Document F) notes that several of the SDM layers are expected to over-predict the likely areas where mapped flora species occur, and therefore resultant habitat maps may be precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.

POPULATION MAPPING	**RECORD SELECTION**
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Populations of the species were defined to include clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.
	IMPORTANT POPULATION CRITERIA
	Populations of *P. spicata* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations of *P. spicata* are considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.21 for a map of records and habitat across the Strategic Assessment Area

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-13 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. spicata* in the Strategic Assessment Area.
	Records
	The majority of records for the species occur in the Blacktown, Prospect, Bankstown and Narellan districts. Populations within the vicinity of Campbelltown and Wollondilly LGAs are close to the southern limit of the species' range (James, 2018b).
	Within the Strategic Assessment Area, a total of 25 important populations have been mapped. Five populations are either wholly or partly located in existing conservation reserves. The majority of these tend to be small and scattered. However, population 53 contains 693 records, and is referred to in the Conservation Advice as a large population containing around 6,000 plants. It occurs outside of the nominated areas within the Camden Golf Club in the suburb of Narellan.
	Within the nominated areas the following populations have been recorded:
	• GPEC:
	  o Population 31 – Two records within Cranebrook surrounded by existing urban development. The population does not occur within urban capable land
	  o Population 34 – Two records near Ropes Creek in Wianamatta Regional Park. The population does not occur within urban capable land

	- Population 534 – One record adjacent to the Western Motorway (M4) in Orchard Hills. The population does not occur within the transport corridor footprint • WSA – no records • GMAC: - Population 51 – One record within roadside vegetation near to an existing industrial area. The population does not occur within urban capable land - Population 532 – One record to the east of the Hume Motorway and south of Glenlee Road within urban capable land of the nominated area - Population 533 – One record on the eastern boundary of the nominated area and Strategic Assessment Area. The population does not occur within urban capable land • Wilton – no records **Potential habitat** The baseline mapping for this assessment has mapped approximately 34,859 ha of known and potential habitat within the Strategic Assessment Area. Habitat is present across the majority of the central and eastern areas of the Strategic Assessment Area and occurs as follows: • In the north, habitat is present in the locality of Freemans Reach and Scheyville, with large areas of habitat also present within the Londonderry locality • Habitat is scattered throughout GPEC and WSA, including (but not confined to) localities such as Cranebrook, Mount Druitt, Glenmore Park, Luddenham and Kemps Creek • Large, connected areas of habitat occur to the east and south of the WSA, spanning from Wetherill Park, down through Kemps Creek and Leppington, to Camden in the south and to Theresa Park in the west • Further areas of scattered habitat occur to the south of Theresa Park and Camden, in localities such as Razorback and Wilton It is noted that mapped habitat is present within all nominated areas for this species.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.4.1 NOMINATED AREAS

RECORDS

A total of six known populations of the species occur within the nominated areas (three within GMAC and three within GPEC). Of these:

- Four populations (31, 34, 534 and 51) occur entirely within excluded lands (three in GPEC and one in GMAC)
- One population (533) occurs entirely within land avoided for biodiversity purposes (one in GMAC)
- One population (532) occurs within urban capable land (GMAC)

It is noted that the Plan includes a commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to known populations of *P. spicata*.

POTENTIAL HABITAT

The baseline mapping for this assessment has mapped 1,463 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 616 ha (42 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 515 ha was avoided for biodiversity purposes
- 100 ha was avoided for other purposes

Of the land that was avoided for biodiversity purposes, 435 ha is of good to reasonable habitat condition (vegetation condition classes include intact, scattered trees, thinned and derived native grassland) and 80 ha is habitat in highly degraded condition (vegetation condition classes include non-offsettable grasslands and urban native/exotic vegetation). The vast majority (84 per cent) of avoidance of biodiversity purposes therefore includes areas of higher quality habitat for the species.

A breakdown of avoidance of potential habitat across each nominated area is provided in Table 29-14.

It is important to note that the avoidance calculations in Table 29-14, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-14 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.4.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

It is noted that there is a total of 386.3 ha of potential habitat for *P. spicata* within tunnel footprints within the transport corridors, with large numbers of records in adjacent areas suggesting it is likely that the species does occur in the tunnel footprint. The Plan includes a commitment (Commitment 4.1) to avoid and minimise impacts to *P. spicata* as a result of tunnel construction activities within or adjacent to the footprints of the Outer Sydney Orbital (OSO) and Metro Rail Future Extension. This commitment will ensure that appropriate avoidance of impacts to *P. spicata* will occur during the development of the transport corridors in known habitat for the species.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.4.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to direct impacts to a known population and a loss of potential habitat. A summary of these impacts is provided in Table 29-15.

IMPACTS TO KNOWN POPULATION

Population 532 is an important population which occurs within the urban capable lands in GMAC. It consists of one record dated from October 2018, with 160 plants noted in the species' record. The record is located within a small (approximately 3 ha) patch of vegetation mapped as Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in a thinned condition. This vegetation patch is isolated from other vegetation and occurs in a significantly cleared landscape.

Given that one individual plant may consist of up to 50 stems (TSSC, 2016f), the exact number of individuals within the population is unclear. However, the population is likely to be moderate in size relative to other known populations, noting that a limited number of known populations contain thousands of individuals, while the majority contain 50 or less (TSSC, 2016f).

It is noted that the population is not located on the edge of the species' extent of occurrence and the small, degraded and isolated condition of the habitat potentially limits the long-term viability of the population. However, as described in the species conservation advice, any habitat where populations are known to occur is considered habitat critical to the survival of the species and all populations are considered to be important populations that are necessary for the species' survival and recovery.

For these reasons, it is recommended that the Plan adopt an additional species-specific commitment for *P. spicata* to retain some or all of population 532 within GMAC. This recommendation is an outcome of this impact assessment which has developed too late in the process to be adopted in the draft version of the Plan for public comment. It is very likely the recommendation will be adopted under the Plan prior to finalisation for endorsement and approval.

It should be noted that this recommendation does not change the risk rating applied to the species. This recommendation is taken to mitigate the scale of impact and possible implications for viability by maintaining part of the population but does not remove the likelihood of some impacts to the population from occurring.

LOSS OF POTENTIAL HABITAT

956 ha of potential habitat for the species will be impacted. This is 2.7 per cent of mapped potential habitat across the Strategic Assessment Area. The loss of potential habitat occurs across all of the nominated areas and transport outside the nominated areas.

It is recognised that, of the 956 ha of potential habitat impacted, 438 ha (46 per cent of impacted vegetation) is in a highly degraded state (being classed as either non-offsettable grassland, or urban native/exotic vegetation). As outlined in the habitat mapping approach overview above, while there is a potential that *P. spicata* may persist in areas of degraded habitat, it is considered highly unlikely that the species would be present in high densities in such areas. Therefore, the habitat mapping for *P. spicata* within impacted areas is considered to be precautionary.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of direct impacts to an important population is considered to be high. This risk ranking is triggered for impacts to species' records, as follows:

- The likelihood of actual impacts occurring to the species has been categorised as almost certain. There will be direct impacts to a known population of the species, with high confidence in the accuracy of the records
- The consequence of any impacts to the species (if they did occur) has been categorised as major. There will be a loss of an endangered (endemic) population which is not at the edge of the species' occurrence

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be medium. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact area (it is noted that habitat mapping for this species includes significant areas (438 ha) of degraded habitat, where there is a lower likelihood of species persistence, and therefore the habitat mapping is considered precautionary)
- The consequence of impacts to the species (if they did occur) has been categorised as major. There will be a loss of 2.7 per cent of mapped potential habitat (endemic species), with moderate confidence that the species occurs in the impact area

29.4.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of potential habitat in the following locations:

- Fragmentation of a moderate area of mapped habitat associated with records of the species at Cobbitty due to the development of the OSO
- Fragmentation of a small area of mapped habitat associated with records of the species within GPEC due to the development of the OSO within Wianamatta Regional Park

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development presents a barrier to dispersal of the species is likely. While seed dispersal of *P. spicata* is highly localised (within 30 cm of adult plants), it is recognised that the species is pollinated by insects and therefore genetic connectivity has potential to be maintained if pollinator movement is not obstructed. While detailed planning for development within the transport corridors has not yet been completed, it is thought to be likely that the OSO will constitute a likely barrier to seed dispersal for the species
  - The type of fragmentation (as defined in the risk assessment approach in Section 29.3) is impact to habitat connected to a population. This is because there are known records located on mapped potential habitat which is fragmented by the OSO development
- The consequence of fragmentation has been categorised as moderate. This is because the area to be fragmented is connected to a known population of the species and is of moderate size

29.4.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the species, the Plan includes a commitment to secure 3 offset locations for the species as part of the conservation program. This will provide a substantial addition to the level of protection of the species within the Strategic Assessment Area where currently only five populations (out of a total of 25) occur in protected areas. In situ protection of *P. spicata* populations is a fundamental component of the species' recovery plan.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.4.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (TSSC, 2016f) and Recovery Plan (DEC, 2005a) (and other key documents) for *P. spicata* identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Weed invasion
- Inappropriate fire regimes
- Hydrological disturbance such as increased urban run-off
- Illegal dumping of rubbish and garden waste
- High frequency land management (e.g. mowing and slashing, weed control including herbicide use)

Browsing by rabbits and intensive livestock grazing have also been identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

WEED INVASION

Weed invasion is identified as a potential threat to *P. spicata*. Weed species which form dense thickets or ground covers are recognised to pose a particular threat to the species. Weeds may out-compete and displace *P. spicata*, reducing reproductive success and re-sprouting potential of adults, and reducing the successful growth of seedlings. Key weed species which threaten *P. spicata* include African olive, lantana (*Lantana camara*), African lovegrass (*Eragrostis curvula*), Rhodes grass (*Chloris gayana*), Kikuyu grass (*Pennisetum clandestinum*) and bridal creeper (*Asparagus asparagoides*) (TSSC, 2016f).

These weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads. Higher risk areas (where *P. spicata* is located in proximity to urban development, roads and publicly accessible land) are located as follows:

- Near Menangle Park, where population 532 occurs adjacent to urban capable development
- Near Twin Creeks, were population 40 occurs in proximity to urban capable development
- North of the Western Motorway, where population 534 occurs adjacent to urban capable development
- Within Wianamatta Regional Park, where population 34 occurs to the west of the OSO footprint
- Where potential habitat for the species is mapped adjacent to urban capable and transport development (which occurs in multiple scattered locations in each nominated area)

The Plan incorporates species-specific measures for the protection of *P. spicata*, which will contribute to the control of weeds within known and potential habitat for the species. Species-specific measures which are relevant to weed control include:

- Protecting three known offset locations for *P. spicata* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of the spread of weeds on *P. spicata* associated with urban (Commitment 5) and transport (Commitment 6) development, including a commitment to control weeds associated with the construction of proposed tunnels within the major transport corridors (Commitment 6.2)

The Plan further incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area (SCA). This includes a number of actions, of which the following are the most relevant to the outcome for *P. spicata*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches

- Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Also relevant for the *P. spicata* is that a known population of the species (population 533), in addition to mapped potential habitat, is located within the proposed footprint for Stage 1 of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include weed management measures to protect the biodiversity values of the reserve.

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from the increased risk of weeds associated with development. This is because:

- Three known offset locations for *P. spicata* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and a known population of *P. spicata.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. spicata*
- There is a specific requirement for the impact of weeds to be managed with regards to the requirements of *P. spicata* in relation to the development of tunnels within major transport corridors
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 616 ha of mapped potential habitat of *P. spicata* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

These controls are consistent with a number of suggested management actions in the Conservation Advice, including (TSSC, 2016f):

- "Incorporate weed management/habitat restoration plans in site-specific management plans developed for all known spiked rice-flower populations, including surrounding buffer zones"
- "Implement relevant weed control measures according to site-specific weed management plans"

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are identified as a potential threat to *P. spicata* (TSSC, 2016f). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the mechanisms outlined above. It is noted *P. spicata* is threatened by both very frequent and very infrequent fire, as frequent fire prevents maturation and reproduction of individuals, whilst infrequent fire reduces the germination of seeds (TSSC, 2016f).

Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads. As outlined above, higher risk areas include populations 532, 40, 534 and 34, in addition to scattered areas of mapped potential habitat in each nominated area.

The Plan incorporates species-specific measures for the protection of *P. spicata*, which will contribute to the maintenance of appropriate fire regimes within species' habitat and provide for protection for the species. Species-specific measures which are relevant to fire regime management include: protecting three known offset locations for *P. spicata* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species.

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. spicata* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. spicata*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

Also relevant for the *P. spicata* is that a known population of the species (population 533), in addition to mapped potential habitat, is located within the proposed footprint for Stage 1 of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include the application of the fire management strategy and a set of measures to control access to bushland which will help minimise risks around arson and accidental fires.

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from altered fire regimes as a result of development. This is because:

- Three known offset locations for *P. spicata* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and a known population of *P. spicata.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. spicata*
- Establishment of environmental zoning of approximately 616 ha of mapped potential habitat of *P. spicata* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *P. spicata* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *P. spicata* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

These controls are consistent with a number of suggested management actions in the Conservation Advice, including (TSSC, 2016f):

- "Develop and implement a fire management strategy for conservation of the based on research of the species' fire ecology and in consultation with the NSW Rural Fire Service and other relevant stakeholders with regards to fire control measures"
- "Physical damage to the habitat and individuals of the threatened species must be avoided during and after fire operations"

HYDROLOGICAL DISTURBANCE

Hydrological disturbance as a result of changed land use patterns has been identified as a potential threat to *P. spicata* (TSSC, 2016f). Key risk areas are those that are those which are in proximity to areas of development (such as urban and industrial areas and roads), which may experience altered runoff and hydrological patterns as a result of development. As outlined above, higher risk areas include populations 532, 40, 534 and 34, in addition to scattered areas of mapped potential habitat in each nominated area.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for *P. spicata*. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines (Roads and Maritime Service, 2011). These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to biodiversity values, including potential habitat for *P. spicata*
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *P. spicata*

ILLEGAL DUMPING OF RUBBISH AND GARDEN WASTE

Habitat degradation through illegal dumping of rubbish and garden waste is identified as a threat to *P. spicata* (TSSC, 2016f). Development under the Plan may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations on public land are considered most at risk from this impact. While illegal access to privately owned land may increase, the rate of increase is expected to be minor in the context of potential impacts to *P. spicata.* This risk will be managed in areas of public land that are managed for conservation. This will include all new conservation areas established by the Plan. However, the risk will remain and likely increase in areas of public land managed for other purposes.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *P. spicata*. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the three offset locations to be obtained for *P. spicata* in association with Commitment 9.1, as well as *P. spicata* populations and mapped potential habitat within the Georges River Koala Reserve to be established under Commitment 10)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. spicata*

These measures under the Plan are expected to adequately manage the threat posed by illegal dumping of rubbish and garden waste to *P. spicata.*

HIGH FREQUENCY LAND MANAGEMENT

High frequency land management (e.g. mowing and slashing, and use of herbicides for weed control) has the potential to reduce the viability of populations and cause local extinctions. Although slashing and mowing activities have largely ceased in government reserves that are known to support the species, these are still considered to exist as a broader landscape risk in areas that are unknown to provide habitat. Indirect impacts from use of herbicides are also considered to be a current threat to the species (TSSC, 2016f). The Plan has the potential to exacerbate this risk in these areas that are close to new development.

The Plan includes a species-specific commitment (Commitment 5.4) to consult with relevant public land managers to minimise disturbance and impacts associated with land management to *P. spicata*, particularly with regards mowing, slashing and weed control activities.

Implementation of Commitment 5.4 is considered adequate to mitigate the threat of high frequency land management impacts to *P. spicata*.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.4.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Records of *P. spicata* occur within GMAC and GPEC, and potential habitat for the species is mapped in all nominated areas. One population (population 533) occurs within avoided land within GMAC, between Appin Road and the Georges River near Wedderburn. This population consists of a single recent record (dated from 2019) which is within the proposed footprint for Stage 1 of the Koala Reserve. It is therefore likely that this site will be formally protected for conservation purposes in the future, subject to approval of the proposed layout of the Koala Reserve and implementation of the Reserve. Nonetheless, the Plan includes a commitment to prioritise avoidance of impacts from essential infrastructure on non-certified land to *P. spicata*, which will contribute to the protection of known records of the species.

As outlined in Chapter 37, any proposed essential infrastructure developments on avoided lands within the nominated areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.4.8 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 386.3 ha of potential habitat for *P. spicata* within the footprints of the Metro Rail Future Extension and OSO tunnels. While there are no records of *P. spicata* within the tunnel footprints, it is considered to be likely that the species may occur within the tunnel footprints due to known records of the species occurring in close proximity to the tunnels (such as population 53, which is a large population at Camden Golf Club, immediately adjacent to the tunnel footprint).

However, the Plan includes commitments to:

- Avoid and minimise impacts to populations and habitat within or adjacent to the OSO and Metro Rail Future Extension footprints for *P. spicata*
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.4.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (TSSC, 2016f) and Recovery Plan (DEC, 2005a) identify the following key issues that are likely to have the greatest influence on the long-term viability of *P. spicata* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
    - Illegal dumping of rubbish and garden waste

- Weed invasion and competition
- High-frequency land-use/management activities
- Inappropriate fire regimes
- Hydrological disturbance

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Direct impacts to a known population (population 532) of the species
- Loss of approximately 956 ha of mapped habitat within the nominated areas and transport corridors
- Potential fragmentation of habitat in two locations

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is high.

The likelihood of potential impacts to population 532 within the urban capable lands in GMAC is the key driver for this risk rating. There is a high level of confidence that the population is extant given the locational accuracy, reputable observer and date of observation attached to the record. The population is of a moderate size comprising up to 160 plants. It is likely that this population is important to the ongoing viability and recovery of the species, in line with the species conservation advice that identifies:

- Any habitat where populations are known to occur as habitat critical to the survival of the species and
- All known populations as important populations that are necessary for the species' survival and recovery

Based on this assessment, it is recommended that the Plan adopt an additional species-specific commitment for *P. spicata* to retain some or all of population 532 within GMAC. As noted above, this recommendation has developed too late in the impact assessment process to be adopted in the draft version of the Plan for public comment. It is very likely the recommendation will be adopted under the Plan prior to finalisation for endorsement and approval and there is confidence that some level of protection will be afforded to at least part of the population. The aim of this recommendation is to ensure that the contribution of population 532 to the species' survival and recovery is not lost. It does not change the overall level of risk to the species based on the risk assessment method applied here.

It is also relevant to note that the existing long-term viability of population 532 is questionable because it is located in a small, degraded patch of woodland surrounded by cleared land, roads and rural buildings. Any commitment to retain part of this population will likely improve the overall long-term outcome for the population.

The Plan will deliver three offset locations to address the high risk to *P. spicata* from direct impacts of development. This will provide a substantial addition to the level of protection for the species which is currently under-represented in protected areas. In situ protection of *P. spicata* populations is a fundamental component of the species' recovery plan. The recovery plan's overall objective is to ensure the continued and long-term survival of *P. spicata* in the wild by promoting the in-situ conservation of the species across its natural range; with a specific [sub] objective to conserve *P. spicata* using land-use and conservation planning mechanisms.

In addition, the Plan includes a broader set of commitments and actions which are likely to benefit the species. The SCAs contain approximately 2,296 ha of mapped potential habitat for *P. spicata*. It is very likely that areas of potential habitat in addition to the three offset sites will be protected within these SCAs as part of offset commitments for other species and ecological communities under the Plan. The conservation advice for *P. spicata* notes that populations of the species have significantly increased in abundance and area of occupancy following the removal of threats (including the removal of weeds and fencing to prevent rabbits). The protection and management of potential habitat within the SCA's therefore provides a real opportunity for recovery within areas where the species might currently be suppressed.

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts of development within the nominated areas and transport corridors associated with inappropriate habitat disturbance, weed invasion, and inappropriate fire regimes have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a species-specific commitment to minimise the impacts of high frequency land use. In addition, any potential indirect impacts associated with the construction of tunnels will be managed and mitigated.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to impacts to one known population of *P. spicata* and areas of potential habitat. While these impacts are considered to present a high risk of adversely impacting the species, implementation of the Plan is not expected to negatively influence the long-term viability of the species for the following key reasons:

- Direct impacts to the known population are likely to be mitigated through a recommendation to retain all or part of the population as part of detailed precinct planning. The long-term persistence of this population in the absence of any further development is already uncertain given the isolated and degraded nature of habitat. A commitment leading to any retention of plants within this population is likely to contribute to the species' broader recovery survival
- The Plan will lead to the protection of three sites known to support the species. This will contribute substantially to the level of existing protection and support the objective underpinning the species' recovery plan
- Protection and management of known habitat through the offset commitment, as well as the protection and management of additional areas of suitable habitat through the Plan's broader commitments with the SCA's, is likely to contribute meaningful outcomes for *P. spicata,* which has been shown to respond positively to the removal of threats on land where it is known to occur
- Potential indirect impacts are addressed through management measures in the Plan

29.4.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan (DEC, 2005a) is to ensure the continued and long-term survival of *P. spicata* in the wild by promoting the in-situ conservation of the species across its natural range. Specific objectives include:

- Conserve *P. spicata* using land-use and conservation planning mechanisms
- Identify and minimise the operation of threats at sites where *P. spicata* occurs
- Develop and implement a survey and monitoring program that will provide information on the extent and viability of *P. spicata*
- Provide the community with information that assists in conserving the species
- Raise awareness of the species and involve the community in the recovery program
- Conduct research that will assist future management decisions

Implementation of the Plan will support a number of these strategies and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *P. spicata*. The Plan will not prevent implementation of any of the actions.

29.4.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-12 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *P. spicata,* there are no relevant Threat Abatement Plans.

Table 29-12: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. spicata*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-13: Occurrence of *P. spicata* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	25	5
(IMPORTANT POPULATIONS)	(25)	(5)
HABITAT MAPPING (Ha)	34,859.0	3,156.0

Table 29-14: Avoidance of *P. spicata* within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	664.4	475.3	512.0	2,164.1	3,815.9
HABITAT WITHIN EXCLUDED LANDS (ha)	104.5	245.2	52.3	1,950.6	2,352.5
HABITAT WITHOUT EXCLUDED LANDS (ha)	**559.9**	**230.2**	**459.8**	**213.5**	**1,463.4**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	151.0	139.6	137.0	87.6	515.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	27.0	60.7	29.8	41.0	35.2
AVOIDANCE FOR OTHER REASONS (ha)	10.6	29.3	45.5	15.0	100.4
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	1.9	12.8	9.9	7.0	6.9
TOTAL AVOIDANCE (ha)	**161.6**	**169.0**	**182.5**	**102.6**	**615.6**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**28.9**	**73.4**	**39.7**	**48.0**	**42.1**

Table 29-15: Direct impacts to *P. spicata* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	398.4	61.2	277.2	111.0	107.8	**955.6**
DIRECT IMPACTS TO POPULATIONS (Number)	0	1	0	0	0	**1**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(1)	(0)	(0)	(0)	**(1)**

29.5 *PULTENAEA PARVIFLORA*

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	A small shrub with single yellow flowers with reddish markings. Usually less than 1 m tall but rarely up to 2 m. (DoEE, 2018c)
ECOLOGY	Flowers mainly from August to November. Fruiting occurs from October to November. There is no evidence of vegetative reproduction for this species. Pollinators for this species are unknown. Seeds may be dispersed by ants. Reproductive maturity is reached after 3-4 years, and peak seed production does not occur until 5-6 years of age. Species is suggested to live for roughly 20 years. Plants are killed by fire and re-establish from soil-stored seed. Plants appear in response to disturbance, such as fire events. Germination can be prolific following medium to high intensity fire events. Repeated and frequent disturbance of populations is likely to result in population decline (when disturbance occurs at intervals of less than 6-8 years) or extinction (when disturbance occurs at intervals of less than 4 years). A fire interval of 10-15 years is required to allow for the development of suitable seed bank, and to create suitably high fuel levels to create moderate to high intensity fires which are required to promote seed germination. Disturbance history is important for influencing the number of individuals present at a site. Fire-induced recruitment tends to produce more evenly-aged populations than soil-disturbance-induced recruitment. (DoEE, 2018c; OEH, 2017f)
DISTRIBUTION AND HABITAT	Confined to the Cumberland Plain, mainly between Penrith and Windsor. Outlier populations are recorded from Kemps Creek and Wilberforce. Grows in dry sclerophyll woodlands, forest or in derived grasslands on laterised Wianamatta Shale or Tertiary alluvium, on infertile sandy to clay soils. (DoEE, 2018c; OEH, 2017f)
POPULATIONS	Populations have been recorded to range in size between 10 and over 5,000 individuals. As of 1995, populations were known to occur within the Blacktown, Hawkesbury, Liverpool and Penrith Local Government Areas.

	As of 2002, the species had been recorded within the following reserved areas: • Scheyville National Park • Windsor Downs Nature Reserve • Castlereagh Nature Reserve • ADI Regional Park (now Wianamatta Regional Park) (DoEE, 2018c) Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *P. parviflora* is considered to be an endemic species to the region.
SOS SITES	The following SOS sites for the species have been identified: • Scheyville • Castlereagh Nature Reserve • Wianamatta Nature Reserve • Colebee
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Pultenaea parviflora* (DEWHA, 2008k)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=19380

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Potential habitat polygons were generated for this species using BioNet PCT associations, vegetation condition (intact, thinned) and elevation (less than 120 m). To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was recorded during surveys in a number of locations. **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. No targeted surveys were undertaken outside the nominated areas.

<table>
<tr><td rowspan="6">POPULATION MAPPING</td><td>RECORD SELECTION</td></tr>
<tr><td>Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
<tr><td>POPULATION DEFINITION</td></tr>
<tr><td>Biological populations were defined using the records dataset and available information about the nature of the species.
Records within 500 m of each other were considered to be a single population.</td></tr>
<tr><td>IMPORTANT POPULATION CRITERIA</td></tr>
<tr><td>Populations of P. parviflora were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. For this species, populations were considered important because they met one or more of the following criteria:
• A population is important for maintaining the Extent of Occurrence of a species
• A population within a conservation reserve
• A large population
• Population is associated with a commitment made under the Sydney Growth Centres conservation program
• A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program</td></tr>
</table>

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

<table>
<tr><td>MAP</td><td>See Map 36.24 for a map of records and habitat across the Strategic Assessment Area</td></tr>
<tr><td>OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA</td><td>See Table 29-17 at the end of this species assessment for a breakdown of the occurrence of records and habitat for P. parviflora in the Strategic Assessment Area.
Records
The Strategic Assessment Area is the core location for the species. Records occur in the northern half of the Strategic Assessment Area, with the majority of records occurring in the locality of Londonderry/Marsden Park.
A total of 34 populations have been mapped within the Strategic Assessment Area, 18 are considered important. Nine populations are wholly or partly located in existing conservation reserves.
The majority of populations of this species, including several large populations, are located in the northern region of the Strategic Assessment Area, in the area bounded by Freemans Reach to the north, Scheyville National Park to the east, the northern region of GPEC to the south (including Wianamatta Regional Park), and Agnes Banks to the west.
Scattered populations also exist to the south of this region, including areas within and adjacent to GPEC and WSA, and in areas to the east in localities including Prospect Reservoir, Bass Hill and Cecil Park. It is further noted that there are multiple populations in the vicinity of Kemps Creek, of which one is an important population.
Potential habitat
The baseline mapping for this assessment has mapped approximately 20,208 ha of known and potential habitat within the Strategic Assessment Area. The majority of this habitat is located to the</td></tr>
</table>

	north of GPEC, in the localities of Londonderry, Scheyville and Freemans Reach. In addition to this, there are: • Moderate areas of habitat on the western, eastern and southern boundaries of WSA, in the localities of Mulgoa, Luddenham, Kemps Creek and Erskine Park • Small, scattered areas of habitat in the southern portion of the Strategic Assessment Area, particularly along the boundaries of the assessment area, occupation of these latter areas in the southern part of the Strategic Assessment Area is not known as it is not associated with known records

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.5.1 NOMINATED AREAS

RECORDS

A total of six important populations of this species occur within the nominated areas (all of which are within GPEC). Of these:

- Four populations (126, 128, 131, and 225) occur entirely within excluded lands
- Two populations (118 and 127) occur entirely within the OSO transport corridor

A total of eight non-important populations of this species occur within the nominated areas (two in WSA and six in GPEC). Of these:

- Five populations (219, 223, 224, 517 and 516) occur entirely within excluded lands (four in GPEC, one in WSA)
- One population (181) in WSA occurs partially in land avoided for biodiversity purposes (11 records), partially in the urban capable lands (7 records), and partially in excluded land (60 records)
- One population (226) in GPEC occurs partially in land avoided for biodiversity purposes (1 record) and partially in the urban capable lands (1 record)
- One population (542) in GPEC occurs partially in the OSO transport corridor (23 records) and partially in excluded land (1 record)

POTENTIAL HABITAT

The baseline mapping for this assessment has mapped 131 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 57 ha (43 per cent) of this has been avoided as part of the urban capable lands and transport corridors (not including excluded lands). Almost all of this was avoided for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 29-18.

It is important to note that the avoidance calculations in Table 29-18, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-18 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.5.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

It is noted that population 127 of *P. parviflora* is currently mapped to occur entirely within the footprint of transport corridors. It is recognised that the Plan contains a commitment to avoid and minimise impacts to areas of high biodiversity value and threatened species and their habitat during the detailed planning of major infrastructure corridors within the Plan's nominated areas (Commitment 3), and therefore some avoidance of this population is likely to occur. However, as this detailed planning has not yet occurred, for the purposes of this assessment (which takes a precautionary approach), it is assumed that the entirety of the OSO transport corridor at this location will be impacted, and therefore that this population will be lost.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.5.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will:

- Lead to direct impacts to six populations, of which three are important populations
- Lead to a loss of potential habitat
- Lead to fragmentation of potential habitat

A summary of the direct impacts to populations and habitat is provided in Table 29-19.

IMPACTS TO KNOWN POPULATIONS

Important populations

Population 118

Population 118 is located in Shanes Park which almost entirely occurs outside of the nominated areas and transport corridors to the north of GPEC. A small part of the southern portion of Shanes Park occurs within the M7/Ropes Crossing Link Road on the northern boundary of GPEC.

The majority of Shanes Park consists of native vegetation in good condition; it is one of the last remaining remnants of largely unmodified native vegetation in the Cumberland subregion (URS, 2008). Subsequently, the majority of Shanes Park is listed on the Commonwealth Heritage List in recognition of its high biodiversity values. The site contains a number of threatened species.

The population consists of 416 BioNet records in total. All BioNet records for this population do not specify the number of plants recorded, and so each record is considered to account for a single plant. Of these:

- 289 BioNet records are located outside of the Strategic Assessment Area
- 127 BioNet records are located inside the Strategic Assessment Area

The majority of the records within the Strategic Assessment Area were recorded in 2018 and in 2019 as part of the targeted surveys for this assessment. All 127 of these records are located within the footprint of the M7/Ropes Crossing Link Road.

Population 119

This population is primarily located in a Metro offset site at Colebee to the north east of GPEC outside of the Strategic Assessment Area. This site is mapped as containing Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849), in an intact condition.

In 1999, 2,000 plants were recorded as part of this population, whilst in November 2017, 655 plants were recorded within this population.

One plant from this population has been recorded within the footprint of the proposed M7/Ropes Crossing Link Road. This plant was recorded in 2015 and is the southernmost record of Population 119.

Population 127

This population consists of 87 BioNet records from between 2016 and 2019 in Wianamatta Regional Park in the north of GPEC. This site was surveyed by the consulting team in June of 2019, during which 83 individuals of the species were recorded, indicating the population is extant and common on site. The site contains Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion, ranging from intact to thinned condition.

All records of this population are located within the transport corridor of the Outer Sydney Orbital.

The Plan includes commitments to avoid impacts threatened species and their habitat during the development of major infrastructure corridors within the nominated areas (Commitment 3), and therefore some avoidance of impacts to this community is expected to occur in the future. However, for the purposes of this assessment (which takes a precautionary approach), it is assumed that the entirely of the OSO transport corridor at this location will be impacted, and therefore that this population will be lost.

Non-important populations

Population 181

This population consists of 78 BioNet records near Kemps Creek within the south east of WSA. All BioNet records for this population do not specify the number of plants recorded, and so each record is considered to account for a single plant. Records of this population range in date from 2015 to 2018. The majority of plants are located along the roadside of Clifton Ave.

Vegetation in the locality is mapped to include patches of Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion (PCT 724, ranging from intact to thinned condition), and Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion (PCT 725, in an intact condition). The wider landscape is otherwise heavily cleared.

Of the 78 records, 7 are mapped within urban capable lands, and will be impacted. Remaining plants outside urban capable land will be avoided.

There is one important population within close proximity of this population (population 130 which is approximately 850 m to the south). This population contains hundreds of plants and is protected under commitments associated with the Sydney Growth Centres Conservation Program.

Population 226

This population consists of two BioNet records near Twin Creeks in Luddenham in the south of GPEC. The first record is from 2013 and does not state the number of individual plants (and so is assumed to constitute a single plant sighting). The second record is from 2016 and reports 150 plants with an accuracy of 100 m.

This site is mapped as containing Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCT 849), in a thinned condition. Satellite imagery of the site indicates significant areas of the site have been cleared.

The 2013 record is located within the proposed urban capable land, and so will be removed. The 2016 record is sufficiently separated from the proposed urban capable land, and will be avoided.

Population 542

This population is located along the northern boundary of GPEC (near Bidwill and Hassall Grove) largely within the footprint of the M7/Ropes Crossing Link Road.

The site is mapped to contain Cumberland Shale Woodlands and Shale-Gravel Transition Forest (PCT 724 and PCT 849, in a thinned condition). It is noted that this site was surveyed in August of 2019 by the consulting team and therefore there is high confidence in the accuracy of mapped habitat conditions. The vegetation exists as a thin corridor, bounded to the south by urban development and to the north by areas of urban and commercial development.

The population consists of 24 BioNet records, 23 of these are located within the footprint of the M7/Ropes Crossing Link Road. The population is not considered to be large in the context of the species and is not key for maintaining the species' extent of occurrence.

LOSS OF POTENTIAL HABITAT

There will be direct impacts to approximately 188 ha of potential habitat. This represents 0.9 per cent of potential habitat within the Strategic Assessment Area. Habitat loss is primarily associated with transport projects inside the nominated areas (Outer Sydney Orbital and M7/Ropes Crossing Link Road).

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of direct impacts to populations is considered to be high. This risk ranking is triggered for impacts to species' records, as follows:

- The likelihood of actual impacts occurring to the species has been categorised as almost certain. There will be direct impacts to known populations of the species, with high confidence in the accuracy of the records
- The consequence of any impacts to the species has been categorised as major. There will be a loss of an important population (population 127) which is not at the edge of the species' occurrence

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat (away from known populations) is considered to be medium. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within areas of mapped habitat away from known populations has been categorised as likely. There will be direct impacts to potential habitat, with high confidence that the species occurs in the impact area (given that most mapped habitat for this species is associated with records, it is considered likely that the habitat mapping accurately represents species' occurrence)
- The consequence of impacts to the species (if they did occur) has been categorised as moderate. There will be a loss of 0.5-1 per cent of mapped potential habitat (endemic species), with high confidence that the species occurs in the impact area

29.5.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of habitat in relation to two important populations and associated habitat due to the development of the OSO within Wianamatta Regional Park.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be medium. This is because:

- The likelihood of fragmentation has been categorised as likely. This is because:
  - The likelihood that development is presents a barrier to dispersal of the species is likely. While the pollinators for this species are unknown, it is thought that seed dispersal may occur via ants (OEH, 2017f). It is thought that the development of the OSO is likely to pose a barrier to reproduction and/or dispersal of this species
  - The type of fragmentation is certain impact between populations. This is because the OSO will fragment habitat between two important populations (population 118 and 128. It is noted that population 127 is considered to be lost as a result of direct impacts)
- The consequence of fragmentation has been categorised as major. This is because the Plan will lead to fragmentation between populations which impacts two or more important populations which are not at the edge of occurrence of the species

29.5.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the species, the Plan includes a commitment to secure two offset locations for the species as part of the conservation program. This will improve the level of protection of the species within the Strategic Assessment Area where nine populations (out of a total of 34) currently occur in protected areas.

In addition to this, two of the Plan's proposed reserves contain areas of mapped habitat for the species. These include:

- 120 ha of mapped habitat in the Georges River Koala Reserve
- 5 ha of mapped habitat in the Gulguer Reserve investigation area

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.5.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DEWHA, 2008k) (and other key documents) for *P. parviflora* identifies a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate habitat disturbance from uncontrolled vehicle access and rubbish dumping
- Weed invasion
- Inappropriate fire regimes

Dryland salinity has also been identified as a key threat. However, it is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the threat across the Strategic Assessment Area.

INAPPROPRIATE HABITAT DISTURBANCE

Habitat degradation through uncontrolled vehicular access and rubbish dumping have been identified as a key threat to *P. parviflora* (DEWHA, 2008k). Development within GPEC and WSA may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations of *P. parviflora* considered most at risk of this threat are those that occur in:

- Public land, as these areas are accessible without the deterrent that comes with trespassing. Eight important populations occur on public land managed for conservation. They are:
  - Scheyville National Park - population 124
  - Windsor Downs Nature Reserve - population 122
  - Castlereagh Nature Reserve - population 117
  - Agnes Banks Nature Reserve - population 123
  - Wianamatta Nature Reserve - population 116
  - Wianamatta Regional Park - population 128 (note population 127 is considered to be lost as a result of development)
  - Kemps Creek - population 130

- An area of freehold land to the north of GPEC which is often mistaken for Crown land. This area contains a number of access tracks, and issues associated with rubbish dumping have been recorded for the site

It is noted that the national parks, nature reserves and Wianamatta Regional Park are managed (three of these sites are Priority Management Sites under the NSW SOS program for *P. parviflora*). Assuming this management continues and adapts to potential increasing visitation over the life of the Plan, the risk to *P. parviflora* from disturbance is expected to be adequately addressed.

With regards to Kemps Creek, it is noted that this site was briefly visited in association with site surveys which were undertaken during preparation of the expert report for *Acacia pubescens*. The expert report for *A. pubescens* notes that remnant habitat at Kemps Creek was "seen to be largely unmanaged and degrading due to several threats" (Douglas, 2019b). This site is part of the Sydney Growth Centres Program and it is recommended that the management of habitat at Kemps Creek under this program be improved. It is considered that improved and ongoing management of habitat at Kemps Creek will provide protection of *P. parviflora* within this locality from impacts associated with inappropriate habitat disturbance.

With regards to site visitation in public land to the north of GPEC, in the absence of tighter controls over access, there is potential for increased disturbance to occurrences of *P. parviflora* on this site as a result of the Plan.

The Plan includes the following development controls to manage the risk of inappropriate habitat disturbance:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including two offset locations for *P. parviflora* under Commitment 9.1)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. parviflora*

The package of measures in the Plan is expected to adequately manage the risk to *P. parviflora* from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of mapped habitat for *P. parviflora* occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands (including offset sites secured for *P. parviflora* under Commitment 9.1) will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

These controls are consistent with a number of priority actions in the Conservation Advice (DEWHA, 2008k). For example, to “raise awareness of *P. parviflora* within the local community, including education about the effects of rubbish dumping, unauthorised vehicular access…” and “control access routes to suitably constrain public access to known sites on public land”.

WEED INVASION

P. parviflora is threatened with invasion and competition by weeds. This species is particularly threatened by invasive perennial grasses, which increase the risk of high-frequency, high-intensity fires which can destroy propagules of the species (OEH, 2017f).

Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

P. parviflora is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include:

- The southern end of Shanes Park where the M7/Ropes Crossing Link Road occurs adjacent to potential habitat areas
- The north-eastern section of Wianamatta Regional Park, where the Outer Sydney Orbital intersects a known population and potential habitat

The Plan incorporates species-specific measures for the protection of *P. parviflora*, which will contribute to the control of weeds within known and potential habitat for the species. Species-specific measures which are relevant to weed control include:

- Protecting two known offset locations for *P. parviflora* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of the spread of weeds on *P. parviflora* within the nominated areas (Commitment 5.1) and from transport development (Commitment 6.1)

The Plan further incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *P. parviflora*:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
    - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

These measures under the Plan are expected to adequately manage the potential threat to *P. parviflora* from weed invasion. This is because:

- Two known offset locations for *P. parviflora* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- There are requirements for the impact of weeds to be managed with regards to the requirements of *P. parviflora* in relation to the urban development in nominated areas (Commitment 5.1) and from transport development (Commitment 6.1)
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 56.9 ha of mapped potential habitat of *P. parviflora* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

INAPPROPRIATE FIRE REGIMES

P. parviflora largely relies upon fire events in order to successfully germinate. Therefore, occasional fire events are likely to be required to maximise the species' ability to recover and persist. Plants are killed by fire, with subsequent generations germinating from seeds stored within the soil. Fire intervals of 10-15 years are recommended to:

- Enable development of adequate seed reserves in the soil to enable successful germination
- Allow for the development of suitable fuel loads for moderate to high intensity fires, which are required for seed germination

Increased human activity within the nominated areas may result in altered fire frequencies. This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the mechanisms outlined above.

Increased and/or decreased fire intervals poses a threat to the long-term persistence of *P. parviflora* within the Strategic Assessment Area as both too-frequent and too-infrequent fires would negatively impact upon the species' ability to successfully reproduce. Key risk areas are those that are easily accessible to the public and in close proximity to urban development.

Several populations of *P. parviflora* occur in conservation reserves with existing fire management strategies. These conservation reserves are:

- Scheyville National Park
- Agnes Banks Nature Reserve
- Windsor Downs Nature Reserve
- Shanes Park
- Castlereagh Nature Reserve
- Wianamatta Nature Reserve
- Wianamatta Regional Park

The Plan incorporates species-specific measures for the protection of *P. parviflora*, which will contribute to the maintenance of appropriate fire regimes within species' habitat and provide for protection for the species. Species-specific measures which are relevant to fire regime management include: protecting two known offset locations for *P. parviflora* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. parviflora*:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. parviflora*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

The package of measures in the Plan is expected to adequately manage the risk to *P. parviflora* from altered fire regimes as a result of development. This is because:

- Two known offset locations for *P. parviflora* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- Establishment of environmental zoning of approximately 56.9 ha of mapped potential habitat of *P. parviflora* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *P. parviflora* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *P. parviflora* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.5.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species has been recorded on avoided lands in GPEC and WSA.

Within GPEC, population 226 (a non-important population with a total of two records) contains one record comprising 150 individuals within avoided land. This population is located in the south east of the nominated area, near Twin Creeks.

In WSA, population 181 (a non-important population with a total of 78 records) contains 11 records within avoided lands. This population is located in the south east of the nominated area, near Kemps Creek.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.5.8 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 0.4 ha of potential habitat for *P. parviflora* mapped within the tunnel footprint under the Plan. However, there are no records of *P. parviflora* in the locality; it is noted that the tunnel footprints are over 10 km south of the southernmost known record of this species, suggesting that the tunnels are likely to occur outside of the extent of occurrence of this species. It is therefore considered to be unlikely that the development of tunnels under the Plan will negatively impact *P. parviflora.*

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.5.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008k) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. parviflora* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate habitat disturbance
  - Inappropriate fire regimes
  - Weed invasion

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Direct impacts to 6 populations, including:
  - The loss of one important population (population 127)
  - Impacts to records of two important populations (population 118 and 119)

  - Impacts to records of three non-important populations (population 181, 226 and 542)
- Loss of approximately 188 ha of potential habitat within the nominated areas and transport corridors
- Potential fragmentation of habitat in one location

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is high.

The likelihood of the loss of population 127 as a result of the development of the OSO within Wianamatta Regional Park in GPEC is the key driver for this risk rating. There is a high level of confidence that the population is extant as the population was detected during site surveys undertaken for this strategic assessment. The population is of a moderate size comprising 83 plants. It is noted that the Plan commits (Commitment 3) to avoid and minimise impacts to *P. parviflora* due to the construction of the Outer Sydney Orbital in GPEC. It will be critical that this process avoids and minimise impacts as far as possible to reduce the scale of impacts.

To address the overall residual risks associated with direct impacts, the Plan will deliver two offset locations to address the high risk to *P. parviflora* from direct impacts of development, which will provide for additional protection for the species. The process of protecting land in the Strategic Assessment Area is likely to support a priority action in the Conservation Advice to "investigate formal conservation arrangements such as the use of covenants, conservation agreements or inclusion in reserve tenure".

In addition, the Plan includes a broader set of commitments and actions which are likely to benefit the species. The SCAs contain approximately 1,371 ha of mapped potential habitat for *P. parviflora*. It is very likely that areas of potential habitat in addition to the two offset sites will be protected within these SCAs as part of offset commitments for other species and ecological communities under the Plan. For example, two of the proposed reserves in the Plan contain mapped habitat for the species (including 120 ha in the Georges River Koala Reserve).

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts of development within the nominated areas and transport corridors associated with inappropriate habitat disturbance, weed invasion, and inappropriate fire regimes have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to impacts to six known populations of *P. parviflora* and areas of potential habitat. Of the six impacted populations, impacts to population 127 are considered to be the most severe. While these impacts are considered to present a high risk of adversely impacting the species, implementation of the Plan is not expected to negatively influence the long-term viability of the species for the following key reasons:

- Direct impacts to population 127 are likely to be minimised through a commitment (Commitment 3) to avoid and minimise impacts to *P. parviflora* due to the construction of the Outer Sydney Orbital in GPEC
- The Plan will lead to the protection of two sites known to support the species, which will contribute to the level of existing protection
- Protection and management of known habitat through the offset commitment, as well as the protection and management of additional areas of suitable habitat through the Plan's broader commitments with the SCA's, is likely to contribute meaningful outcomes for *P. parviflora,* which has been shown to respond positively to the removal of threats on land where it is known to occur
- Potential indirect impacts are addressed through management measures in the Plan

29.5.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.5.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-16 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *P. parviflora,* there are no relevant Threat Abatement Plans.

Table 29-16: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. parviflora*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-17: Occurrence of *P. parviflora* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	34	9
(IMPORTANT POPULATIONS)	(18)	(9)
HABITAT MAPPING (Ha)	20,207.9	2,222.7

Table 29-18: Avoidance of *P. parviflora* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	0.9	80.2	249.0	330.1
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	0.9	11.1	186.9	198.8
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**<0.1**	**69.1**	**62.2**	**131.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	<0.1	46.0	10.5	56.5
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	55.4	66.5	16.9	43.0
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.2	0.2	0.4
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	0.0	0.3	0.2	0.3
TOTAL AVOIDANCE (ha)	**0.0**	**<0.1**	**46.2**	**10.7**	**56.9**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**55.4**	**66.9**	**17.2**	**43.3**

Table 29-19: Direct impacts to *P. parviflora* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	<0.1	22.8	51.5	114.0	**188.4**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	1	4	1	**6**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(2)	(1)	**(3)**

SPECIES AT MEDIUM RISK OF DIRECT IMPACTS

29.6 *CYNANCHUM ELEGANS* (WHITE-FLOWERED WAX PLANT)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Cynanchum elegans* is a climber or twiner with a highly variable form, ovate to broadly-ovate leaves, white tubular flowers and dry pointed-pod fruit. Mature stems can climb to 10 m high and be 3.5 cm thick. (DEWHA, 2008b; DoEE, 2018c)
ECOLOGY	Flowering occurs between August and May; seed production is variable and unreliable. Seeds are wind dispersed and it is thought to be unlikely that a soil seed bank exists for this species. Fruit can take four to six months to mature after flowering. Plants are also capable of clonal reproduction from underground suckering stems. Often seen after physical disturbance such as slashing and grazing. (DoEE, 2018c; OEH, 2018k)
DISTRIBUTION AND HABITAT	Occurs in eastern NSW, from Brunswick Heads on the north coast to the Illawarra region. The distribution overlaps with the following TECs: • Shale Sandstone Transition Forest • White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland • Cumberland Plain Woodlands • Upland Wetlands of the New England Tablelands and the Monaro Plateau • Turpentine-Ironbark Forest in the Sydney Basin Bioregion Inhabits the transition zone between dry subtropical rainforest and sclerophyll forest/woodland communities, occurring on steep slopes with varying degrees of soil fertility. (DEWHA, 2008b)
POPULATIONS	Records are restricted from Wollongong (NSW), north to southeast Queensland and west to Mt Danger. Population estimates are old. In 1993 the species was known from 31 sites with around 1,000 plants. Populations usually contain less than 30 individuals. (DoEE, 2018c)

SOS SITES	*C. elegans* has been assigned to the 'Keep-watch species' management stream under the SOS program. Currently, a considerable number (at least 40) populations of *C. elegans* are known to occur within existing conservation reserves in NSW. These sites are already actively managed for conservation purposes. Current management is considered sufficient to protect this species in NSW in the long-term. *C. elegans* is therefore a lower priority species for conservation investment in NSW. (OEH, 2018l)
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Cynanchum elegans* (White-flowered Wax Plant) (DEWHA, 2008b)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=12533

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** Not applicable as the species is not a candidate species credit species. Mapping was done as per the species distribution model described below. **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. The report for this process (Supporting Document F) notes that there were few (23) records of *C. elegans* with which to produce a model (generally, over 50 records are required to produce a reliable SDM). The mapping is considered to be highly precautionary. The SDM produced for *C. elegans* is therefore considered to be indicative and should be treated with caution.

POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.

	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Little is known of the reproduction and dispersal ecology of *C. elegans* (DoEE, 2018c). As part of this assessment, a population was considered to be clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.
	IMPORTANT POPULATION CRITERIA
	Populations of *C. elegans* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.5 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-21 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *C. elegans* in the Strategic Assessment Area. **Records** Populations are found in small isolated remnant patches of dry rainforest within the Strategic Assessment Area. The baseline mapping for this assessment has mapped a total of nine populations (from 22 BioNet records), of which two population either wholly or partly occur on land which is already protected for conservation purposes. Of these: • One occurs in Kurrajong • One occurs at Cobbitty • One occurs in Abbotsbury • The remaining five occur in the Razorback district None of the identified populations occur within any of the nominated areas. **Potential habitat** Approximately 3,343 ha of potential habitat has been mapped within the Strategic Assessment Area, as follows: • Scattered habitat patches are mapped to occur in the Razorback district, in the locality bounded by Tahmoor in the south, Menangle in the east, Theresa Park in the north and the strategic assessment boundary in the west • Small, scattered habitat patches are mapped within Cobbitty and along the Nepean River to the east of Silverdale • A moderate habitat patch is mapped to occur in remnant vegetation in Abbotsbury, near the intersection of the M7 and Elizabeth Drive • Small, scattered areas of habitat occur in the north and north-east of the Strategic Assessment Area, including localities such as Castlereagh (along the Nepean River), Kurrajong, Freemans Reach and Wilberforce None of the mapped habitat occurs within any of the nominated areas.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.6.1 NOMINATED AREAS

There is no potential habitat for the species mapped within the nominated areas. Avoidance of habitat was therefore not necessary.

29.6.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.6.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to any direct impacts to known records. However, it will lead to loss of potential habitat within a transport corridor outside of the nominated areas. A summary of direct impacts is provided in Table 29-22.

LOSS OF POTENTIAL HABITAT

Approximately 19.6 ha of potential habitat will be lost as a result of implementation of the Plan. The impacts relate to a transport project (the Outer Sydney Orbital) at Cobbitty. This is 0.6 per cent of mapped potential habitat across the Strategic Assessment Area. This habitat is in proximity to population 14, a known important population of *C. elegans*.

It is noted that, as detailed planning of the transport corridors has yet to be completed, the Plan includes a commitment (Commitment 4) to ensure that appropriate avoidance of impacts to *C. elegans* is undertaken as part of this process. The commitment requires that the design of the OSO at Cobbitty avoids and minimises impacts to *C. elegans* populations and habitat.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of direct impacts to mapped habitat is considered to be low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species has been categorised as likely. While there is a commitment to avoid and minimise impacts as part of the design of the OSO, it will not be possible to avoid all mapped potential habitat. In addition, taking a precautionary approach there is high confidence that the species occurs in the impact area (given that the impacted mapped habitat occurs in close proximity to known records of the species, it is thought to be likely that the mapped habitat represents real habitat for the species)
- The consequence of impacts to the species (if they did occur) has been categorised as minor. There will be a loss of <1 per cent of mapped potential habitat (endangered species), with high confidence that the species occurs in the impact area

29.6.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

Implementation of the Plan will lead to fragmentation of a known population (population 14) due to the development of the OSO near Cobbitty. The population comprises six records from 1991 to 1996, with an accuracy of 100 m. The number of individuals in the records range from 0 (presumably 1) to 13.

The population occurs in in vegetation mapped as Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion (PCT 877), which is mapped to occur in association with Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (PCT 850). This vegetation occurs in a wider landscape of scattered patches and corridors of vegetation within a landscape which has primarily been cleared for agricultural production.

The population will be fragmented because four records containing 5 individuals occur on the western side of the OSO and two records containing 14 individuals occur on the eastern side of the OSO.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be medium. This is because:

- The likelihood of fragmentation has been categorised as likely. This is because:
    - The likelihood that development is presents a barrier to dispersal of the species is likely. The breeding system for *C. elegans* is poorly understood (NPWS, 2002) although it is thought that seeds are wind dispersed (OEH, 2018k). Given the uncertainty regarding dispersal requirements for the species, the OSO has been considered to be a likely barrier to dispersal for the species based on the precautionary principle
    - The type of fragmentation is likely impact within a population. This is because the OSO will fragment habitat within a single population of the species (population 14), where there is some uncertainty associated with the accuracy of the records
- The consequence of fragmentation has been categorised as major. This is because the Plan will lead to internal fragmentation of a population of an endangered species

29.6.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the species, the Plan includes a commitment to secure two offset locations for the species as part of the conservation program. While the species is considered to be well protected across its range, these offsets will improve the level of protection of the species within the Strategic Assessment Area where two populations (out of a total of nine) currently occur in protected areas.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.6.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (and other key documents) for *C. elegans* identifies a range of threats to the species (DEWHA, 2008b). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to the implementation of the Plan:

- Weed invasion
- Inappropriate fire regimes
- Hydrological disturbance
- Habitat disturbance due to track construction/widening

Disturbance due to landfill development and livestock grazing are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

WEED INVASION

C. elegans is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport infrastructure occur adjacent to known populations or habitat. The key risk area is where the OSO intersects habitat at Cobbitty in proximity to population 14.

The Plan incorporates species-specific measures for the protection of *C. elegans*, which will contribute to the control of weeds within known and potential habitat for the species. Species-specific measures which are relevant to weed control include:

- Protecting two known offset locations for *C. elegans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of the spread of weeds on *C. elegans* associated with transport development (Commitment 6)

The Plan further incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *C. elegans*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16

These commitments and actions under the Plan are expected to adequately manage the risk to *C. elegans* from weed invasion. This is because:

- Two known offset locations for *C. elegans* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species

- There is a specific requirement for the impact of weeds to be managed with regards to the requirements of *C. elegans* in relation to the development of major transport corridors
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are an identified potential threat to the species (DEWHA, 2008b) although the response to fire is not well understood.

Increased human activity within the Strategic Assessment Area has the potential to alter fire regimes through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation or key infrastructure

The area with the highest risk of potential impacts is where the OSO intersects habitat for *C. elegans* at Cobbitty.

The Plan incorporates species-specific measures for the protection of *C. elegans*, which will contribute to the maintenance of appropriate fire regimes within species' habitat and provide for protection for the species. Species-specific measures which are relevant to fire regime management include: protecting two known offset locations for *C. elegans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species.

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include: a commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *C. elegans* being:

- Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
- Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
- A process to work with delivery partners to implement the fire management strategy
- Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans

The package of measures in the Plan is expected to adequately manage the risk to *C. elegans* from altered fire regimes as a result of development. This is because:

- Two known offset locations for *C. elegans* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- Fire management authorities will be engaged to ensure they understand the requirements of *C. elegans* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

HYDROLOGICAL DISTURBANCE

Changes to hydrology are an identified threat to the species (OEH, 2018k). There is potential that the development and subsequent operation of the OSO near Cobbitty may lead to hydrological disturbance of the habitat for *C. elegans* within this locality.

The Plan incorporates species-specific measures for the protection of *C. elegans*, which will contribute to the control of hydrological disturbance within known and potential habitat for the species. Species-specific measures which are relevant to hydrological disturbance include:

- Protecting two known offset locations for *C. elegans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species

- Implementation of mitigation measures to address the impacts of the hydrological disturbance on *C. elegans* associated with transport development (Commitment 6)

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for *C. elegans*. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from transport development (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through the implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology.

The package of measures in the Plan is expected to adequately manage the risk to *C. elegans* from changes to hydrology because:

- Offset sites will be secured to manage habitat for *C. elegans* for conservation purposes
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *C. elegans*

HABITAT DISTURBANCE DUE TO TRACK CONSTRUCTION/WIDENING

Habitat disturbance due to track construction and/or widening may occur as either a temporary or permanent indirect impact within, or adjacent to, the OSO, and will depend upon the final design elements of the OSO which will influence the likelihood of site visitation and track use in the future. The mapped habitat for *C. elegans* at Cobbitty is more likely to experience site visitation and track creation if the site is made easily accessible to the public due to design decisions associated with the OSO (e.g. placement of a rest stop close to areas of habitat may encourage public visitation of the locality).

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *C. elegans*. In summary, these include:

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the two offset locations to be obtained for *C. elegans* in association with Commitment 9.1)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *C. elegans*

These measures under the Plan are expected to adequately manage the risk to *C. elegans* from habitat disturbance. This is because:

- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to tunnels associated with transport projects.

Given that it is not present in the nominated areas it is not at risk from essential infrastructure projects.

29.6.7 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 0.4 ha of potential habitat for *C. elegans* mapped within the tunnel footprint under the Plan. While no records of *C. elegans* occur within the tunnel footprint, it is recognised that there are records of the species in the locality of the tunnel footprint near Cobbitty. However, given the small area of mapped potential habitat to be impacted, it is considered unlikely that development of the tunnel will lead to adverse impacts for *C. elegans*.

It is recognised that the Plan includes commitments to mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process.

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.6.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008b) and other key documents identify the following key issues that are likely to have the greatest influence on the long-term viability of *C. elegans* in relation to implementation of the Plan.

- Habitat loss and fragmentation
- Indirect impacts including
  - Degradation of habitat due to weed invasion, grazing and inappropriate fire management
  - Hydrological disturbance

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Loss of approximately 19.6 ha of mapped habitat within the transport corridors
- Potential fragmentation of population 14 due to the development of the OSO at Cobbitty

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>medium.</u>

It is considered to be likely that the development of the OSO will result in internal fragmentation of a population of *C. elegans* near Cobbitty, which is the key driver for this risk rating. There is some uncertainty regarding the accuracy of the records, given that the most recent record of this population was recorded in 1996. The population is of moderate size comprising of up to 19 plants. It is likely that this population is important to the ongoing viability and recovery of the species, as this species is endangered.

The Plan will deliver two offset locations to address the medium risk to *C. elegans* from direct impacts of development. Under the NSW Saving Our Species Program, it is noted that *C. elegans* already has a considerable number of populations (over 40) which are known to occur within existing conservation reserves in NSW, which are actively managed for conservation purposes (OEH, 2018l). The addition of two new conservation reserves to protect this species will add to the existing level of protection for *C. elegans* in NSW and contribute to the long-term preservation of the species and its habitat.

In addition, the Plan includes a broader set of commitments and actions which are likely to benefit the species. The SCAs contain approximately 1,502 ha of mapped potential habitat for *C. elegans*. It is very likely that areas of potential habitat in addition to the 2 offset sites will be protected within these SCAs as part of offset commitments for other species and ecological communities under the Plan.

The current level of protection for *C. elegans* within NSW is considered to be sufficient to protect the species in the long-term (OEH, 2018l). The Plan will add to existing protection for *C. elegans* by securing additional populations and areas of habitat within new conservation reserves.

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

C. elegans is most at risk from indirect impacts associated with the development of the OSO at Cobbitty. The potential indirect impacts of this development include weed invasion, inappropriate fire regimes, hydrological disturbance and habitat disturbance. Indirect impacts have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to fragmentation of one known population of *C. elegans* and impacts to areas of potential habitat. While these impacts are considered to present a medium risk of adversely impacting the species, implementation of the Plan is not expected to negatively influence the long-term viability of the species for the following key reasons:

- The Plan will lead to the protection of two sites known to support the species
- Potential indirect impacts are addressed through management measures in the Plan
- *C. elegans* is well-represented in conservation reserves in NSW, and subsequently its long-term future in the state is considered to be secure (OEH, 2018l)

29.6.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.6.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in **Table** 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *C. elegans,* there are no relevant Threat Abatement Plans.

Table 29-20: Relevant key Threatening Processes and associated Threat Abatement Plans for *C. elegans*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-21: Occurrence of *C. elegans* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	9	2
(IMPORTANT POPULATIONS)	(9)	(2)
HABITAT MAPPING (Ha)	3,342.5	477.6

Table 29-22: Direct impacts to *C. elegans* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	0.0	19.6	**19.6**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.7 *PERSOONIA NUTANS* (NODDING GEEBUNG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Persoonia nutans* is an erect to spreading shrub with reddish stems and branches and yellow, pendant flowers. Grows from 0.5-2.5 m tall. (DoEE, 2018c)
ECOLOGY	Flowers from November to April. Main pollinators are wasps and native bees. Seed is likely to be dispersed after consumption by large birds such as currawongs and parrots, and mammals such as kangaroos, wallabies and possums. Plants are killed by fire and other disturbances and recruitment is only by seed. Subsequently, populations are dynamic in space and time. It is not known how long seeds persist in the soil, or whether all seeds germinate in a single disturbance event. It is unlikely that high levels of germination would occur without the presence of disturbance as a trigger for germination. (DoEE, 2018c) (Douglas, 2019d)
DISTRIBUTION AND HABITAT	Known records are restricted to the Cumberland subregion. In particular between Richmond and Macquarie Fields, near the Nepean and Georges Rivers. The species is fragmented with 99 per cent occurring in the north at Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs. The species occurs predominantly in the Penrith area. The species has been found in the following vegetation communities: • Agnes Banks Woodland • Castlereagh Scribbly Gum Woodland • Cooks River/Castlereagh Ironbark Forest • Shale Sandstone Transition Forest The species is dependent on aeolian and alluvial sediments and is found in the Agnes Banks and Berkshire Park soil landscapes. It is more common on the deeper sands at the Agnes Banks soil landscape than at the edge of the deposit. It occurs on low rises rather than swales in the Berkshire Park formation. (DoEE, 2018c; NSW DEC, 2005)
POPULATIONS	As of 2005, there were around 5,500 individuals in total from 27 populations. Approximately 99 per cent are found in the north of the species range, and some isolated smaller populations are found in the south. (NSW DEC, 2005)

	Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *P. nutans* is considered to be an endemic species to the region.
SOS SITES	The following SOS sites for the species have been identified: • Cumberland Plain
RELEVANT PLANS AND POLICIES	*Persoonia nutans R. Br.* (Nodding Geebung) Recovery Plan (NSW DEC, 2005) Threat abatement plan for competition and land degradation by rabbits (DoEE, 2016a) Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=18119

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	Yes	Yes
EXPERT REPORT (BCAR PROCESS)	Yes (Douglas, 2019d). Available at Supporting Document C				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Expert report polygons.** Potential habitat polygons were generated based on the occurrence of PCT 724, 725, 883, 1081 and 1395, with the application of riparian exclusion buffers to account for the fact that wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat. All vegetation condition states were included except for derived native grasslands. To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was recorded during surveys in GPEC. Results of surveys were used to update the expert report habitat polygons for *P. nutans*. The potential habitat mapped through this process is considered precautionary and does not necessarily equate with actual habitat. The species is naturally rare and patchily distributed, which means that it is unlikely that a large percentage of the potential habitat would actually support the species, even though it can sometimes be locally abundant in favourable conditions. It is noted that different vegetation classes have different potential to be habitat for *P. nutans*; PCT 883 is considered to be highly likely to constitute habitat for this species, while PCT 724 and 725 have moderate likelihood of constituting habitat, and PCT 1081 and 1395 have low and very low likelihoods respectively (Douglas, 2019d).				

	OUTSIDE THE NOMINATED AREAS
	Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The report for this process (Supporting Document F) notes that the model for the species predicts more potential habitat than would be expected in the far south and to the north east of the Strategic Assessment Area. The mapping is considered to be highly precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION** Biological populations were defined using the records dataset and available information about the nature of the species. Populations of the species were defined to include clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators. **IMPORTANT POPULATION CRITERIA** Populations of *P. nutans* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations of *P. nutans* are considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.19 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-24 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. nutans* in the Strategic Assessment Area. **Records** A total of 11 important populations have been mapped within the Strategic Assessment Area and three are wholly or partly located in existing conservation reserves. The largest of these populations (population number 64, which comprises 1,317 records) is located in the Londonderry locality to the north of GPEC. This population partially occurs within existing lands protected for conservation purposes, including Agnes Banks Nature Reserve, Wianamatta Nature Reserve, Castlereagh Nature Reserve and Windsor Downs Nature Reserve. Remaining populations are distributed as follows: • 2 small populations are located to the north west of Agnes Banks Nature Reserve, in Grose Wold • 4 small populations occur within GPEC, in the following localities: o Wianamatta Regional Park and Ropes Crossing o Near Wianamatta (South Creek) in St Marys o Colyton o North of the M4 in Orchard Hills

	• 1 small population occurs near Bill Anderson Park in Kemps Creek, within and adjacent to the southern border of WSA • 2 populations (one large and one small) occur in the Holsworthy/Hammondville locality • 1 moderate population occurs adjacent to the Georges River, near Macquarie Fields and Long Point **Potential habitat** The baseline mapping for this assessment has mapped approximately 14,875 ha of known and potential habitat has been mapped within the Strategic Assessment Area. The majority of habitat is located in the Londonderry area, where the majority of records of the species occurs. Within the nominated areas, habitat is predicted to occur: • In the GPEC and WSA nominated areas, at Wianamatta Regional Park, Ropes Crossing, North St Marys, Claremont Meadows, Colyton and Kemps Creek • In the northern portion of GMAC, including Leumeah, Ingleburn and Macquarie Fields It is noted that there is no habitat mapped for *P. nutans* in Wilton. Outside of the nominated areas, and in addition to the large area of habitat in the Londonderry locality, habitat is mapped to occur: • As moderate and well-connected areas of habitat in the far east of the Strategic Assessment Area, in the Moorebank/Holsworthy/Macquarie Fields/Kentlyn district • As a small area of habitat at Scheyville National Park • As very small scattered patches in the region to the south and east of WSA, ranging from Cobbitty in the south west through to Leumeah in the south east, up to the locality of Bossley Park It is noted that the habitat map for *P. nutans* over-predicts habitat to occur outside the natural range of the species, and therefore habitat mapped in the south, and outside the north-east and north-west boundary of the strategic assssmentis not considered to include real habitat for the species (Ascelin Gordon & Koshkina, 2018). It is thought that the related (and restricted) *Persoonia bargoensis* occupies the equivalent ecological niche in habitat in the south of the Strategic Assessment Area (Douglas, 2019d).

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.7.1 NOMINATED AREAS

RECORDS

A total of five populations of this species occur within the nominated areas (four within GPEC and one within WSA). Of these:

- Three populations (61, 62 and 524) occur entirely within excluded lands (all in GPEC)
- One population (60) has one record that occurs in land avoided for biodiversity purposes in WSA, whilst the remainder of the population occurs outside the boundary of WSA
- One population (63) occurs partially within excluded lands, and partially in certified land for transport development (in GPEC)

It is noted that the Plan includes a commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to known populations of *P. nutans.*

POTENTIAL HABITAT

The baseline mapping for this assessment has mapped 97 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 56 ha (58 per cent) of this has been avoided as part of the urban capable lands and transport corridors (not including excluded lands). Almost all of this was avoided for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 29-25.

It is important to note that the avoidance calculations in Table 29-25, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-25 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.7.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.7.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to direct impacts to a known population, loss of potential habitat, and fragmentation of potential habitat. A summary of these impacts is provided in Table 29-26.

IMPACTS TO KNOWN POPULATIONS

Population 63

This population comprises six records from 1993 to 2019 in and to the north of GPEC. Of these, four records occur within Wianamatta Regional Park, while the remaining two occur within Ropes Crossing. The number of individual plants ranges from 0 (presumed to be 1) to 7 across the records.

Of the records within Wianamatta Regional Park, one was detected during a survey conducted by the consulting team in June 2019, confirming that the species is still present at the site. This site contains Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion, ranging from intact to thinned condition. Based on the mapped location of the records within BioNet, three of the six records will be lost due to construction of the Outer Sydney Orbital.

LOSS OF POTENTIAL HABITAT

41 ha of potential habitat for the species will be lost. This is 0.3 per cent of mapped potential habitat across the Strategic Assessment Area. The loss of potential habitat occurs predominantly within GPEC and WSA.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to an important population is considered to be medium. This risk ranking is triggered for impacts to species' records, as follows:

- The likelihood of actual impacts occurring to the species has been categorised as almost certain. There will be direct impacts to a known population of the species, with high confidence in the accuracy of the records
- The consequence of any impacts to the species (if they did occur) has been categorised as moderate. There will be a loss of records within an endangered population which is not at the edge of the species' occurrence

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as likely. There will be direct impacts to potential habitat with high confidence that the species occurs in the impact area
- The consequence of impacts to the species (if they did occur) has been categorised as minor. There will be a loss of 0.3 per cent of mapped potential habitat (endemic species), with high confidence that the species occurs in the impact area

29.7.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of a moderate area of mapped habitat associated with records of the species within GPEC due to the development of the OSO within Wianamatta Regional Park.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of fragmentation is considered to be low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development presents a barrier to dispersal of the species is possible. The main pollinators of *P. nutans* are thought to be wasps and bees, and seed is likely to be dispersed by large birds and mammals. Transport infrastructure may represent a barrier to gene flow
  - The type of fragmentation is impact to habitat connected to a population. This is because there are known records located on mapped potential habitat which is fragmented by the OSO development
- The consequence of fragmentation has been categorised as moderate. This is because the area to be fragmented is connected to a known population of the species and is of moderate size

29.7.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the species, the Plan includes a commitment to secure two offset locations for the species as part of the conservation program. This will provide an addition to the level of protection of the species within the Strategic Assessment Area where currently only three populations (out of a total of 11) occur in protected areas. In situ protection of *P. nutans* populations is a fundamental component of the species' recovery plan.

In addition to this, one of the Plan's proposed reserves (the Georges River Koala Reserve) contains 120 ha of mapped habitat for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.7.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan (NSW DEC, 2005) (and other key documents) for *P. nutans* identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Habitat degradation and rubbish dumping related to unrestricted access
- Infection by root-rot fungus *Phytophthora cinnamomi*

Honeybee competition and grazing by rabbits have also been identified as key threats. However, these were not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes constitute one of the major threats to the survival of *P. nutans* (NSW DEC, 2005). The species is an obligate seed regenerator, with fire being an important mechanism to promote germination. Too frequent fire will prevent maturation and reproduction of the species, while too infrequent fire will result in senescence and death of adults with minimal or no recruitment.

Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads, and include the Londonderry locality to the north of GPEC, potential habitat within and near Wianamatta Regional Park in GPEC, potential habitat near Kemps Creek in WSA, and potential habitat adjacent to the north-east boundary of GMAC near Holsworthy.

The Plan incorporates species-specific measures for the protection of *P. nutans*, which will contribute to the maintenance of appropriate fire regimes within species' habitat and provide for protection for the species. Species-specific measures which are relevant to fire regime management include: protecting two known offset locations for *P. nutans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species.

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for *P. nutans* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

- Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. nutans*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

These controls support a range of recovery actions within the species' Recovery Plan which suggests the species' fire requirements be taken into account with regards to site management plans (NSW DEC, 2005).

WEED INVASION

P. nutans is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

P. nutans is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include:

- The southern end of Shanes Park where the M7/Ropes Crossing Link occurs adjacent to potential habitat areas
- The north-eastern section of Wianamatta Regional Park, where the Outer Sydney Orbital corridors within GPEC in areas of potential habitat

The Plan incorporates species-specific measures for the protection of *P. nutans,* which will contribute to the control of weeds within known and potential habitat for the species. Species-specific measures which are relevant to weed control include:

- Protecting two known offset locations for *P. nutans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of the spread of weeds on *P. nutans* associated with and urban capable (Commitment 5) and transport (Commitment 6) development

The Plan further incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *P. nutans*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes: partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies

        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk to *P. nutans* from the increased risk of weeds associated with development. This is because:

- Two known offset locations for *P. nutans* will be obtained (Commitment 9.1) and managed for conservation purposes, which will ensure long-term protection of known populations and habitat of this species
- Commitments 5 and 6 will provide for mitigation measures to be implemented for the benefit of *P. nutans* to address the impacts associated with the spread of weeds associated with urban capable and transport development
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 56.3 ha of mapped potential habitat of *P. nutans* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

HABITAT DEGRADATION AND RUBBISH DUMPING RELATED TO UNRESTRICTED ACCESS

Habitat degradation through unrestricted public access has been identified as a key threat to *P. nutans*. Development within GPEC and WSA may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations of *P. nutans* on public land, and areas which are often mistaken for public land, are considered most at risk from this impact. It is noted that an area of freehold land to the north of GPEC which is often mistaken for Crown land, contains a number of access tracks, and issues associated with rubbish dumping have been recorded for the site.

Two populations occur on public land managed for conservation. They are:

- Population 63 – Wianamatta Regional Park
- Population 64 - Castlereagh Nature Reserve, Wianamatta Nature Reserve, Agnes Banks Nature Reserve, Windsor Downs Nature Reserve

The Plan incorporates species-specific measures for the protection of *P. nutans,* which will contribute to the control of habitat disturbance within known and potential habitat for the species. Species-specific measures which are relevant to habitat disturbance include:

- Protecting two known offset locations for *P. nutans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of the spread of weeds on *P. nutans* associated with and urban capable (Commitment 5) and transport (Commitment 6) development
- A commitment (Commitment 5.4) to manage habitat disturbance within Wianamatta Regional Park through requiring that walking tracks and management trails are located in a way that avoids and minimises exposure of *P. nutans* to human disturbance

The Plan incorporates a range of additional measures to mitigate the risks associated with inappropriate habitat disturbance for *P. nutans*. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the two offset locations to be obtained for *P. nutans* in association with Commitment 9.1)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to *P. nutans* from inappropriate habitat disturbance as a result of development. This is because:

- Walking and maintenance trails within Wianamatta Regional Park will be located to minimise the risk of habitat disturbance to the species
- Avoided lands where mapped habitat for *P. nutans* occurs will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

INFECTION BY ROOT-ROT FUNGUS PHYTOPHTHORA CINNAMOMI

P. nutans is threatened by exposure to *Phytophthora cinnamomi*, a soil-borne water mould which is fatal to many *Persoonia* species.

Development under the Plan has the potential to increase the spread of *P. cinnamomi* through increased site visitation rates and earthworks activities conducted during construction works. The areas which are most at risk are those which are in close proximity to development sites, in particular available habitat within Wianamatta Regional Park which has potential to be impacted by the development of the OSO.

The Plan incorporates species-specific measures for the protection of *P. nutans*, which will contribute to the control of weeds within known and potential habitat for the species. Species-specific measures which are relevant to weed control include:

- Protecting two known offset locations for *P. nutans* (Commitment 9.1). It is noted that offset locations will be managed as conservation reserves which will provide for long-term protection of known populations of the species
- Implementation of mitigation measures to address the impacts of *Phytophthora cinnamomi* on *P. nutans* associated with and urban capable (Commitment 5) and transport (Commitment 6) development

The Plan incorporates a range of measures to manage the risks associated with *Phytophthora cinnamomi*. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
    - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
    - Entering into written agreements with delivery partners to implement priority disease control programs

- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to *P. nutans* from *Phythophthora cinnamomi* because:

- Conservation lands (including offset sites obtained for *P. nutans*) will be actively managed which will address threats in those areas including disease threats
- Development controls will be put in place to address potential impacts associated with construction
- It supports a landscape scale approach to the issue across the Cumberland subregion

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to development of essential infrastructure within nominated areas but outside the urban capable lands.

There is no mapped habitat within the footprints for the tunnels and the species will not be impacted in those areas.

29.7.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species has been recorded in WSA and GPEC. However, no populations in GPEC occur on avoided lands. One population (population 60) has one record within avoided lands in WSA, with the remaining records of this population being located outside of the nominated area boundary.

To ensure that the record of population 60 is protected from impacts from essential infrastructure, the Plan includes a commitment to avoid direct impacts due to essential infrastructure to known populations of *P. nutans* within WSA.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.7.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Recovery Plan (NSW DEC, 2005) (and other key documents) identify the following key issues that are likely to have the greatest influence on the long-term viability of *P. nutans* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Habitat degradation and rubbish dumping related to unrestricted access
  - Infection by root-rot fungus *Phytophthora cinnamomi*

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Direct impacts to a known population (population 63) of the species
- Loss of approximately 41 ha of potential habitat
- Potential fragmentation of habitat in one location

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>medium.</u>

The likelihood of potential impacts to population 63 due to the development of the OSO within Wianamatta Regional Park is the key driver for this risk rating. There is a high level of confidence that the population is extant, as the population was detected on site during surveys conducted for this strategic assessment.

It is noted that the Plan commits (Commitment 3) to avoid and minimise impacts to *P. nutans* due to the construction of the Outer Sydney Orbital in GPEC. It will be critical that this process avoids and minimise impacts as far as possible to reduce the scale of impacts.

The Plan will deliver two offset locations to address the medium risk to *P. nutans* from direct impacts of development, which will provide for additional protection for the species. The process of protecting land in the Strategic Assessment Area is likely to support a performance criterion within the species' recovery plan, which aims to increase the level of protection afforded to *P. nutans* through conservation planning and land use decisions.

In addition, the Plan includes a broader set of commitments and actions which are likely to benefit the species. The SCAs contain approximately 1,617 ha of mapped potential habitat for *P. nutans.* It is very likely that areas of potential habitat in addition to the two offset sites will be protected within these SCAs as part of offset commitments for other species and ecological communities under the Plan.

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, habitat disturbance and rubbish dumping related to unrestricted access and infection by root-rot fungus *Phytophthora cinnamomi* have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to impacts to a known population of *P. nutans* and areas of potential habitat. While these impacts are considered to present a medium risk of adversely impacting the species, implementation of the Plan is not expected to negatively influence the long-term viability of the species for the following key reasons:

- Direct impacts to population 63 are likely to be mitigated through a commitment (Commitment 3) to avoid and minimise impacts to *P. nutans* due to the construction of the Outer Sydney Orbital in GPEC
- The Plan will lead to the protection of two sites known to support the species, which will contribute to the level of existing protection
- Protection and management of known habitat through the offset commitment, as well as the protection and management of additional areas of suitable habitat through the Plan's broader commitments with the SCA's, is likely to contribute meaningful outcomes for *P. nutans*, which has been shown to respond positively to the removal of threats on land where it is known to occur
- Potential indirect impacts are addressed through management measures in the Plan

29.7.9 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan (NSW DEC, 2005) to ensure the continued and long-term survival of *P. nutans* in the wild by promoting the in situ conservation of the species across its natural range. Specific objectives include:

- Minimise the loss and fragmentation of *P. nutans* habitat using land-use planning mechanisms
- Identify and minimise the operation of threats at sites where *P. nutans* occurs
- Implement a survey and monitoring program that will provide information on the extent and viability of *P. nutans*
- Provide public authorities with information that assists in conserving the species
- Raise awareness of the species and involve the community in the recovery program
- Promote research questions that will assist future management decisions.

Implementation of the Plan will support a number of these strategies and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *P. nutans*. The Plan will not prevent implementation of any of the actions.

29.7.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-23 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any Threat Abatement Plans.

Table 29-23: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. nutans*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-24: Occurrence of *P. nutans* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	11	3
(IMPORTANT POPULATIONS)	(11)	(3)
HABITAT MAPPING (Ha)	14,874.7	1,578.2

Table 29-25: Avoidance of *P. nutans* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	23.6	80.0	219.7	323.4
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	23.6	8.7	194.1	226.4
HABITAT WITHOUT EXCLUDED LANDS (ha)	0.0	**<0.1**	**71.3**	**25.6**	**97.0**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	45.7	10.2	55.9
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	0.0	64.0	39.9	57.6
AVOIDANCE FOR OTHER REASONS (ha)	0.0	<0.1	0.2	0.1	0.4
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	100.0	0.3	0.5	0.4
TOTAL AVOIDANCE (ha)	**0.0**	**<0.1**	**45.9**	**10.4**	**56.3**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**100.0**	**64.3**	**40.4**	**58.0**

Table 29-26: Direct impacts to *P. nutans* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	25.4	15.3	0.5	**41.2**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	1	0	**1**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(1)	(0)	**(1)**

SPECIES AT LOW RISK OF DIRECT IMPACTS

29.8 *EUCALYPTUS BENTHAMII* (CAMDEN WHITE GUM, NEPEAN RIVER GUM)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Eucalyptus benthamii* is a smooth, white barked tree with loose bark ribbons and a flaky bark stocking at its base. Has long thin leaves and white flowers. Grows to approximately 40 m tall. (OEH, 2017b)
ECOLOGY	Flowers in summer and autumn. Sporadic flowering may occur throughout the year. Depends on flooding for seedling establishment. (DoE, 2014a)
DISTRIBUTION AND HABITAT	Occurs west of Sydney in the Cumberland subregion and Blue Mountains. Distribution overlaps with the following EPBC Act-listed TECs: • Cumberland Plain Shale Woodlands and Shale Gravel Transition Forest • Shale Sandstone Transition Forest Inhabits open forest in areas with deep, fertile alluvial sands and a flooding regime that permits the establishment of seedlings. Recruitment is successful on bare sediment deposits in rivers and streams after flooding. (DoE, 2014a)
POPULATIONS	Records occur on the flats of the Nepean River and its tributaries. As of 2005, two major sub-populations have been recorded: up to 6,500 individuals in Kedumba Valley of the Blue Mountains National Park and up to 300 plants in the Bents Basin State Recreation Area. (DoE, 2014a)
SOS SITES	The following SOS sites for the species have been identified: • Kedumba • Bents Basin • Camden Airport

RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Eucalyptus benthamii* (Camden White Gum) (DoE, 2014a) Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (DoEE, 2017c)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=2821

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	Yes	Yes	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report available for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Habitat maps were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned, scattered trees), waterways (habitat restricted to within a 350 m buffer of the 'Nepean River Hydro Area'), geology ('Alluvium', 'Bringelly Shale', 'Hawkesbury Sandstone') and elevation (between 25 m and 300 m). **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. The report notes that there were a moderate number (582) of records of *E. benthamii* with which to produce a model (generally, over 50 records are required to produce a reliable SDM). The approach to SDM mapping may over-predict habitat for the species. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION** Biological populations were defined using the records dataset and available information about the nature of the species. There is limited information available regarding pollination and dispersal thresholds for *E. benthamii.*

	Therefore, a population was considered to constitute clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.
	IMPORTANT POPULATION CRITERIA
	Populations of *E. benthamii* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations of *E. benthamii* were considered important because they met one or more of the following criteria: • A population identified or inferred in a Commonwealth conservation advice, plan, final determination, or other relevant policy document as being important • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program • A large population • A population within a conservation reserve • A population that is important for maintaining the Extent of Occurrence of a species

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.8 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-28 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *E. benthamii* in the Strategic Assessment Area. **Records** A total of eight important populations (from 578 records) have been mapped within the Strategic Assessment Area. Of these: • One occurs along Werriberri Creek and its tributaries, near The Oaks in the south-west region of the Strategic Assessment Area • Remaining populations occur in scattered localities along the Nepean River and its tributaries, with populations occurring at Yarramundi, Glenmore Park, Wallacia, Gulguer, Theresa Park, the area spanning from Brownlow Hill through to Spring Farm, and Menangle Park It is noted that no records occur within the nominated areas. **Potential habitat** The baseline mapping for this assessment has mapped approximately 4,800 ha of potential habitat within the Strategic Assessment Area (see Table 29-28). Habitat is primarily associated with riparian corridors, particularly those associated with the Nepean River and its tributaries. Specifically, habitat is mapped to occur in the following localities: • Well-connected areas of habitat incorporating the Nepean River and its tributaries in the south-western area of the Strategic Assessment Area, in the locality bounded by Picton to the south, Belimbla Park in the west, Mulgoa in the north, and Menangle Park in the east • Scattered habitat along the Nepean River between Richmond and Jamisontown • Scattered occurrences along Wianamatta (South Creek), between Windsor and Wianamatta Regional Park, near Erskine Park, and between Badgerys Creek and Oran Park • Small, scattered occurrences along Hinchinbrook Creek, Georges River and Bunbury Curran Creek in the eastern section of the Strategic Assessment Area • Along Badgerys Creek, Bardwell Gully and Lowes Creek and Rileys Creek to the south of WSA

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.8.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 0.5 ha of potential habitat within the nominated areas (not including excluded lands). Of this land, <0.1 ha was avoided for biodiversity purposes, with the remaining land avoided for other reasons.

A breakdown of avoidance across each nominated area is provided in Table 29-29.

It is important to note that the avoidance calculations in Table 29-29, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-29 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.8.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

It is noted that the Plan contains a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to *E. benthamii* as a result of tunnel construction activities in transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.8.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to loss of potential habitat. A summary of these impacts is provided in Table 29-30.

LOSS OF POTENTIAL HABITAT

There will be approximately 47 ha of impacts to potential habitat (1 per cent of mapped habitat across the Strategic Assessment Area). These impacts are primarily due to the Outer Sydney Orbital as it traverses north from Cobbitty across a tributary of the Nepean River.

There is also one other very small and discrete loss of habitat where a transport corridor crosses Cosgroves Creek outside GPEC, in the vicinity of Twin Creeks.

The areas being impacted upon do not support known records or populations of *E. benthamii*.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact area (it is noted that the impacted habitat was modelled via the SDM process, which is considered to be precautionary and may over-predict habitat. There are no records in close proximity to the impacted areas of habitat)
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of 1 per cent of mapped potential habitat (vulnerable species), with moderate confidence that the species occurs in the impact area

29.8.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of potential habitat in the following locations:

- Fragmentation of a small area of mapped habitat associated with records of the species at Cobbitty due to the development of the OSO
- Fragmentation of a very small area of mapped habitat that is not associated with records of the species in the vicinity of Twin Creeks, where a proposed transport corridor crosses Cosgroves Creek to the south of GPEC

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of fragmentation is considered to be low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development presents a barrier to dispersal of the species is possible While seedling establishment is thought to occur in association with flooding events, there is otherwise limited information available regarding pollination and dispersal thresholds for *E. benthamii.* It is therefore thought to be possible that development of the OSO may constitute a dispersal barrier for this species
  - The type of fragmentation is impact to habitat connected to a population. This is because there are known records located on mapped potential habitat which is fragmented by the OSO development
- The consequence of fragmentation has been categorised as minor. This is because the area to be fragmented is connected to a known population of the species and is of small size

29.8.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for *E. benthamii.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.8.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (and other key documents) for the *E. benthamii* identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Changed hydrology
- Myrtle rust
- Weed invasion

Inappropriate revegetation works (impacting genetic diversity), isolated populations, impacts on genetic integrity (such as through hybridisation with *E. viminalis*), raising the height of the Warragamba Dam wall, construction of smaller dams, loss of regeneration opportunities and feral pigs have also been identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

E. benthamii is threatened by altered fire regimes. The Plan has the potential to impact fire regimes as a result of increased human activity associated with development of urban capable land within the nominated areas and development of transport corridors outside of the nominated areas.

Small areas of mapped potential habitat occur in close proximity with urban capable development in the vicinity of Twin Creeks (outside of the nominated areas), and in the vicinity of Kemps Creek (outside of the nominated areas). Otherwise, mapped potential habitat is spatially removed from urban capable lands, and as such the likelihood of potential habitat being impacted by urban capable development is low.

Transport corridor development outside of the nominated areas has the potential to impact habitat for *E. benthamii* as a result of development of the OSO near Cobbitty, in addition to near Twin Creeks where a proposed transport corridor crosses Cosgroves Creek.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity associated with development of transport corridors. In summary, these include: a commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *E. benthamii* being:

- Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
- Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values (it is noted that the SCA contains approximately 1,495 ha of mapped potential habitat for *E. benthamii*).
- A process to work with delivery partners to implement the fire management strategy
- Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans

The package of measures in the Plan is expected to adequately manage the risk to *E. benthamii* from altered fire regimes as a result of development. This is because fire management authorities will be engaged to ensure they understand the requirements of *E. benthamii* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas.

CHANGED HYDROLOGY

Changes to hydrology and nutrient runoff are an identified threat to the species. The Plan has the potential to impact hydrology as a result of development within urban capable land and transport corridors. As outlined above, the areas which are most at risk of indirect impacts from development are those in close proximity to areas of development, and include mapped potential habitat near urban capable development at Twin Creeks, Kemps Creek, and mapped potential habitat close to the OSO footprint near Cobbitty.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for *E. benthamii*. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from transport development (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through the implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology.

It is further noted that the Plan includes a species-specific commitment to control indirect impacts (including changed hydrology) to *E. benthamii* associated with the development of tunnels within the major transport corridors (Commitment 6.2). This commitment is discussed further below in Section 29.8.8, and will provide additional protection to *E. benthamii* from potential impacts associated with hydrological disturbance.

The package of measures in the Plan is expected to adequately manage the risk to *E. benthamii* from changes to hydrology because transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *E. benthamii*.

MYRTLE RUST

E. benthamii is threatened by exposure to myrtle rust, an exotic fungus which is can lead to growth defects and mortality of *Eucalyptus* species.

Development under the Plan has the potential to increase the spread of myrtle rust through increased site visitation rates and earthworks activities conducted during construction works. The areas which are most at risk are those which are in close proximity to development sites, and include mapped potential habitat near urban capable development at Twin Creeks, Kemps Creek, and mapped potential habitat close to the OSO footprint near Cobbitty.

The Plan incorporates a range of measures to manage the risks associated with disease including myrtle rust. In summary, these include:

- A commitment (Commitment 6) will result in implementation of mitigation measures to address indirect and prescribed impacts to threatened species associated with the development of transport corridors
- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

It is further noted that the Plan includes a species-specific commitment to control indirect impacts (including spread of disease) to *E. benthamii* associated with the development of tunnels within the major transport corridors (Commitment 6.2). This commitment is discussed further below in Section 29.8.8, and will provide additional protection to *E. benthamii* from potential impacts associated with myrtle rust.

The package of measures in the Plan is expected to adequately manage the risk to *E. benthamii* from myrtle rust because:

- Development controls will be put in place to address potential impacts associated with construction
- It supports a landscape scale approach to the issue across the Cumberland subregion

WEED INVASION

E. benthamii is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where urban capable lands or transport occur adjacent to known populations or habitat. The areas most at risk include mapped potential habitat near urban capable development at Twin Creeks, Kemps Creek, and mapped potential habitat close to the OSO footprint near Cobbitty.

The Plan incorporates a range of measures to manage the risks associated with weed invasion. In summary, these include:

- A commitment (Commitment 6) will result in implementation of mitigation measures to address indirect and prescribed impacts to threatened species associated with the development of transport corridors
- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *E. benthamii*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16

It is further noted that the Plan includes a species-specific commitment to control indirect impacts (including weed invasion) to *E. benthamii* associated with the development of tunnels within the major transport corridors (Commitment 6.2). This commitment is discussed further below in Section 29.8.8, and will provide additional protection to *E. benthamii* from potential impacts associated with weed invasion.

The package of measures in the Plan is expected to adequately manage the risk to *E. benthamii* from the increased risk of weeds associated with development. This is because:

- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *E. benthamii*
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.8.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species has been recorded in none of the nominated areas, and there is only a very small (0.5 ha) amount of potential habitat mapped for this species within avoided lands.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.8.8 POTENTIAL IMPACTS FROM TUNNELS

Both the Metro Rail Future Extension and the OSO tunnels intercept mapped potential habitat for *E. benthamii.* Of these two tunnels, however, only the OSO is considered to have potential to negatively impact upon *E. benthamii*.

The Metro Rail Future Extension has a total of 1.7 ha of mapped potential habitat for *E. benthamii* within the impact footprint. This habitat is a small, isolated patch of habitat associated with Narellan Creek, which is in a heavily cleared and highly disturbed landscape in close proximity to existing urban development. There are no records of the species in the proximity of this habitat. It is considered to be unlikely that the species would be present at this site.

The OSO tunnel intercepts approximately 44 ha of potential habitat for *E. benthamii*, in addition to an important population of the species (population 95), which is partially located in two conservation reserves (a Registered Property Agreement site, and the Mater Dei BioBank site), in addition to occurring outside of the reserve boundaries in the Camden locality between Spring Farm and Cobbitty Road along the Nepean River. This population is recognised to be important for maintaining the genetic diversity of the species (DoE, 2014a).

The Plan includes commitments to:

- Avoid and minimise impacts to populations and habitat within or adjacent to the OSO and Metro Rail Future Extension footprints for *E. benthamii* (Commitment 4.1)
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process (Commitment 6.2)

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.8.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014a) and other key documents identifies the following key issues that are likely to have the greatest influence on the long-term viability of *E. benthamii* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:

- Inappropriate fire regimes
- Changed hydrology
- Myrtle rust
- Weed invasion

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Loss of 47 ha of mapped habitat within the nominated areas and transport corridors
- Potential fragmentation of habitat in two locations

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is low. The total area of potential habitat which will be impacted is a small proportion of available habitat for the species with only moderate confidence of the species' presence in impacted areas. Fragmentation of a small area of mapped potential habitat connected with species' records will also occur. It is noted that no known records of the species are directly impacted or fragmented from other known records.

It is noted that *E. benthamii* occurs within the footprint of the proposed OSO tunnel. The Plan contains a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to *E. benthamii* as a result of tunnel construction activities in transport corridors, which is considered to protect the individuals within the tunnel footprint from direct impacts.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 1,495 ha of potential habitat for *E. benthamii*.

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts of development corridors associated with inappropriate fire regimes, changed hydrology, myrtle rust and weed invasion have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a species-specific commitment to minimise the impacts of high frequency land use. In addition, any potential indirect impacts associated with the construction of tunnels will be managed and mitigated through a species-specific commitment (Commitment 6.2).

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.8.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.8.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-27 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15.

Table 29-27: Relevant key Threatening Processes and associated Threat Abatement Plans for *E. benthamii*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation, habitat degradation, competition and disease transmission by feral pigs	Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (DoEE, 2017c)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-28: Occurrence of *E. benthamii* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	8	2
(IMPORTANT POPULATIONS)	(8)	(2)
HABITAT MAPPING (Ha)	4,799.7	540.7

Table 29-29: Avoidance of *E. benthamii* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	73.8	0.1	0.2	74.1
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	73.3	0.1	0.2	73.6
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.5**	**<0.1**	**0.0**	**0.5**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	<0.1	0.0	0.0	<0.1
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	0.1	0.0	N/A	0.1
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.5	<0.1	0.0	0.5
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	99.9	100.0	N/A	99.9
TOTAL AVOIDANCE (ha)	**0.0**	**0.5**	**<0.1**	**0.0**	**0.5**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**100.0**	**100.0**	**N/A**	**100.0**

Table 29-30: Direct impacts to *E. benthamii* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	0.0	47.3	**47.3**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.9 *GREVILLEA PARVIFLORA* SUBSP. *PARVIFLORA* (SMALL-FLOWER GREVILLEA)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Grevillea parviflora* subsp. *parviflora* is a low, open to erect shrub with narrow leaves and white flowers. Grows from 0.3-1 m high. (DEWHA, 2008d)
ECOLOGY	Flowers between July – December and between April – May. Reproduces vegetatively via rootstocks. Following fire, recruitment from seed is unlikely. Individuals can live for 25-60 years. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Endemic to NSW, occurring in the Picton, Bargo and Appin areas. Other disjunct populations occur in Holsworthy, the Lower Hunter Valley, on the Central Coast and in the Port Stephens area. It grows on crests, upper slopes or flat plains on sandy to gravelly clay soils. Distribution overlaps with the following TECs: • Shale Sandstone Transition Forest • Cumberland Plain Woodlands • Turpentine-Ironbark Forest in the Sydney Basin Bioregion • Castlereagh Scribbly Gum and Agnes Banks Woodland • Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion (DEWHA, 2008d)
POPULATIONS	Populations vary between small populations of less than 20 stems, medium populations of 50-100 stems, to a small number of large populations of over 2,000 individuals. It is hard to establish the number of plants within a population due to its suckering nature (DoEE, 2018c).
SOS SITES	The species is managed under the data-deficient species management stream under the SOS program. Currently there are no identified management sites.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea) (DEWHA, 2008d)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.

SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64910

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

<table>
<tr><td rowspan="3">NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)</td><td>ECOSYSTEM CREDIT SPECIES</td><td colspan="4">CANDIDATE SPECIES CREDIT SPECIES</td></tr>
<tr><td rowspan="2">No</td><td>WILTON</td><td>GMAC</td><td>WSA</td><td>GPEC</td></tr>
<tr><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>EXPERT REPORT (BCAR PROCESS)</td><td colspan="5">There is no expert report for this species.</td></tr>
<tr><td rowspan="4">HABITAT MAPPING</td><td colspan="5">WITHIN THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Potential habitat polygons were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned), elevation (between 25m and 300m), soil units (‘Berkshire Park’, ‘Lucas Heights’, ‘South Creek’) and rock units (‘alluvial channel deposits-in-channel bar’, ‘alluvial floodplain deposits’, ‘alluvium’, ‘Mittagong Formation’, ‘alluvial terrace deposits’). Additional habitat added where PCTs occur on or within 200m of Hawkesbury soils and sandstone geology.
To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was recorded in Wilton during surveys.</td></tr>
<tr><td colspan="5">OUTSIDE THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The mapping is considered to be highly precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.</td></tr>
<tr><td rowspan="4">POPULATION MAPPING</td><td colspan="5">RECORD SELECTION</td></tr>
<tr><td colspan="5">Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
<tr><td colspan="5">POPULATION DEFINITION</td></tr>
<tr><td colspan="5">Biological populations were defined using the records dataset and available information about the nature of the species.
Little is known about the life cycle of G. parviflora subsp. parviflora. Flowers are insect pollinated, and it is likely that seeds have limited dispersal distances (probably <2 m) (DoEE, 2018c).
Populations were identified as clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.</td></tr>
</table>

	IMPORTANT POPULATION CRITERIA
	Populations of *G. parviflora* subsp. *parviflora* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations of *G. parviflora* subsp. *parviflora* were considered important because they met one or more of the following criteria: • A population that is important for maintaining the Extent of Occurrence of a species • A population within a conservation reserve • A large population

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.10 for a map of records and habitat across the Strategic Assessment Area

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-32 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *G. parviflora* subsp. *parviflora* in the Strategic Assessment Area.
	Records
	A total of 11 important populations have been identified within the Strategic Assessment Area, of which five populations are either wholly or partly located in existing conservation reserves. Important populations are distributed as follows:
	• Within GPEC:
	  ○ Population 103: this population consists of 86 records and partially occurs within GPEC in the locality of Bingara Gorge, in addition to occurring in the land in between GPEC and GMAC, including within the Appin West Biobanking Agreement site and St Marys Tower Biobanking Agreement site. The majority of records within GPEC that are associated with this population are in an area subject to a previously approved EPBC Act approval (EPBC 2014/7400)
	  ○ Population 104: this population consists of 13 records and partially occurs in the north-west of Wilton, in addition to occurring outside the western boundary of Wilton. This is a large population with over 300 individuals recorded. Records of this population were detected during site surveys for this strategic assessment
	  ○ Population 518: this population consists of a single record of 50 individuals, and occurs to the south of population 104 within the western boundary of GMAC
	• To the south of WSA within Kemps Creek, in a site protected through the previous Growth Centres Program
	• One large population occurs adjacent to Anzac Creek near Holsworthy
	• Remaining populations are scattered throughout the southern portion of the Strategic Assessment Area
	A total of five non-important populations have been identified within the Strategic Assessment Area. These occur as follows:
	• One occurs wholly within GPEC (adjacent to Ropes Creek near Colyton)
	• One occurs adjacent to Kemps Creek, to the south of WSA
	• One occurs partially within GMAC, adjacent to the Georges River to the east of Appin
	• One occurs to the south of the Nepean River, between GMAC and Wilton
	• One occurs in the south of the Strategic Assessment Area
	Potential habitat

	The baseline mapping for this assessment has mapped 7,504.7 ha of known and potential habitat within the Strategic Assessment Area. The majority of this habitat occurs in a band spreading along the south-eastern boundary of the Strategic Assessment Area. Other areas of habitat occur as follows: • Small, scattered patches of habitat occur in the locality of Ruse, Minto Heights, Ingleburn and Denham Court • A moderate patch occurs near Holsworthy and Moorebank, to the north-east of GMAC • Small, scattered patches of habitat occur to the north and north-east of Holsworthy, in Chipping Norton, Fairfield and Miller • Small, scattered patches of habitat occur within and near to the GPEC and WSA, in locations including Kemps Creek, Claremont Meadows, North St Marys, within and near Wianamatta Regional Park, within and near Castlereagh Nature Reserve and near Windsor Downs Nature Reserve

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.9.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 594.4 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 578.4 ha (97.3 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 434.2 ha was avoided for biodiversity purposes.
- 144.2 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-33.

It is important to note that the avoidance calculations in Table 29-33 including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-33 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

It is noted that there is a species-specific commitment under the Plan (Commitment 2.4) to prioritise avoidance of impacts from essential infrastructure on non-certified land to *Grevillea parviflora* subsp. *parviflora*.

29.9.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.9.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to direct impacts to mapped potential habitat. A summary of these impacts is provided in Table 29-34.

It is noted that population 101 is an important population that predominantly occurs in the Kemps Creek area of the existing South West Growth Centre. One record of this population is mapped to occur within the urban capable land footprint within WSA (to the north of Kemps Creek), however, information associated with this record indicates that the positional accuracy of the record is 100 m, and that the record is located within Kemps Creek Park at the western end of park in buffer zone between playing field and bushland, along a track. Therefore, this record is considered to be located within Kemps Creek Park (to the south of WSA), and placement of this record within WSA is not considered to be accurate. There will be no direct impacts to known records of this species as a result of implementation of the Plan.

The Plan will not result in fragmentation of habitat for *G. parviflora* subsp. *parviflora*.

Loss of potential habitat

16 ha of potential habitat for the species will be lost. This is 0.2 per cent of mapped potential habitat across the Strategic Assessment Area. These impacts primarily relate to a transport project (the Outer Sydney Orbital within GPEC).

Risk of residual adverse impacts to the species

The risk of residual adverse impacts occurring to the species as a result of impacts to an important population is considered to be low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species has been categorised as likely. There will be direct impacts to potential habitat with high confidence that the species occurs in the impact area
- The consequence of any impacts to the species (if they did occur) has been categorised as minor. There will be a loss of <2 per cent of mapped potential habitat with high confidence of species' occurrence in the impact area

29.9.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for *G. parviflora* subsp. *parviflora.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.9.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DEWHA, 2008d) (and other key documents) for *G. parviflora* subsp. *parviflora* identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Weed invasion
- Inappropriate fire regimes
- Habitat disturbance from recreational activities, rubbish dumping and road maintenance

Agriculture has also been identified as a key threat. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate this threat across the Strategic Assessment Area.

The important populations of *G. parviflora* subsp. *parviflora* which are most at risk of indirect impacts are those in close proximity to development associated with the Plan. Important populations which are in close proximity to development include:

- Population 103: This important population occurs in Wilton and between Wilton and GMAC, and includes records within: the Appin West Biobanking Agreement site, the St Marys Tower Biobanking Agreement site, and land subject to a previously approved EPBC Act approval (EPBC 2014/7400)
- Population 104: This is a large population which occurs along the north-western boundary of Wilton, on either side of the Nepean River
- Population 518: This is a moderate population which occurs within Wilton, to the south of population 104

Of these three populations, population 104 is the most at risk from indirect impacts, given its large size (and subsequent importance for species conservation), proximity to development and lack of current protection. Comparatively, population 103 already has a level of protection, through its inclusion in two Biobanking sites and conservation land associated with EPBC approval 2014/7400. Population 50, while not located in a conservation reserve, is not as large as population 104 and therefore is not considered to be as important for conservation of the species. Given the high risk associated with population 104, a number of species-specific measures will be implemented under the Plan to protect this population from indirect impacts, as outlined below.

It is noted that population 101 is an important population which occurs to the south of WSA at Kemps Creek, in a site associated with the Sydney Growth Centres Program. This site was briefly visited in association with site surveys which were undertaken during preparation of the expert report for *Acacia pubescens*. The expert report for *A. pubescens* notes that remnant habitat at Kemps Creek was "seen to be largely unmanaged and degrading due to several threats" (Douglas, 2019b). This site is part of the Sydney Growth Centres Program and it is recommended that the management of habitat at Kemps Creek under this program be improved. It is considered that improved and ongoing management of habitat at Kemps Creek will provide protection of *G. parviflora* subsp. *parviflora* within this locality from impacts associated with indirect impacts.

The following sections consider the potential indirect impacts of development and proposed mitigation measures under the Plan on important populations 103, 104 and 518 of *Grevillea parviflora* subsp. *parviflora*.

INAPPROPRIATE HABITAT DISTURBANCE

Habitat degradation through unrestricted public access and rubbish dumping has been identified as a key threat to *G. parviflora* subsp. *parviflora* (DEWHA, 2008d).

The Plan includes a species-specific measure to consult with land managers of land containing population 104 of *Grevillea parviflora* subsp. *parviflora*, to mitigate indirect impacts from human disturbance during construction and operation of the development, including controlling public access, managing maintenance activities such as mowing and slashing, and managing rubbish dumping.

The Plan further incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *G. parviflora* subsp. *parviflora*. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance. It is noted that 578.4 ha of potential habitat for *G. parviflora* subsp. *parviflora* to the outcome
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values

- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations. It is noted that approximately 2,975 ha of potential habitat for *G. parviflora* subsp. *parviflora* is mapped to occur within SCAs
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *G. parviflora* subsp. *parviflora*

The package of measures in the Plan is expected to adequately manage the risk to *G. parviflora* subsp. *parviflora* from inappropriate habitat disturbance as a result of development. This is because:

- The Plan contains a species-specific measure to protect population 104 from impacts associated with habitat disturbance
- Avoided lands where mapped habitat for *G. parviflora* subsp. *parviflora* occurs will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

WEED INVASION

G. parviflora subsp. *parviflora* is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The Plan includes a species-specific measure to implement mitigation measures to manage weeds for population 104 of *G. parviflora* subsp. *parviflora*, taking into account relevant guidance in the Weed Control Implementation Strategy.

The Plan further incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area. This includes a number of actions, of which the following are the most relevant to the outcome for *G, parviflora* subsp. *parviflora*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:

    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk to *G. parviflora* subsp. *parviflora* from the increased risk of weeds associated with development. This is because:

- There is a specific requirement for the impact of weeds to be managed for population 104 of *G. parviflora* subsp. *parviflora*
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of 578.4 ha of mapped potential habitat of *G. parviflora* subsp. *parviflora* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are an identified threat to *G. parviflora* subsp. *parviflora* (DEWHA, 2008d). Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

The Plan includes a species-specific measure to consult with land managers of population 104 for *G. parviflora* subsp. *parviflora* to mitigate indirect impacts from fire during construction and operation of the development, taking into account guidance in the Fire Management Strategy.

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *G. parviflora* subsp. *parviflora* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *G. parviflora* subsp. *parviflora*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

The package of measures in the Plan is expected to adequately manage the risk to *G. parviflora* subsp. *parviflora* from altered fire regimes as a result of development. This is because:

- There is a species-specific measure to protect population 104 from impacts associated with altered fire regimes
- Establishment of environmental zoning of approximately 578.4 ha of mapped potential habitat of *G. parviflora* subsp. *parviflora* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *G. parviflora* subsp. *parviflora* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *G. parviflora* subsp. *parviflora* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas (it is noted there is 2,295.9 ha for *G. parviflora* subsp. *parviflora* mapped within the SCAs)

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

It is noted that no habitat or records are mapped for *G. parviflora* subsp. *parviflora* within the footprints of the proposed tunnels associated with transport corridors, and therefore it is considered that there is negligible potential for this species to be negatively impacted by the development of the tunnels.

29.9.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Records of this species occur within GPEC, GMAC and Wilton. Of these, records within GMAC and Wilton occur within avoided land.

A non-important population (519) within GMAC occurs on avoided lands to the east of Appin, near the Georges River. Within GMAC, this population occurs within the proposed footprint for Stage 1 of the Georges River Koala Reserve (Commitment 10). Given the proposed use of this land for conservation purposes under the Plan, population 519 is not considered to be at risk of impacts from essential infrastructure development.

Within Wilton, important population 104 and important population 518 occur within land avoided for biodiversity purposes. To minimise potential impacts to these populations, the Plan includes a species-specific commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to *G. parviflora* subsp. *parviflora.*

Further, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area

- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.9.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008d) (and other key documents) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *G. parviflora* subsp. *parviflora* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Weed invasion
  - Inappropriate fire regimes
  - Habitat disturbance from recreational activities, rubbish dumping and road maintenance

HABITAT LOSS AND FRAGMENTATION

As outlined above, the Plan will lead to impacts to potential habitat.

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>low.</u> The total area of potential habitat which will be impacted is a small proportion of the total habitat available for the species, and there will be no other direct impacts (such as impacts to known records or fragmentation) under the Plan.

It is noted that the Plan includes a species-specific commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to *G. parviflora* subsp. *parviflora.*

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 2,975 ha of potential habitat for *G. parviflora* subsp. *parviflora.*

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate habitat disturbance, weed invasion, and inappropriate fire regimes have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a range of species-specific commitments to protect important population 104 from indirect impacts associated with development under the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

Conclusion

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.9.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.9.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-31 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *G. parviflora* subsp. *parviflora,* there are no relevant Threat Abatement Plans.

Table 29-31: Relevant key Threatening Processes and associated Threat Abatement Plans for *G. parviflora* subsp. *parviflora*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-32: Occurrence of *G. parviflora* subsp. *parviflora* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	16	5
(IMPORTANT POPULATIONS)	(11)	(5)
HABITAT MAPPING (Ha)	7,504.7	590.9

Table 29-33: Avoidance of *G. parviflora* subsp. *parviflora* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	428.0	285.4	17.0	68.2	798.6
HABITAT WITHIN EXCLUDED LANDS (ha)	43.8	96.3	0.3	63.8	204.2
HABITAT WITHOUT EXCLUDED LANDS (ha)	**384.2**	**189.1**	**16.7**	**4.4**	**594.4**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	327.5	96.8	9.6	0.3	434.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	85.2	51.2	57.3	6.5	73.0
AVOIDANCE FOR OTHER REASONS (ha)	52.7	91.3	0.1	0.1	144.2
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	13.7	48.3	0.7	2.2	24.3
TOTAL AVOIDANCE (ha)	**380.3**	**188.1**	**9.7**	**0.4**	**578.4**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**99.0**	**99.4**	**58.0**	**8.7**	**97.3**

Table 29-34: Direct impacts to *G. parviflora* subsp. *parviflora* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	3.9	1.1	7.0	4.0	0.0	**16.0**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.10 *PERSOONIA BARGOENSIS* (BARGO GEEBUNG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Persoonia bargoensis* is an erect, bushy shrub with small thin leaves and yellow tubular flowers. Fruits are pear-shaped, green and grow to 12mm long. Ranges from 0.6-2.5m tall. (DoEE, 2018c)
ECOLOGY	Flowers appear mainly in summer. Fruits hang on the plant for an indefinite period. Recruitment is solely from seed. This species is expected to live for up to 20 years. Disturbance, including fire, plays an important role in the germination of the seed bank. As a result, this species often appears along trail margins. Populations at sites which have been undisturbed for 10 years or so may not be representative of the potential population size of that site. This species is likely to be killed by fire. Frequent disturbance (such as regular track maintenance, slashing, and/or fire frequencies of less than 10-15 year intervals) are likely to result in a decline of a population of this species, as an adequate seedbank will not have time to develop between disturbance events. This species is pollinated by native bees. Populations within 500m are likely to be interbreeding. Urban development which discourages native bees from travelling between *P. bargoensis* populations and individuals is likely to result in increased isolation of populations and individuals. Seeds of this species are likely to be dispersed by birds and marsupials. Developments which prevent dispersal of seeds would also increase population isolation. (DoE, 2014e; DoEE, 2018c; NPWS, 2000a)
DISTRIBUTION AND HABITAT	Records are restricted to a small area south-west of Sydney on the western edge of the Woronora Plateau and the northern edge of the Southern Highlands. It is known to occur in the Burragorang, Cumberland and Sydney Cataract IBRA subregions (OEH, 2019a). Inhabits dry sclerophyll eucalypt woodland or forest. Occurs on the heavier, well-drained, gravelly soils of Hawkesbury Sandstone and Wianamatta Shale. (DoEE, 2018c)
POPULATIONS	As of 1999, the total number of individuals was likely to be less than 250. Populations at this time were small (often less than eight plants) and fragmented. (DoEE, 2018c)
SOS SITES	The following SOS sites for the species have been identified:

	• Wilton (proposed) • Bargo (proposed) • Hume Highway (proposed)
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Persoonia bargoensis* (DoE, 2014e) Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
SPECIES-SPECIFIC GUIDELINES	*Persoonia bargoensis* Environmental Impact Assessment Guidelines (NPWS, 2000a)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=56267

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	Yes	Yes	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Habitat maps were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned), elevation (between 0m and 450m), rock units (Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member', 'Razorback Sandstone Member') and soil units (Blacktown, Glenorie, Picton, Luddenham) within 80m of the edge of the sandstone geology. To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was recorded in Wilton during surveys. **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. The report notes that there 390 records of *P. bargoensis* with which to produce a model (generally, over 50 records are required to produce a reliable SDM). The approach to SDM mapping may over-predict habitat for the species. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the

	historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. All recorded plants were mapped as a single population as occurrence of the species within the Plan Area spans 20 km, and genetic flow (fruit dispersal by birds and pollination) could potentially move across the population within the life span of each plant (expected to be 20 years (OEH, 2019a)).
	IMPORTANT POPULATION CRITERIA
	Populations of *P. bargoensis* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations of *P. bargoensis* were considered important within the Strategic Assessment Area because they met one or more of the following criteria: • A large population (number of individuals) • Only known population of this species

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.16 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-36 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. bargoensis* in the Strategic Assessment Area. **Records** *P. bargoensis* occurs as a single important population in the Strategic Assessment Area. The population spans from Bargo, to Picton in the north west, through to Appin in the east, and is bounded by the Strategic Assessment Area boundary in the south. This population is large and comprises 342 BioNet records. **Potential habitat** The baseline mapping for this assessment has mapped 12,338.6 ha of potential habitat within the Strategic Assessment Area. Mapped habitat is located in the southern portion of the assessment area, aligning with the location of known records. Potential habitat occurs within Wilton and GMAC. Within these nominated areas, potential habitat is generally associated with vegetation along riparian corridors as the majority of remaining land is cleared.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.10.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 2,396.8 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 2,315.4 ha (96.6 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,709.8 ha was avoided for biodiversity purposes
- 605.5 ha was avoided for other reasons

A breakdown of avoidance across each nominated area is provided in Table 29-37.

It is important to note that the avoidance calculations in Table 29-37, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-37 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

It is noted that there is a species-specific commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure to *P. bargoensis* on non-certified land.

29.10.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at <u>medium</u> or <u>high</u> risk of residual adverse impacts. Offsets are not provided for species that are considered to be at <u>low</u> or <u>very low</u> risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.10.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to impacts to mapped potential habitat. A summary of these impacts is provided in Table 29-38.

LOSS OF POTENTIAL HABITAT

Approximately 81.4 ha of potential habitat will be impacted as a result of the implementation of the Plan. This represents 0.7 per cent of potential habitat within the Strategic Assessment Area. The loss of potential habitat is associated with urban development in Wilton and GMAC. In both cases, direct impacts relate to the fringes of habitat areas.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be <u>low</u>. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as <u>likely</u>. The proximity of impacted habitat to multiple known records of the species suggests that it is likely that the species would be present within habitat areas
- The consequence of impacts to the species (if they did occur) has been categorised as <u>minor</u>. There will be a loss of <2 per cent of mapped potential habitat (vulnerable species), with high confidence that the species occurs in the impact area

29.10.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. bargoensis.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the potential indirect impacts to the species that may occur as a result of development under the Plan. It also outlines if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.10.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *P. bargoensis* (DoE, 2014e) (and other key documents) identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes and fire maintenance activities
- Inappropriate habitat disturbance associated with maintenance activities, illegal dumping and recreational activities
- Infection by *Phytophthora cinnamomi*

Inbreeding depression due to small and scattered populations and lack of genetic diversity, feral European honeybees making effective pollination unlikely, grazing by domestic animals and subsidence associated with underground coal extraction have also been identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES AND MAINTENANCE ACTIVITIES

P. bargoensis plants are killed by fire, with subsequent generations germinating from seeds stored within the soil. A minimum interval of approximately 10-15 years between fire events is required to enable the development of a suitable seed bank to ensure the species' persistence following a fire event.

However, it is also noted that *P. bargoensis* relies upon disturbance events in order to successfully germinate. Therefore, occasional fire events are likely to be required to maximise the species' ability to recover and persist.

The ideal frequency of fire for the conservation purpose of *P. bargoensis* is unknown. It is noted that the Conservation Advice for the species identifies research into determining the optimal fire regime for regeneration of the species as a research priority (DoE, 2014e).

Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Burning and slashing activities for hazard reduction purposes, and increased unnatural ignition sources, have increased the disturbance and fire frequency within the species' habitat and is considered a threat (OEH, 2019a). Increased fire risk poses a threat to the long-term persistence of *P. bargoensis* within the Plan Area, as frequent fires would negatively impact upon the species' ability to successfully reproduce.

The areas which are most at risk from inappropriate fire regimes are those in close proximity to areas of development. This includes known populations and mapped habitat for the species within and near Wilton and the southern portion of GMAC.

For *P. bargoensis,* a species-specific measure relating to fire management is appropriate given its sensitivity to inappropriate fire regimes, and the fact that the species is only known from the area within and around Wilton and GMAC, significantly increasing the level of risk.

The Plan includes a species-specific measure to consult with land managers of containing known habitat or populations of *P. bargoensis* to mitigate indirect impacts from fire during construction and operation of the development, taking into account guidance in the Fire Management Strategy.

The Plan further incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. bargoensis* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. bargoensis.* While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

The package of measures in the Plan is expected to adequately manage the risk to *P. bargoensis* from altered fire regimes as a result of development. This is because:

- There is a species-specific measure to protect the species from impacts associated with altered fire regimes
- Establishment of environmental zoning of approximately 2,315.4 ha of mapped potential habitat of *P. bargoensis* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *P. bargoensis* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *P. bargoensis* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas (it is noted there is 5,173.8 ha of potential habitat for *P. bargoensis* mapped within the SCAs)

INAPPROPRIATE HABITAT DISTURBANCE ASSOCIATED WITH MAINTENANCE ACTIVITIES, ILLEGAL DUMPING AND RECREATIONAL ACTIVITIES

A large proportion of the species occurs on road verges, suggesting that *P. bargoensis* may be dependent on disturbance, and that the species may benefit from reduced competition and increased light available on disturbance margins. As a result, most known sites of the species are managed by relevant infrastructure authorities (including TfNSW, Wollondilly Council and Transgrid) (DoE, 2014e).

P. bargoensis is also threatened by illegal dumping, recreational activities and vehicle use within areas of the species' habitat (OEH, 2019a). The areas which are most at risk of impacts include those in close proximity to development, particularly around Wilton and the southern portion of GMAC.

The Plan includes a species-specific measure to consult with land managers of land containing known populations or habitat for *P. bargoensis* to mitigate indirect impacts from habitat disturbance during construction and operation of the development, including controlling public access, managing maintenance activities such as mowing and weed control, and managing rubbish dumping.

The Plan also includes the following development controls to manage the risk of inappropriate habitat disturbance:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. bargoensis*

The package of measures in the Plan is expected to adequately manage the risk to *P. bargoensis* from inappropriate habitat disturbance as a result of development. This is because:

- A species-specific measure will require consultation with land managers to ensure protection of *P. bargoensis* from inappropriate habitat disturbance
- Avoided lands where areas of mapped habitat for *P. bargoensis* occur will be zoned appropriately to enable an adequate framework for management (this includes 2,315.4 ha of mapped potential habitat for the species)
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas (it is noted there is 5,173.8 ha of potential habitat for *P. bargoensis* mapped within the SCAs)
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

INFECTION BY PHYTOPHTHORA CINNAMOMI

P. bargoensis is threatened by exposure to *Phytophthora cinnamomi,* a soil-borne water mould which is fatal to many *Persoonia* species.

Development within GMAC and Wilton has the potential to increase the spread of *P. cinnamomi* through increased site visitation rates and earthworks activities conducted during construction works.

The Plan includes a species-specific measure to incorporate best practice site hygiene protocols to manage the potential spread of pathogens, such as *P. cinnamomi* and myrtle rust adjacent to potential habitat for *P. bargoensis.*

The Plan incorporates a range of measures to manage the risks associated with *Phytophthora cinnamomi*. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs

- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to *P. bargoensis* from *Phythophthora cinnamomi* because:

- Development controls will be put in place to address potential impacts associated with construction
- It supports a landscape scale approach to the issue across the Cumberland subregion

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.10.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Three records of *P. bargoensis* occur within avoided land in Wilton. To minimise potential impacts to these populations, the Plan includes a species-specific commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to *P. bargoensis*.

Further, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.10.7 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 0.1 ha of potential habitat for *P. bargoensis* mapped within the tunnel footprint under the Plan. However, there are no records of *P. bargoensis* in the locality; it is noted that the tunnel footprints are over 10 km north of the northernmost known record of this species, suggesting that the tunnels are likely to occur outside of the extent of occurrence of this species. It is therefore considered to be unlikely that the development of tunnels under the Plan will negatively impact *P. bargoensis*.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.10.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014e) (and other key documents) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. bargoensis* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts including:
  - Inappropriate fire regimes and fire maintenance activities
  - Inappropriate habitat disturbance associated with maintenance activities, illegal dumping and recreational activities
  - Infection by *Phytophthora cinnamomi*

HABITAT LOSS

As outlined above, the Plan will lead to impacts to potential habitat.

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>low.</u> The total area of potential habitat which will be impacted is a small proportion of the total habitat available for the species, and there will be no other direct impacts (such as impacts to known records or fragmentation) under the Plan.

It is noted that the Plan includes a species-specific commitment (Commitment 2.4) to prioritise the avoidance of impacts from essential infrastructure on non-certified land to *P. bargoensis.*

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 5,174 ha of potential habitat for *P. bargoensis.*

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes and fire maintenance activities, inappropriate habitat disturbance associated with maintenance activities, illegal dumping and recreational activities and infection by *Phytophthora cinnamomi* have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a range of species-specific commitments to protect *P. bargoensis* from indirect impacts associated with development under the Plan.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.10.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.10.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-35 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any of the Threat Abatement Plans.

Table 29-35: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. bargoensis*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-36: Occurrence of *P. bargoensis* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	12,338.6	1,201.7

Table 29-37: Avoidance of *P. bargoensis* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,279.8	1,852.2	0.0	0.0	3,132.0
HABITAT WITHIN EXCLUDED LANDS (ha)	265.3	469.9	0.0	0.0	735.2
HABITAT WITHOUT EXCLUDED LANDS (ha)	**1,014.5**	**1,382.2**	**0.0**	**0.0**	**2,396.8**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	707.7	1,002.1	0.0	0.0	1,709.8
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	69.8	72.5	N/A	N/A	71.3
AVOIDANCE FOR OTHER REASONS (ha)	267.4	338.1	0.0	0.0	605.5
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	26.4	24.5	N/A	N/A	25.3
TOTAL AVOIDANCE (ha)	**975.1**	**1,340.2**	**0.0**	**0.0**	**2,315.4**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**96.1**	**97.0**	**N/A**	**N/A**	**96.6**

Table 29-38: Direct impacts to *P. bargoensis* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	39.4	42.0	0.0	0.0	0.0	**81.4**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.11 *POMADERRIS BRUNNEA* (RUFOUS POMADERRIS)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Pomaderris brunnea* is a compact shrub with hairy stems, leaves with toothed margins and small yellowish or cream clustered flowers. Grows from 1-4 m in height. (DoEE, 2018c; OEH, 2019c)
ECOLOGY	Limited information is available for the ecology of this species. Flowers between September and October. Expected to live for 10-20 years. Minimum time for the plant to produce seeds is approximately 4-6 years. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Endemic to south-eastern Australia. Occurs in eastern NSW in the Sydney Basin, NSW North Coast and New England Tableland IBRA bioregions and in eastern Victoria. Inhabits moist woodland or forest on clay and alluvial soils of flood plains and creek lines. (Sutter, Department of Sustainability and Environment et al., 2011) The Strategic Assessment Area is one of the core locations for the species.
POPULATIONS	As of 2011, sixteen populations of about 1,000 individuals had been recorded. However, at this time, records for some occurrences were over 30 years old, and it was not known if the species was still extant at all sites. (Sutter, Department of Sustainability and Environment et al., 2011)
SOS SITES	The following SOS sites for the species have been proposed: • Oakwood property • Gundengarra Reserve – Spring Farm • Wirrumburra Wildlife Sanctuary • Upper Nepean SCA
RELEVANT PLANS AND POLICIES	National Recovery Plan for Rufous Pomaderris (*Pomaderris brunnea*) (Sutter, Department of Sustainability and Environment et al., 2011)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species

SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=16845

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

<table>
<tr><td rowspan="3">NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)</td><td>ECOSYSTEM CREDIT SPECIES</td><td colspan="4">CANDIDATE SPECIES CREDIT SPECIES</td></tr>
<tr><td rowspan="2">No</td><td>WILTON</td><td>GMAC</td><td>WSA</td><td>GPEC</td></tr>
<tr><td>Yes</td><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>EXPERT REPORT (BCAR PROCESS)</td><td colspan="5">There is no expert report available for this species.</td></tr>
<tr><td rowspan="4">HABITAT MAPPING</td><td colspan="5">WITHIN THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Potential habitat polygons were generated for this species using BioNet PCT associations, vegetation condition (intact, thinned), waterways (mapping restricted to 100 m around waterways), soil type (Blacktown, Lucas Heights) and elevation (up to 450 m).
To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was recorded during surveys.</td></tr>
<tr><td colspan="5">OUTSIDE THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. Significant areas of habitat have been mapped and it is considered to be highly conservative mapping.
No targeted surveys as part of this project were undertaken outside the nominated areas.</td></tr>
<tr><td rowspan="6">POPULATION MAPPING</td><td colspan="5">RECORD SELECTION</td></tr>
<tr><td colspan="5">Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
<tr><td colspan="5">POPULATION DEFINITION</td></tr>
<tr><td colspan="5">Biological populations were defined using the records dataset and available information about the nature of the species.
Records within 1 km of one another are considered a single population.</td></tr>
<tr><td colspan="5">IMPORTANT POPULATION CRITERIA</td></tr>
<tr><td colspan="5">Populations of P. brunnea were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11.</td></tr>
</table>

	Populations of *P. brunnea* were considered important because they met one or more of the following criteria: • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program • A population within a conservation reserve • A large population

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.22 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-40 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. brunnea* in the Strategic Assessment Area. **Records** A total of 21 populations have been mapped within the Strategic Assessment Area. They occur from Camden, south east into GMAC, and around Bargo. Seven are mapped as important and 14 are not. Five populations are either wholly or partly located in existing conservation reserves. Of the four nominated areas, only GMAC contains known records of *P. brunnea*. These are located as follows: • Important populations: o Population 469 – one record within the nominated area in an existing conservation reserve. The population occurs in excluded land o Population 586 - occurs within vegetation associated with Ousedale Creek, in the centre of southern GMAC, partially in avoided lands and partially in excluded land. This population was detected during site surveys conducted in 2018 for this strategic assessment o Population 587 - occurs within the southern boundary of GMAC, in land avoided for biodiversity purposes. This population was detected during site surveys conducted in 2018 for this strategic assessment • Non-important populations: o Population 468 – one record on the western boundary of the nominated area, which occurs in excluded land o Population 470 – one record in the centre of the nominated area. The population occurs in land avoided for biodiversity purposes o Population 471 - one record on the western boundary of the nominated area. The population occurs in avoided lands o Populations 513/514/515 – three populations with two to eight records each, on the eastern boundary of the nominated area. These populations occur in avoided lands There are no records of *P. brunnea* within Wilton, GPEC or WSA. Outside of the nominated areas, populations are located as follows: • Important populations: o Population 73 - Occurs along the Nepean River near Spring Farm. This population partially occurs within the Gungungurra Biobanking Agreement site o Population 177 - Occurs within the south of the Strategic Assessment Area, and is partially located in a site protected by a conservation agreement

	- Population 465 - Occurs adjacent to the Nepean River within the footprint of the proposed OSO tunnel, within a site protected by a Registered Property Agreement - Population 510 - A record within the St Marys Tower Biobanking Agreement, just outside the north-eastern border of Wilton • Non-important populations include: - A number of populations in the south of the Strategic Assessment Area - One population near Douglas Park, between Wilton and GMAC, near the Nepean River and Hume Motorway - A number of populations in the vicinity of Menangle Park and Spring Farm (near important population 73), outside of the western boundary of GMAC **Potential habitat** The baseline mapping for this assessment has mapped 26,092.1 ha of known and potential habitat within the Strategic Assessment Area. Due to the broad habitat associations in the model, potential habitat has been identified widely across the Strategic Assessment Area, with habitat primarily occurring as thin corridors associated with drainage lines within the region. It is noted that the area to the west of GMAC, between Spring Farm and Menangle has been identified as a more substantial patch of mapped potential habitat. Habitat is not mapped within GPEC and WSA because the species is not a candidate species credit species in those nominated areas.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.11.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 959.3 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 924.7 ha (96.4 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 733.1 ha was avoided for biodiversity purposes
- 191.5 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-41.

It is important to note that the avoidance calculations in Table 29-41, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-41 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.11.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

It is noted that the Plan includes a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to *P. brunnea* as a result of tunnel construction activities in transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.11.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to a loss of potential habitat and fragmentation of habitat. A summary of these impacts is provided in Table 29-42.

LOSS OF POTENTIAL HABITAT

Approximately 202.5 ha of potential habitat for the species will be lost. This is 0.8 per cent of mapped potential habitat across the Strategic Assessment Area. The loss of potential habitat occurs across Wilton, GMAC, and transport corridors in the south of the Strategic Assessment Area. The majority of impacts to potential habitat occur due to transport outside the nominated areas.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as likely. The presence of records of the species within the vicinity of impacted habitat suggests that it is likely the species would be present within impacted areas
- The consequence of impacts to the species (if they did occur) has been categorised as minor. There will be a loss of <2 per cent of mapped potential habitat (vulnerable species), with high confidence that the species occurs in the impact area

29.11.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The development of the OSO to the south of Camden Park will fragment mapped potential habitat for *P. brunnea*.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development presents a barrier to dispersal of the species is likely. Limited information is available regarding the reproductive and dispersal ecology of *P. brunnea*, and therefore a precautionary approach has been taken and it is thought to be likely that the development of the OSO would fragment habitat for the species
  - The type of fragmentation (as defined in the risk assessment approach in Section 29.3) is impact to habitat connected to a population. This is because there are known records located on mapped potential habitat which is fragmented by the OSO development
- The consequence of fragmentation has been categorised as moderate. This is because the area to be fragmented is connected to a known population of the species and is of moderate size

29.11.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. brunnea.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the potential indirect impacts to the species that may occur as a result of development under the Plan. It also outlines if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.11.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan (Sutter, Department of Sustainability and Environment et al., 2011) (and other key documents) for *P. brunnea* identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Weed invasion
- Disturbance from trampling and recreational vehicle use
- Stormwater run-off
- Altered fire regimes

Sand extraction, browsing by cattle and timber harvesting have also been identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

WEED INVASION

P. brunnea is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

P. brunnea is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include development within Wilton and GMAC.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *P. brunnea*:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
    - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:

    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Also relevant for the *P. brunnea* is that three known populations of the species (513, 514 and 515), in addition to mapped potential habitat, is located within the proposed footprint for Stage 1 of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include weed management measures to protect the biodiversity values of the reserve.

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from the increased risk of weeds associated with development. This is because:

- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and three known populations of *P. brunnea.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. brunnea*
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 925 ha of mapped potential habitat of *P. brunnea* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

DISTURBANCE FROM TRAMPLING AND RECREATIONAL VEHICLE USE

Habitat degradation through unrestricted public access and rubbish dumping has been identified as a key threat. Development within the nominated areas (particularly Wilton and GMAC) may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat. In particular, populations at risk include important populations 586 and 587, and non-important populations 470, 471, each of which occur directly adjacent to urban capable land within GMAC. It is noted that each of these populations occur on avoided land.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *P. brunnea.* In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including *P. brunnea* populations and mapped potential habitat within the Georges River Koala Reserve to be established under Commitment 10)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand

and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. brunnea*

The package of measures in the Plan is expected to adequately manage the risk to *P. brunnea* from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where mapped habitat for *P. brunnea* occurs will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

STORMWATER RUN-OFF

Stormwater runoff is identified as a threat to *P. brunnea*. The areas that are most at risk include populations which occur adjacent to urban capable development within GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for *P. brunnea.* In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through development controls in nominated areas in relation to:

- Water cycle management. For example:
  - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
  - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
- Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
- Soil erosion and sedimentation. For example:
  - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
  - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application

The package of measures in the Plan is expected to adequately manage the risk to *P. brunnea* from stormwater runoff because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to biodiversity values, including potential habitat for *P. brunnea*

ALTERED FIRE REGIMES

The sensitivity of *P. brunnea* to fire is unknown, although the species is known to occur in moist habitats where fire is infrequent and which may be sensitive to fire, and other *Pomaderris* species do not resprout after fire. As *P. brunnea* requires 4-6 years to reach maturity and produce seed, it is considered that a fire interval of less than 10 years would be detrimental to the species (Sutter, Department of Sustainability and Environment et al., 2011).

Increased human activity within the nominated areas has the potential to the risk of fire to habitat areas supporting the species, through the following mechanisms:

- Arson and accidental lighting of fires
- The application of fire by authorities to manage fire risk

The areas which are most at risk of increased fire frequency are where the species occurs in proximity to development under the Plan, and includes known populations and mapped potential habitat within GMAC.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. brunnea* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. brunnea*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

Also relevant for the *P. brunnea* is that three known population of the species (populations 513, 514 and 515), in addition to mapped potential habitat, is located within the proposed footprint for Stage 1 of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include the application of the fire management strategy and a set of measures to control access to bushland which will help minimise risks around arson and accidental fires.

The package of measures in the Plan is expected to adequately manage the risk to *P. brunnea* from altered fire regimes as a result of development. This is because:

- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and three known populations of *P. brunnea.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. brunnea*
- Establishment of environmental zoning of approximately 925 ha of mapped potential habitat of *P. brunnea* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *P. brunnea* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *P. brunnea* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*

- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.11.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species has been recorded within avoided lands in GMAC. There is a total of seven populations (five non-important and two important) within GMAC which occur within avoided lands. Of these, three are located within the footprint of the proposed Georges River Koala Reserve, and will be managed for conservation purposes. The remaining four populations occur either entirely or partially within avoided lands adjacent to urban capable development.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.11.8 POTENTIAL IMPACTS FROM TUNNELS

Both the Metro Rail Future Extension and the OSO tunnels intercept mapped potential habitat for *P. brunnea.* In total, 137.9 ha of potential habitat for *P. brunnea* occurs within the two tunnel footprints.

The Metro Rail Future Extension has a total of 71.8 ha of mapped potential habitat for *P. brunnea* within the impact footprint. This habitat occurs mostly as small scattered patches which are not associated with known records of the species. The largest area of impacted habitat is located in association with Narellan Creek the vicinity of Harrington Park, in an area which is already extensively cleared and developed. The potential habitat values of this locality for *P. brunnea* are considered to be marginal.

The OSO tunnel intercepts approximately 66.1 ha of potential habitat for *P. brunnea* which is associated with an important population of the species (population 465), which is wholly located in a conservation reserve (a Registered Property Agreement site). This is a large population, comprising 22 records of the species (it is noted that most known populations of the species are small).

The Plan includes commitments to:

- Avoid and minimise impacts to populations and habitat within or adjacent to the OSO and Metro Rail Future Extension footprints for *P. brunnea* (Commitment 4.1)
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process (Commitment 6.2)

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.11.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Recovery Plan identifies the following key issues that are likely to have the greatest influence on the long-term viability of the species in relation to implementation of the Plan

- Habitat loss
- Indirect impacts including:
  - Weed invasion
  - Disturbance from trampling and recreational vehicle use
  - Stormwater run-off
  - Altered fire regimes

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to:

- Loss of 202.5 ha of mapped habitat within the nominated areas and transport corridors
- Potential fragmentation of habitat in one location

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>low.</u> The total area of potential habitat which will be impacted is a small proportion of available habitat for the species. Fragmentation of a moderate area of mapped potential habitat connected with species' records may also occur. It is noted that no known records of the species are directly impacted or fragmented from other known records.

It is noted that *P. brunnea* occurs within the footprint of the proposed OSO and Metro Rail Future Extension tunnels. The Plan contains a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to *P. brunnea* as a result of tunnel construction activities in transport corridors, which is considered to protect the individuals within the tunnel footprint from direct impacts.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain 7,605.6 ha of potential habitat for *P. brunnea.* It is also recognised that three known populations of the species occur within the proposed footprint of the Georges River Koala Reserve, which will be managed for conservation purposes and is expected to deliver benefits for these populations

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts of development corridors associated with weed invasion, disturbance from trampling and recreational vehicle use, stormwater run-off and altered fire regimes have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan. In addition, any potential indirect impacts associated with the construction of tunnels will be managed and mitigated through a species-specific commitment (Commitment 6.2).

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.11.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan (Sutter, Department of Sustainability and Environment et al., 2011) is to minimise the probability of extinction of *P. brunnea* in the wild and to increase the probability of populations becoming self-sustaining in the long-term. Specific objectives include:

- Determine current status and threats
- Determine habitat requirements
- Protect and manage populations on public and private land
- Monitor response of populations to active management
- Identify key biological functions
- Establish a population in cultivation
- Build community support for conservation

Implementation of the Plan will support a number of these strategies and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *P. brunnea*. The Plan will not prevent implementation of any of the actions.

29.11.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-39 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *P. brunnea,* there are no relevant Threat Abatement Plans.

Table 29-39: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. brunnea*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-40: Occurrence of *P. brunnea* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	21	5
(IMPORTANT POPULATIONS)	(7)	(5)
HABITAT MAPPING (Ha)	26,092.1	2,614.0

Table 29-41: Avoidance of *P. brunnea* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	531.7	756.4	<0.1	<0.1	1,288.1
HABITAT WITHIN EXCLUDED LANDS (ha)	90.4	238.5	<0.1	<0.1	328.9
HABITAT WITHOUT EXCLUDED LANDS (ha)	**441.3**	**518.0**	**<0.1**	**0.0**	**959.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	319.9	413.2	0.0	0.0	733.1
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	72.5	79.8	0.0	N/A	76.4
AVOIDANCE FOR OTHER REASONS (ha)	105.1	86.4	<0.1	0.0	191.5
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	23.8	16.7	100.0	N/A	20.0
TOTAL AVOIDANCE (ha)	**425.0**	**499.7**	**<0.1**	**0.0**	**924.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**96.3**	**96.5**	**100.0**	**N/A**	**96.4**

Table 29-42: Direct impacts to *P. brunnea* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	16.3	18.3	0.0	0.0	167.9	**202.5**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

SPECIES AT VERY LOW RISK OF DIRECT IMPACTS

29.12 *ACACIA BYNOEANA* (BYNOE'S WATTLE)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	A semi-prostrate shrub with narrow leaves and cream to yellow flowers. It grows to 0.2-1 m tall. (DoEE, 2018c)
ECOLOGY	Flowers from September to March. Seedpods occur from September to January. Pollination is likely to be carried out by small native bees and wasps. Seed dispersal is likely to be by ants. Seeds are likely to remain viable for many years, which can lead to the development of a persistent soil-stored seed bank in the absence of cues for germination. The species may also reproduce vegetatively (Douglas, 2019a). This species may appear in response to disturbance. It is not always apparent, and can be cryptic and difficult to detect (particularly when not in flower) (Douglas, 2019a).
DISTRIBUTION AND HABITAT	Records occur in central-eastern NSW. They range from the Hunter District in the north to the Southern Highlands in the south and the Blue Mountains in the west. It is known to occur in the Cumberland IBRA subregion (OEH, 2019b). Inhabits heath or dry sclerophyll forests on sandy soils. It is recorded in open and sometimes slightly disturbed sites such as trail margins, edges of roadside, grading spoil mounds and in recently burnt patches (OEH, 2017a).
POPULATIONS	As of 2006, populations were known in around 113 locations and most were small in size (Douglas, 2019a). A natural population is considered at a critically low level if it contains less than 50 mature individuals (DoE, 2013a).
SOS SITES	The following SOS sites for the species have been proposed: • Dora Creek • Eastern Yengo • Castlereagh • Dharawal • Colymea SCA

RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Acacia bynoeana* (Bynoe's wattle) (DoE, 2013a)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=8575

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	Yes	Yes	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	Yes (Douglas, 2019a). Available at Supporting Document C
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Expert report polygons**. Potential habitat polygons were generated based on the occurrence of PCTs 725, 883, 1081, 1181 and 1395, with the application of riparian exclusion buffers to account for the fact that wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat. To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. The species was not recorded during surveys and these areas were removed from the potential habitat mapping. However, it was not possible to access and survey all areas of potential habitat within the nominated areas. Any remaining potential habitat is considered precautionary and does not necessarily equate with actual habitat. Douglas (2019a) notes that the species is naturally rare and patchily distributed, which means that it is unlikely that a large percentage of the potential habitat would actually support the species, even though it can sometimes be locally abundant in favourable conditions. **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. The report for this process (Supporting Document F) notes that the model for the species predicts more potential habitat than would be expected based on soils and PCTs alone. The mapping is therefore considered to be highly precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.

	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. It should be noted that limited information is available on the dispersal distance of *A. bynoeana*. However, the recovery plan for *A. pubescens* notes that dispersal over a distance of 300 m is considered likely for Acacia spp. (NSW NPWS, 2003). Based on this, plants within 300 m of each other were defined as one population.
	IMPORTANT POPULATION CRITERIA
	Populations of *A. bynoeana* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations were considered important because they met one or more of the following criteria: • They are considered necessary for maintaining the extent of the species' occurrence • They are relatively large in size (number of individuals), in the context of known information regarding species ecology and population characteristics • They occur within a conservation reserve • They are part of an SOS site

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.1 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-44 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *A. bynoeana* in the Strategic Assessment Area. **Records** The species is known to occur in three main locations in the Strategic Assessment Area: • To the north of GPEC where there are a significant number of populations • Just to the north-east of GMAC • And within Wilton where it occurs in the conservation area for the previously approved Bingara Gorge development (EPBC 2014/7400) In total there are 45 populations within the Strategic Assessment Area. Of these populations, 37 are considered important, and 12 are wholly or partly located in existing conservation reserves. It is important to note that surveys undertaken for the strategic assessment within the nominated areas did not record the species. **Potential habitat** The baseline mapping for the assessment mapped approximately 30,678 ha of known and potential habitat within the Strategic Assessment Area. 2,434 ha of this occurs within protected lands. As a general trend, habitat within the Strategic Assessment Area is located in the north and south of the assessment area, with scattered areas towards the eastern and western edges. Specifically, potential habitat for *A. bynoeana* is located: • In the Londonderry area to the north of GPEC, where a large patch occurs in the area incorporating Agnes Banks, Wianamatta Nature Reserve, Castlereagh and Windsor Downs nature reserves and the Waste Assets Management Corporation stewardship on The Northern Road • In moderate patches to the north of the Londonderry area, including localities such as Scheyville, Freemans Reach and North Richmond • Within the Wianamatta Regional Park and Ropes Crossing, located within GPEC

	• In moderate to large connected areas occurring in the southern and south-eastern region of the Strategic Assessment Area, including areas around Buxton, Tahmoor and Bargo, Wilton, Douglas Park, vegetation corridors near Appin, and the Kentlyn/Minto Heights region • In small to moderate patches near Gulguer Nature Reserve in the west of the Strategic Assessment Area • In small scattered patches near Kemps Creek, from the mid-east to the east of the Strategic Assessment Area, with some habitat occurring within WSA Mapped potential habitat is relatively limited within GPEC, WSA and the northern half of GMAC, compared with Wilton and the southern half of GMAC where it is associated with most of the remnant vegetation.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.12.1 NOMINATED AREAS

The baseline mapping for the assessment mapped 1,814 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 1,619 ha (89 per cent) was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,556 ha was avoided for biodiversity purposes
- 63 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-45.

It is important to note that the avoidance calculations in Table 29-45, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', were calculated without including excluded lands as these lands are not covered by the Plan. Table 29-45 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.12.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.12.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to the loss of potential habitat for the species. However, it will not result in direct impacts to any known populations. A summary of these impacts is provided in Table 29-46.

Loss of potential habitat

Approximately 199 ha of potential habitat for the species will be lost as a result of the implementation of the Plan (195 ha within the nominated areas and 4 ha within transport corridors outside the nominated areas). This habitat occurs predominantly within Wilton and GMAC and represents 0.6 per cent of mapped potential habitat across the Strategic Assessment Area.

Risk of residual adverse impacts to the species

The risk of residual adverse impacts occurring to the species as a result of the loss of potential habitat is considered to be very low. This is because:

- The likelihood of actual impacts occurring to the species has been categorised as possible. There will be no impacts to known populations, and there is moderate confidence that the species could occur in the potential habitat to be impacted. As outlined in the Approach to Baseline Data section above, the potential habitat mapping is considered precautionary and does not necessarily equate with actual habitat
- The consequence of any impacts to the species (if they did occur) has been categorised as negligible. There will be loss of less than 2 per cent of mapped potential habitat in the Strategic Assessment Area, with moderate confidence of the species' occurrence in impacted areas. There are no impacts to known populations.

29.12.4 FRAGMENTATION OF HABITAT

The placement of urban capable land and transport corridors within the Strategic Assessment Area will not lead to fragmentation of records or habitat of *A. bynoeana*, as it will not lead to the removal of habitat which links other areas of habitat or records together. All impacts to habitat of *A. bynoeana* are to already fragmented patches.

Therefore, there is no residual adverse risk of fragmentation as a result of loss of potential habitat under the Plan.

29.12.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *A. bynoeana*.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.12.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (and other key documents) for *A. bynoeana* identifies a range of threats to the species (DoE, 2013a). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate habitat disturbance
- Weed invasion
- Inappropriate fire regimes

Browsing by native and introduced herbivores has also been identified as a key threat. However, this is not considered relevant to the implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

INAPPROPRIATE HABITAT DISTURBANCE

Disturbance to the species can occur:

- During road, trail and powerline maintenance
- By recreational vehicles, horse riding and pedestrian use on the margins of trails where the species can occur (DoE, 2013a)

Activities associated with maintenance are likely to be a current issue for the species where known records occur outside the nominated areas (particularly to the north of GPEC). It is considered unlikely that activities approved under the Plan would exacerbate this threat.

Disturbance due to recreational use of natural areas may increase due to development within the nominated areas. Populations of *A. bynoeana* considered most at risk of this threat are those that occur on:

- Public land, as these areas are accessible without the deterrent that comes with trespassing. Populations occur on the following public land managed for conservation: Castlereagh Nature Reserve, Wianamatta Nature Reserve and possibly Agnes Banks Nature Reserve (there is one historical record of the species in this reserve, yet detailed surveys for associated species in recent years have failed to detect the species (Douglas, 2019a)). While access is potentially an issue in all of these areas, the reserves are all managed for conservation purposes and have measures to control the impacts of public visitation
- An area of freehold land to the north of GPEC which is often mistaken for Crown land. This area contains a number of access tracks, and issues associated with rubbish dumping have been recorded for the site

In addition, some habitat for the species (around Populations 82 and 239) is subject to approval conditions to protect and manage it from indirect impacts, under a previous EPBC Act referral (EPBC 2014/7400). Conditions of approval include:

- Preparation of an environment management plan for the approval of the Commonwealth to address indirect impacts, which includes the following measures:
    - Fencing and signage to restrict access in the areas
    - Provision of bins to reduce littering

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *A. bynoeana*. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (which will include land obtained for conservation within the SCAs. It is noted that there is 5,482 ha of habitat for *A. bynoeana* within the SCAs)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *A. bynoeana*

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where mapped habitat for *A. bynoeana* occurs will be zoned appropriately to enable an adequate framework for management. It is noted there is approximately 1,814 of mapped potential habitat for *A. bynoeana* in avoided lands
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

WEED INVASION

A. bynoeana is threatened with invasion and competition by weeds. The species is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include:

- The southern end of Shanes Park where the M7/Ropes Crossing Link occurs adjacent to potential habitat areas
- The north-eastern section of Wianamatta Regional Park, where the Outer Sydney Orbital corridor within GPEC occurs near potential habitat
- Within Wilton at Bingara Gorge (noting this area is subject of a previous EPBC Act approval (EPBC 2014/7400) which includes weed control requirements to protect the species)
- North east and south east of GMAC

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area. This includes a number of actions, of which the following are the most relevant to the outcome for *A. bynoeana*:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
    - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The Plan further includes a commitment to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA.

These measures are expected to adequately manage the potential threat to *A. bynoeana* from weed invasion.

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are an identified potential threat to *A. bynoeana* (DoE, 2013a). Increased human activity within the nominated areas has the potential to increase the risk of fire within adjacent areas of habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for *A. bynoeana* being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *A. bynoeana.* While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

These measures are considered to adequately mitigate the threat to potential habitat for the species.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.12.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

A. bynoeana records occur within Wilton wholly within excluded lands. No records of the species occur within other nominated areas.

Mapped potential habitat for *A. bynoeana* occurs within avoided lands in all nominated areas, with the majority of habitat in avoided areas occurring in Wilton and GMAC. The development of essential infrastructure within avoided lands therefore has some potential to impact upon mapped habitat for *A. bynoeana*. It is noted that habitat which has the highest potential to be impacted would be habitat occurring at the edge of the urban capable lands and transport corridors, and therefore would likely constitute more marginal habitat with greater exposure to edge effects.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.12.8 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 4.2 ha of potential habitat for *A. bynoeana* within the footprints of the Metro Rail Future Extension and OSO tunnels. No records of the species occur within or in the vicinity of the tunnel footprints. Given the small area of mapped potential habitat within the footprint and the absence of records, it is considered unlikely that *A. bynoeana* is present in the locality of the tunnel developments.

The Plan includes commitments to mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process.

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.12.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2013a) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *A. bynoeana* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate habitat disturbance
  - Weed invasion
  - Inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

The risk of residual adverse impacts to the species from habitat loss and fragmentation under the Plan is very low. Although the Plan authorises the clearing of 199 ha of potential habitat, the mapping for this species is highly precautionary and the impacts relate to 0.6 per cent of the mapped habitat in the Strategic Assessment Area. The vast majority of mapped habitat in the nominated areas was avoided in the design of the urban capable lands. There will be no impacts to known populations or fragmentation of potential habitat. This clearing is not expected to influence the long-term viability of the species.

While specific offsets for this species are not considered necessary, the Plan includes broader commitments and actions that are likely to benefit the species. In particular:

- The SCAs contain approximately 5,842 ha of mapped potential habitat for the species. Although the final extent of potential habitat that will be secured in these areas is unclear, the opportunity to secure large, well connected and high quality vegetation that provides potential habitat makes it likely that the conservation program will deliver benefits for this species

The process of protecting land in the Strategic Assessment Area is likely to support a priority action from the Conservation Advice to increase the area of habitat for the species that is secured and managed for conservation.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate habitat disturbance, weed invasion, and inappropriate fire regimes will be managed and mitigated through the generic management strategies in the Plan, and through an existing EPBC Act approval in the Bingara area.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There will be no direct impacts to known populations. There are large areas of potential habitat (30,678 ha) and impacts to this are relatively minor (199 ha). There will be no fragmentation of potential habitat.

Potential indirect impacts are addressed through management measures in the Plan and a previous EPBC Act approval.

Collectively these will ensure that the implementation of the Plan does not adversely influence the long-term viability of *A. bynoeana*.

29.12.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.12.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *A. bynoeana*, there are no relevant Threat Abatement Plans.

Table 29-43: Relevant key Threatening Processes and associated Threat Abatement Plans for *A. bynoeana*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-44: Occurrence of *A. bynoeana* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	45	12
(IMPORTANT POPULATIONS)	(37)	(12)
HABITAT MAPPING (Ha)	30,677.7	2,433.8

Table 29-45: Avoidance of *A. bynoeana* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,000.7	1,365.8	35.1	105.7	2,507.3
HABITAT WITHIN EXCLUDED LANDS (ha)	215.1	373.3	1.1	103.9	693.4
HABITAT WITHOUT EXCLUDED LANDS (ha)	**785.6**	**992.5**	**34.0**	**1.8**	**1,813.9**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	637.8	892.4	25.6	0.1	1,555.9
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	81.2	89.9	75.3	6.8	85.8
AVOIDANCE FOR OTHER REASONS (ha)	25.7	37.0	0.1	0.0	62.8
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	3.3	3.7	0.3	0.0	3.5
TOTAL AVOIDANCE (ha)	**663.4**	**929.5**	**25.7**	**0.1**	**1,618.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**84.4**	**93.6**	**75.6**	**6.8**	**89.2**

Table 29-46: Direct impacts to *A. bynoeana* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	122.2	63.0	8.3	1.7	3.5	**198.7**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.13 *ACACIA PUBESCENS* (DOWNY WATTLE, HAIRY-STEMMED WATTLE)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Acacia pubescens* is a weeping, spreading shrub with brilliant yellow flowers, bipinnate leaves and hairy branchlets. It grows approximately 1-5 m tall. (TSSC, 2016a)
ECOLOGY	Flowers between August and October. Pods mature between October and December. Plants first flower when they are around 3-5 years old. The species is pollinated by insects (most likely small native bees and wasps) and birds (Douglas, 2019b). Recruitment is often by vegetative means and this can reduce the genetic diversity of a population. The percentage of seed fall may be low, possibly due to predation when on the plant. The species is likely to have high seed dormancy and a long-lived persistent soil seed bank. Regeneration can occur following fire, however, severe fires kill the stems. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Records are restricted to the Sydney district predominantly in the Cumberland subregion (NSW NPWS, 2003) The species inhabits open woodland and forest in a variety of plant communities (Cooks River/Castlereagh Ironbark Forest, Shale Gravel Transition Forest and Cumberland Plain Woodland). It occurs on alluviums, shales and at the intergrade between shales and sandstones. (DoEE, 2018c)
POPULATIONS	As of 2003, there were 116 known populations of this species. At that time, just over half of those known populations contained fewer than 20 stems (NSW NPWS, 2003). Populations should be considered viable unless there is evidence to the contrary. This is because most recruitment is from vegetative reproduction and small population sizes are not necessarily relevant in the assessment of viability (NSW NPWS, 2003). Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *A. pubescens* is considered to be an endemic species to the region.
SOS SITES	The following SOS sites for the species have been identified: • Mountain Lagoon • Hawkesbury

	• Bankstown-Liverpool
RELEVANT PLANS AND POLICIES	Conservation Advice *Acacia pubescens* Downy Wattle (TSSC, 2016a) Downy Wattle (*Acacia pubescens*) Recovery Plan (NSW NPWS, 2003)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=18800

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	Yes	Yes	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	Yes (Douglas, 2019b). Available at Supporting Document C
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Expert report polygons. Potential habitat polygons were generated based on the occurrence of PCTs 724, 725, 835, 849, 883, 1081 and 1395, with the application of riparian exclusion buffers to account for the fact that wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat. All condition classes of vegetation for this species were considered to be suitable habitat as this species is able to occur in quite disturbed habitats. The species may also occur in sites which are so modified that they would not be mapped as native vegetation community. To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. The species was not recorded during surveys and these areas were removed from the potential habitat mapping. However, it was not possible to access and survey all areas of potential habitat within the nominated areas. Douglas (2019b) notes that any remaining potential habitat is considered precautionary and does not necessarily equate with actual habitat. The species is naturally rare and patchily distributed, which means that it is unlikely that a large percentage of the potential habitat would actually support the species. It can sometimes be locally abundant in favourable conditions.
	OUTSIDE THE NOMINATED AREAS
	Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The report for this process (Supporting Document F) notes that the model for the species predicts more potential habitat than would be expected based on soils and PCTs alone. The mapping is considered to be highly precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.
	RECORD SELECTION

<table>
<tr><td rowspan="5">POPULATION MAPPING</td><td>Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
<tr><td>POPULATION DEFINITION</td></tr>
<tr><td>Biological populations were defined using the records dataset and available information about the nature of the species.
The recovery plan for A. pubescens notes that dispersal over a distance of 300 m is considered likely for Acacia spp. (NSW NPWS, 2003). Based on this, plants within 300 m of each other have been defined as one population.</td></tr>
<tr><td>IMPORTANT POPULATION CRITERIA</td></tr>
<tr><td>Populations of A. pubescens were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations were considered important because they met one or more of the following criteria:
• A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program
• A large population
• Is associated with a commitment made under the Sydney Growth Centres conservation program
• A population within a conservation area</td></tr>
</table>

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

<table>
<tr><td>MAP</td><td>See Map 36.2 for a map of records and habitat across the Strategic Assessment Area</td></tr>
<tr><td>OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA</td><td>See Table 29-48 at the end of this species assessment for a breakdown of the occurrence of records and habitat for A. pubescens in the Strategic Assessment Area.
Records
Known records for A. pubescens are distributed across two core areas which have been identified for site management under the NSW Saving our Species (SOS) program:
• One area associated with the Hawkesbury SOS site in the north-east of the Strategic Assessment Area, including Windsor Downs, Pitt Town and Scheyville National Park
• The second associated with the Bankstown-Liverpool SOS site, comprising an area that straddles the central-east boundary of the Strategic Assessment Area around Lansdowne
Scattered records occur more broadly, but still within the region of these two core areas. There are also a small number of outlier populations outside and to the west of the Strategic Assessment Area, at Mountain Lagoon in the north-west and The Oaks in the south-west.
There are a total of 97 important populations within the Strategic Assessment Area, of which 13 either wholly or partly occur within existing protected areas as shown in Table 29-48. None of these important populations occur within the nominated areas.
One of these populations is located at Kemps Creek just outside the southern boundary of WSA. This population has been identified as important because it is the subject of a commitment made under the Sydney Growth Centres Program.
The remaining 96 populations within the Strategic Assessment Area have been identified as important because they are all associated with the Saving our Species sites across the two core areas described above.</td></tr>
</table>

	A further 8 non-important populations have been mapped within the Strategic Assessment Area. These populations broadly occur around Minchinbury within GPEC and further south within the Austral and Hoxton Park areas, outside of the nominated areas. **Potential habitat** The baseline mapping for this assessment has mapped approximately 35,102 ha of known and potential habitat within the Strategic Assessment Area as shown in Table 29-48. The majority of this habitat is associated with the two core areas for the species and mostly occurs outside of the nominated areas. Within the nominated areas, potential habitat has been identified: • Within GPEC and WSA, where potential habitat areas align closely with patches of remnant vegetation. This potential habitat is within the western extent of the core area associated with the Bankstown-Liverpool SOS site • Within GMAC, where potential habitat areas again align closely with patches of remnant vegetation. A small proportion of this occurs within the northern section of the nominated area which forms part of the southern extent of the Bankstown-Liverpool SOS site. However, the majority of this potential habitat occurs within the southern half of the nominated area approximately 22 km south of this core area in a locality where the species has not previously been recorded • Within Wilton, where potential habitat is not just associated with remnant patches of vegetation, but has been mapped more broadly in a number of areas. However, it is noted that this area is well outside the core range of *A. pubescens* in areas where (according the expert report) the species is not known from or likely to occur (Douglas, 2019b) It is relevant to note that surveys throughout remnant vegetation within GMAC and Wilton undertaken as part of this assessment did not detect the species. This, combined with the fact that the majority of potential habitat mapped within these areas is outside the species' core range, suggests that *A. pubescens* is unlikely to occur within mapped potential habitat within GMAC and Wilton.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.13.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 2,853 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 2,118 ha (74 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,885 ha was avoided for biodiversity purposes
- 234 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-49.

It is important to note that the avoidance calculations in Table 29-49, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including 'excluded lands' as these lands are not covered by the Plan. Table 29-49 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.13.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.13.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to any direct impacts to known populations. However, it will lead to a loss of potential habitat. A summary of these impacts is presented in Table 29-50.

Loss of potential habitat

Approximately 792 ha of potential habitat for the species will be lost as a result of the implementation of the Plan (735 ha within the nominated areas and 57 ha within transport corridors outside the nominated areas). This habitat occurs in the following areas:

- Within GPEC and WSA, at the western extent of the core area for the species associated with the Bankstown-Liverpool SOS site
- Potential habitat within Wilton and the southern section of GMAC

This habitat represents 2.3 per cent of mapped potential habitat across the Strategic Assessment Area.

Risk of residual adverse impacts

The risk of residual adverse impacts occurring to the species as a result of the loss of potential habitat is considered to be very low. This is because:

- The likelihood of actual impacts occurring to the species has been categorised as unlikely. There will be no impacts to known populations, and there is low confidence that the species could occur in the potential habitat to be impacted. The habitat which is to be impacted within GPEC and WSA consists of small, scattered and isolated patches which are considered unlikely to support the species. Impacted potential habitat within GMAC and Wilton is located outside of the core range of the species, and the species has never been recorded in these localities.
- The consequence of any impacts to the species (if they did occur) has been categorised as minor. There will be loss of between 2-5 per cent of mapped potential habitat in the Strategic Assessment Area with low confidence of the species' occurrence in impacted habitat (endemic species). Species mapping for this assessment is highly precautionary, with much impacted habitat being mapped beyond the known range of the species, suggesting the species is unlikely to occur in these localities, and as such there is low confidence of species presence in impacted habitat

29.13.4 FRAGMENTATION OF HABITAT

Fragmentation impacts

The placement of urban capable land and transport corridors within the Strategic Assessment Area will lead to fragmentation of a small area of potential habitat with no associated records. This habitat is located to the south of WSA in the vicinity of Cobbitty, which will be fragmented as a result of the development of the OSO.

Risk of residual adverse impacts

The risk of residual adverse impacts occurring to the species as a result of the loss of fragmentation is considered to be very low. This is because:

- The likelihood of fragmentation has been categorised as unlikely. This is because:

- The likelihood that development is presents a barrier to dispersal of the species is possible. *A. pubescens* is pollinated by insects and birds, and it is thought that individuals of the species within 300 m of each other are likely to be within the same population, suggesting that the species has the capacity to breed with and/or disperse up to 300 m from adult plants. While detailed planning for development within the transport corridors has not yet been completed, it is anticipated that the width of the OSO will be less than 300 m. The OSO is further thought to have potential to deter movement of pollinators and/or seed dispersers between adult plants.
- The type of fragmentation is impact to mapped habitat only. This is because there are no known records on, or in the vicinity of, mapped potential habitat which is impacted by the OSO near Cobbitty.

- The consequence of fragmentation has been categorised as negligible. This is because the area to be fragmented consists of a small area of potential habitat with no associated records.

29.13.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *A. pubescens.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.13.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (TSSC, 2016a) and Recovery Plan (NSW NPWS, 2003) (and other key documents) for *A. pubescens* identify a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate habitat disturbance through illegal track creation and maintenance activities
- Weed invasion
- Inappropriate fire regimes

Hybridisation with non-naturally occurring bipinnate wattles within natural range and impacts to individuals from an unknown disease was also identified as a key threat. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the threat across the Strategic Assessment Area.

However, it is considered unlikely that these indirect impacts will adversely affect the majority of populations of the species within or surrounding the Strategic Assessment Area for the following reasons:

- All populations within the nominated areas (population 485, 486 and 487 in GPEC and population 474 in GMAC) are non-important populations which are within landscapes which are already highly developed. These populations would be subject to a range of threatening processes from the existing urban environment and are unlikely to be affected by development under the Plan
- The important populations associated with the Bankstown-Liverpool SOS site occur approximately 6 km east of the nearest development within WSA, and are also in a landscape which is highly developed which is subject to existing threatening processes. Development under the Plan is unlikely to affect these populations
- The important populations associated with the Hawkesbury SOS site occur some distance from proposed development under the Plan (over 8 km from the nearest transport corridor outside of the nominated areas and over 12 km to the nearest urban capable land within GPEC) and a number of these populations are already managed for conservation within the Scheyville National Park

The only important population which has potential to be indirectly impacted by development under the Plan is population 479. This important population that forms part of a commitment under the Sydney Growth Centres Program which requires field validation of the records before habitat associated with the population will be protected.

A brief survey of the locality of Kemps Creek was undertaken in mid-November of 2018, as described in the expert report for this species. While no new records of the species were reported, it was considered possible that the species may occur on disturbance margins which were not traversed, or that the species may be restricted to seed bank at that location. Overall, the remnant habitat of this locality was largely unmanaged and degrading due to several threats at the time of survey. It is recognised that *A. pubescens* is relatively tolerant of significant disturbance and can persist as a long-lived seedbank or as root suckers, and therefore the species may persist in disturbed areas. It is recommended that the management of habitat at Kemps Creek under this program be improved. It is considered that improved and ongoing management of habitat at Kemps Creek will provide protection of *A. pubescens* within this locality from impacts associated with indirect impacts.

A small non-important population (population 487) has potential to be indirectly impacted by development under the Plan. The following sections outline the control measures under the Plan to manage indirect impacts to *A. pubescens*.

INAPPROPRIATE HABITAT DISTURBANCE

The Plan includes the following development controls to manage the risk of inappropriate habitat disturbance:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (it is noted the SCAs contain approximately 3,475 ha of habitat for *A. pubescens*)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. parviflora*

The package of measures in the Plan is expected to adequately manage the risk to *A. pubescens* from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of mapped habitat for *A. pubescens* occur will be zoned appropriately to enable an adequate framework for management. It is noted there is approximately 2,118 ha of potential habitat for *A. pubescens* within avoided lands
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands (including mapped potential habitat for *A. pubescens* within the SCAs) will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

WEED INVASION

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- Implementation of mitigation measures to address the impacts of the spread of weeds on threatened species associated with and urban capable (Commitment 5) and transport (Commitment 6) development
- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area. This includes a number of actions, of which the following are the most relevant to the outcome for *A. pubescens*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk to *A. pubescens* from the increased risk of weeds associated with development. This is because:

- Commitments 5 and 6 will provide for mitigation measures to be implemented for the benefit of *A. pubescens* to address the impacts associated with the spread of weeds associated with urban capable and transport development
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 2,118 ha of mapped potential habitat of *A. pubescens* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

INAPPROPRIATE FIRE REGIMES

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *A. pubescens*:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values (it is noted the SCAs contain approximately 3,475 ha of habitat for *A. pubescens*)
  - A process to work with delivery partners to implement the fire management strategy

  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *A. pubescens.* While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

The package of measures in the Plan is expected to adequately manage the risk to *A. pubescens* from altered fire regimes as a result of development. This is because:

- Establishment of environmental zoning of approximately 2,118 ha of mapped potential habitat of *A. pubescens* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat for *A. pubescens* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *A. pubescens* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.13.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

A. pubescens records occur within GMAC and GPEC wholly within excluded lands. No records of the species occur within other nominated areas.

Mapped potential habitat for *A. pubescens* occurs within avoided lands in all nominated areas, with the majority of habitat in avoided areas occurring in Wilton and GMAC. The development of essential infrastructure within avoided lands therefore has some potential to impact upon mapped habitat for *A. pubescens.* It is noted that habitat which has the highest potential to be impacted would be habitat occurring at the edge of the urban capable lands and transport corridor, and therefore would likely constitute more marginal habitat with greater exposure to edge effects.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area

- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.13.8 POTENTIAL IMPACTS FROM TUNNELS

There is a total of 68.5 ha of mapped potential habitat for *A. pubescens* within the footprints of the Metro Rail Future Extension and OSO tunnels, which occurs as small and fragmented habitat patches. No records of the species occur within or in the vicinity of the tunnel footprints. Given the relatively small area and fragmented nature of mapped potential habitat within the footprint and the absence of records, it is considered unlikely that *A. pubescens* is present in the locality of the tunnel developments.

The Plan includes commitments to mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process.

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.13.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (TSSC, 2016a) identifies the following key issues that are likely to be the highest risk threat to the long-term viability of *A. pubescens* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Weed invasion
  - Habitat disturbance through illegal track creation and maintenance activities
  - Inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

The risk of residual adverse impacts to the species from habitat loss and fragmentation under the Plan is very low. Although the Plan authorises the clearing of 792 ha of potential habitat, the mapping for this species is highly precautionary and these impacts relate to approximately 2.3 per cent of the mapped habitat in the Strategic Assessment Area. The vast majority of mapped habitat in the nominated areas was avoided in the design of the urban capable lands. There will be no impacts to known populations, and the risk of fragmentation is very low. Direct impacts are not expected to negatively impact the long-term viability of the species.

While specific offsets for this species are not considered necessary, the Plan includes broader commitments and actions that are likely to benefit the species. In particular:

- The SCAs contain approximately 3,475 ha of mapped potential habitat for the species. Although the final extent of potential habitat that will be secured in these areas is unclear, the opportunity to secure large, well connected and high quality vegetation that provides potential habitat makes it likely that the conservation program will deliver benefits for this species

The process of protecting land in the Strategic Assessment Area is likely to support a priority action from the Conservation Advice to prevent further loss of habitat.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate habitat disturbance, weed invasion, and inappropriate fire regimes will be managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There will be no direct impacts to known populations. There are large areas of potential habitat (35,102 ha) and impacts to this are relatively minor (792 ha). The risk of fragmentation is very low.

Potential indirect impacts are addressed through management measures in the Plan.

This will ensure that the implementation of the Plan does not adversely influence the long-term viability of *A. pubescens*.

29.13.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan is to prevent the status of *A. pubescens* from becoming endangered, by reducing habitat loss and by implementing management regimes aimed at maintaining representative populations across the species' range (NSW NPWS, 2003).

Recovery plan strategies have been identified to support the overall objective. They are:

- To ensure that a representative sample of *A. pubescens* populations occurring on public and private lands are protected from habitat loss and managed for conservation;
- To reduce the impacts of threats at sites across the species' range;
- To ensure that any planning and management decisions that are made which affect the species, are made in accordance with the recovery objectives of this plan;
- To understand the biology, ecology, health and distribution of the species including the range of genetic variation;
- To develop the awareness and involvement of the broader community in the species and its conservation; and
- To re-assess the conservation status of the species.

Implementation of the Plan will support a number of these strategies by including development controls that manage and control the risks of potential indirect impacts consistent with actions in the Conservation Advice and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *Acacia pubescens*. The Plan will not prevent implementation of any of the actions.

29.13.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-47 where they relate to:

- The potential direct impacts of the Plan, or

- The relevant indirect impacts

For *A. pubescens*, there are no relevant Threat Abatement Plans.

Table 29-47: Relevant key Threatening Processes and associated Threat Abatement Plans for *A. pubescens*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-48: Occurrence of *A. pubescens* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	105	13
(IMPORTANT POPULATIONS)	(97)	(13)
HABITAT MAPPING (Ha)	35,102.3	2,812.4

Table 29-49: Avoidance of *A. pubescens* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,123.3	1,997.7	580.9	2,491.9	6,193.7
HABITAT WITHIN EXCLUDED LANDS (ha)	227.1	811.2	81.2	2,220.9	3,340.4
HABITAT WITHOUT EXCLUDED LANDS (ha)	**896.2**	**1,186.5**	**499.6**	**271.0**	**2,853.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	671.2	942.4	178.7	92.7	1,884.9
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	74.9	79.4	35.8	34.2	66.1
AVOIDANCE FOR OTHER REASONS (ha)	57.5	122.4	37.3	16.2	233.5
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	6.4	10.3	7.5	6.0	8.2
TOTAL AVOIDANCE (ha)	**728.7**	**1,064.8**	**216.0**	**108.9**	**2,118.4**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**81.3**	**89.7**	**43.2**	**40.2**	**74.2**

Table 29-50: Direct impacts to *A. pubescens* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	167.5	121.7	283.6	162.0	56.7	**791.7**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.14 *ALLOCASUARINA GLAREICOLA*

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Allocasuarina glareicola* is an erect, smooth-barked shrub with cones that grows to approximately 2 m tall (DoEE, 2018c; OEH, 2018b)
ECOLOGY	The species is monoecious or dioecious and flowers around October each year. The time taken for the plants to flower and set seed is not known. Regeneration is commonly by suckers. Root suckers can appear up to 3 m from the parent plant, where clumps of up to hundreds of stems may be a single individual. Seedling recruitment has only been observed at one site. The species is wind pollinated which means the distance between individuals may be a critical factor in enabling pollination and seed set. (DoEE, 2018c; OEH, 2018b)
DISTRIBUTION AND HABITAT	Records are primarily restricted to the Castlereagh and Londonderry areas of the Cumberland subregion, with an outlier population found in Liverpool (Holsworthy Military Area). The total extent of occurrence (EOO) of the species is approximately 27 km^2. Inhabits Castlereagh woodland and open woodland (with *Eucalyptus parramattensis, Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla* and *Melaleuca decora*). It occurs on strongly acidic soils with low fertility. (DoEE, 2018c; OEH, 2018b)
POPULATIONS	There were 457 clumps of *A. glareicola* known in 1996. The largest population, which consisted of 405 clumps, is likely to have reduced due to the expansion of an adjacent rubbish tip. (DoEE, 2018c) Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *A. glareicola* is considered to be an endemic species to the region. It is further noted that this species has been identified as an SAII species under the BCAR process. Refer to Chapter 25 for further information.
SOS SITES	The following SOS sites for the species have been proposed: • East of Agnes Banks Nature Reserve • Castlereagh Nature Reserve • Wianamatta Nature Reserve • Heathcote Rd

RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Allocasuarina glareicola* (DEWHA, 2008a)

SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=21932

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

<table>
<tr><td rowspan="3">NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)</td><td>ECOSYSTEM CREDIT SPECIES</td><td colspan="4">CANDIDATE SPECIES CREDIT SPECIES</td></tr>
<tr><td rowspan="2">No</td><td>WILTON</td><td>GMAC</td><td>WSA</td><td>GPEC</td></tr>
<tr><td>No</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td>EXPERT REPORT (BCAR PROCESS)</td><td colspan="5">There is no expert report for this species.</td></tr>
<tr><td rowspan="4">HABITAT MAPPING</td><td colspan="5">WITHIN THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Potential habitat polygons were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned) and soils including Blacktown, Agnes Banks, Berkshire Park and Gymea.
Potential habitat was confined to within GPEC, as there are no records in Wilton and GMAC, and no records or suitable habitat in WSA, suggesting the species is unlikely to be present in those areas.
To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas.
It was not possible to access and survey all areas of potential habitat within the nominated areas. However, the species was not observed as part of surveys conducted through sections of suitable habitat in urban capable land.</td></tr>
<tr><td colspan="5">OUTSIDE THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Potential habitat polygons were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned), elevation (below 50 m), geographic restrictions (species is primarily restricted to the Richmond (NW Cumberland subregion) district, but with an outlier population found at Voyager Point, Liverpool), and patch size (>40 ha, based on exclusion of small patches of vegetation not meeting the known geographic extent of the species).</td></tr>
<tr><td rowspan="2">POPULATION MAPPING</td><td colspan="5">RECORD SELECTION</td></tr>
<tr><td colspan="5">Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
</table>

	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Biological populations were defined based on clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollination
	IMPORTANT POPULATION CRITERIA
	All populations of *A. glareicola* were considered important as the species is endangered

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.3 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	A total of 10 populations (from 36 BioNet records) have been mapped within the Strategic Assessment Area. All populations are considered important and one population is wholly or partly located in an existing conservation reserve. Of these: • Nine are located within the Londonderry area, including a large population (Population 3) within the Castlereagh Nature Reserve to the north of GPEC • One (Population 1) is located within a rail corridor along Hobart St in St Marys The outlier population that has been recorded within the Holsworthy Military Area is outside the Strategic Assessment Area. The baseline mapping for this assessment has mapped approximately 4,417.6 ha of known and potential habitat within the Strategic Assessment Area. This potential habitat is primarily associated with the vegetation in the Londonderry area. In addition to this, there are: • Three moderate sized patches of potential habitat – one associated with Shanes Park and Wianamatta Regional Park, one near Kemps Creek, and one in the Holsworthy area • Scattered and more isolated patches of potential habitat within each of the nominated areas, including a number of patches in GPEC and fewer, smaller patches in GMAC and Wilton It is important to note that surveys of the Outer Sydney Orbital for this project within the Wianamatta Regional Park did not identify the species, and it had not previously been recorded in the Park. A breakdown of occurrence for *A. glareicola* in the Strategic Assessment Area is provided in Table 29-52.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.14.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 21.9 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 10.1 ha (45.9 per cent) of this has been avoided as part of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 10.0 ha was avoided for biodiversity purposes
- 0.1 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-53.

It is important to note that the avoidance calculations in Table 29-53, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-53 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.14.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.14.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to any direct impacts to known populations or fragmentation of habitat. However, it will lead to the loss of potential habitat.

LOSS OF POTENTIAL HABITAT

The Plan will lead to the loss of 11.9 ha of potential habitat. This represents a very small percentage of the mapped potential habitat across the Strategic Assessment Area. These impacts relate to urban development in GPEC, near Orchard Hills.

A summary of these impacts is provided in Table 29-54.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of direct impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as unlikely. While there will be direct impacts to potential habitat within the vicinity of Orchard Hills, there is low confidence that the species will occur in the impact area because:
  - A small section of suitable habitat within urban capable land which could be accessed as part of this biodiversity certification process was surveyed and the species was not observed
  - It is generally considered unlikely that suitable habitat in this area contributes to the ongoing survival or viability of the species more broadly
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of <0.5 per cent of mapped potential habitat (endemic species, SAII species), with low confidence that the species occurs in the impact area

29.14.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *A. glareicola*.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.14.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *A. glareicola* identifies a range of threats to the species (DEWHA, 2008a). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Habitat degradation from rubbish dumping and unrestricted access
- Weed invasion
- Inappropriate fire regimes

HABITAT DEGRADATION

Habitat degradation through unrestricted public access and rubbish dumping have been identified as a key threat to *A. glareicola* (DEWHA, 2008a). Development within GPEC and WSA may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations of *A. glareicola* considered most at risk of this threat are those that occur on:

- Public land, as these areas are accessible without the deterrent that comes with trespassing. Only one recorded population, labelled Population 3, occurs on public land, within the Castlereagh Nature Reserve. This population comprises 11 of the 36 records for the species within the Strategic Assessment Area, making it one of the most significant known occurrences. Impacts associated with public access are an identified threat to the biodiversity of the Castlereagh Nature Reserve and restrictions, signage and management measures (such as rationalising the network of management trails) are already in place to address potential impacts (NSW NPWS, 1999). Assuming this management continues and adapts to potential increasing visitation over the life of the Plan, the risk to *A. glareicola* from disturbance in this area is expected to be adequately addressed.
- An area of freehold land to the north of GPEC which is often mistaken for Crown land, contains a number of access tracks, and issues associated with rubbish dumping have been recorded for the site.

The Plan incorporates a range of broader measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure

compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing

- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

WEED INVASION

A. glareicola is threatened with invasion and competition by weeds, with African lovegrass *(Eragrostis curvula)*, Whisky grass (*Andropogon virginicus*), *Pennisetum clandestinum*, *Ricinus communis* and Asparagus fern considered to be the main competitors. These weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

INAPPROPRIATE FIRE REGIMES

A. glareicola can regenerate following fire. However, plants may be damaged and fruit production and seed set prevented by too frequent fires (DEWHA, 2008a). Increased human activity within the nominated areas increases the risk of fire to habitat areas supporting the species.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

Mapped habitat does not occur within the tunnel footprints and the species is not at risk from impacts in those locations.

29.14.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

A small area of species habitat has been mapped within avoided lands in GPEC. Given the limited extent of habitat, impacts to habitat are considered unlikely due to essential infrastructure.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.14.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008a) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *A. glareicola* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Habitat degradation from rubbish dumping and unrestricted access
  - Weed invasion
  - Inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

Given the very low risk to the species associated with habitat loss and fragmentation, implementation of the Plan will not adversely influence the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with habitat degradation, weed invasion, and inappropriate fire regimes will be managed and mitigated through a number of commitments and actions in the Plan. Indirect impacts will not adversely influence the long-term viability of the species.

CONCLUSION

The limited scale of direct and indirect impacts to the species will ensure that implementation of the Plan does not adversely influence the long-term viability of the species.

29.14.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.14.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *A. glareicola*, there are no relevant Threat Abatement Plans.

Table 29-51: Relevant key Threatening Processes and associated Threat Abatement Plans for *A. glareicola*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-52: Occurrence of *A. glareicola* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	10	1
(IMPORTANT POPULATIONS)	(10)	(1)
HABITAT MAPPING (Ha)	4,417.6	1,159.6

Table 29-53: Avoidance of *A. glareicola* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	0.0	0.0	185.6	185.6
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	0.0	0.0	163.7	163.7
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**0.0**	**21.9**	**21.9**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	0.0	10.0	10.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	45.4	45.4
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.0	0.1	0.1
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	0.5	0.5
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**0.0**	**10.1**	**10.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**N/A**	**45.9**	**45.9**

Table 29-54: Direct impacts to *A. glareicola* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	11.9	0.0	**11.9**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.15 *MELALEUCA DEANEI* (DEANE'S MELALEUCA)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Melaleuca deanei* is a flaky-barked shrub with narrow pointed leaves and white flowers. Grows to 3m tall. (DoEE, 2018c)
ECOLOGY	Flowers in mid-October to December. Produces seeds infrequently and relies on clonal reproduction. Seeds can be held for up to 15 years, until fire, frost or drought triggers their release. (DoEE, 2018c) Longevity of individuals can be 100 years. (NSW DECCW, Goeth et al., 2010)
DISTRIBUTION AND HABITAT	Records occur primarily in the Ku-ring-gai/Berowra and Holsworthy/Wedderburn areas. Isolated records also occur in Springwood, Wollemi National Park, Yalwal and Central Coast areas. It is known to occur in the Cumberland IBRA subregion (OEH, 2019e). More than 50 per cent of all populations are protected in nature reserves or national parks (NSW DECCW, Goeth et al., 2010). Inhabits ridgetop woodland and wet heath, on sandstone and sandy soils (DoEE, 2018c; OEH, 2019e). The majority of records come from ridgetop woodland (OEH, 2019e). *M. deanei* is associated with sandy loam soils which are low in nutrients (NSW DECCW, Goeth et al., 2010).
POPULATIONS	As of 1993, the species was known from 94 populations, of which very few were considered reproductively viable. In 1993, it was estimated that there were 1,000-3,000 individuals of this species though this was likely as a ramet (stem) count. Population distribution is fragmented. (DoEE, 2018c) An important population has been identified in Holsworthy Military Reserve, it contains 17 per cent of the known population outside formal conservation reserves (NSW DECCW, Goeth et al., 2010).
SOS SITES	The following SOS sites for the species have been identified: • Ku-ring-gai Chase National Park • Berowra Valley National Park • Holsworthy • Nepean-Avon Plateau • Nepean Dam

RELEVANT PLANS AND POLICIES	National Recovery Plan for *Melaleuca deanei* F. Muell. (Deane's Paperbark) (NSW DECCW, Goeth et al., 2010)
SPECIES-SPECIFIC GUIDELINES	There are no specific impact guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=5818

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

<table>
<tr><td rowspan="3">NOMINATED AREA CANDIDATE SPECIES
(BCAR PROCESS)</td><td>ECOSYSTEM CREDIT SPECIES</td><td colspan="4">CANDIDATE SPECIES CREDIT SPECIES</td></tr>
<tr><td rowspan="2">No</td><td>WILTON</td><td>GMAC</td><td>WSA</td><td>GPEC</td></tr>
<tr><td>Yes</td><td>Yes</td><td>No</td><td>No</td></tr>
<tr><td>EXPERT REPORT
(BCAR PROCESS)</td><td colspan="5">Yes (Douglas, 2019c). Available at Supporting Document C</td></tr>
<tr><td rowspan="4">HABITAT MAPPING</td><td colspan="5">WITHIN THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Expert report polygons. Potential habitat polygons were generated based on the occurrence of PCT 1081, 1181 and 1395, with the application of graded riparian exclusion buffers to account for the fact that wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat.
To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was not recorded during surveys.</td></tr>
<tr><td colspan="5">OUTSIDE THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Potential habitat polygons were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned), and elevation (below 400m) and rainfall thresholds (1000-1400mm) sourced from SPRAT. No targeted surveys as part of this project were undertaken outside the nominated areas.</td></tr>
<tr><td rowspan="4">POPULATION MAPPING</td><td colspan="5">RECORD SELECTION</td></tr>
<tr><td colspan="5">Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.</td></tr>
<tr><td colspan="5">POPULATION DEFINITION</td></tr>
<tr><td colspan="5">Biological populations of were defined using the records dataset and available information about the nature of the species.
A population is considered to be individuals within 500 m of each other, as species dispersal is unlikely to occur beyond this distance (NSW DECCW, Goeth et al., 2010).</td></tr>
</table>

	IMPORTANT POPULATION CRITERIA
	Populations of *M. deanei* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. Populations of *M. deanei* were considered important because they met one or more of the following criteria: • A large population • A population within a conservation reserve • A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.13 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-56 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *M. deanei* in the Strategic Assessment Area. **Records** There are two populations which have been identified within the Strategic Assessment Area, both of which are important populations. One population (population 77) is located adjacent to the confluence of Allens Creek with Stringybark Creek, within Wilton. This population occurs within the boundary of a previously approved development under the EPBC Act (EPBC 2014/7400). The other population (population 520) occurs on the eastern edge of the Strategic Assessment Area to the north-east of Campbelltown, within the footprint of the proposed Georges River Koala Reserve. It is noted that numerous additional records of this species occur in remnant vegetation outside of the Strategic Assessment Area boundary, in areas to the south of Wilton and to the east of Appin, Campbelltown and Macquarie Fields. **Potential habitat** The baseline mapping for this assessment has mapped 14,445.1 ha of known and potential habitat within the Strategic Assessment Area. Habitat for this species tends to occur along the south-eastern, southern, western and north-western boundary of the Strategic Assessment Area, with an absence of potential habitat throughout the middle and north-eastern areas of the assessment area. With respect to the nominated areas, well-connected habitat is mapped within Wilton and the southern section of GMAC, which strongly corresponds to the locations of wooded areas in these localities. There is no habitat mapped within GPEC or WSA. Outside of the nominated areas, habitat is mapped as follows: • Well-connected habitat occurs along the Strategic Assessment Area boundary, from the Holsworthy locality, down to the southern portion of the Strategic Assessment Area (including localities such as Douglas Park, Bargo and Tahmoor) • Moderately connected habitat patches occur along the western boundary of the Strategic Assessment Area between Orangeville in the south through to Mulgoa in the north • Small, scattered patches of habitat occur in the north-west corner of the Strategic Assessment Area in the Kurrajong locality

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.15.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 1,757.5 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 1,655.1 ha (94.2 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,553.3 ha was avoided for biodiversity purposes.
- 101.7 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-57.

It is important to note that the avoidance calculations in Table 29-57, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-57 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.15.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.15.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to loss of potential habitat. It will not lead to direct impacts to known populations or fragmentation of potential habitat or populations. A summary of these impacts is provided in Table 29-58.

LOSS OF POTENTIAL HABITAT

Approximately 102.5 ha of potential habitat for the species will be lost. This is 0.7 per cent of mapped potential habitat across the Strategic Assessment Area. The loss of potential habitat occurs within GMAC and Wilton.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact area. This is because of the small number of records of the species in the vicinity of impacted habitat, and based on knowledge that mapped habitat is precautionary as the species is naturally rare and patchily distributed (Douglas, 2019c)

- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of <2 per cent of mapped potential habitat (vulnerable species), with moderate confidence that the species occurs in the impact area

29.15.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *M. deanei.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the potential indirect impacts to the species that may occur as a result of development under the Plan. It also outlines if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.15.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan (NSW DECCW, Goeth et al., 2010) (and other key documents) for *M. deanei* identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes and mechanical methods of bushfire fuel reduction
- Inappropriate habitat disturbance from construction and maintenance of tracks and easements, unrestricted access and rubbish dumping
- Weed invasion

Low fecundity and viability, hybridisation and trampling/plant damage due to army training exercises have also been identified as key threats. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

There are two known populations of *M. deanei* within the Strategic Assessment Area. Population 520 occurs on the eastern edge of the Strategic Assessment Area within the footprint of the proposed Georges River Koala Reserve, and subsequently is not considered to be at risk of indirect impacts under the Plan due to its distance from urban capable land and the fact that the site will be managed for conservation purposes.

Population 77 occurs within Wilton, and is located within habitat which is managed in accordance with an approved development under the EPBC Act (EPBC 2014/7400). Approval conditions which protect this population from indirect impacts include fencing to restrict access, and preparation of an environmental management plan for the approval of the Commonwealth to deal with pressures to the population. Overall, population 77 is not considered to be at risk of indirect impacts under the Plan as it has existing site management to protect the species from indirect impacts.

The following assessments therefore consider the potential impacts of development under the Plan upon mapped potential habitat for *M. deanei.* The areas which are most at risk of impact include mapped habitat within Wilton and the southern portion of GMAC, which occurs close to urban capable lands.

INAPPROPRIATE FIRE REGIMES AND MECHANICAL METHODS OF BUSHFIRE FUEL REDUCTION

Inappropriate fire regimes are an identified threat to *M. deanei* (NSW DECCW, Goeth et al., 2010). Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk

- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

It is additionally noted that mechanical bushfire reduction methods of habitat in close proximity to urban and other kinds of development pose a risk to *M. deanei* (NSW DECCW, Goeth et al., 2010).

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *M. deanei* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *M. deanei.* While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

The package of measures in the Plan is expected to adequately manage the risk to *M. deanei* from altered fire regimes as a result of development. This is because:

- Establishment of environmental zoning of approximately 1,655.1 ha of mapped potential habitat of *M. deanei* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *M. deanei* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *M. deanei* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas (it is noted there is 7,288.6 ha for *M. deanei* mapped within the SCAs)

INAPPROPRIATE HABITAT DISTURBANCE FROM CONSTRUCTION AND MAINTENANCE OF TRACKS AND EASEMENTS, UNRESTRICTED ACCESS AND RUBBISH DUMPING

Impacts relating to construction and maintenance of tracks and easements, unrestricted site access and rubbish dumping have been identified as threats to *M. deanei* (NSW DECCW, Goeth et al., 2010). Areas most at risk included areas of mapped potential habitat within Wilton and GMAC.

The Plan includes a species-specific measure to consult with land managers of land containing known populations or habitat for *M. deanei* to mitigate indirect impacts from habitat disturbance during construction and operation of the development, including controlling public access, managing maintenance activities such as mowing and weed control, and managing rubbish dumping.

The Plan further incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *M. deanei.* In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance. It is noted that 1,655.1 ha of potential habitat for *M. deanei* is mapped to occur within avoided lands

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations. It is noted that approximately 7,288.6 ha of potential habitat for *M. deanei* is mapped to occur within SCAs
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *M. deanei*

The package of measures in the Plan is expected to adequately manage the risk to *M. deanei* from inappropriate habitat disturbance as a result of development. This is because:

- A species-specific measure will require consultation with land managers to ensure protection of *M. deanei* from inappropriate habitat disturbance
- Avoided lands where mapped habitat for *M. deanei* occurs will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

WEED INVASION

Inappropriate fire regimes are an identified threat to *M. deanei* (NSW DECCW, Goeth et al., 2010). Areas most at risk of weed invasion due to development under the Plan included areas of mapped potential habitat within Wilton and GMAC.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Area. This includes a number of actions, of which the following are the most relevant to the outcome for *M. deanei*:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:

- Require proponents to undertake the following when applying for/undertaking development:
  - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
  - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
  - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
- Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk to *M. deanei* from the increased risk of weeds associated with development. This is because:

- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of 1,655.1 ha of mapped potential habitat of *M. deanei* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

It is noted that there is no mapped potential habitat, and no known records of the species, within either the OSO tunnel footprint or the Metro Rail Future Extension tunnel footprint. It is therefore considered unlikely that development within the tunnel footprints will negatively impact *M. deanei*.

29.15.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no known records of *M. deanei* within avoided lands in any of the nominated areas. However, there is 1,655.1 ha of potential habitat mapped for the species within avoided lands within Wilton and GMAC, and therefore it is considered to be possible that the species may occur within avoided lands in these nominated areas.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.15.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Recovery Plan (NSW DECCW, Goeth et al., 2010) and other key documents identifies the following key issues that are likely to have the greatest influence on the long-term viability of *M. deanei* in relation to implementation of the Plan*:*

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes and mechanical methods of bushfire fuel reduction
  - Inappropriate habitat disturbance from construction and maintenance of tracks and easements, unrestricted access and rubbish dumping
  - Weed invasion

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to loss of 102.5 ha of mapped habitat within the nominated areas and transport corridors. No fragmentation of species' habitat will occur.

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>low.</u> The total area of potential habitat which will be impacted is a small proportion of available habitat for the species with only moderate confidence of the species' presence in impacted areas.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 7,288.6 ha of potential habitat for *M. deanei.*

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts of development corridors associated with inappropriate fire regimes and mechanical methods of bushfire fuel reduction, inappropriate habitat disturbance from construction and maintenance of tracks and easements, unrestricted access and rubbish dumping, and weed invasion have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a species-specific commitment to minimise the impacts inappropriate habitat disturbance.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.15.8 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan (NSW DECCW, Goeth et al., 2010) is to prevent the status of *M. deanei* from becoming critically endangered by reducing the further loss of populations and, by implementing in-situ management regimes aimed at maintaining representative populations of the species' across its natural range. Specific objectives include:

- Coordinate the recovery of *M. deanei*
- Protect known occurrences of *M. deanei* using land-use and conservation planning mechanisms
- To identify and minimise the threats operating at *M. deanei* sites
- To improve awareness of *M. deanei* amongst operational staff working within easements, walking tracks and fire trails
- To promote surveys, research and monitoring that will assist with the management of *M. deanei*
- To provide stakeholders with information that assist in conserving *M. deanei*
- To raise awareness about the threats to the species and involve the community in the recovery program
- To coordinate an ex-situ conservation program to safeguard genetic material from extinction

Implementation of the Plan will support a number of these strategies and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *Melaleuca deanei*. The Plan will not prevent implementation of any of the actions.

29.15.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-55 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *M. deanei*, there are no relevant Threat Abatement Plans.

Table 29-55: Relevant key Threatening Processes and associated Threat Abatement Plans for *M. deanei*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-56: Occurrence of *M. deanei* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	2	1
(IMPORTANT POPULATIONS)	(2)	(1)
HABITAT MAPPING (Ha)	14,445.1	1,635.8

Table 29-57: Avoidance of *M. deanei* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	909.4	1,412.5	0.0	0.0	2,321.8
HABITAT WITHIN EXCLUDED LANDS (ha)	201.7	362.6	0.0	0.0	564.3
HABITAT WITHOUT EXCLUDED LANDS (ha)	**707.7**	**1,049.8**	**0.0**	**0.0**	**1,757.5**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	623.4	929.9	0.0	0.0	1,553.3
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	88.1	88.6	N/A	N/A	88.4
AVOIDANCE FOR OTHER REASONS (ha)	38.0	63.7	0.0	0.0	101.7
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	5.4	6.1	N/A	N/A	5.8
TOTAL AVOIDANCE (ha)	**661.4**	**993.7**	**0.0**	**0.0**	**1,655.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**93.5**	**94.6**	**N/A**	**N/A**	**94.2**

Table 29-58: Direct impacts to *M. deanei* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	46.3	56.2	0.0	0.0	0.0	**102.5**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.16 *MICROMYRTUS MINUTIFLORA*

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Micromyrtus minutiflora* is a slender spreading shrub. Grows to 2 m high. Flowers are solitary but can be abundant on plants and have small white petals. (DEWHA, 2008f)
ECOLOGY	Flowers sporadically from June to March. Response to disturbance (such as fire or mechanical disturbance) is uncertain. Regeneration may occur as a result of re-sprouting, or germination of seeds stored within the soil. (OEH, 2019f)
DISTRIBUTION AND HABITAT	Endemic to the western parts of the Cumberland Plain in the Richmond-Castlereagh area of the Sydney Region. The distribution overlaps with the following TECs: • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest • Cooks River/Castlereagh Ironbark Forest • Castlereagh Scribbly Gum and Agnes Banks Woodlands Grows in Scribbly Gum Woodland, Ironbark Forest, Shale Gravel Transition Forest, open forest on tertiary alluvium and consolidated river sediments. (DEWHA, 2008f; OEH, 2019f)
POPULATIONS	As of 1997, there were over 1,160 individuals in the ADI Site and 500 individuals present in Marsden Park. As of 2002, there were 11 population sites with approximately 1,800 individuals across the Blacktown, Hawkesbury and Penrith Local Government Areas. Populations range from fewer than 50 plants to over 1,000. (DEWHA, 2008f) The 2016 fire in Wianamatta Nature Reserve has seriously affected the total known individuals and regeneration post fire has not yet been seen. This may have led to the loss of more than 60 per cent of the known individuals. Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *M. minutiflora* is considered to be an endemic species to the region. It is further noted that this species has been identified as an SAII species under the BCAR process. Refer to Chapter 25 for further information.

SOS SITES	The following SOS site for the species has been identified: Wianamatta Nature Reserve
RELEVANT PLANS AND POLICIES	Approved conservation advice for *Micromyrtus minutiflora* (DEWHA, 2008f)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=11485

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Potential habitat polygons were generated using BioNet PCT associations, vegetation condition (intact, thinned, scattered trees) and elevation (up to 50 m). To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. The species was not recorded during surveys. **OUTSIDE THE NOMINATED AREAS** **Species distribution model (SDM).** Potential habitat outside the nominated areas was mapped using an SDM. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION** Biological populations were defined using the records dataset and available information about the nature of the species. Populations were defined by clustered records connected by relatively intact and continuous vegetation and not separated by a distance of >1 km (approx.). This is based on the distance travelled by insect pollinators and potential unrecorded individuals. **IMPORTANT POPULATION CRITERIA**

	All populations of *M. minutiflora* were considered important within the Strategic Assessment Area because the species is identified as an SAII entity through the BC Act process.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.14 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	A total of 15 populations (from 180 BioNet records) have been mapped within the Strategic Assessment Area. All populations are considered important and five populations are wholly or partly located in existing conservation reserves. The majority of the populations are located to the north of GPEC and one population (Population 108) occurs within GPEC. The baseline mapping for this assessment has mapped approximately 36,680.4 ha of known and potential habitat within the Strategic Assessment Area. This habitat is primarily associated with the vegetation in the Londonderry area. In addition to this, there are: • Small, scattered areas of habitat to the north and south of the Londonderry Area, including scattered habitat within GPEC and WSA • Scattered areas of habitat across the southern areas of the Strategic Assessment Area, in the area bounded by Silverdale in the north-west, Camden in the centre north, Liverpool in the north-east and the Strategic Assessment Area boundary along the south. It is noted that there is no mapped habitat within Wilton and only very small and isolated areas of potential habitat within GMAC It is also noted that the southernmost record known for this species occurs near Mulgoa, and that no records of the species have ever been found within or south of Silverdale or Liverpool. Therefore, whilst potential habitat has been mapped for this species within the southern portion of the Strategic Assessment Area through the SDM mapping, it is considered unlikely that this mapped habitat would be occupied by the species. A breakdown of occurrence for *M. minutiflora* in the Strategic Assessment Area is provided in Table 29-60.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.16.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 50.3 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 28.3 ha (56.2 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 27.9 ha was avoided for biodiversity purposes
- 0.3 ha was avoided for other reasons

A breakdown of avoidance across each nominated area is provided in Table 29-61.

It is important to note that the avoidance calculations in Table 29-61, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-61 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.16.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.16.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to direct impacts to known populations. However, it will lead to:

- A loss of potential habitat
- Fragmentation of potential habitat

LOSS OF POTENTIAL HABITAT

Approximately 160.3 ha of potential habitat will be lost. This is 0.4 per cent of mapped potential habitat across the Strategic Assessment Area. Habitat will be impacted:

- In several parts of the Outer Sydney Orbital corridor to the west of GMAC. Impacts in these areas account for the majority of the habitat to be lost (138.3 ha). It is noted that these areas are to the south of the known range of the species, and occur in habitat mapped through the SDM process which is considered to be very precautionary
- In small areas in GPEC and WSA

A summary of these impacts is provided in Table 29-62.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as unlikely. While there will be direct impacts to potential habitat, there is low confidence that the species will occur in the impact areas. This is because:
  - The majority of impacts occur beyond the known southern range of the species
  - Other impacts occur to small, fragmented patches of potential habitat that do not occur within the vicinity of records
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of <0.5 per cent of mapped potential habitat (SAII, endemic species), with low confidence that the species occurs in the impact areas

29.16.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of mapped habitat in the several parts of the Outer Sydney Orbital corridor to the west of GMAC.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be very low. This is because:

- The likelihood of fragmentation has been categorised as unlikely. This is because:
  - The likelihood that development is presents a barrier to dispersal of the species is possible. While there are uncertainties about the ecology of the species, it is possible that the Outer Sydney Orbital would present a barrier to pollination if the species were present in that area
  - The type of fragmentation is impact to mapped habitat only
- The consequence of fragmentation has been categorised as negligible. This is because the Plan will lead to fragmentation of mapped habitat in an area that the species is unlikely to occur

29.16.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *M. minutiflora*.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.16.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *M. minutiflora* identifies a range of threats to the species (DEWHA, 2008f). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Habitat degradation

INAPPROPRIATE FIRE REGIMES

The response of *M. minutiflora* to fire is unknown. However, altered fire regimes are an identified threat (DEWHA, 2008f) and a 2016 fire in the Wianamatta Nature Reserve (outside of the nominated areas to the north of GPEC) may have substantially affected the species. Increased human activity within the nominated areas increases the risk of fire to habitat areas supporting the species.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

WEED INVASION

M. minutiflora is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

M. minutiflora is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include:

- Population 108 that occurs within GPEC
- The various populations to the north of GPEC

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:

  - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
  - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
  - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
- Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

HABITAT DEGRADATION

Habitat degradation through unrestricted public access and rubbish dumping have been identified as a key threat to *M. minutiflora* (DEWHA, 2008f). Development within GPEC and WSA may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations of *M. minutiflora* considered most at risk of this threat are those that occur on:

- Public land, as these areas are accessible without the deterrent that comes with trespassing. Populations occur on the following public land managed for conservation: Castlereagh Nature Reserve, Wianamatta Nature Reserve, Wianamatta Regional Park and Agnes Banks Nature Reserve. Potential impacts associated with public access are managed in all of these areas. Assuming this management continues and adapts to potential increasing visitation over the life of the Plan, the risk to *M. minutiflora* from disturbance is expected to be adequately addressed
- An area of freehold land to the north of GPEC which is often mistaken for Crown land, contains a number of access tracks, and issues associated with rubbish dumping have been recorded for the site. In the absence of tighter controls over access, there is potential for increased disturbance to occurrences of *M. minutiflora* on this site as a result of the Plan

The Plan incorporates a range of measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

29.16.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Small areas of species habitat have been mapped within avoided lands in GPEC and WSA. Given the limited extent of habitat, impacts to habitat are considered unlikely due to essential infrastructure.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

29.16.8 POTENTIAL IMPACTS FROM TUNNELS

Mapped habitat occurs within the footprint of the Metro Rail Future Extension tunnel. However, as noted previously this habitat is beyond the known southern range of the species and it is not considered likely to be present.

Nevertheless, the Plan includes commitments to:

- Avoid and minimise impacts to threatened species, populations and communities as a result of tunnel construction activities in major infrastructure corridor
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species (if it was to be present) in the tunnel footprints from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.16.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008f) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *M. minutiflora* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts including:

- Inappropriate fire regimes
- Weed invasion
- Habitat degradation

HABITAT LOSS AND FRAGMENTATION

Given the very low risk to the species associated with habitat loss and fragmentation, implementation of the Plan will not adversely influence the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, and habitat degradation from increase public access and will be managed and mitigated through a number of commitments and actions in the Plan (see Chapter 15 for details). Indirect impacts will not adversely influence the long-term viability of the species.

CONCLUSION

The limited scale of direct and indirect impacts to the species will ensure that implementation of the Plan does not adversely influence the long-term viability of the species.

29.16.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.16.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *M. minutiflora* there are no relevant Threat Abatement Plans.

Table 29-59: Relevant key Threatening Processes and associated Threat Abatement Plans for *M. minutiflora*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-60: Occurrence of *M. minutiflora* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	15	5
(IMPORTANT POPULATIONS)	(15)	(5)
HABITAT MAPPING (Ha)	36,680.4	2,036.1

Table 29-61: Avoidance of *M. minutiflora* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	0.0	34.8	196.6	232.5
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	0.0	6.0	175.1	182.2
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**28.8**	**21.5**	**50.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	17.7	10.2	27.9
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	61.5	47.6	55.6
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.2	0.2	0.3
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	0.5	0.7	0.6
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**17.9**	**10.4**	**28.3**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**0.0**	**62.1**	**48.3**	**56.2**

Table 29-62: Direct impacts to *M. minutiflora* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	<0.1	10.9	11.1	138.3	**160.3**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.17 *PERSICARIA ELATIOR* (TALL KNOTWEED)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Persicaria elatior* is an erect herb up to 90 cm tall. Leaves are 3 cm to 11 cm long and 1cm to 3 cm wide. Stalked, glandular hairs are present on most parts of the plant. Flowers on long, narrow, spikes of up to 5 cm long. Pink flower-segments are less than 4 mm in length. Fruits are lens-shaped nuts approximately 2.5 mm long. (DEWHA, 2008g; DoEE, 2018c)
ECOLOGY	*P. elatior* germinates from seed following rain events, and lives for up to two years. Plants grow rapidly; flowering and seed set occurs within six months of germination. Flowering mostly occurs during summer, and profuse flowering has been observed. Plants die back during dry periods, and regenerate during wet periods. This species has been observed to take advantage of areas of soil which had been made bare by dry periods. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	This species has a patchy distribution along the south-eastern coastal regions of Australia, from south-east Queensland to south-east NSW. In NSW, the species occurs in the North Coast, Central Coast and South Coast Botanical Subdivisions, whilst it occurs in the Moreton Pastoral District in Queensland. The species has been recorded from a total of 15 sites across this area. *P. elatior* grows in damp places, such as along watercourses, streams and lakes, in swamp forest, in coastal swampy areas and in disturbed areas. The species grows on sandy, alluvial soil. Associated plant species include *Melaleuca linearifolia, M. quinquenervia, Pseudognaphalium luteoalbum, Persicaria hydropiper*, and *Cyperus semifertilis*. The distribution of this species overlaps with the distribution of the following EPBC Act-listed threatened ecological community: Coastal Swamp Oak (*Casuarina Glauca*) Forest. (DEWHA, 2008g; DoEE, 2018c)
POPULATIONS	There is limited information regarding populations of this species. As of 2008, 12 specimens were recorded at Cornubia Wetland in Queensland. Population data is not available for other sites of this species. (DoEE, 2018c)
SOS SITES	The following SOS sites for the species have been identified: • Mallanganee (proposed)

	• Gibberagee (proposed) • Wanda wetlands (proposed) • Bevian swamp (proposed)
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Persicaria elatior* (Knotweed) (DEWHA, 2008g)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=5831

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	Yes	Yes	Yes
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Knowledge based map (KBM). Mapping within the nominated areas was prepared using the following parameters: BioNet PCT associations, vegetation condition (intact, thinned, scattered trees, derived native grassland) and habitat mapped within vegetation polygons occurring within 50 m of the following HydroAreas: Anabranch, Backwater, Billabong, Branch, Cowal, Creek, Pond, River, Stream, Swamp, Watercourse, Waterway. Habitat PCTs restricted to soils South Creek, Richmond, Freemans Reach, Berkshire Park and Upper Castlereagh.				
	OUTSIDE THE NOMINATED AREAS				
	Knowledge based map (KBM). Mapping outside the nominated areas was prepared using the following parameters: BioNet PCT associations, vegetation condition (intact, thinned, scattered trees, derived native grassland) and habitat mapped within vegetation polygons occurring within 50 m of the following HydroAreas: Anabranch, Backwater, Billabong, Branch, Cowal, Creek, Pond, River, Stream, Swamp, Watercourse, Waterway.				
POPULATION MAPPING	**RECORD SELECTION**				
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.				
	POPULATION DEFINITION				
	Biological populations were defined using the records dataset and available information about the nature of the species.				

	They were defined based on clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollination.
	IMPORTANT POPULATION CRITERIA
	Populations of *P. elatior* were considered important because they met one or more of the following criteria: A large population (number of individuals)

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.15 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	One important population of *P. elatior* has been mapped partially inside the Strategic Assessment Area. This population was recorded on the edge of a lake in moist soil. It comprises three BioNet records, two recorded from 2010 and one recorded from 1949. The 2010 records occur just outside the south-western boundary of the Strategic Assessment Area, in Thirlmere Lakes National Park. A "large number of plants" were noted in one of the 2010 records. The 1949 record is inaccurately mapped to the east of Picton, within the Strategic Assessment Area. The text descriptions of the record indicate this record should be placed at Thirlmere Lakes. The baseline mapping for this assessment has mapped 1,703.4 ha of potential habitat within the Strategic Assessment Area (see Table 29-64). Potential habitat has been mapped within the Strategic Assessment Area in the following localities: • Along the Nepean River and associated waterways between Douglas Park and Mulgoa, and between Emu Plains and Wilberforce • Along Wianamatta (South Creek) and associated waterways between Mulgrave and Kemps Creek • Along the Georges River and associated waterways near Liverpool Mapped habitat occurs within: • GPEC – 220.7 ha • WSA – 37.6 ha • GMAC – 7.3 ha

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.17.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 85 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 37.8 ha (45.5 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 13.2 ha was avoided for biodiversity purposes
- 24.6 ha was avoided for other reasons

A breakdown of avoidance across each nominated area is provided in Table 29-65.

It is important to note that the avoidance calculations in Table 29-65, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-65 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.17.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.17.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to direct impacts to known populations. However, it will lead to the loss of potential habitat and possible fragmentation.

LOSS OF POTENTIAL HABITAT

The Plan will lead to the loss of 48.3 ha of potential habitat. This represents 2.8 per cent of potential habitat mapped across the Strategic Assessment Area. The majority of habitat loss occurs within GPEC, where the footprint of the proposed Outer Sydney Orbital coincides with Wianamatta (South Creek) and associated waterways. It is noted that no records of this species have been recorded within or near to GPEC, and the Strategic Assessment Area more broadly appears unlikely to support records of the species.

A summary of these impacts is provided in Table 29-66.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of direct impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as unlikely. While there will be direct impacts to potential habitat, there is low confidence that the species will occur in the impact area. There are no confirmed records of the species within the Strategic Assessment Area and it is considered that the habitat mapping is highly precautionary
- The consequence of impacts to the species (if they did occur) has been categorised as minor. There will be a loss of 2.8 per cent of mapped potential habitat, with low confidence that the species occurs in the impact area

29.17.4 FRAGMENTATION OF HABITAT

The footprint of the proposed Outer Sydney Orbital intersects mapped habitat along Wianamatta (South Creek) in GPEC.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be very low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development would present a barrier to dispersal of the species is likely. While detailed planning for development within the transport corridors has not yet been completed, it is thought to be likely that the OSO will constitute a likely barrier to dispersal for the species
  - The type of fragmentation (as defined in the risk assessment approach in Section 29.3) is impact to mapped
- The consequence of fragmentation has been categorised as negligible. This is because the area to be fragmented relates to a small area of potential habitat with no associated records

29.17.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. elatior*.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.17.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *P. elatior* identifies a range of threats to the species (DEWHA, 2008g). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Hydrological changes to wetlands
- Damage to populations from road and track maintenance
- Weed invasion

However, it is considered unlikely that any of these potential impacts will adversely affect *P. elatior* within or surrounding the Strategic Assessment Area for the following reasons:

- There are no identified populations of this species within the Strategic Assessment Area
- The closest identified important population is located at Thirlmere Lakes National Park. This population is separated by a distance of approximately 7 km to the nearest urban capable land and is within an area already managed for conservation
- While potential habitat within and adjacent to GMAC, WSA and GPEC may be subject to indirect impacts, the species has not been recorded in this area and it is therefore unlikely to be important to the viability of the populations in the region

It is worth noting that the Plan includes a range of measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, pest animal control implementation strategy, development controls to manage changes to hydrology). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this species if it is present in the Strategic Assessment Area.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the low likelihood of the species occurring within the Strategic Assessment Area, it is not considered likely that there will be additional risks due to essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.17.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008g) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. elatior* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts including:
  - Hydrological changes to wetlands
  - Damage to populations from road and track maintenance
  - Weed invasion

HABITAT LOSS AND FRAGMENTATION

Given the very low risk to the species associated with habitat loss and fragmentation, implementation of the Plan will not adversely influence the long-term viability of the species.

INDIRECT IMPACTS

Indirect impacts associated with implementation of the Plan are not considered likely to be an issue for the species. However, there are a range of measures in the Plan that may provide a benefit to the species if it did exist in the Strategic Assessment Area.

CONCLUSION

The Plan will not lead to direct impacts to known populations of *P. elatior*. The Strategic Assessment Area does not appear to be a stronghold for the species and potential indirect impacts are addressed through management measures in the Plan.

This will ensure that implementation of the Plan does not adversely influence the long-term viability of *P. elatior*.

29.17.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.17.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *P. elatior*, there are no relevant Threat Abatement Plans.

Table 29-63: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. elatior*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-64: Occurrence of *P. elatior* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	0
(IMPORTANT POPULATIONS)	(1)	(0)
HABITAT MAPPING (Ha)	1,703.4	206.6

Table 29-65: Avoidance of *P. elatior* habitat within the nominated areas

	Wilton	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	7.3	37.6	220.7	265.6
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	7.3	7.3	166.0	180.6
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**30.2**	**54.7**	**85.0**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	8.3	4.9	13.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	27.6	8.9	15.6
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	21.8	2.8	24.6
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	72.0	5.2	28.9
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**30.1**	**7.7**	**37.8**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**99.6**	**14.1**	**44.5**

Table 29-66: Direct impacts to *P. elatior* within the nominated areas and transport corridors

	Wilton	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.1	47.0	1.2	**48.3**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	Wilton	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.18 *PERSOONIA HIRSUTA* (HAIRY GEEBUNG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	The Hairy Geebung is a spreading shrub with small leaves of variable shape and yellow or orange tubular flowers on a short stem that grows into a leafy shoot. Long coarse hairs appear on flowers and short stiff ones on leaves. Grows from 0.3-1.5m tall. (DoE, 2014f; DoEE, 2018c)
ECOLOGY	Flowers in November to January, with flowers occasionally appearing as early as September. All *Persoonia* species rely upon insect pollination. It is likely that *Persoonia* pollination movement would occur within a distance of 130 m from each plant. This species is probably killed by fire, yet will regenerate from seed. All *Persoonia* species are dependent on heat or mechanical disturbance for germination. It is often found in disturbed areas such as along track edges. (DoE, 2014f; DoEE, 2018c)
DISTRIBUTION AND HABITAT	Records of this species are scattered around Sydney from Singleton in the north, along the east coast to Bargo in the south, and the Blue Mountains in the west. It is known to occur in the Cumberland IBRA subregion. Inhabits dry sclerophyll open forest and woodland with shrubby understory, on sandy to stony soils derived from sandstone. (DoE, 2014f; OEH, 2017d)
POPULATIONS	As of 2007, the species was known 21 populations, mostly containing fewer than 10 individuals. One population near Appin contains 88 individuals. Total number of individuals is not known. (DoE, 2014f; DoEE, 2018c)
SOS SITES	The following SOS sites for the species have been identified: • Yengo (proposed) • Parr (proposed) • Maroota Ridge (proposed) • Fred Caterson Reserve (proposed) • Cromer (proposed)

	• WestCliff Mine (proposed) • Bargo (proposed)
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Persoonia hirsuta* (DoE, 2014f)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=19006

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Not applicable as the species is not a candidate species credit species. There is no habitat for *P. hirsuta* within the nominated areas. Mapping outside of the nominated areas was done as per species distribution model description below.
	OUTSIDE THE NOMINATED AREAS
	Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The report for this process notes that this species has a small proportion of its records within the Cumberland Plain subregion, and therefore the SDM estimates that only a small proportion of available habitat for this species occurs within the Cumberland Plain. The mapping is considered to be highly precautionary. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION**
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.
	IMPORTANT POPULATION CRITERIA

	Populations of *P. hirsuta* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations if *P. hirsuta* are considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.18 for a map of records and habitat across the Strategic Assessment Area. It is important to note that the records for this species are sensitive and have been denatured for representation on the map.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-68 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. hirsuta* in the Strategic Assessment Area. **Records** A total of six populations have been mapped within the Strategic Assessment Area. Of these: • Three are located in the south-west corner of the assessment area, in the Bargo/Buxton locality • One is located east of Campbelltown • Two are located to the north of GPEC **Potential habitat** The baseline mapping for this assessment has mapped 11,433.3 ha of potential habitat within the Strategic Assessment Area. This potential habitat is distributed as follows: • A large area of habitat is mapped within the Londonderry area to the north of GPEC • A large area of habitat is also mapped to occur in the Tahmoor/Bargo/Buxton locality in the south-west corner of the Strategic Assessment Area • Scattered habitat occurs in several disjunct locations It is noted that the Species Distribution Model (SDM) predicted that the majority of habitat for this species occurs outside of the Cumberland subregion. The SDM predicted the occurrence of significant areas of habitat outside of the western, southern, south-eastern and north-eastern boundaries of the Strategic Assessment Area.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.18.1 NOMINATED AREAS

There is no potential habitat for the species mapped within the nominated areas. Avoidance of habitat was therefore not necessary.

29.18.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.18.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to loss of potential habitat. A summary of these impacts is provided in Table 29-69.

LOSS OF POTENTIAL HABITAT

There will be approximately 6.2 ha of impacts to potential habitat (0.1 per cent of mapped habitat across the Strategic Assessment Area). These impacts are primarily due to the development of the M7/Ropes Crossing Link Road outside the north-eastern corner of GPEC, and the development of a transport corridor to the east of WSA.

The areas being impacted upon do not support known records or populations of *P. hirsuta.*

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact area (it is noted that the impacted habitat was modelled via the SDM process, which is considered to be precautionary and may over-predict habitat. There are no records in close proximity to the impacted areas of habitat)
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of 0.1 per cent of mapped potential habitat (endangered species), with moderate confidence that the species occurs in the impact area

29.18.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. hirsuta.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the potential indirect impacts to the species that may occur as a result of development under the Plan. It also outlines if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.18.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DoE, 2014f) (and other key documents) for *P. hirsuta* identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered:

- Inappropriate fire regimes
- Disturbance from recreational users
- Altered hydrology
- Weed invasion
- Infection with *Phytophthora cinnamomi*

Competition with dense native vegetation species, low population numbers, feral European honeybees making effective pollination unlikely have also been identified as key threats. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

P. hirsuta is threatened by altered fire regimes. The Plan has the potential to impact fire regimes as a result of increased human activity associated with development of urban capable land within the nominated areas and development of transport corridors outside of the nominated areas. As there is no mapped potential habitat within the nominated areas, the sites most at risk at the small areas of impacted potential habitat which are intercepted by the development of transport corridors.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity associated with development of transport corridors. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. hirsuta* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values (it is noted that the SCA contains approximately 2,690 ha of mapped potential habitat for *P. hirsuta*).
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans

The package of measures in the Plan is expected to adequately manage the risk to *P. hirsuta* from altered fire regimes as a result of development. This is because:

- Fire management authorities will be engaged to ensure they understand the requirements of *P. hirsuta* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

DISTURBANCE FROM RECREATIONAL USERS

Habitat disturbance from recreational users has been identified as a threat for *P. hirsuta*. The sites most at risk at the small areas of impacted potential habitat which are intercepted by the development of transport corridors.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *P. hirsuta.* In summary, these include:

- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations. It is noted that approximately 2,690 ha of potential habitat for *P. hirsuta* is mapped to occur within SCAs
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping

- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. hirsuta*

The package of measures in the Plan is expected to adequately manage the risk to *P. hirsuta* from inappropriate habitat disturbance as a result of development. This is because:

- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

ALTERED HYDROLOGY

Altered hydrology has been identified as a risk to *P. hirsuta*. As outlined above, sites most at risk at the small areas of impacted potential habitat which are intercepted by the development of transport corridors.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for *P. hirsuta.* In particular, these include commitments which relate to mitigating indirect and prescribed impacts from transport development (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through the implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology.

The package of measures in the Plan is expected to adequately manage the risk to *P. hirsuta* from changes to hydrology because transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *P. hirsuta.*

WEED INVASION

P. hirsuta is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The Plan incorporates a range of measures to manage the risks associated with weed invasion. In summary, these include:

- A commitment (Commitment 6) will result in implementation of mitigation measures to address indirect and prescribed impacts to threatened species associated with the development of transport corridors
- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *P. hirsuta:*
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
    - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16

The package of measures in the Plan is expected to adequately manage the risk to *P. hirsuta* from the increased risk of weeds associated with development. This is because:

- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to biodiversity values, including potential habitat for *P. hirsuta*
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development

INFECTION WITH PHYTOPHTHORA CINNAMOMI

P. hirsuta is threatened by exposure to *Phytophthora cinnamomi*, a soil-borne water mould which is fatal to many *Persoonia* species.

Development under the Plan has the potential to increase the spread of *Phytophthora cinnamomi* through increased site visitation rates and earthworks activities conducted during construction works. The areas which are most at risk are the small areas of impacted potential habitat which are intercepted by the development of transport corridors.

The Plan incorporates a range of measures to manage the risks associated with disease including *Phytophthora cinnamomi*. In summary, these include:

- A commitment (Commitment 6) will result in implementation of mitigation measures to address indirect and prescribed impacts to threatened species associated with the development of transport corridors
- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to *P. hirsuta* from *Phytophthora cinnamomi* because:

- Development controls will be put in place to address potential impacts associated with construction
- It supports a landscape scale approach to the issue across the Cumberland subregion

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

No habitat for *P. hirsuta* has been mapped in any of the nominated areas, nor in or adjacent to any of the tunnel footprints. Therefore, *P. hirsuta* is not considered to be at risk from development of essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.18.6 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014f) (and other key documents) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. hirsuta* in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts such as:
  - Inappropriate fire regimes
  - Disturbance from recreational users
  - Altered hydrology
  - Weed invasion
  - Infection with *Phytophthora cinnamomi*

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to loss of 6.2 ha of mapped habitat within transport corridors. No fragmentation of species' habitat will occur.

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is very low. The total area of potential habitat which will be impacted is a small proportion of available habitat for the species with only moderate confidence of the species' presence in impacted areas.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 2,690 ha of potential habitat for *P. hirsuta.*

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, disturbance from recreational users, altered hydrology, weed invasion and infection with *Phytophthora cinnamomi* have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.18.7 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.18.8 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-67 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any of the Threat Abatement Plans.

Table 29-67: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. hirsuta*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-68: Occurrence of *P. hirsuta* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	6	0
(IMPORTANT POPULATIONS)	(6)	(0)
HABITAT MAPPING (Ha)	11,433.3	1,338.8

Table 29-69: Direct impacts to *P. hirsuta* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	0.0	6.2	**6.2**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.19 *PIMELEA CURVIFLORA* VAR. *CURVIFLORA*.

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	An erect, open shrub with elliptical leaves and dark red to yellow flowers. Grows to 40-50 cm high. (DoEE, 2018c)
ECOLOGY	May flower all year round but mostly October to January. Can survive for some time without foliage following fire or grazing, during which time it relies on energy reserves from its root system. The species is likely to be fire tolerant. Seedlings have been observed following fire events. (DEWHA, 2008i; DoEE, 2018c)
DISTRIBUTION AND HABITAT	Occurs in the coastal area of the Sydney and Illawarra regions of NSW. As of 1998, it was known from around 20 locations between northern Sydney and Maroota including Baulkham Hills, Blacktown, Hornsby, Parramatta and Warringah Local Government Areas. In 2011, another population was found at in Shellharbour Local Government Area. Distribution overlaps with the following TECs: • Shale Sandstone Transition Forest • Blue Gum High Forest of the Sydney Basin Bioregion • Cumberland Plain Woodlands • Turpentine-Ironbark Forest in the Sydney Basin Bioregion Can be found on sandy soil, shaly soil or shale/sandstone transition soils. Occurs on ridge tops and upper slopes in open forest and woodland. (DEWHA, 2008i; DoEE, 2018c)
POPULATIONS	Total population size is not known. As of 1998, two sites at Maroota had around 300 plants. However, the majority of populations contain fewer than 100 individuals. (DoEE, 2018c)
SOS SITES	The following SOS sites for the species have been identified: • Muogamarra Nature Reserve • John Moroney Correctional Centre

	• Albion Park
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Pimelea curviflora* var. *curviflora* (DEWHA, 2008i)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species
SPRAT LINK	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=4182

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	Yes

EXPERT REPORT (BCAR PROCESS)	There is no expert report available for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Potential habitat polygons were generated for this species using BioNet PCT associations, vegetation condition (intact, thinned), geology ('Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member', 'Razorback Sandstone Member'), soil (all Blacktown soil landscape within a 500 m buffer on Wianamatta (South Creek) Plus all Berkshire Park soil), elevation (below 300 m) and LiDAR/DEM data (Sandstone units selected only within a 100 m buffer on "Ridge and Crest" DEM layer). To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was not recorded during surveys. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM).** Potential habitat polygons were generated for this species using BioNet PCT associations, vegetation condition (intact, thinned), geology ('Hawkesbury Sandstone', 'Minchinbury Sandstone', 'Mount Hercules Sandstone Member, 'Razorback Sandstone Member'), soil (all Blacktown soil landscape within a 500 m buffer on Wianamatta (South Creek) Plus all Berkshire Park soil) and elevation (below 300 m). No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION**

	Biological populations were defined using the records dataset and available information about the nature of the species. Populations were defined by clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.
	IMPORTANT POPULATION CRITERIA
	Populations of *P. curviflora* var. *curviflora* were considered important because they met one or more of the following criteria: a large population.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.20 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	Within the vicinity of the Cumberland subregion, the core area for the species is to the north east of the subregion (outside the Strategic Assessment Area) within areas of extensive remnant vegetation. The Strategic Assessment Area supports many fewer records and includes three populations (from three BioNet records dated 2000). One population is considered to be important (population 456). The populations are located as follows: • Population 456 is located within the John Morony Correctional Complex, adjacent to Windsor Downs Nature Reserve • Populations 79 and 80 are located to the south of Douglas Park, between GMAC and Wilton. Despite extensive surveys at nearby Bingara Gorge in suitable habitat, the species was not recorded, suggesting that these two records may be misapplications for *P. curviflora* var. *sericea* which is recorded in that area The baseline mapping for this assessment has mapped 13,064.1 ha of known and potential habitat within the Strategic Assessment Area. Habitat for this species occurs as follows: • Scattered habitat occurs in the northern portion of the Strategic Assessment Area in the Kurrajong, Scheyville and Londonderry localities. It is noted that the Londonderry locality supports a significant area of potential habitat • Thin and scattered areas of habitat occur along the western boundary of the Strategic Assessment Area, along the Nepean River to the north of Penrith, and southwards through Mulgoa to the locality of The Oaks • Scattered habitat occurs within and to the south of the GPEC nominated area, including the localities of Wianamatta Regional Park, North St Marys, Mount Druitt, Orchard Hills, Glenmore Park and Luddenham • Scattered habitat occurs between WSA and GMAC, in localities including Badgerys Creek, Kemps Creek, Middleton Grange, Catherine Field and Edmondson Park • Scattered habitat occurs to the west of Wilton and between Wilton and GMAC It is noted that no habitat is mapped as being present within WSA, Wilton or GMAC. A breakdown of occurrence for *P. curviflora* var. *curviflora* in the Strategic Assessment Area is provided in Table 29-71.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.19.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 91.1 ha of potential habitat within GPEC (not including excluded lands). Approximately 18.1 ha (19.9 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 17.7 ha was avoided for biodiversity purposes.
- 0.5 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 29-72.

It is important to note that the avoidance calculations in Table 29-72, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-72 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.19.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.19.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will not lead to direct impacts to known populations. However, it will lead to:

- A loss of potential habitat
- Fragmentation of potential habitat

LOSS OF POTENTIAL HABITAT

Approximately 75.9 ha of potential habitat for the species will be lost. This is 0.6 per cent of mapped potential habitat across the Strategic Assessment Area. A summary of these impacts is provided in Table 29-73.

Direct impacts to potential habitat occur:

- In Wianamatta Regional Park due to the Outer Sydney Orbital. However, there are no records of the species in that area despite the site being well visited in the past, and the fact that it was not identified in surveys undertaken as part of this project. The species is considered unlikely to occur in this location
- In scattered habitat within GPEC. There are no historical records of the species within the vicinity of these small habitat patches and, while it is possible the species may occur, it is considered to be unlikely

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact areas. This is considered a precautionary rating
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of <2 per cent of mapped potential habitat (vulnerable species), with moderate confidence that the species occurs in the impact areas

29.19.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of mapped habitat in the several parts of the Outer Sydney Orbital corridor within GPEC.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of fragmentation is considered to be very low. This is because:

- The likelihood of fragmentation has been categorised as unlikely. This is because:
  - The likelihood that development is presents a barrier to dispersal of the species is possible
  - The type of fragmentation is impact to mapped habitat only
- The consequence of fragmentation has been categorised as negligible. This is because the Plan will lead to fragmentation of mapped habitat in:
  - An area that the species is unlikely to occur (Wianamatta Regional Park)
  - In other small, isolated areas of mapped habitat that do not occur within the vicinity of historical records

29.19.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. curviflora* var. *curviflora*.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.19.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *P. curviflora* var. *curviflora* identifies a range of threats to the species (DEWHA, 2008i). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered:

- Weed invasion
- Habitat degradation
- Inappropriate fire regimes

Grazing by pest fauna such as the European rabbit, feral goats and feral pigs have also been identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

WEED INVASION

P. curviflora var. *curviflora* is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

P. curviflora var. *curviflora* is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include:

- Habitat within and to the north of GPEC
- Habitat adjacent to Wilton and GMAC

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

HABITAT DEGRADATION

Habitat degradation through unrestricted public access has been identified as a key threat to *P. curviflora* var. *curviflora* (DEWHA, 2008i). Development within GPEC, Wilton and GMAC may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat.

Populations of *P. curviflora* var. *curviflora* on public land are considered most at risk from this impact. Population 456 (to the north of GPEC) is close to (and may occur within) Windsor Downs Nature Reserve where access is managed. The other two populations in the Strategic Assessment Area are not on public land managed for conservation.

The Plan incorporates a range of measures that are considered adequate to mitigating the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are an identified threat (OEH, 2019h). Increased human activity within the nominated areas increases the risk of fire to habitat areas supporting the species.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for the species. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the

sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

Mapped habitat does not occur within the tunnel footprints and impacts to the species will not occur in those locations.

29.19.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Small areas of species habitat have been mapped within avoided lands in GPEC. Given the lack of records and the limited extent of habitat, impacts to habitat are considered unlikely due to essential infrastructure.

However, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.19.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008i) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. curviflora* var. *curviflora* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts including:
  - Weed invasion
  - Habitat degradation from recreational activities, road and trail maintenance, and bush rock removal
  - Inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

Given the very low risk to the species associated with habitat loss and fragmentation, implementation of the Plan will not adversely influence the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts on *P. curviflora* var. *curviflora* will be managed and mitigated through a number of commitments and actions in the Plan (see Chapter 15 for details). Indirect impacts will not adversely influence the long-term viability of the species.

CONCLUSION

The limited scale of direct and indirect impacts to the species will ensure that implementation of the Plan does not adversely influence the long-term viability of the species.

29.19.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.19.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *P. curviflora* var. *curviflora*, there are no relevant Threat Abatement Plans.

Table 29-70: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. curviflora* var. *curviflora*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-71: Occurrence of *P. curviflora* var. *curviflora* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	3	0
(IMPORTANT POPULATIONS)	(1)	(0)
HABITAT MAPPING (Ha)	13,064.1	1,916.9

Table 29-72: Avoidance of *P. curviflora* var. *curviflora* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	0.0	0.0	545.1	545.1
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	0.0	0.0	454.0	454.0
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**0.0**	**91.1**	**91.1**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	0.0	17.7	17.7
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	19.4	19.4
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.0	0.5	0.5
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	0.5	0.5
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**0.0**	**18.1**	**18.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**N/A**	**19.9**	**19.9**

Table 29-73: Direct impacts to *P. curviflora* var. *curviflora* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	73.0	2.9	**75.9**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

29.20 *PTEROSTYLIS SAXICOLA* (SYDNEY PLAINS GREENHOOD ORCHID)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	A ground orchid with reddish brown and green flowers on a slender stem. Grows to 35 cm tall. (DoEE, 2018c)
ECOLOGY	Flowers from September to December and is probably dependent on climatic conditions. Following seed dispersal, the above ground parts of the plant die but the underground tuberoid remains until the following year. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Records are restricted to western Sydney between Freemans Reach in the north and Picton in the south. It is known from seven primary locations in Western Sydney: • Georges River National Park, near Yeramba Lagoon • Ingleburn • Holsworthy • Peter Meadows Creek • St Marys Towers, near Douglas Park • Freemans Reach near Windsor • Scheyville near Windsor (DEWHA, 2008j; DoEE, 2018c) Occurs on the Cumberland Plain along an ecological gradient from: • Clay soils on gently hilly landscapes in PCT 849 • To clay to sandy soils in PCT 1395 on the edge of the Cumberland Plain • To thin accumulations of humus-rich sandy soil on sandstone rock shelves in PCTs 1081, 1083, 1181 and 1789 (Weston, 2018a)
POPULATIONS	Total population size is approximately 500 individuals. Individual population sizes are typically small. (DoEE, 2018c)

SOS SITES	A ground orchid with reddish brown and green flowers on a slender stem. Grows to 35 cm tall. (DoEE, 2018c)
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Pterostylis saxicola* (Sydney Plains Greenhood) (DEWHA, 2008j) Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*) (DoEE, 2017c) Cumberland Plain Recovery Plan identifies actions at the state level (DECCW, 2011).
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64537

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	Yes	Yes	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	Yes (Weston, 2018b, 2018a). Available at Supporting Document C
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Expert report polygons**. Potential habitat polygons were generated based on the occurrence of the following parameters: • Vegetation type (suitable habitat included PCT 849, 1081, 1181 or 1395) • Vegetation condition (intact) • Soil type and topography (clay soils derived from Ashfield Shale on flat to gently hilly landscapes; clay to sandy soils derived from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition substrates on gently hilly landscapes; thin accumulations of humus-rich sandy soil on Hawkesbury Sandstone sheets and rock shelves on the either rims and steep sides of river valleys, sandstone plateaux, or dry sandstone gullies) To refine these potential habitat polygons, targeted surveys for the species were then undertaken in a number of locations within the nominated areas. These surveys either confirmed presence (known habitat) or absence (no longer considered potential habitat). The species was not recorded during the targeted surveys. It was not possible to access and survey all areas of potential habitat within the nominated areas. Any remaining potential habitat is considered precautionary and does not necessarily equate with actual habitat. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM).** Mapping was prepared for this species using the following parameters: BioNet PCT associations, vegetation condition (intact), geology ('Hawkesbury

	Sandstone', 'Ashfield Shale', 'Mittagong Formation'), soil ('Lucas Heights', 'Woodlands') and elevation (<300 m).
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION** Biological populations of were defined using the records dataset and available information about the nature of the species. Records within 500 m of one another considered a single population. **IMPORTANT POPULATION CRITERIA** Populations of *P. saxicola* were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations of this species were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.23 for a map of records and habitat across the Strategic Assessment Area It is important to note that the records for this species are sensitive and have been denatured for representation on the map.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 29-75 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *P. saxicola* in the Strategic Assessment Area. **Records** A total of nine important populations have been identified within the Strategic Assessment Area: • Two populations occur in the north of the Strategic Assessment Area • One population (unsubstantiated) is located near Emu Plains, to the west of the GPEC nominated area • Four populations occur to the east of the northern part of GMAC • Two population occur between Wilton and GMAC, one near Douglas Park and the other near Menangle It is noted that no species records are located within any of the nominated areas. **Potential habitat** The baseline mapping for this assessment has mapped 11,792.4 ha of potential habitat within the Strategic Assessment Area for this species. Habitat for this species is predominantly located towards the outer edges of the Strategic Assessment Area, with no mapped habitat located in the centre of the assessment area. Specifically, habitat is located as follows: • Scattered areas of habitat occur in the north of the Strategic Assessment Area, in the localities of Scheyville, Freemans Reach and Kurrajong • Thin areas of habitat occur between Mulgoa and Castlereagh, which are associated with the Nepean River • Areas of intermittently scattered and connected habitat occur in the localities of Mulgoa, Silverdale, Theresa Park and Werombi

	• Areas of intermittently scattered and connected habitat occur along the south-eastern and eastern boundary of the Strategic Assessment Area, from Mowbray Park, through Wilton and Douglas Park, up to Menangle and through to St Helens Park, Kentlyn and Macquarie Fields. It is noted that no potential habitat is mapped for this species within WSA.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.20.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 2,196.5 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 2,149.9ha (97.9 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,551.9 ha was avoided for biodiversity purposes
- 598.0 ha was avoided for other reasons

A breakdown of avoidance across each nominated area is provided in Table 29-76.

It is important to note that the avoidance calculations in Table 29-76, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-76 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.20.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

29.20.3 LOSS OF KNOWN POPULATIONS AND POTENTIAL HABITAT

Implementation of the Plan will lead to the loss of potential habitat. No known records will be impacted and habitat for the species will not be fragmented. A summary of these impacts is provided in Table 29-77.

LOSS OF POTENTIAL HABITAT

Approximately 46.6 ha of potential habitat for the species will be lost. This is 0.4 per cent of mapped potential habitat across the Strategic Assessment Area. The impacts occur predominantly within GMAC and Wilton.

The areas being impacted upon do not support known records or populations of *P. saxicola*.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of impacts to mapped habitat are considered to be very low. This risk ranking is triggered for impacts to species' habitat, as follows:

- The likelihood of actual impacts occurring to the species within mapped habitat has been categorised as possible. While there will be direct impacts to potential habitat, there is moderate confidence that the species will occur in the impact area (it is noted that *P. saxicola* is sporadically distributed rather than continuously spread through its habitat (Weston, 2018b, 2018a), and therefore it is considered that there is moderate potential for the species to be present within mapped habitat)
- The consequence of impacts to the species (if they did occur) has been categorised as negligible. There will be a loss of <1 per cent of mapped potential habitat (endangered species), with moderate confidence that the species occurs in the impact area

29.20.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for *P. saxicola.*

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the potential indirect impacts to the species that may occur as a result of development under the Plan. It also outlines if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.20.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DEWHA, 2008j) (and other key documents) for *P. saxicola* identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats in key species documents) are considered relevant to implementation of the Plan:

- Weed invasion
- Inappropriate fire regimes
- Inappropriate habitat disturbance including unauthorised collection, trampling, recreational and maintenance activities and rubbish dumping

Grazing from domestic stock, feral pigs, and small population size and restricted distribution have also been identified as key threats. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

WEED INVASION

P. saxicola is threatened with invasion and competition by weeds. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

P. saxicola is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occur adjacent to known populations or habitat. Key risk areas include vegetated areas in GPEC, Wilton and GMAC.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome for *P. saxicola*:

  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Also relevant for the *P. saxicola* is that a known population of the species (population 67), in addition to mapped potential habitat, is located within the proposed footprint of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include weed management practices.

The package of measures in the Plan is expected to adequately manage the risk to *P. spicata* from the increased risk of weeds associated with development. This is because:

- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and a known population of *P. saxicola.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. saxicola*
- There are commitments (Commitment 16 and Commitment 23) which will coordinate, enable and conduct effective weed control programs in strategic locations within the Strategic Assessment Area to manage priority weed species
- Proponents will be required to minimise the risk of weed spread, and to manage weeds, during the design, development and operational stages of development
- Establishment of environmental zoning of approximately 2,150 ha of mapped potential habitat of *P. saxicola* within avoided lands will enable establishment of an adequate framework for management of weeds in these areas

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are an identified threat (DEWHA, 2008j). Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the following mechanisms:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

It is noted *P. saxicola* is threatened by both very frequent and very infrequent fire. A minimum fire interval of 7 years and a maximum fire interval of 15 years is recommended for *P. saxicola* (DoEE, 2018c). Key risk areas include vegetated areas in GPEC, Wilton and GMAC.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for *P. saxicola* being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from habitat for *P. saxicola*. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

Also relevant for the *P. saxicola* is that a known population of the species (population 67), in addition to mapped potential habitat, is located within the proposed footprint of the Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include the application of the fire management strategy and a set of measures to control access to bushland which will help minimise risks around arson and accidental fires.

The package of measures in the Plan is expected to adequately manage the risk to *P. saxicola* from altered fire regimes as a result of development. This is because:

- The proposed Georges River Koala Reserve (Commitment 10) intercepts mapped potential habitat and a known population of *P. saxicola.* Protection of this reserve and management for conservation purposes will contribute to long-term protection of known populations and habitat of *P. saxicola*
- Establishment of environmental zoning of approximately 2,150 ha of mapped potential habitat of *P. saxicola* within avoided lands will enable establishment of an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting mapped potential habitat and/or known records for *P. saxicola* which is located adjacent to urban capable lands
- Fire management authorities will be engaged to ensure they understand the requirements of *P. saxicola* and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

INAPPROPRIATE HABITAT DISTURBANCE INCLUDING UNAUTHORISED COLLECTION, TRAMPLING, RECREATIONAL AND MAINTENANCE ACTIVITIES AND RUBBISH DUMPING

Inappropriate habitat disturbance has been identified as a threat to *P. saxicola*. Key risk areas include mapped potential habitat and known populations of the species, which occur in the vicinity of Wilton and GMAC. It is noted that mapped potential habitat for the species within GPEC is also at risk of habitat disturbance, although as there are no reliable known records within or directly adjacent to GPEC, the risk to the species in the locality of GPEC is not considered to be major.

The Plan includes a species-specific measure to consult with land managers of land containing known populations or habitat for *P. saxicola* to mitigate indirect impacts from habitat disturbance during construction and operation of the development, including controlling public access, managing maintenance activities such as mowing and weed control, and managing rubbish dumping.

The Plan further incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for *P. saxicola*. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about *P. saxicola*

The package of measures in the Plan is expected to adequately manage the risk to *P. saxicola* from inappropriate habitat disturbance as a result of development. This is because:

- A species-specific measure will require consultation with land managers to ensure protection of *P. saxicola* from inappropriate habitat disturbance
- Avoided lands where areas of mapped habitat for *P. saxicola* occur will be zoned appropriately to enable an adequate framework for management (this includes 2,149.9 ha of mapped potential habitat for the species)
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas (it is noted there is 6,074.1 ha of potential habitat for *P. saxicola* mapped within the SCAs)
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

It is noted that there is no mapped potential habitat, nor known records of the species, within the footprint of the proposed tunnel developments within the transport corridors. Therefore, it is considered that development of tunnels under the Plan will not pose a threat to *P. saxicola*.

29.20.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no known records of *P. saxicola* within avoided lands in any of the nominated areas. However, there is 2,149.9 ha of potential habitat mapped for the species within avoided lands within Wilton and GMAC, and therefore it is considered to be possible that the species may occur within avoided lands in these nominated areas.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.20.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008j) (and other key documents) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *P. saxicola* in relation to implementation of the Plan:

- Loss of habitat
- Indirect impacts including:
  - Weed invasion
  - Inappropriate fire regimes
  - Inappropriate habitat disturbance including unauthorised collection, trampling, recreational and maintenance activities and rubbish dumping

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to loss of 46.6 ha of mapped habitat within the nominated areas. No fragmentation of species' habitat will occur.

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is <u>very low.</u> The total area of potential habitat which will be impacted is a small proportion of available habitat for the species with only moderate confidence of the species' presence in impacted areas.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 6,074.1 ha of potential habitat for *P. saxicola.*

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with weed invasion, inappropriate fire regimes and inappropriate habitat disturbance including unauthorised collection, trampling, recreational and maintenance activities and rubbish dumping have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan, and through a species-specific commitment to manage habitat disturbance.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.20.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.20.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-74 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any of the Threat Abatement Plans.

Table 29-74: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. saxicola*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan
Predation, habitat degradation, competition and disease transmission by feral pigs	Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*) (DoEE, 2017c)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 29-75: Occurrence of *P. saxicola* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	9	1
(IMPORTANT POPULATIONS)	(9)	(1)
HABITAT MAPPING (Ha)	11,792.4	1,601.5

Table 29-76: Avoidance of *P. saxicola* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	953.9	1,795.2	0.0	14.3	2,763.5
HABITAT WITHIN EXCLUDED LANDS (ha)	173.5	380.1	0.0	13.4	567.0
HABITAT WITHOUT EXCLUDED LANDS (ha)	**780.4**	**1,415.1**	**0.0**	**0.9**	**2,196.5**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	531.4	1,020.5	0.0	0.0	1,551.9
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	68.1	72.1	N/A	0.0	70.7
AVOIDANCE FOR OTHER REASONS (ha)	234.7	363.3	0.0	0.0	598.0
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	30.1	25.7	N/A	0.0	27.2
TOTAL AVOIDANCE (ha)	**766.1**	**1,383.8**	**0.0**	**0.0**	**2,149.9**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**98.2**	**97.8**	**N/A**	**0.0**	**97.9**

Table 29-77: Direct impacts to *P. saxicola* within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	14.3	31.3	0.0	0.9	0.0	**46.6**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

SPECIES AT NO RISK OF DIRECT IMPACTS

29.21 *COMMERSONIA PROSTRATA* (DWARF KERRAWANG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	A prostrate, mat-forming shrub with trailing branches up to 2 m long. Shows hairy, star-shaped flowers that change from white to pale pink with age. Flowers appear in clusters of 3-12. (DoEE, 2018c; OEH, 2020)
ECOLOGY	Flowers between September and November. Germinates in response to disturbance such as fire or flooding. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Endemic to south-eastern Australia, distributed from central Gippsland in Victoria to the New South Wales coast. In NSW, it can be found near Tallong, Penrose and Goulburn on the Southern Tablelands, and near Newcastle. It is known to occur in the Cumberland IBRA subregion In NSW, the species can be found on sandy or peaty soils in several habitats, such as: • Snow Gum Woodland at Rose Lagoon • Blue Leaved Stringybark Open Forest at Tallong • Brittle Gum Low Open Woodland at Penrose • Scribbly Gun Swamp Mahogany Broad-leaved Paperbark Ecotonal Forest at Tomago • The ecotone between Sedge Swamp and Swamp Forest on the Tomago Sandbeds (DoEE, 2018c; OEH, 2017c, 2020)
POPULATIONS	As of 2010, there were over 100,000 plants in 40 populations. A population in the North of the Providence Ponds Flora and Fauna Reserve in east Victoria contains almost all of the plants. The majority of the remaining populations contain less than 50. (DoEE, 2018c) In NSW populations range in size from one individual to approximately 2,000 (Rowes Lagoon). (OEH, 2020)
SOS SITES	The following SOS sites for the species have been identified: • Tomago area

	• Thirlmere Lakes National Park • Rowes Lagoon area
RELEVANT PLANS AND POLICIES	National Recovery Plan for the Dwarf Kerrawang (*Rulingia prostrata*) (Carter & Walsh, 2010) Threat Abatement Plan for Competition and Land Degradation by Rabbits (DoEE, 2016a)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=87152

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** Not applicable as the species is not a candidate species credit species. Mapping was done as per the knowledge based mapping method described below. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM).** Potential habitat maps were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned, scattered trees), soil restrictions ('Berkshire Park', 'Freemans Reach', 'Hawkesbury', Monkey Creek, 'Richmond', 'South Creek', 'Theresa Park', 'Upper Castlereagh', 'Bakers Lagoon', 'Ettalong') and geology ('Hawkesbury Sandstone', 'Minchinbury Sandstone').
POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset. **POPULATION DEFINITION** Biological populations were defined using the records dataset and available information about the nature of the species. Populations were considered to constitute clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators. **IMPORTANT POPULATION CRITERIA**

	All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.4 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	A single important population of this species (from 18 BioNet records) has been mapped within Thirlmere Lakes National Park on the south western edge of the Strategic Assessment Area. The baseline mapping for this assessment has mapped approximately 61.9 ha of potential habitat within the Strategic Assessment Area. Mapped habitat shows very small and scattered occurrences of habitat on the edges of the Strategic Assessment Area, near Castlereagh, to the south of Wilton, to the south of Bargo and extremely small (<100 m^2) potential habitat patches occurring between Thirlmere and Mulgoa. No habitat is mapped within any of the nominated areas or transport corridors. See Table 29-79 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *C. prostrata* in the Strategic Assessment Area.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

No species habitat or records occur within the nominated areas or transport corridors. Avoidance of habitat was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the species. As a result the Plan does not provide offsets for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*

- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.21.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan for *C. prostrata* identifies a range of threats to the species (Carter & Walsh, 2010). As outlined in Chapter 15 (Section 15.5 and Attachment A), consideration was given to the potential relevance of these threats as indirect impacts that may result from implementation of the Plan.

Given the limited extent of species habitat and records in the Strategic Assessment Area, and the distance that they occur from the nominated areas, it was considered unlikely that implementation of the Plan would exacerbate any of the identified threats and would therefore not result in any indirect impacts.

Climate change is a relevant threat to the species. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

It is worth noting that the Plan includes a range of landscape scale measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, and pest animal control implementation strategy). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this species.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the species does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

As outlined above, implementation of the Plan will not lead to any direct or indirect impacts to the species. This will ensure that the implementation of the Plan does not adversely influence their long-term viability.

29.21.2 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?

- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan (Carter & Walsh, 2010) is to minimise the probability of extinction of the Dwarf Kerrawang in the wild and to increase the probability of important populations becoming self-sustaining in the long-term. Specific objectives include:

- Acquire accurate information as baseline data for ongoing monitoring
- Identify habitat that is critical, common or potential.
- Ensure that all populations and their habitat are protected and managed appropriately
- Manage threats to populations
- Identify key biological functions
- Determine the growth rates and viability of populations
- Establish populations in cultivation
- Build community support for conservation

Implementation of the Plan will not impact the species and will not prevent the achievement of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT THE IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to support the overall recovery of *C. prostrata*. The Plan will not prevent implementation of any of the actions.

29.21.3 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-78 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *C. prostrata*, there are no relevant Threat Abatement Plans.

Table 29-78: Relevant key Threatening Processes and associated Threat Abatement Plans for *C. prostrata*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data table for occurrence.

Table 29-79: Occurrence of *C. prostrata* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	61.9	42.5

29.22 *DEYEUXIA APPRESSA*

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	An erect perennial grass. Leaves are deeply grooved, hairy on top and rough underneath. Displays compound inflorescence containing spikelets. Grows to approximately 0.9 m tall. (OEH, 2018e)
ECOLOGY	Flowers in spring to summer, and grows in moist conditions. Given that the species hasn't been observed in over 60 years, very little is known of the species' ecology. (DEWHA, 2008c; OEH, 2018e)
DISTRIBUTION AND HABITAT	Records are highly restricted to the Sydney area (south of Bankstown, Killara). Records of this species have not been collected since pre-1942. This species may now be extinct as a result of habitat loss due to development. Grows in moist conditions and inhabits the following TECs: • Shale Sandstone Transition Forest • Cumberland Plain Woodlands • Turpentine-Ironbark Forest in the Sydney Basin Bioregion (DEWHA, 2008c; OEH, 2018e)
POPULATIONS	First collected in 1930 at Herne bay, Saltpan Creek off the Georges River south of Bankstown, then in 1941 at Killara, near Hornsby. This species has not been observed since and may be extinct in the wild. (DEWHA, 2008c)
SOS SITES	*D. appressa* has been allocated to the Data Deficient management stream of the Saving our Species program, as there is no known extant population in NSW.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Deyeuxia appressa* (DEWHA, 2008c)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.

SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=7438

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Not applicable as the species is not a candidate species credit species. Mapping was done as per knowledge based mapping method described below.
	OUTSIDE THE NOMINATED AREAS
	Knowledge based map (KBM). Mapping was prepared for this species utilising the following parameters: BioNet PCT associations, vegetation condition (intact, thinned), and geographic restrictions (habitat restricted to 10 km around species records).
POPULATION MAPPING	**RECORD SELECTION**
	All available BioNet records were used to identify populations, with no date restrictions.
	POPULATION DEFINITION
	There are not thought to be any extant populations of this species (as there are no recent records) and it is considered possible that the species is now extinct.
	IMPORTANT POPULATION CRITERIA
	All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.7 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	*D. appressa* has no records or important populations within the Strategic Assessment Area. Two important populations (from 3 BioNet records) have been mapped in the north-east of the Cumberland subregion. It is noted that this species has not been recorded since 1942 and that it may be extinct in the wild.

	The baseline mapping for this assessment has mapped 19.3 ha of habitat for this species within the Strategic Assessment Area. Habitat occurs as very small and disjointed patches in the north-east of the Strategic Assessment Area, in the district of Holsworthy, Hammondville, Moorebank and Cabramatta. No habitat has been mapped within, or in close proximity to, any of the nominated areas or transport corridors. See Table 29-81 at the end of this species assessment for a breakdown of the occurrence of records and habitat for *D. appressa* in the Strategic Assessment Area.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

No species habitat or records occur within the nominated areas or transport corridors. Avoidance of habitat was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the species. As a result the Plan does not provide offsets for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.22.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *D. appressa* identifies a range of threats to the species if it is still extant. As outlined in Chapter 15 (Section 15.5 and Attachment A), consideration was given to the potential relevance of these threats as indirect impacts that may result from implementation of the Plan.

Given the lack of records and the limited extent of species habitat in the Strategic Assessment Area, and the distance that they occur from the nominated areas, it was considered unlikely that implementation of the Plan would exacerbate any of the identified threats and would therefore not result in any indirect impacts.

It is worth noting that the Plan includes a range of landscape scale measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, and pest animal control implementation strategy). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this species if it is still extant.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the species does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

As outlined above, the species is now considered likely to be extinct. In addition, implementation of the Plan will not lead to any direct or indirect impacts to mapped habitat for the species. This will ensure that the implementation of the Plan does not adversely influence its long-term viability if it is still extant.

29.22.2 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.22.3 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *D. appressa*, there are no relevant Threat Abatement Plans.

Table 29-80: Relevant key Threatening Processes and associated Threat Abatement Plans for *D. appressa*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data table for occurrence.

Table 29-81: Occurrence of *D. appressa* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	0	0
(IMPORTANT POPULATIONS)	(0)	(0)
HABITAT MAPPING (Ha)	19.3	0.0

29.23 *GENOPLESIUM BAUERI* (YELLOW GNAT-ORCHID)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	A terrestrial orchid growing to 6-15 cm high. Inflorescence is 1-3 cm long with 1-6 flowers that are 15 mm across. Flowers are green and red or reddish. (DoE, 2014i)
ECOLOGY	Flowers between December and April. Plants are visible above ground for approximately two months. Often seen after fire. (DoE, 2014i)
DISTRIBUTION AND HABITAT	Endemic to New South Wales. Occurs within coastal areas from Ulladulla on the south coast to Port Stephens on the mid-north coast, although it has been recorded from as far west as Woodford in the Blue Mountains and Penrose State Forest in the southern highlands. Area of occupancy is 168 km^2. It grows in heathland to shrubby woodland on sands or sandy loams, or in shrubby forest to heathy forest on well-drained sandy and gravelly soils. (DoE, 2014i)
POPULATIONS	As of 2010, total number of mature individuals was thought to be less than 250 (DoE, 2014i).
SOS SITES	The following SOS sites for the species have been identified: • Ku-ring-gai Chase National Park • Ku-ring-gai Wildflower Garden • Bomaderry Creek • Callala
RELEVANT PLANS AND POLICIES	Conservation Advice for *Genoplesium baueri* (brittle midge orchid, yellow gnat orchid) (DoE, 2014i)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=7528

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report available for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Not applicable as the species is not a candidate species credit species. Mapping was done as per knowledge based mapping method described below.
	OUTSIDE THE NOMINATED AREAS
	Knowledge based map (KBM). Potential habitat polygons were generated for this species using BioNet PCT associations, vegetation condition (intact), and elevation (below 500 m). No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION**
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Records within 500 m of each other have been considered to be a single population.
	IMPORTANT POPULATION CRITERIA
	All populations of *G. baueri* have been considered as important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.9 for a map of records and habitat across the Strategic Assessment Area. It is important to note that the records for this species are sensitive and have been denatured for representation on the map.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	There is a single population (with a single record from June 2017) within the Strategic Assessment Area, which is found on the eastern side of Appin village within GMAC (outside urban capable land). The population is considered important. The baseline mapping for this assessment has mapped approximately 772.1 ha of known and potential habitat within the Strategic Assessment Area. Habitat for this species is located in the south of the Strategic Assessment Area, in the following areas: • A patch of habitat occurs to the south of Wilton, south of the intersection of Macarthur Drive and Picton Road • Long and thin stretches of habitat occur along the south-eastern boundary of the Strategic Assessment Area, spanning from Appin in the south through to Holsworthy in the north. It is likely that suitable habitat for this species continues to the east of this area, beyond the Strategic Assessment Area boundary and into adjacent remnant vegetation Overall, very little suitable habitat for this species occurs within the Strategic Assessment Area. A breakdown of occurrence for *G. baueri* in the Strategic Assessment Area is provided in Table 29-83.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.23.1 NOMINATED AREAS

The single record in GMAC occurs within a very small area of mapped habitat (<0.1 ha). This area has been avoided. See Table 29-84 for a breakdown of avoidance.

29.23.2 TRANSPORT

There is no mapped habitat within the transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the species. As a result the Plan does not provide offsets for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.23.3 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the *G. baueri* identifies habitat disturbance as a key threat to the species (DoE, 2014i). This threat is considered relevant to implementation of the Plan and is discussed below.

HABITAT DISTURBANCE

Habitat disturbance through unrestricted public access and rubbish dumping have been identified as a key threat to the species (DoE, 2014i). Development within Wilton and GMAC may lead to an increase in human activity within the species' known and potential habitat areas, and this may exacerbate the threat. This is most relevant to the known population that occurs on avoided lands within GMAC.

The Plan includes a species-specific commitment (part of Commitment 5) to manage the risk of human disturbance to the population within GMAC (population 21).

The Plan also incorporates a range of broader measures to mitigate the risks associated with inappropriate habitat disturbance. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in locations where species habitat occurs in protected areas
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the species from inappropriate habitat disturbance as a result of development. This is because:

- There is a species-specific commitment to manage the threat to the known population
- Avoided lands will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

There is no mapped habitat within transport corridors and the species is not at risk of impacts in these locations.

29.23.4 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species occurs on avoided lands within GMAC. The Plan includes a commitment (Commitment 2.4) which requires avoidance of impacts to this species to be prioritised from impacts associated with essential infrastructure projects. Given the limited distribution of the species within avoided lands it is considered likely that avoidance of direct impacts will be possible.

In addition (as outlined in Chapter 37), any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.23.5 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014i) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *G. baueri* in relation to implementation of the Plan:

- Habitat loss
- Habitat disturbance

HABITAT LOSS

There will be no habitat loss as a result of implementation of the Plan.

HABITAT DISTURBANCE

The Plan includes a range of measures (including a species-specific commitment) to ensure that habitat disturbance will not affect the species.

CONCLUSION

There are no direct impacts to the species and suitable management measures in the Plan to address potential indirect impacts. This will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.23.6 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.23.7 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *G. baueri*, there are no relevant Threat Abatement Plans.

Table 29-82: Relevant key Threatening Processes and associated Threat Abatement Plans for *G. baueri*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence and avoidance. Cross references to the tables are provided throughout the text above.

Table 29-83: Occurrence of *G. baueri* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	0
(IMPORTANT POPULATIONS)	(1)	(0)
HABITAT MAPPING (Ha)	772.1	85.3

Table 29-84: Avoidance of *G. baueri* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	<0.1	0.0	0.0	<0.1
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	<0.1	0.0	0.0	<0.1
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**<0.1**	**0.0**	**0.0**	**<0.1**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	<0.1	0.0	0.0	<0.1
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	5.0	N/A	N/A	5.0
AVOIDANCE FOR OTHER REASONS (ha)	0.0	<0.1	0.0	0.0	<0.1
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	95.0	N/A	N/A	95.0
TOTAL AVOIDANCE (ha)	**0.0**	**<0.1**	**0.0**	**0.0**	**<0.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**100.0**	**N/A**	**N/A**	**100.0**

29.24 *HIBBERTIA PUBERULA* SUBSP. *GLABRESCENS*

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the subspecies. It provides an overview of the subspecies' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key subspecies' documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	A prostrate shrub with spreading, wiry branches which can be up to 40 cm long. Flowers are yellow with notched petals. (DoEE, 2018c)
ECOLOGY	Flowers from October to December. Seeds occur from October to January. Vegetative reproduction is theoretically possible as the subspecies is a prostrate shrub, however, occurrences of vegetative reproduction have not been observed for this species. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Only known from Bankstown Airport, south-west of Sydney. Occurs over an area covering two hectares. It is noted that since 1986, comprehensive surveys have been carried out in remnant vegetation throughout the suburb of Bankstown, and no further sites for this species have been located. Occurs in highly modified Georges River Tertiary Alluvium Floodplain Communities with sandy tertiary alluvium with high silt content. (DoEE, 2018c) Recent attempts were made to translocate the subspecies to Voyager Point Reserve. This occurs outside of the Strategic Assessment Area and the current status of that translocated population is not known.
POPULATIONS	As of 2009, there were estimated to be fewer than 50 individuals from one population in Area 5, Bankstown Airport. As the subspecies was first observed in 2006, historical population data is limited, although it is suspected the subspecies has undergone historical reduction in numbers based on aerial photography records showing ongoing destruction of suitable habitat. (DoEE, 2018c) Assessment of all BioNet records of the species indicates that over 90 per cent of known records occur within the Cumberland subregion. Therefore, for the purposes of this assessment, *H. puberula* subsp. *glabrescens* is considered to be an endemic species to the region.

SOS SITES	The following SOS sites for the subspecies have been identified: • Bankstown Airport • Voyager Point Reserve
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Hibbertia* sp. Bankstown (R.T. Miller & C.P. Gibson s.n. 18/10/06) (a shrub) (DEWHA, 2008l)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this subspecies.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=81969

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the subspecies is a candidate species under the BCAR process*
- *If an expert report was prepared for the subspecies under the BCAR process*
- *An overview of the habitat mapping for the subspecies within and outside the nominated areas*
- *An overview of the population mapping for the subspecies*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	While *Hibbertia puberula* subsp. *glabrescens* is not a candidate species credit species, two expert reports were prepared for the *Hibbertia puberula* species group. These reports included some discussion about subsp. *glabrescens*. The reports were prepared because *Hibbertia puberula* subsp. *puberula* (which is not listed under the EPBC Act) is a candidate species credit species for the BCAR process. The two expert reports address the *Hibbertia puberula* species group in: • GPEC and WSA (Miller, 2018a) • Wilton and GMAC (Miller, 2018b)
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** Not applicable as the subspecies is not a candidate species credit species. Mapping was done as per the knowledge based mapping method described below. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM).** Mapping for this subspecies was undertaken using the following parameters: • BioNet PCT associations • Geographic restrictions. Given the very limited distribution of the subspecies, potential habitat was restricted to 1 km surrounding known records
POPULATION MAPPING	**RECORD SELECTION** All available BioNet records were used to identify populations, with no date restrictions. **POPULATION DEFINITION** The subspecies is known to occur naturally in one location, as a single population.

	The translocation site at Voyager Point Reserve has been planted with a number of individuals propagated from the Bankstown location.
	IMPORTANT POPULATION CRITERIA
	The population of *H. puberula* subsp. *glabrescens* was considered to be important due to the threat status of the subspecies.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the subspecies in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment.

This section also provides a discussion of how the occurrence information used in the assessment compares to information in the expert reports for the species.

MAP	See Map 36.11 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	*H. puberula* subsp. *glabrescens* has no records within the Strategic Assessment Area. The subspecies is only known from Bankstown Airport (which occurs just outside of the eastern edge of the Strategic Assessment Area). It has not been recorded at any other sites, despite targeted surveys throughout the Bankstown area. A total of 43 ha of potential habitat has been mapped on the edge of the Strategic Assessment Area, along the Georges River to the east of Moorebank. Mapped habitat is confined to areas in proximity to the Bankstown Airport. Overall, the area of potential habitat for this subspecies within the Strategic Assessment Area is very small. No habitat has been mapped within, or in close proximity to any of the nominated areas or transport corridors.
COMPARISON WITH EXPERT REPORTS	**Expert report for WSA and GPEC (Miller, 2018a)** The expert report for WSA and GPEC concludes that for *H. puberula* subsp. *glabrescens*: *"The likelihood of occurrence within or adjacent to the GPEC is considered to be low to moderate, and the likelihood of occurrence within or adjacent to the WSA is assessed as low."* The subspecies was not included in the BCAR as a candidate species credit species in these two nominated areas because: • Of a lack of suitable habitat in urban capable lands • Surveys for *H. puberula* subsp. *fumana* and *H. puberula* subsp. *puberula* did not identify any records for subsp. *glabrescens* Mapping for the subspecies within WSA and GPEC was therefore not prepared which is consistent with the approach taken in the expert report. **Expert report for Wilton and GMAC (Miller, 2018b)** The expert report for Wilton and GMAC concludes that the species is not likely to be present in Wilton. This is consistent with the BCAR which does not identify it as a candidate species credit species in that location, and the mapping for the project. However, it is noted that the expert report for Wilton and GMAC identifies an area of potential habitat for the subspecies at Menangle Park within GMAC. The expert report says: *"Likely habitat for Hibbertia puberula* subsp. *glabrescens occurs at Menangle Park. An area of approximately 92ha could contain likely habitat niches within the growth area footprint, and a further 31 ha of land containing likely habitat niches adjacent to the footprint"* At the time the expert report was prepared, the area in question near Menangle Park was part of the proposed urban capable land. This area has since been removed from urban capable land and is mapped as excluded land. The area is subject to a separate planning proposal and it is understood

	that it is undergoing a separate biodiversity approvals process. Ecological reports relating to that area have not identified the subspecies as being present. No areas identified by the expert as potential habitat for *H. puberula* subsp. *glabrescens* occur within urban capable lands and the subspecies is not a candidate credit species within GMAC for this assessment. Given the species is not a candidate credit species within GMAC, the habitat mapping was undertaken using the KBM approach described above for areas outside the nominated areas. This process appropriately mapped habitat for the subspecies only within the vicinity of Bankstown Airport.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the subspecies through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

No habitat or records for the subspecies occur within the nominated areas or transport corridors. Avoidance of habitat was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the subspecies occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the subspecies. As a result the Plan does not provide offsets for the subspecies.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.24.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the *H. puberula* subsp. *glabrescens* identifies a range of threats to the subspecies (DEWHA, 2008l). However, given the lack of records, the limited extent of habitat in the Strategic Assessment Area, and the distance that they occur from the nominated areas, it was considered unlikely that implementation of the Plan would exacerbate any of the identified threats and would therefore not result in any indirect impacts.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the subspecies does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the subspecies. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

As outlined above, implementation of the Plan will not lead to any direct or indirect impacts to mapped habitat for the species. This will ensure that the implementation of the Plan does not adversely influence its long-term viability if it is still extant.

29.24.2 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.24.3 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *H. puberula* subsp. *glabrescens*, there are no relevant Threat Abatement Plans.

Table 29-85: Relevant key Threatening Processes and associated Threat Abatement Plans for *H. puberula* subsp. *glabrescens*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data table for occurrence.

Table 29-86: Occurrence of *H. puberula* subsp. *glabrescens* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	0	0
(IMPORTANT POPULATIONS)	(0)	(0)
HABITAT MAPPING (Ha)	43.3	0.0

29.25 *LEUCOPOGON EXOLASIUS* (WORONORA BEARD-HEATH)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	An erect shrub with pointed leaves and white, tubular flowers. Grows to 1m tall. (DoEE, 2018c)
ECOLOGY	Flowers in August and fruit matures in October. Seasonal changes trigger seed germination and fire may improve uptake. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Has a fragmented distribution over seven known locations. It is endemic to the Sydney region and central coast of NSW. It is known to occur in the Cumberland IBRA subregion. The species can be found: • Along the Georges River and Stokes Creek • Holsworthy Military Reserve • In Royal National Park and Heathcote National Park • Along the Grose River and Woronora River in the Blue Mountains The distribution overlaps with the Shale Sandstone Transition Forest TEC. It is found on rocky hillsides along creek banks and inhabits woodland on sandstone and sandy alluvium in areas with low nutrient soils. (DoEE, 2018c; OEH, 2017h)
POPULATIONS	There is limited population information for this species. BioNet Atlas of NSW Wildlife shows some occurrences in the Cumberland Plain south of Liverpool and east of Campbelltown. (OEH, 2019b)
SOS SITES	The following SOS sites for the species have been identified: • Dharawal/Heathcote • Upper Nepean State Conservation Area
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Leucopogon exolasius* (DEWHA, 2008e)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species

SPRAT LINK	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=14251

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Not applicable as the species is not a candidate species credit species. Mapping was done as per knowledge based mapping method described below.				
	OUTSIDE THE NOMINATED AREAS				
	Knowledge based map (KBM). Potential habitat mapping was completed for this species using the following parameters: BioNet PCT associations, vegetation condition (intact, thinned), waterways (restricted to within a 200 m buffer distance of the Cataract River and the Georges River), soil type ('Berkshire Park', 'Freemans Reach', 'Hawkesbury', 'Monkey Creek', 'Richmond', 'South Creek', 'Theresa Park', 'Upper Castlereagh'), geology ('Alluvial channel deposits- in-channel bar', 'Alluvial floodplain deposits', 'Alluvial terrace deposits', 'Alluvium', 'Hawkesbury Sandstone', 'Minchinbury Sandstone'), elevation (below 400 m) and rainfall (between 1,000 mm – 4,000 mm).				
POPULATION MAPPING	**RECORD SELECTION**				
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.				
	POPULATION DEFINITION				
	Biological populations were defined using the records dataset and available information about the nature of the species. Clustered records connected by relatively intact and continuous vegetation and/or riparian corridors, or if separated, not by permanent barriers likely to obstruct pollinators.				
	IMPORTANT POPULATION CRITERIA				
	There are no important populations of *L. exolasius* identified in the Strategic Assessment Area.				

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.12 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	A total of four populations occur in the Strategic Assessment Area. All are in the south or east, none of which are considered important. The baseline mapping for this assessment has mapped 267.2 ha of potential habitat within the Strategic Assessment Area (see Table 29-88). The potential habitat predominantly occurs along the Georges River, in the south-eastern edge of the Strategic Assessment Area. Habitat is located as follows: • A small area occurs along the Cataract River, at the intersection of the river with Wilton Road • Small, thin areas of habitat occur along the Georges River to the east of the Appin township • Small, thin areas of habitat occur along the Georges River, to the south east of Ruse and Airds • A small, isolated patch of habitat occurs at Voyager Point, adjacent to the Georges River

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

29.25.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 23.7 ha of potential habitat within the nominated areas (not including excluded lands). All of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 13.7 ha was avoided for biodiversity purposes
- 10.0 ha was avoided for other reasons

A breakdown of avoidance across each nominated area is provided in Table 29-89.

It is important to note that the avoidance calculations in Table 29-89, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 29-89 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

29.25.2 TRANSPORT

There is no mapped habitat within the transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the species. As a result the Plan does not provide offsets for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.25.3 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *L. exolasius* identifies a range of threats to the species (DEWHA, 2008e). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion

Stochastic events leading to localised extinctions, small range and population size, unknown distribution and abundance of individual populations have also been identified as key threats. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these threats across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are identified as a potential threat to the species (DEWHA, 2008e). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas has the potential to alter fire regimes, through potentially increasing fire frequencies in some areas, and decreasing fire frequencies in others, through the mechanisms outlined above.

Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads. Population 76 in particular occurs close to the southern part of GMAC.

The Plan incorporates a range of general measures to manage the bushfire risk to biodiversity that are expected to adequately manage the risk to the species from altered fire regimes as a result of development. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the strategic assessment area. This includes a number of actions with the most relevant to the outcome for the species being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values

  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

WEED INVASION

Weed invasion is identified as a potential threat to the species. Weeds are already present within the Strategic Assessment Area and are unlikely to pose a novel threat. However, urban, transport and agricultural development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

Key risk areas are those that are easily accessible to the public and in close proximity to urban development and roads. Population 76 in particular occurs close to the southern part of GMAC.

The Plan incorporates a range of general measures to manage the risk posed by weed invasion to biodiversity that are expected to adequately manage the risk to the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCA. This includes a number of actions, of which the following are the most relevant to the outcome of the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land, which includes:
  - Partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

The species does not occur within the vicinity of the tunnels and will not be at risk of further impacts in those locations.

29.25.4 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

A small area of species habitat has been mapped within avoided lands in GMAC in the south of the nominated area. Given its location, impacts to habitat are considered unlikely due to essential infrastructure.

However, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.25.5 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2008e) identifies the following key issues that are likely to have the greatest influence on the long-term viability of *L. exolasius* in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts
    - Inappropriate fire regimes
    - Weed invasion

HABITAT LOSS

There will be no habitat loss as a result of implementation of the Plan.

INDIRECT IMPACTS

The potential indirect impacts associated with changed inappropriate fire regimes and weed invasion will be managed and mitigated through a number of commitments and actions in the Plan (see Chapter 15 for details).

CONCLUSION

The lack of direct impacts, limited scale of potential indirect impacts to the species' habitat and the management measures in the Plan to address indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

29.25.6 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.25.7 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For *L. exolasius*, there are no relevant Threat Abatement Plans.

Table 29-87: Relevant key Threatening Processes and associated Threat Abatement Plans for *L. exolasius*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence and avoidance. Cross references to the tables are provided throughout the text above.

Table 29-88: Occurrence of *L. exolasius* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	4	0
(IMPORTANT POPULATIONS)	(0)	(0)
HABITAT MAPPING (Ha)	267.2	0.0

Table 29-89: Avoidance of *L. exolasius* habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	24.0	0.0	0.0	24.0
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	0.3	0.0	0.0	0.3
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**23.7**	**0.0**	**0.0**	**23.7**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	13.7	0.0	0.0	13.7
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	57.9	N/A	N/A	57.9
AVOIDANCE FOR OTHER REASONS (ha)	0.0	10.0	0.0	0.0	10.0
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	42.1	N/A	N/A	42.1
TOTAL AVOIDANCE (ha)	0.0	**23.7**	0.0	0.0	**23.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**100.0**	**N/A**	**N/A**	**100.0**

29.26 *PERSOONIA GLAUCESCENS* (MITTAGONG GEEBUNG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	An erect shrub with greyish-green erect leaves, yellow flowers and fruit that resemble small plums. It grows up to 3 m tall. (OEH, 2019g)
ECOLOGY	Flowers from late summer to autumn. Fire-sensitive species, adults are killed by fire and recruitment is only by seed. Often seen following disturbance. (DEWHA, 2008h; OEH, 2019g)
DISTRIBUTION AND HABITAT	Restricted distribution in NSW from Picton to Kangaroo Valley. The species has been collected in Buxton, Hill Top, Nattai Creek, Welby and Kangaloon. It is known to occur in the Cumberland IBRA subregion. Distribution overlaps the following TECs: • Shale Sandstone Transition Forest • White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland • Turpentine-Ironbark Forest in the Sydney Basin Bioregion • Temperate Highland Peat Swamps on Sandstone Inhabits woodland to dry sclerophyll forest on clayey and gravely laterite, and well-drained soils. Prefers ridge-tops, plateau and upper slopes. (DEWHA, 2008h; OEH, 2017e, 2019g)
POPULATIONS	Population information is limited. The BioNet Atlas of NSW Wildlife shows several occurrences around Bargo and Buxton in the south of the Strategic Assessment Area. (OEH, 2019b)
SOS SITES	The following SOS sites for the species have been identified: • Bargo • Cordeaux record • Mt Alexandra, Welby and Jellore • Upper Nepean State Conservation Area

RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Persoonia glaucescens* (Mittagong Geebung) (DEWHA, 2008h)
SPECIES-SPECIFIC GUIDELINES	*Persoonia glaucescens* Environmental Impact Guidelines (NPWS, 2000b)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=12770

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Not applicable as the species is not a candidate species credit species. Mapping was done as per knowledge based mapping method described below.				
	OUTSIDE THE NOMINATED AREAS				
	Knowledge based map (KBM). Mapping was prepared for this species using the following parameters: BioNet PCT associations, vegetation condition (intact, thinned) and elevation (250m-650m).				
POPULATION MAPPING	**RECORD SELECTION**				
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.				
	POPULATION DEFINITION				
	Biological populations were defined using the records dataset and available information about the nature of the species. Individuals within 500 m of each other are likely to be interbreeding and are therefore considered to be the same population.				
	IMPORTANT POPULATION CRITERIA				
	Populations of *P. glaucescens* were considered important because they met one or more of the following criteria: • A population that is important for maintaining the Extent off Occurrence of a species • A population within a conservation reserve				

	• A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.17 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	Within the Strategic Assessment Area, the species occurs in the south western corner. A total of 10 important populations have been mapped, of which two populations are either wholly or partly located within existing conservation reserves. Important populations occur in the area between Buxton, Couridjah, Charlies Point Road and the northern boundary of Buxton. Two non-important populations have also been mapped within the Strategic Assessment Area. Non-important populations occur to the south of the Bargo township, in the area between Remembrance Drive and the western boundary of the Strategic Assessment Area. The baseline mapping for this assessment has mapped approximately 2,378.2 ha of potential habitat within the Strategic Assessment Area (see Table 29-91). This occurs as scattered habitat in the south western portion of the Strategic Assessment Area. No habitat is mapped in any of the nominated areas or transport corridors for this species.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

No species habitat or records occur within the nominated areas or transport corridors. Avoidance of habitat was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 29.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

Implementation of the Plan will not lead to direct impacts or fragmentation of the species. As a result the Plan does not provide offsets for the species.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

29.26.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for *P. glaucescens* identifies a range of threats to the species (DEWHA, 2008h). However, given the distance of mapped habitat and records from the nominated areas and transport corridors implementation of the Plan is considered unlikely to exacerbate these threats for the species.

It is worth noting that the Plan includes a range of landscape scale measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, and pest animal control implementation strategy). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this species.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the species does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

29.26.2 IMPLICATIONS FOR LONG-TERM VIABILITY

As outlined above, implementation of the Plan will not lead to any direct or indirect impacts to the species. This will ensure that the implementation of the Plan does not adversely influence their long-term viability.

29.26.3 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

29.26.4 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 29-43 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any Threat Abatement Plans.

Table 29-90: Relevant key Threatening Processes and associated Threat Abatement Plans for *P. glaucescens*

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus *(Phytophthora cinnamomi*)	Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant Threat Abatement Plan
Novel biota and their impact on biodiversity	There is no relevant Threat Abatement Plan

DATA TABLES

This section sets out the data tables for occurrence.

Table 29-91: Occurrence of *P. glaucescens* in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	12	2
(IMPORTANT POPULATIONS)	(10)	(2)
HABITAT MAPPING (Ha)	2,378.2	283.6

30 Threatened fauna impact assessment

30.1 INTRODUCTION

There are 20 Category 1 threatened fauna species that are assessed in this Chapter. These species were identified as needing detailed assessment (see Part 3 for the approach, and Chapter 28 for the results) as they are reliant on the Cumberland subregion and have some potential to be impacted (directly, indirectly or cumulatively).

The Chapter is structured around the level of risk of residual adverse direct impacts (prior to the application of offsets) occurring to each species (see Table 30-1). Species most at risk from direct impacts from development under the Plan are discussed first, with species at lower levels of risk discussed subsequently.

The overall assessment approach for threatened fauna is presented below in Section 30.2, and the methodology for the risk assessment is set out in Section 30.3.

The analysis in this Chapter concludes that the avoidance, mitigation and offset measures in the Plan will ensure that the long-term viability of all 20 threatened fauna species will not be adversely influenced.

Given the amount of information and complexity of the assessment for Koala, it is assessed and presented differently to the other species (see Section 30.4).

Given their similarities, the five threatened migratory shorebirds are assessed together in the one section (see Section 30.19)

Table 30-1: Species assessed in the threatened flora chapter categorised according to the risk of residual adverse direct impacts

Level of risk of residual adverse direct impacts to species	Number of species	Species names
High risk	1	• *Phascolarctos cinereus* (Koala)
Medium risk	1	• *Lathamus discolor* (Swift Parrot)
Low risk	5	• *Anthochaera phrygia* (Regent Honeyeater) • *Botaurus poiciloptilus* (Australasian Bittern) • *Chalinolobus dwyeri* (Large-eared Pied Bat) • *Dasyurus maculatus maculatus* (Spot-tailed Quoll) • *Pteropus poliocephalus* (Grey-headed Flying Fox)
Very low risk	4	• *Litoria aurea* (Green and Golden Bell Frog) • *Petauroides volans* (Greater Glider) • *Pommerhelix duralensis* (Dural Land Snail) • *Rostratula australis* (Australian Painted Snipe)
No risk	9	• *Heleioporus australiacus* (Giant Burrowing Frog) • *Hirundapus caudacutus* (White-throated Needletail) • *Hoplocephalus bungaroides* (Broad-headed Snake) • *Macquaria australasica* (Macquarie Perch) • **Threatened migratory shorebirds:** o *Calidris canutus* (Red Knot) o *Calidris ferruginea* (Curlew Sandpiper) o *Charadrius leschenaultia* (Greater Sand Plover) o *Limosa lapponica baueri* (Bar-tailed Godwit) o *Numenius madagascariensis* (Eastern Curlew)

30.2 THREATENED FAUNA ASSESSMENT APPROACH

The assessments for threatened fauna follow a standard format. However, the content is tailored for the specific context of each species.

There are nine sections to the assessments. They are described below and include:

- Species background
- Approach to baseline data
- Occurrence in the Strategic Assessment Area
- Avoidance of impacts
- Direct impacts and offsets
- Potential indirect impacts and mitigation
- Potential additional impacts from essential infrastructure and tunnels
- Likely effects of implementation of the Planon the long-term viability of the species
- Data tables

To assist the reader, standard explanatory text about the purpose and content of each section is provided throughout the assessments in *blue italics text*. The text is repeated for each species. It enables the reader to quickly understand the content of each section and where in the broader report more detailed information is available about a particular issue.

30.2.1 SPECIES BACKGROUND

Sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

30.2.2 APPROACH TO BASELINE DATA

Provides a summary of the baseline information used in the assessment. It sets out:

- If the species is a candidate species under the BCAR process. A candidate species is a species that has been determined through the BCAR assessment as needing to be assessed because suitable habitat occurs in the nominated areas. A candidate species can be either an ecosystem credit species (ECS) (one that can be reasonably predicted to occur within a nominated area based on the habitat that occurs there - surveys are not required to determine the presence of these species); or a species credit species (SCS) (one that cannot be reasonably predicted to occur within a nominated areas based on habitat – species in these areas may either be assumed present, or their presence needs to be determined through surveys or a report prepared by an expert on that species). Understanding whether a species has been categorised as a candidate species is useful to know for the EPBC Act assessments as it is based on the application of a systematic method under the BCAR process and provides an initial indication of how development in the nominated areas might interact with the species. This helps to shape the assessment narrative
- If an expert report was prepared for the species under the BCAR process. Expert reports were prepared as part of the BCAR process for a subset of species that: could not be sufficiently surveyed for within the nominated areas due to either access restrictions, seasonality or their cryptic nature; or had highly specific habitat requirements and restrictions for which expert advice was required. It is relevant to note that the expert reports were prepared as a requirement of the BCAR process and were not specifically prepared to support the EPBC assessments. As a result, the expert reports are not relied on heavily in these assessments and instead, information (particularly relating to species ecology and distribution) has been identified and drawn on as relevant
- An overview of the habitat mapping for the species within and outside the nominated areas. Habitat maps were generated using either species distribution models (SDMs), knowledge-based maps (KBMs) reflecting broad habitat associations (for instance, with mapped PCTs) and expert polygons defined through the expert reports under the BCAR process
- An overview of the population mapping for the species. This includes:
  - Any filters applied to the use of species (BioNet) records
  - Assumptions made in identifying biological populations from the species records. It is relevant to note that the method used to define populations for this assessment was tailored to the available data and purpose of the baseline mapping. While the definition used is based on the theoretical definition of a biological population

used elsewhere in the literature, it is confounding to try to match or relabel these populations to corresponding populations in other publications, such as recovery plans or species profiles, which will be based on a different dataset, often with a different purpose, set of criteria and level of resolution. The population mapping presented in this report therefore needs to be considered as standalone and fit for purpose.

  - Any criteria met in determining the importance of populations

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

30.2.3 OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

Describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file (layered PDF). The map provides critical context for the assessment and should be viewed in conjunction with the text presented in the assessments. This section also provides a qualitative description of where records and habitat occur.

For threatened migratory shorebirds, habitat mapping was undertaken using a different approach. This is described in detail in Chapter 32 and is based on identifying the importance of habitat sites for shorebirds across the Cumberland subregion in accordance with the relevant significant impact guidelines.

30.2.4 AVOIDANCE OF IMPACTS

Provides an overview of the area of potential habitat that was avoided for each species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan.

The definition of what constitutes avoidance has been adopted from the BCAR process. Under the BAM, avoidance refers to land that is suitable for development and included in the area proposed for development or biodiversity certification, but has been avoided because of its biodiversity value. This is referred to as avoidance for 'biodiversity purposes' in this assessment.

Land not impacted because it is not suitable for development or biodiversity certification, or land that has been excluded from the area proposed for development is not considered to have been avoided under the BAM. This land is referred to as avoidance for 'other purposes' and includes:

- Riparian corridors consistent with the *Water Management Act 2000*:
  - Strahler stream order 2 - buffer 20 m either side
  - Strahler stream order 3 - buffer 30 m either side
  - Strahler stream order 4 and above - buffer 40 m either side
- State protected land (>18 degrees slope, considered too steep for urban development)

Some land within the nominated areas was not considered for inclusion in the area proposed for development and has therefore been identified as 'excluded' land. These lands include:

- Existing protected land, including reserves and established offset sites
- Council owned land which is zoned for environmental conservation, environmental management or recreation
- Commonwealth land, such as Defence Establishment Orchard Hills
- Lands within the nominated areas already assessed as part of another development approval (Bingara Gorge), or lands progressing through an alternate assessment (Mount Gilead, Menangle Park, Sydney Metro Stage 1)
- Lands already developed (existing urban areas, urban land zones and roads)

A further, detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.2.5 DIRECT IMPACTS AND OFFSETS

Provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat.

Direct impacts were determined based on an intersect of the urban capable lands and transport corridors with the baseline mapping generated for each threatened fauna species. It has been assumed that total permanent clearing will occur within the urban capable lands and transport corridors for the purposes of the assessment. However, it is important to note that in reality:

- Further avoidance will be undertaken within the transport corridors (see Chapter 7)
- Direct impacts will occur progressively over the life of the Plan, which reduces the severity of impacts

The extent or scale of loss is presented in terms of:

- Number and size of populations/important populations
- Hectares of potential habitat

The analysis also considers the likelihood of direct impacts leading to fragmentation of populations and areas of potential habitat.

To provide a sense of the magnitude and importance of direct impacts, the risk of residual adverse impacts to each species occurring as a result of any direct impacts was characterised as per the methodology set out in Section 30.3 below.

The Plan provides offsets for species that are considered to be at <u>medium</u> or <u>high</u> risk of residual adverse impacts. Offsets are not provided for species that are considered to be at <u>low</u> or <u>very low</u> risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.2.6 POTENTIAL INDIRECT IMPACTS AND MITIGATION

Identifies the potential indirect impacts to each species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to a species if:

- The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, *and*
- The threat is present in the Cumberland subregion, *and*
- The Plan has the potential to exacerbate the threat

Relevant indirect impacts were identified by drawing on ecological and life history information in species profiles, conservation advices and recovery plans, and species records and habitat maps prepared for this Assessment Report.

The indirect impacts section then goes on to determine if the generic management strategies in the Plan will be adequate for addressing indirect impacts, or if species-specific commitments are necessary. Species-specific commitments were generally considered necessary where a species was found to have a particular vulnerability or susceptibility to a potential indirect impact in a discrete location.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.1.1 POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

Considers the potential additional impacts to species due to essential infrastructure projects that are needed to support development within the nominated areas. These might include projects such as water and electricity utilities, communications facilities, stormwater management systems, and waste or resource management systems. The assessment covers projects that may need to be located outside urban capable lands and on areas that are identified as avoided lands <u>within the nominated areas</u>.

This section also assesses the likelihood of potential additional impacts to species due to the tunnel sections of the transport corridors. The impacts of tunnels were assessed separately to the rest of the transport corridors as only small areas of the footprints will be disturbed and it is not possible to determine at this stage the nature and extent of those impacts.

Please refer to the following chapters for details about these development types:

- Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels

- Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)

30.2.7 LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

Considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.2.8 DATA TABLES

Sets out the data tables for occurrence, avoidance and direct impacts for each species.

30.3 RISK ASSESSMENT APPROACH FOR THREATENED FAUNA

This section sets out:

- The purpose of the risk assessment approach
- The risk assessment framework
- A description of the risk ratings
- The likelihood and consequence definitions for direct impacts to populations and/or potential habitat
- The likelihood and consequence definitions for direct impacts leading to fragmentation

30.3.1 PURPOSE

The purpose of the risk assessment for threatened fauna was to determine the level of risk of residual adverse impacts occurring to a species as a result of direct impacts. Indirect impacts were assessed differently (see Chapter 15) and were not subject to the same risk assessment process.

The term “residual adverse impacts” was used as it forms part of the EPBC Act Environmental Offsets Policy (DSEWPC, 2012c). Offsets are typically required under the EPBC Act when residual adverse impacts remain after avoidance and mitigation measures have been applied. In this case, the Plan provides offsets for species which are considered to be at high or medium risk of residual adverse impacts. Offsets are not provided for species which are considered to be at low or very low risk. As outlined above, the rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

A risk based approach to considering residual adverse impacts is appropriate for the strategic assessment. The ToR (Clause 4.2) identify the need for the impact assessment to consider the “level of likely risk to each protected matter”. The spatial and temporal scale of the Plan means that there is an inherent level of uncertainty in the baseline data (both for habitat and records). In particular, the potential habitat mapping for the majority of species is highly precautionary and does not necessarily indicate with great certainty if a species will occur in an impact area. It is critical therefore to understand the level of risk to each species rather than take a simplistic view of direct impacts as presented in the impact numbers.

30.3.2 RISK ASSESSMENT FRAMEWORK

Risk is generally considered to be the combination of the likelihood and consequence of an event occurring. The methodology used in the assessment is based on an adapted version of the Australian Standard on Risk Management (Standards Australia, 2018).

The assessment for threatened fauna first considered if a species is restricted in its use of habitat (e.g. Green and Golden Bell Frog) or if it is mobile and wide ranging (e.g. Swift Parrot). This distinction was made as the criteria for risk differs depending on the nature of the species. A known location for a species which is restricted in terms or habitat or movement is generally going to be assessed as more important and vulnerable. A restricted species has limited ability or opportunity to disperse or seek refuge and the potential impacts to that location will necessarily be more concerning. In contrast, a record for a highly mobile species indicates the likely suitability and value of that area as habitat, and issues relating to barriers to movement and proportion of habitat impacted are more relevant to understanding the level of concern from potential impacts.

RESTRICTED SPECIES

The determination of the risk of residual adverse impacts for restricted species (see Section 30.3.4 for more information) was based on:

- The risk ratings in Table 30-2 Table 30-2
- Understanding the risk of residual adverse impacts due to direct impacts to populations and/or potential habitat based on:
    - The likelihood definitions in Table 30-3
    - The consequence definitions in Table 30-4, Table 30-5, Table 30-6 and Table 30-7
- Understanding the risk of residual adverse impacts due to fragmentation based on:
    - The likelihood definitions in Table 30-8
    - The consequence definitions in Table 30-11

The final level of risk for a species was determined on a precautionary basis. The highest level of risk based on the consideration of impacts to populations, potential habitat, or due to fragmentation was taken.

WIDE RANGING SPECIES

The determination of the risk of residual adverse impacts for wide ranging species (see Section 30.3.5 for more information) was based on:

- The risk ratings table shown in Table 30-2
- The likelihood definitions in Table 30-12
- The consequence definitions in Table 30-13

30.3.3 RISK RATINGS

Four levels of risk were defined through the process (see Table 30-2). They were:

- Very low risk = very low risk that residual adverse impacts to a species will occur. Offsets for residual impacts were not considered necessary
- Low risk = low risk that residual adverse impacts to a species will occur. Offsets for residual impacts were not considered necessary
- Medium risk = medium risk that residual adverse impacts to a species will occur. Offsets were considered necessary
- High risk = high risk that residual adverse impacts to a species will occur. Offsets were considered necessary

Where there were no direct impacts to a species, there was considered to be no risk of residual adverse impacts.

Table 30-2: Risk ratings table

	CONSEQUENCE				
LIKELIHOOD	**Negligible**	**Minor**	**Moderate**	**Major**	**Extreme**
Almost certain	Low	Medium	Medium	High	High
Likely	Low	Low	Medium	Medium	High
Possible	Very low	Low	Low	Medium	Medium
Unlikely	Very low	Very low	Low	Low	Medium

30.3.4 RISK APPROACH FOR RESTRICTED SPECIES

LIKELIHOOD AND CONSEQUENCE DEFINITIONS FOR DIRECT IMPACTS TO POPULATIONS AND/OR POTENTIAL HABITAT

Likelihood

Table 30-3 sets out the definitions for the likelihood that a threatened flora species will be directly impacted due to impacts to populations and/or potential habitat. These definitions:

- Draw on the baseline data for the species in terms of records and potential habitat mapping
- Consider the level of confidence in the records and potential habitat mapping. Strict definitions of "high", "moderate" and "low" confidence are not provided as they are species specific in relation to the baseline data. Judgements about the level of confidence in the data were instead determined based on the expert judgement of the assessment team who created the baseline data

Table 30-3: Likelihood definitions for direct impacts to populations and/or potential habitat

Likelihood	Definition
Almost certain	• Direct impacts to a known population with high confidence in the accuracy of the records
Likely	• Direct impacts to a known population with some uncertainty in the accuracy of the records OR • Direct impacts to potential habitat with high confidence that the species occurs in the impact area
Possible	• No direct impacts to a known population • Direct impacts to potential habitat with moderate confidence that the species occurs in the impact area
Unlikely	• No direct impacts to a known population • Direct impacts to potential habitat with low confidence that the species occurs in the impact area

Consequences

Consequence was determined by separately considering impacts to potential habitat as well as any impacts to known populations. The highest ranking of consequence was then taken for a species.

The criteria for determining consequence were based on a range of factors including:

- Conservation status. Impact thresholds for consequence were smaller for critically endangered species than for endangered species, and smaller for endangered species than for vulnerable species
- If the species is considered to be an SAII entity under the BCAR process or is endemic (>90 per cent of records in the subregion) to the Cumberland subregion. Species that met either of these criteria were treated under the consequence thresholds for critically endangered species even if they had a lower conservation status
- The application of both population impact thresholds and potential habitat impact thresholds. It should be noted that like all threshold approaches the numbers are arbitrary to a degree. However, the thresholds are considered to be appropriate because they:
    - Reflect the nature of the baseline data. In particular the potential habitat mapping which has been generated across the Strategic Assessment Area is precautionary in many cases and over-maps habitat
    - Are structured around conservation status
    - Reflect the expert view of the assessment team about the level of risk to species

The consequence definitions for direct impacts due to impacts to populations and/or potential habitat are set out in:

- Table 30-4, Table 30-5 and Table 30-6 for potential habitat
- Table 30-7for populations

Table 30-4: Consequence definitions for direct impacts to potential habitat for vulnerable species

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >15% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 10-15% of mapped potential habitat	Extreme	Major	Minor
Loss of 6-10% of mapped potential habitat	Major	Moderate	Negligible
Loss of 2-6% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <2% of mapped potential habitat	Minor	Negligible	Negligible

Table 30-5: Consequence definitions for direct impacts to potential habitat for endangered species

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >10% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 7-10% of mapped potential habitat	Extreme	Major	Minor
Loss of 3-7% of mapped potential habitat	Major	Moderate	Negligible
Loss of 1-3% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <1% of mapped potential habitat	Minor	Negligible	Negligible

Table 30-6: Consequence definitions for direct impacts to potential habitat for critically endangered, SAII* and/or endemic species**

Potential habitat thresholds	Confidence that species occurs in impact area		
	High	Moderate	Low
Loss of >5% of mapped potential habitat	Extreme	Extreme	Minor
Loss of 2-5% of mapped potential habitat	Extreme	Major	Minor
Loss of 1-2% of mapped potential habitat	Major	Moderate	Negligible
Loss of 0.5-1% of mapped potential habitat	Moderate	Minor	Negligible
Loss of <0.5% of mapped potential habitat	Minor	Negligible	Negligible

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90% of records of the species occur within the subregion

Table 30-7: Consequence definitions for direct impacts to populations

Consequence	TYPE OF IMPACT	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
Extreme	• Impacts to known population, OR	• Loss of 2 or more important populations	• Loss of 2 or more populations	• Loss of 1 or more populations
	• Impacts to population at edge of occurrence, OR	• Loss of 1 important population at edge of occurrence	• Loss of 1 population at edge of occurrence	• Loss of records within a population at the edge of occurrence
Major	• Impacts to known population, OR	• Loss of 1 important population	• Loss of 1 population	• Loss of records within a population
	• Impacts to population at edge of occurrence	• Loss of records within an important population at the edge of occurrence	• Loss of records within a population at the edge of occurrence	• N/A
Moderate	• Impacts to known population, OR	• Loss of records within an important population, or the loss of a non-important population	• Loss of records within a population	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A
Minor	• Impacts to known population, OR	• Loss of records within a non-important population	• N/A	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A
Negligible	• Impacts to known population, OR	• N/A	• N/A	• N/A
	• Impacts to population at edge of occurrence	• N/A	• N/A	• N/A

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90% of records of the species occur within the subregion

LIKELIHOOD AND CONSEQUENCE DEFINITIONS FOR FRAGMENTATION IMPACTS

Likelihood

Table 30-8 Table 30-8 sets out a matrix for determining the likelihood that a threatened flora species will be impacted by fragmentation. The two axes of the matrix are:

- Barrier likelihood which represents a judgement about how likely a particular development will disrupt connectivity for a species. Table 30-9 provides examples of different barrier likelihoods
- Fragmentation type which sets out how a species may be impacted. Table 30-10 provides criteria for fragmentation types

Table 30-8: Likelihood definitions for fragmentation

	FRAGMENTATION TYPE (see Table 30-10)			
BARRIER LIKELIHOOD (see Table 30-9)	**Certain impact within population**	**Likely impact within population OR certain impact between populations**	**Possible impact between populations OR likely impact to habitat connected to a population**	**Impact to mapped habitat only**
Certain barrier	Almost certain	Almost certain	Likely	Possible
Likely barrier	Almost certain	Likely	Possible	Possible
Possible barrier	Likely	Likely	Possible	Unlikely
Unlikely barrier	Possible	Possible	Unlikely	Unlikely

Table 30-9: Examples of barrier likelihood

Barrier likelihood	Examples
Certain barrier	• If species thought to be unable to cross barriers >100 m, a 1 km barrier is inconsistent with dispersal requirements • If species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with little to no vegetation (such as high density urban and/or commercial areas) is inconsistent with dispersal requirements • If species is highly susceptible to being impacted by major roads with high traffic density (either through high roadkill rates, through aversion to noise and light, or through aversion to crossing open spaces) a major road is inconsistent with dispersal requirements
Likely barrier	• If species thought to be unable to cross barriers >100 m, a 300 m barrier is likely to be inconsistent with dispersal requirements • If species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with sparse vegetation (such as low to moderate density urban areas with gardens) are likely to be inconsistent with dispersal requirements • If species is thought to be susceptible to being impacted by major roads with high traffic density (either through moderate roadkill rates, through moderate aversion to noise and light, or through moderate aversion to crossing open spaces) a major road is likely to be inconsistent with dispersal requirements
Possible barrier	• If species thought to be unable to cross barriers >100 m, a 150 m barrier may be inconsistent with dispersal requirements • If species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with sparse vegetation

Barrier likelihood	Examples
	(such as rural residential areas and agricultural areas) may be inconsistent with dispersal requirements • If species is thought to have potential to be impacted by major roads with high traffic density (either through possible roadkill occurrences, possible aversion to noise and light, or through possible aversion to crossing open spaces), a major road may be inconsistent with dispersal requirements
Unlikely barrier	• If species thought to be unable to cross barriers >100 m, barrier of <100 m is unlikely to be inconsistent with dispersal requirements • If species requires continuous or semi-continuous vegetated areas for dispersal (e.g. to provide shelter for fauna or to support pollinator populations), areas with moderate vegetation density (such as parks, nature reserves and vegetated areas) are unlikely to be inconsistent with dispersal requirements • If species is not known to be impacted by major roads with high traffic density (the species is not known to be susceptible to roadkill, noise or light aversion, or aversion to open spaces), then a major road is unlikely to be inconsistent with dispersal requirements

Table 30-10: Criteria for fragmentation types

Fragmentation type	Criteria
Certain impact within population	• Barrier is placed between records of a single population, with high confidence in the accuracy of the records
Likely impact within population **OR** **certain impact between populations**	• Barrier is placed between records of a single population, with some uncertainty in the accuracy of the records, OR • Barrier is placed in mapped potential habitat between records of two or more different populations, with high confidence in the accuracy of the records
Possible impact between populations OR likely impact to habitat connected to a population	• Barrier is placed in mapped potential habitat between records of two or more different populations, with some uncertainty in the accuracy of the records, OR • Barrier is placed in mapped potential habitat, where the mapped habitat is in the vicinity of, or connected to, only one known population of the species
Impact to mapped habitat only	• Barrier is placed in mapped potential habitat, where the mapped habitat is not connected to any known populations of the species

Consequences

Consequence was determined by considering fragmentation type and applying different criteria depending on the conservation status of the species.

Table 30-11: Consequence definitions for fragmentation

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
Extreme	Internal fragmentation	• Internal fragmentation of two or more important populations, OR • Internal fragmentation of an important population at edge of occurrence	• Internal fragmentation of two or more populations, OR • Internal fragmentation of a population at edge of occurrence	• Internal fragmentation of one population
	Fragmentation between populations	• Fragmentation between populations, which impacts an important population at the edge of occurrence	• Fragmentation between populations, which impacts a population at the edge of occurrence	• Fragmentation between populations, which impacts a population at the edge of occurrence, OR • Fragmentation between populations, which impacts two or more populations which are not at the edge of occurrence
	Fragmentation between a population and potential habitat	• N/A	• N/A	• N/A
	Fragmentation of potential habitat	• N/A	• N/A	• N/A
Major	Internal fragmentation	• Internal fragmentation of one important population	• Internal fragmentation of one population	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts two or more important populations which are not at the edge of occurrence	• Fragmentation between populations, which impacts two or more populations which are not at the edge of occurrence	• N/A

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a large area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a large area of connected mapped potential habitat, OR • Fragmentation of two or more populations, where each population is connected to either a moderate or small area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a large area of connected mapped potential habitat, OR • Fragmentation of two or more populations, where each population is connected to either a moderate or small area of connected mapped potential habitat
	Fragmentation of potential habitat	• N/A	• N/A	• Fragmentation of a large area of potential habitat with no associated records
Moderate	Internal fragmentation	• Internal fragmentation of two or more non-important populations	• N/A	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts one important population and one or more non-important populations not at the edge of occurrence	• N/A	• N/A
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a moderate area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a moderate area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a moderate area of connected mapped potential habitat
	Fragmentation of potential habitat	• Fragmentation of a large area of potential habitat with no associated records	• Fragmentation of a large area of potential habitat with no associated records	• Fragmentation of a moderate area of potential habitat with no associated records
Minor	Internal fragmentation	• Internal fragmentation of one non-important populations	• N/A	• N/A
	Fragmentation between populations	• Fragmentation between populations, which impacts two or more non-	• N/A	• N/A

Consequence	FRAGMENTATION TYPE	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
		important populations not at the edge of occurrence		
	Fragmentation between a population and potential habitat	• Fragmentation of one important population, where the population is separated from a small area of connected mapped potential habitat, OR • Fragmentation of one or more non-important population, where the population is separated from a large area of connected mapped potential habitat	• Fragmentation of one or more populations, where the population is separated from a small area of connected mapped potential habitat	• Fragmentation of one population, where the population is separated from a small area of connected mapped potential habitat
	Fragmentation of potential habitat	• Fragmentation of a moderate area of potential habitat with no associated records	• Fragmentation of a moderate area of potential habitat with no associated records	• Fragmentation of a small area of potential habitat with no associated records
Negligible	Internal fragmentation	• N/A	• N/A	• N/A
	Fragmentation between populations	• N/A	• N/A	• N/A
	Fragmentation between a population and potential habitat	• Fragmentation of one or more non-important populations, where the population is separated from a moderate or small area of connected mapped potential habitat	• N/A	• N/A
	Fragmentation of potential habitat	• Fragmentation of a small area of potential habitat with no associated records, OR • Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species	• Fragmentation of a small area of potential habitat with no associated records, OR • Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species	• Fragmentation of mapped habitat, where impacted habitat occurs outside of the known range of the species

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90% of records of the species occur within the subregion

30.3.5 RISK APPROACH FOR WIDE-RANGING SPECIES

An amended risk assessment approach was applied for wide-ranging species. This reflected the difference in how wide-ranging species use habitat.

LIKELIHOOD

Table 30-12 sets out the definitions for the likelihood that a wide-ranging fauna species will be subjected to substantial impacts. "Substantial" in this case is defined as impacts that could materially affect the species' use of the Strategic Assessment Area.

These definitions:

- Draw on the baseline data for the species in terms of records and potential habitat mapping
- Consider the scale of impacts to records and potential habitat mapping. Strict definitions of "major", "moderate" and "minor" impacts are not provided as they are species specific in relation to the baseline data. Judgements about how to categorise the scale of impacts were instead determined based on the expert judgement of the assessment team who created the baseline data

Table 30-12: Likelihood definitions for direct impacts for wide ranging species

Likelihood	Definition
Almost certain	• Impacts to breeding or roosting habitat
Likely	• No impacts to breeding or roosting habitat • Major impacts to foraging habitat
Possible	• No impacts to breeding or roosting habitat • Moderate impacts to foraging habitat
Unlikely	• No impacts to breeding or roosting habitat • Minor impacts to foraging habitat

CONSEQUENCES

Consequence was determined by separately considering impacts to potential habitat as well as any impacts to known populations. The highest ranking of consequence was then taken for a species.

Consistent with the approach for restricted species, the criteria for determining consequence were based on a range of factors including:

- Conservation status. Impact thresholds for consequence were smaller for critically endangered species than for endangered species, and smaller for endangered species than for vulnerable species
- If the species is considered to be an SAII entity under the BCAR process or is endemic (>90 per cent of records in the subregion) to the Cumberland subregion. Species that met either of these criteria were treated under the consequence thresholds for critically endangered species even if they had a lower conservation status
- The application of both population impact thresholds and potential habitat impact thresholds. It should be noted that like all threshold approaches the numbers are arbitrary to a degree. However, the thresholds are considered to be appropriate because they:
    - Reflect the nature of the baseline data. In particular the potential habitat mapping which has been generated across the Strategic Assessment Area is precautionary in many cases and over-maps habitat
    - Are structured around conservation status
    - Reflect the expert view of the assessment team about the level of risk to species

Table 30-13: Consequence definitions for impacts to wide ranging species

Consequence	TYPE OF IMPACT	MEASURE BY CONSERVATION STATUS		
		Vulnerable	Endangered	Critically endangered or SAII* or endemic**
Extreme	• Impacts to core breeding or roosting area, OR	• Loss of a core breeding or roosting area	• Moderate impacts to a core breeding or roosting area	• Any impacts to a core breeding or roosting area
	• Impacts to mapped potential habitat	• Loss of >15% of mapped potential habitat	• Loss of >10% of mapped potential habitat	• Loss of >5% of mapped potential habitat
Major	• Impacts to core breeding or roosting area, OR	• Major impacts to a core breeding or roosting area	• Minor impacts to a core breeding or roosting area	• N/A
	• Impacts to mapped potential habitat	• Loss of 10-15% of mapped potential habitat	• Loss of 7-10% of mapped potential habitat	• Loss of 2-5% of mapped potential habitat
Moderate	• Impacts to core breeding or roosting area, OR	• Moderate impacts to a core breeding or roosting area	• N/A	• N/A
	• Impacts to mapped potential habitat	• Loss of 6-10% of mapped potential habitat	• Loss of 3-7% of mapped potential habitat	• Loss of 1-2% of mapped potential habitat
Minor	• Impacts to core breeding or roosting area, OR	• Minor impacts to a core breeding or roosting area	• N/A	• N/A
	• Impacts to mapped potential habitat	• Loss of 2-6% of mapped potential habitat	• Loss of 1-3% of mapped potential habitat	• Loss of 0.5-1% of mapped potential habitat
Negligible	• Impacts to core breeding or roosting area, OR	• No impacts to a core breeding or roosting area	• N/A	• N/A
	• Impacts to mapped potential habitat	• Loss of <2% of mapped potential habitat	• Loss of <1% of mapped potential habitat	• Loss of <0.5% of mapped potential habitat

* SAII = species that are potentially subject to Serious and Irreversible Impacts as identified through the BCAR process

** Endemic = species that are considered endemic to Cumberland subregion because more than 90% of records of the species occur within the subregion

SPECIES AT HIGH RISK OF DIRECT IMPACTS

30.4 *PHASCOLARCTOS CINEREUS* (KOALA)

30.4.1 INTRODUCTION

Phascolarctos cinereus (Koala) is recognised as one of Australia's most iconic animals. There is an important population of the species in Southern Sydney which is the focus of this assessment. The species is listed under the:

- EPBC Act as Vulnerable for the combined populations of Queensland, New South Wales and the Australian Capital Territory
- BC Act as Vulnerable

This section provides a detailed EPBC Act assessment of the outcomes for Koalas associated with implementation of the Plan in accordance with the requirements of the ToR. Given the extensive information available for the Koala assessment and the complexity of the issues, it is presented differently and in more detail than the other threatened species in this chapter.

It is noted that the risk assessment process set out in the previous section (Section 30.3) was not applied to Koalas as they were considered a high risk species due to the importance of the Southern Sydney population, and the potential for direct and indirect impacts.

The Koala assessment sets out:

- Implications of the 2019/20 bushfires
- Background to the species
- The regulatory context for assessing impacts to Koalas under the EPBC Act
- A summary of the baseline information
- Occurrence within the Strategic Assessment Area
- The efforts to avoid and minimise impacts
- The direct and indirect impacts to the species
- The proposed outcomes, commitments and actions to protect Koalas
- A detailed evaluation of the outcome for the species against the statutory and policy requirements
- A conclusion

Hyperlinks to maps are provided throughout the text and are not included directly within the document.

In addition, a detailed set of Koala attachments are provided at the end of the chapter. They include:

- Attachment A – Terminology used in this assessment
- Attachment B – Detailed background information on Koalas
- Attachment C – Habitat mapping used in the assessment

The impact assessment for Koalas in relation to the BC Act requirements is provided in Part 5 of the report.

30.4.2 IMPLICATIONS OF THE 2019/20 BUSHFIRES

As outlined in Part 1 of this report, the 2019/20 bushfires in NSW are unprecedented in their extent and intensity. As of 28 January 2020, the fires had burnt 5.3 million hectares (6.7 per cent of NSW), including 2.7 million hectares in national parks (37 per cent of the national park estate) and over 80 per cent of the Greater Blue Mountains World Heritage Area (EES, 2020).

The fires destroyed large areas of habitat and populations across NSW for some species potentially impacted by the development under the Plan. Because the extent and intensity of the fires are unprecedented, ultimate recovery of some of these species is uncertain and could be affected. This means that:

- The fires may increase the significance of the impacts of the development under the Plan for some species

- Additional commitments under the Plan may be needed for some species to help address the impacts of the fires

The full impact of the fires on biodiversity will not be understood for some time (EES, 2020).

As part of the process of preparing this report, an initial assessment of the implications of the fires for the Plan has been undertaken based on available information. The assessment will be reviewed as further information on the impacts of the fires becomes available.

Koalas were identified as one of the species that is likely to have been significantly impacted by the fires. In particular this relates to populations in the northern part of NSW and closer to the Plan Area in the Blue Mountains.

The assessment for Koalas in this report incorporates consideration of the implications of the fires as far as possible.

30.4.3 BACKGROUND TO KOALAS

This section provides an overview of the species and describes its status in NSW. More detailed information is provided at Attachment B.

OVERVIEW

Koalas are arboreal marsupials that are distributed within coastal and inland regions of eastern Australia, from South Australia to northern Queensland.

They are specialist folivores, meaning that they eat leaves and are highly selective in their choice of diet. They are known to eat the leaves of over 100 *Eucalyptus* species and over 30 non-*Eucalyptus* species (including genera such as *Angophora* and *Corymbia*) (OEH, 2018a). However, local Koala populations typically tend to select their diet from only a small number of trees in their local area, with the preferred tree species varying between populations (McAlpine, Rhodes et al., 2008).

Overall, Koalas typically preference trees growing on fertile soils, as fertile soils result in higher leaf nutrient content in trees.

They are territorial animals which exist in complex social networks. Males are more prone to dispersal, whereas female Koalas tend to remain close to natal sites (Houlden, Costello et al., 1999). Male ranges typically tend to be significantly larger than female ranges. The average size of a Koala's home range varies significantly between populations and between different areas and habitats (NSW Chief Scientist & Engineer, 2016).

Koalas had already undergone a series of population bottlenecks prior to European arrival (likely as a result of glacial/interglacial cycles). They therefore already had low genetic diversity prior to the impacts of European activities on the population (Black, Price et al., 2014). Predicting population trends has its challenges but it is thought that the species has declined across most of its range.

Koala populations have been declining as a result of a diverse number of threats, including (McAlpine, Lunney et al., 2015; OEH, 2017g):

- Habitat loss
- Habitat modification and fragmentation
- Predation from domestic and feral dogs
- Vehicle strike
- Fire (particularly increased fire intensity which burns the crown of trees)
- Disease (particularly *Chlamydia*)
- Heat stress through drought and heatwaves
- Climate change (which increases drought and heatwaves, but also alters habitat quality)

STATUS OF KOALAS IN NSW

In December 2016, the NSW Chief Scientist and Engineer released a Report of the Independent Review into the Decline of Koala Populations in Key Areas of NSW. Using up-to-date scientific information, that report described the status of Koalas in NSW as at 2016. The key findings of the report are as follows:

- Koalas were historically distributed throughout the woodlands and forests of NSW, but have experienced significant declines in both numbers and distribution
- Koala numbers continue to decline despite a range of initiatives to protect them
- Surveys indicate that populations of Koalas have disappeared from many areas (particularly from the southern and western edges of their distribution)
- Estimates at 2016 suggest there are approximately 36,000 Koalas in NSW, representing a 26 per cent decline over the past three Koala generations (15-21 years)
- Across 13 regional Koala populations in NSW, nine Koala populations were estimated to be in decline, three stable and one increasing

A more recent report (Lane, Wallis et al., 2020) set out to quantify the effects of the 2019-20 fires on Koalas in the context of broader population trends in NSW. That report concluded that over the past three Koala generations, numbers may have declined by a minimum of 28.52 per cent up to a possible 65.95 per cent. The report suggests declines are more likely to have occurred towards the upper estimate, and that the ongoing threats of climate change and high frequency fires will severely threaten the species in NSW over the coming years.

30.4.4 REGULATORY AND POLICY CONTEXT

The overall regulatory and policy framework surrounding Koala conservation in NSW is complex, with multiple layers of overlapping instruments, all of which aim to provide for the protection and preservation of the species.

Table 30-14 provides an overview of the key instruments and policies in place that regulate and guide Koala conservation activities within NSW. These documents provided a framework for assessing the impacts and commitments for Koalas. They are:

- Conservation advice for the species
- EPBC Act Koala referral guidelines
- An advice document from EES about conserving Koalas in the in Wollondilly and Campbelltown LGAs
- NSW Koala recovery plan (not a statutory document under the EPBC Act)
- Koala Habitat Protection SEPP (previously SEPP 44)
- Saving our Species program for Koalas
- NSW Koala strategy
- Draft Campbelltown Comprehensive Koala Plan of Management

EPBC ACT APPROVAL CONSIDERATIONS

Section 146K of the EPBC Act sets out the formal approval considerations in relation to threatened species. In summary, the outcomes of the Plan must:

- Not be inconsistent with:
    - Any of the international agreements relating to threatened species
    - A recovery plan
    - A relevant Threat Abatement Plan
- Have regard for a conservation advice

At present, there is no recovery plan for the species recognised under the EPBC Act or relevant Threat Abatement Plans. The key statutory consideration therefore relates to the conservation advice for Koalas (DSEWPC, 2012a).

EVALUATION APPROACH

The evaluation at the end of this analysis draws together the information from the Koala assessment to provide a robust way of:

- Understanding the predicted outcomes for the Southern Sydney Koala population as a result of implementation of the Plan
- Determining acceptability of the Plan for Koalas in an EPBC Act context

The evaluation is based on posing a series of questions that are structured around:

- The outcome for Koalas specified in the Plan
- The key regulatory and policy documents:
  - EES principles from *Conserving Koalas in Wollondilly and Campbelltown LGAs. Final* (OEH, 2018d)
  - EPBC referral guidelines for Koalas
  - The Koala Conservation Advice

The results of the evaluation are presented at Section 30.4.10.

Table 30-14: Overview of the key regulatory and policy documents for Koalas in NSW

Document	Type	Description
Commonwealth Documents		
Approved Conservation Advice for *Phascolarctos cinereus* (combined populations of Queensland, New South Wales and the Australian Capital Territory) (Koala Northern Designatable Unit) (DSEWPC, 2012a)	EPBC Act statutory document	The purpose of this document is to provide guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of the listed species. It provides an overview of broad-scale conservation advice for Koalas across NSW, QLD and the ACT, through distilling key findings of a range of other publications concerning Koala conservation. Given its very broad scope and the diversity of conservation needs of Koala populations across the species' range, the document recognises that in many cases, other more detailed and targeted reports are likely to be more applicable at local and regional scales. Regard for the Conservation Advice in developing the Plan is a statutory consideration under the EPBC Act.
EPBC Act referral guidelines for the vulnerable Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) (DoE, 2014j)	EPBC Act policy document	The purpose of this document is to provide guidance to proponents undertaking impact assessments for the Koala, in accordance with a nationally consistent assessment framework and in accordance with assessment requirements outlined by the EPBC Act. These guidelines are a key document underpinning the current impact assessment of Koalas. The guidelines provide a range of definitions and assessment criteria which have been considered, including: • Definition of 'habitat critical to the survival of the species' • Definition of impacts that 'substantially interfere with the recovery of the species' • A suite of criteria around assessing impacts • Determining the requirements for implementation, monitoring and duration of mitigation measures

Document	Type	Description
NSW Documents		
Conserving Koalas in Wollondilly and Campbelltown LGAs. Final (OEH, 2018d)	NSW guidance document	The document provides key ecological context and information for the Southern Sydney population of Koalas around Wollondilly and Campbelltown LGAs. This includes habitat and corridor mapping based on recent Koala tracking. The document sets out four key principles for managing Koalas in the context of residential and urban development Wilton and GMAC. The principles aim to ensure an ongoing healthy population and are: 1. Avoid new residential development within core Koala habitat [identified as 'principal' habitat in this report] and primary corridors 2. Separate residential development and Koala populations to minimise ongoing threats from domestic dogs and vehicles 3. Identify critical revegetation zones that will augment and strengthen core habitat and corridors 4. Identify Koala roadkill hotspots requiring roadkill mitigation fencing and/or underpasses to allow safe passage of Koalas
Recovery plan for the Koala (*Phascolarctos cinereus*) (DECC, 2008b)	NSW statutory document	The objective of the Recovery Plan is "to reverse the decline of the Koala in NSW, to ensure adequate protection, management and restoration of Koala habitat, and to maintain healthy breeding populations of Koalas throughout their range." This document has been considered as a background document to help to identify key management considerations regarding the protection of Koalas. The Recovery Plan was originally intended to be implemented over a five-year period commencing in 2008 and reviewed at the conclusion of the five-year period. However, this review did not occur.
State Environmental Planning Policy (Koala Habitat Protection) 2019	NSW planning instrument	This SEPP replaces the long standing SEPP 44 (Koala Habitat Protection). It came into effect in March 2020. The aim of the SEPP is to "…encourage the conservation and management of areas of natural vegetation that provide habitat for Koalas to support a permanent free-living population over their present range and reverse the current trend of Koala population decline" The SEPP is supported by the Koala Habitat Protection Guideline (draft) which provides details around implementation. At the time of writing this report the guidelines were still in draft form and had not yet been finalised.

Document	Type	Description
Securing the Koala in the wild in NSW for 100 years: Saving Our Species Iconic Koala Project 2017-2021 (OEH, 2017g)	NSW funding program for threatened species	The Saving Our Species Iconic Koala Project (SOS Project) aims to secure the Koala in the wild in NSW for 100 years by reducing critical threats to the species, ensuring adequate protection, management and ecological restoration of Koala habitat, and maintaining healthy breeding populations of Koalas through their current range. The SOS Project aims to achieve these objectives through coordinating and funding a range of actions across NSW, including conservation, ecological restoration, research and strategic management actions. This assessment draws upon findings obtained through field surveys and associated research which have been funded and implemented by the SOS Project.
NSW Koala Strategy (OEH, 2018h)	NSW policy document	The NSW Koala Strategy aims to stabilise and increase Koala numbers over the long term, ensuring genetically diverse and viable populations across NSW. The Strategy provides additional resources to enable the completion of a range of actions to assist in conserving the Koala. It builds on the findings of, complements the works undertaken, as part of the SOS Project. This assessment draws upon findings obtained through research sponsored by the NSW Government’s investment in conserving Koala populations in the wild.
Draft Campbelltown Comprehensive Koala Plan of Management (Phillips & Biolink, 2016)	Campbelltown City Council planning document	This document is a draft planning document prepared in relation to SEPP 44. It has not been finalised but aims to provide a consistent, landscape-based approach to matters relating to how Koalas and their habitat are managed, and provides a strategic approach to protection, management and ecological restoration of Koala habitat throughout the Campbelltown City Council LGA.

30.4.5 SUMMARY OF BASELINE INFORMATION

There is a significant amount of information that was used in this assessment. Sources include:

- Literature on the ecology of Koalas
- Species records
- Cumberland subregion species distribution model
- Habitat mapping
- Connectivity analysis

Further details are provided at Attachments B and C.

LITERATURE ON THE ECOLOGY OF KOALAS

Literature on the ecology of Koalas was used to understand the broad context for the species, and the specific values and issues of the Koala populations. Information was gathered from academic publications, government research (e.g. information from the Saving our Species program), planning documents, and studies done specifically for this project.

The work had a particular focus on the Southern Sydney Koala population. For example, information about the population is available regarding:

- Koala home range sizes and densities (OEH, 2018d; Ward, 2002)
- Potential population size (Biolink, 2016; OEH, 2018d; Ward, 2002)
- Population trends (Biolink, 2016, 2018b)
- Preferred feed tree species (OEH, 2018d; Phillips & Callaghan, 2000; Sluiter, Close et al., 2002; Ward, 2002)
- Habitat connectivity requirements (Biolink, 2018a)
- Population genetics (Kjeldsen, Raadsma et al., 2019; Lee, Zenger et al., 2010)
- Key threats (Phillips & Biolink, 2016)

The available literature and resources provide a solid foundation with which to understand the key characteristics and conservation needs of the Koalas within (and near) to the Strategic Assessment Area.

SPECIES RECORDS

Koala records within and adjacent to the Strategic Assessment Area were accessed from the NSW BioNet Atlas database.

The BioNet Atlas contains species records within the Plan Area which were obtained during recent research conducted by the Saving Our Species program, and is considered a resource containing contemporary knowledge of Koala distributions within the area.

BioNet records were used in research to assess population trends (Biolink, 2016, 2018b) and identify Koala roadkill locations and hotspots (OEH, 2018d).

BioNet records have also been used to conduct Species Distribution Model mapping as part of the current assessment process (discussed below).

HABITAT MAPPING

Three types of Koala habitat mapping were prepared for this assessment. They are:

- A species distribution model
- Corridor mapping in a way that is consistent with EES work in the area (OEH, 2018d)
- Mapping of habitat critical to the survival of the species in accordance with the EPBC Act referral guidelines (DoE, 2014j)

See Attachment C for details of the mapping approaches.

Species distribution model

RMIT (see Supporting Document F) prepared a species distribution model (SDM) for the Koala across the Cumberland subregion. SDMs are statistical models used to estimate the relationship between species records at sites and the environmental and/or spatial characteristics of those sites. Once this relationship has been estimated, the model can be used to predict other locations in the landscape where a species is likely to occur. The model was developed using the software 'Maxent'.

The SDM provides useful context about the occurrence of the species within the Strategic Assessment Area. However, given the availability of more detailed habitat mapping (see below) it is not used for detailed analysis of impacts.

Corridor mapping

Corridor mapping was undertaken for each of the nominated areas, as well as areas within the vicinity of Wilton and GMAC for the Southern Sydney population. The process was based on work undertaken by EES (2018d). It mapped movement corridors and supporting habitat.

See Table 30-15 for categories within the mapping and definitions (further definitions are provided at Attachment A).

The NSW Threatened Biodiversity Data Collection requires the assessment of impacts on Koala to be determined on the basis of 'important habitat'. Important habitat comprises the species polygons for Koala as required by the BAM (see Part 5). For this BAM assessment, 'important habitat' was defined as primary and secondary corridors. Primary and secondary corridors provide stronger connections across Koala habitat than tertiary corridors and are therefore likely to provide the most important connections and contribute most to the long-term persistence of Koala in the region.

Table 30-15: Habitat definitions for Koala corridor mapping

Habitat category	Definition
Movement corridors	Areas of habitat (often but not always linear) which facilitate the movement and dispersal of Koalas between habitat patches which would otherwise be disconnected
Movement corridors are comprised of:	
• **Primary corridors**	Defined as connected areas of principal habitat (and associated supporting habitat) that provide for ecological function of a population
• **Secondary corridors**	Defined as corridor areas that become narrowed to less than 50 metres wide across the crown width, or that are not connected at both ends
• **Tertiary corridors**	Smaller corridor areas that are not connected at the landscape level
Supporting habitat	The remaining areas of suitable habitat and vegetation structure that are outside principal habitat. Comprises scattered trees peripheral to and outside of identified Koala movement corridors

Habitat critical to the survival

To provide additional information for the assessment, "habitat critical to the survival" of Koalas was mapped in accordance with the EPBC Act referral guidelines for the species (DoE, 2014j). The mapping process was based on scoring criteria and considered the following key parameters in determining the value of Koala habitat:

- Koala occurrence
- Vegetation composition
- Habitat connectivity
- Existing threats
- The value of the potentially impacted Koalas to the recovery of the wider Koala community

CONNECTIVITY ANALYSIS

In addition to habitat mapping, a connectivity analysis conducted by Biolink (2018a) was undertaken for the Southern Sydney population across Wilton and the southern portion of GMAC. The purpose of the assessment was to assess the current habitat connectivity of the area, and then model projected changes following development within the nominated areas and upgrading of Appin Road.

The analysis was undertaken using the modelling software GAPCLoSR.

30.4.6 OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

There are two known populations of Koalas that occur within or near to the Strategic Assessment Area. The most relevant to this assessment is the Southern Sydney population which occurs within and near to Wilton and GMAC. The other is the Blue Mountains population which has infrequent records in the western portion of the Strategic Assessment Area.

This section:

- Presents the results of the mapping for Koalas that has been undertaken across the Strategic Assessment Area
- Provides a high-level summary of each population

HABITAT IN THE STRATEGIC ASSESSMENT AREA

Table 30-16 presents the areas of habitat within the Strategic Assessment Area and the nominated areas using the three types of mapping. There are significant areas of important habitat (and habitat critical to the survival) within and around Wilton and GMAC. This reflects the fact that the area supports an important and recovering population of the species (see below for details about the Southern Sydney population). There is no important habitat (or habitat critical to the survival) for Koalas in GPEC or WSA. This reflects the lack of use of the area by the species and minimal records (see below for details about the Blue Mountains population).

Please refer to the following maps for information about habitat:

- Map 37 - Koala species distribution model with records
- Map 38 - Koala corridor mapping for WSA and GPEC
- Map 39 - Koala corridor mapping for Wilton and GMAC
- Map 40 - Habitat critical to the survival for Wilton and GMAC

Table 30-16: Habitat for Koalas in the Strategic Assessment Area

OCCURRENCE	SAA TOTAL (Ha)	WILTON (Ha)	GMAC (Ha)	GPEC (Ha)	WSA (Ha)	NOMINATED AREAS TOTAL (Ha)
SPECIES DISTRIBUTION MODEL						
LIKELY HABITAT	3,269.5	176.8	1,348.1	0.0	0.0	1,524.9
POTENTIAL HABITAT	17,787.1	1,954.0	2,905.7	0.1	24.2	4,884.0
SDM TOTAL	**21,056.6**	**2,130.8**	**4,253.8**	**0.1**	**24.2**	**6,408.9**
CORRIDORS						
PRIMARY CORRIDORS	11,998.9	1,529.3	1,202.3	0.0	0.0	2,731.6
SECONDARY CORRIDORS	2,433.2	0.0	1,165.8	0.0	0.0	1,165.8
IMPORTANT HABITAT SUBTOTAL*	**14,432.1**	**1,529.3**	**2,368.2**	**0.0**	**0.0**	**3,897.4**
TERTIARY CORRIDORS	724.3	85.8	56.7	0.0	0.0	142.5
SUPPORTING HABITAT	4,895.7	75.5	562.4	3,226.2	803.4	4,667.6
CORRIDOR TOTAL	**20,052.2**	**1,690.7**	**2,987.2**	**3,226.2**	**803.4**	**8,707.6**

OCCURRENCE	SAA TOTAL (Ha)	WILTON (Ha)	GMAC (Ha)	GPEC (Ha)	WSA (Ha)	NOMINATED AREAS TOTAL (Ha)
HABITAT CRITICAL						
HABITAT CRITICAL TOTAL	14,718.8	1,633.4	2,513.6	0.0	0.0	4,147.0

* Important habitat comprises primary and secondary corridors

SOUTHERN SYDNEY POPULATION

Overview

The Southern Sydney population includes Koalas in the Campbelltown and Wollondilly Local Government Areas. The population is important and thought to be in recovery.

The exact boundaries of the population are unknown. However, it is likely that it extends:

- East to the coast
- South from Holsworthy until it connects with the Koalas in the Southern Highlands
- An unknown distance to the west. It is unclear whether or not the Hume Highway poses a significant barrier to movement

In this report, the population is assessed in the areas between Campbelltown and Bargo (see Map 39 and Map 40 for the mapped extent of habitat). It is estimated that there were approximately 433 Koalas living in this region prior to the 2019-20 fires (OEH, 2018d). The majority of the area was not affected by fire. However, some vegetation within the vicinity of Bargo and Tahmoor was burnt (DPIE, 2020).

The Southern Sydney Koalas prefer habitat on Wianamatta shale soils (due to the high nutrient content of the shale). As these soils are fertile, much of the area has been heavily cleared for agriculture and associated development. This makes remaining areas of vegetation on Wianamatta shale soils a high conservation priority. While Koalas will live in low densities in forests in sandstone areas (e.g. to the east of the Strategic Assessment Area), these areas are considered to be not as important for conservation.

Historically, Koalas in the Campbelltown area have remained free from infection with *Chlamydia.* However, recent research is showing that the disease is moving north from the Southern Highlands towards Campbelltown (Saving Our Species, 2019). This is likely to be a result of increased connectivity between Koalas in these areas.

The Southern Sydney Koalas are exposed to a range of current threats. They include:

- Vehicle strike. This is particularly relevant to major roads in the area and is an increasing issue as traffic volumes increase
- Dog predation. There are a range of existing developed areas and Koalas would be subject to dog attack (particularly where habitat occurs close to houses)
- Disease (particularly *Chlamydia*). This is an emerging issue. The Koalas around Campbelltown have been recognised as disease free. However, Koalas further to the south have been recorded with the disease

See Attachment B for more detail on the population, and the indirect impacts section below for further discussion about threats.

Habitat and connectivity

There are significant areas of important habitat within the area between Campbelltown and Bargo (see Map 39). This includes approximately 12,000 ha of primary corridors, and 2,433 ha of secondary corridors. As a subset of this, the two nominated areas provide approximately:

- 1,529 ha of primary corridors in Wilton. There is no secondary corridor habitat
- 1,202 ha of primary corridors, and 1,166 ha of secondary corridors in GMAC

Koala populations rely upon habitat connectivity in order to be viable. Habitat connectivity permits the dispersal of individuals (particularly for the dispersal of young Koalas to new territories and for reproduction during breeding season) and also helps to protect Koala populations from localised extinctions following stochastic events such as fire.

The work by EES (2018d) on corridor mapping emphasised the importance of north to south corridors (particularly to the east of Campbelltown and Appin) for the viability of the population. It also identified the areas of east to west connectivity.

Connectivity analysis conducted by Biolink (2018a) supported the importance of north-south connectivity for Koalas through the area. It also emphasised the importance of east-west connection, and analysed the relative importance of east-west corridors which varied according to factors such as their existing width and barriers to movement.

Further discussion about connectivity is provided below in the section on indirect impacts.

BLUE MOUNTAINS POPULATION

Overview

The Blue Mountains Koala population is the closest population to the northern and western parts of the Cumberland subregion. The majority of the population occurs outside the Strategic Assessment Area.

There is less known about the population compared to the Koalas in Southern Sydney. Most of the research on these Koalas has occurred in the Kurrajong/Richmond/Wollemi area and Kanangra-Boyd/Hartley region. Preliminary surveys have also recently begun in the area between Yarramundi in the north and the Southern Highlands in the south.

The population is known to occur from the north of Kurrajong, and is thought to extend down through national parks to the west of the Cumberland subregion. It has high genetic diversity and is important for conservation purposes. However, it is uncertain how many Koalas are in the Blue Mountains. Increased sightings suggest that the population is expanding. This expansion is occurring even though up to one third of the population is infected with *Chlamydia*.

Significant areas of vegetation within the Blue Mountains were burnt in the 2019-20 fires (DPIE, 2020). It is unknown what the long-term implications of this are for the population.

Presence in the nominated areas

GPEC and WSA are heavily cleared and urbanised. Neither nominated area has any important Koala habitat, with only small areas of supporting habitat. Further, both nominated areas have significant existing threats to Koalas, including threats posed by roads and high traffic density, roaming and domestic dogs, barriers to movement (such as fences) and landscape hazards (such as swimming pools). There are very few Koala records in either nominated area, which suggests that Koalas are not living there.

Overall, GPEC and WSA do not contain suitable habitat to support resident Koala populations. Therefore, any Koala records in these areas would comprise dispersing Koalas, travelling between areas of suitable habitat. These Koalas are thought to originate from the Blue Mountains Koala population, which is the closest Koala population.

30.4.7 AVOIDANCE

CONTEXT

Avoidance of impacts within the nominated areas was a key process in developing the Plan. Chapter 14 of the assessment report describes this process in detail and provides the overall results.

Design of the urban capable footprints in each nominated area was an iterative process that involved:

- Compilation of data on biodiversity values of each nominated area
- Development of criteria to identify priorities for avoidance of biodiversity values
- Workshops to apply the avoidance criteria to each nominated area and refine urban capable footprints
- Consultation with key stakeholders and resolution of issues
- Finalisation of initial urban capable footprints

Importantly for Koala, the species was specifically identified in the avoidance criteria as a priority. Avoiding areas of important habitat or connectivity was a key driver for refining the footprints to reduce impacts. One of the significant results of the avoidance process was the decision by the Department not to allow intensification of development to the east of Appin Road (which was proposed at one point in the process). This decision was specifically made to protect Koalas and facilitate implementation of the proposed Koala park (see Section 30.4.9).

Two types of avoidance were undertaken (see Chapter 14 of the report for details):

- Avoidance of land because of its biodiversity value
- Avoidance of land for other reasons. For example, land that is not suitable for development such as steep slopes (>18 degrees) or land within riparian corridors (Strahler stream order 2 and above). Due to the nature of this land the areas identified for avoidance often contain areas of biodiversity value

Information is reported for both types of avoidance.

It is important to note that there are a range of lands which were excluded from the avoidance calculations as they were not considered for certification as part of this project. This means that there is additional habitat for Koalas that may not be impacted that is not included in the avoidance figures. The excluded lands include areas:

- Already assessed as part of another development approval (e.g. Bingara Gorge in Wilton)
- Progressing through an alternate development assessment (e.g. Mount Gilead in GMAC)
- Already developed (e.g. existing urban areas, urban land zones)
- Not available for development (e.g. easements, Orchard Hills Defence Establishment, existing protected lands)

RESULTS

The results of the avoidance processes for Koala habitat are presented in Table 30-17. Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

Approximately 2,865 ha of important Koala habitat (primary and secondary corridors) was avoided within the nominated areas as part of the urban capable footprint design. This represents approximately 92 per cent of important habitat within the nominated areas (not including excluded lands). 2,182 ha of was avoided for biodiversity purposes.

In terms of habitat critical to the survival of Koalas, approximately 2,961 ha (approximately 90 per cent of the nominated areas total not including excluded lands) was avoided. 2,257 ha of this was avoided for biodiversity purposes.

Table 30-17: Avoidance of Koala habitat across all nominated areas

AVOIDANCE ACROSS ALL NOMINATED AREAS	HABITAT WITHOUT EXCLUDED LANDS	HABITAT AVOIDED FOR BIODIVERSITY PURPOSES		HABITAT AVOIDED FOR OTHER REASONS		TOTAL AVOIDANCE	
	AREA (ha)	AREA (ha)	% HABITAT WITHOUT EXC. LANDS	AREA (ha)	% HABITAT WITHOUT EXC. LANDS	AREA (ha)	% HABITAT WITHOUT EXC. LANDS
CORRIDORS							
PRIMARY CORRIDORS	2,288.2	1,618.3	70.7%	525.7	23.0%	2,144.0	93.7%
SECONDARY CORRIDORS	837.7	564.6	67.4%	156.7	18.7%	721.3	86.1%
IMPORTANT HABITAT SUBTOTAL*	**3,125.9**	**2,182.9**	**69.8%**	**682.4**	**21.8%**	**2,865.3**	**91.7%**
TERTIARY CORRIDORS	79.5	51.8	65.2%	10.2	12.9%	62.1	78.1%
SUPPORTING HABITAT	1,385.4	359.4	25.9%	226.3	16.3%	585.7	42.3%
CORRIDOR TOTAL	**4,590.8**	**2,594.2**	**56.5%**	**918.9**	**20.0%**	**3,513.1**	**76.5%**

AVOIDANCE ACROSS ALL NOMINATED AREAS	HABITAT WITHOUT EXCLUDED LANDS	HABITAT AVOIDED FOR BIODIVERSITY PURPOSES		HABITAT AVOIDED FOR OTHER REASONS		TOTAL AVOIDANCE	
	AREA (ha)	AREA (ha)	% HABITAT WITHOUT EXC. LANDS	AREA (ha)	% HABITAT WITHOUT EXC. LANDS	AREA (ha)	% HABITAT WITHOUT EXC. LANDS
HABITAT CRITICAL							
HABITAT CRITICAL TOTAL	3,297.7	2,257.4	68.5%	703.1	21.3%	2,960.5	89.8%

* Important habitat comprises primary and secondary corridors

30.4.8 IMPACT ANALYSIS

The plan will lead to direct and indirect impacts to Koalas. These are addressed in the following sections.

The potential for additional impacts due to essential infrastructure and tunnels are also discussed.

DIRECT IMPACTS

Implementation of the Plan will lead to the loss of some habitat for Koalas. Table 30-18 sets out the impacts to habitat across the four nominated areas.

GPEC and WSA

There is no important habitat (or habitat critical to the survival) within GPEC and WSA. Impacts are therefore limited to supporting habitat.

In GPEC, development will result in the loss of approximately 331 ha of supporting habitat, or 10.3 per cent of the total in the nominated area. In WSA, development will result in the loss of approximately 329 ha of supporting habitat, or 41.0 per cent of the total in the nominated area.

There are very limited to no records of the species in either nominated area, and they do not support a viable population of the species. The impacts to supporting habitat are not considered to be notable for Koalas in this context.

Wilton and GMAC

Impacts in Wilton and GMAC occur for all habitat types. Approximately 261 ha of important habitat (144 ha of primary and 116 ha of secondary corridors) will be lost across the two nominated areas. This equates to:

- 5.3 per cent of primary corridors within the two nominated areas (including excluded lands) (or 1.2 per cent of mapped primary corridors for the Southern Sydney population)
- 10 per cent of secondary corridors within the two nominated areas (or 4.8 per cent of mapped secondary corridors for the Southern Sydney population)

In terms of habitat critical to the survival of Koalas, approximately 337 ha will be lost which equates to 8.1 per cent within the two nominated areas (or 2.29 per cent of mapped habitat critical to the survival for the Southern Sydney population).

There will also be additional impacts to tertiary corridors (17 ha) and supporting habitat (139 ha).

Direct impacts to primary corridors are the most significant as these corridors provide for ecological function of the population. Impacts to secondary corridors are also of concern as they have the potential to play a supporting role within the landscape. However secondary corridors are considered less important because they:

- Have narrow points (less than 50 m wide) which can create bottlenecks for movement and expose Koalas to greater edge effects, or
- Are not connected at both ends which means they lack important landscape function at the population level

Impacts to tertiary corridors and supporting habitat are less significant from a landscape perspective given they represent smaller, poorly connected, and lower quality habitats.

Table 30-18: Impacts to Koala habitat across the nominated areas

DIRECT IMPACTS TO HABITAT	WILTON		GMAC		WSA		GPEC		TOTAL	
	AREA (ha)	PERCENTAGE of NOMINATED AREA TOTAL (%)	AREA (ha)	PERCENTAGE of NOMINATED AREA TOTAL (%)	AREA (ha)	PERCENTAGE of NOMINATED AREA TOTAL (%)	AREA (ha)	PERCENTAGE of NOMINATED AREA TOTAL (%)	AREA (ha)	PERCENTAGE of NOMINATED AREA TOTAL (%)
CORRIDORS										
PRIMARY CORRIDORS	116.7	7.6%	27.5	2.3%	0.0	N/A	0.0	N/A	144.2	5.3%
SECONDARY CORRIDORS	0.0	N/A	116.4	10.0%	0.0	N/A	0.0	N/A	116.4	10.0%
IMPORTANT HABITAT SUBTOTAL*	**116.7**	**7.6%**	**143.9**	**6.1%**	**0.0**	**N/A**	0.0	N/A	**260.6**	**6.7%**
TERTIARY CORRIDORS	5.3	6.1%	12.1	21.4%	0.0	N/A	0.0	N/A	17.4	12.2%
SUPPORTING HABITAT	41.7	55.3%	97.5	17.3%	329.2	41.0%	331.4	10.3%	799.7	17.1%
CORRIDOR TOTAL	**163.7**	**9.7%**	**253.5**	**8.5%**	**329.2**	**41.0%**	331.4	10.3%	**817.1**	**9.4%**
HABITAT CRITICAL										
HABITAT CRITICAL TOTAL	**137.8**	**8.4%**	**199.5**	**7.9%**	**0.0**	**N/A**	0.0	N/A	**337.2**	**8.1%**

* Important habitat comprises primary and secondary corridors

INDIRECT IMPACTS

The following potential indirect impacts have been identified in relation to Koalas:

- Vehicle strike
- Effects of urban development
- Disruption of connectivity
- Fire
- Disease (Chlamydiosis caused by infection with *Chlamydia*)

These impacts reflect the range of activities associated with implementation of the Plan when considered against the known threats to the species.

Given that GPEC and WSA do not support Koalas, the focus of this section is the Southern Sydney population within the vicinity of Wilton and GMAC.

Vehicle strike

Description

Vehicle strike refers to the collision of road-based vehicles (such as cars) and Koalas, and can result in the injury or death of the animal. Vehicle strike occurs when Koalas attempt to cross roads, and motorists are unable to avoid them.

Koalas are at risk from vehicle strike due to multiple factors:

- Koalas do not recognise roads and traffic as a potential threat and therefore are likely to cross roads even in dangerous environments
- Koalas are a highly mobile species prone to dispersal, increasing the likelihood of them crossing barriers in search of areas of new habitat
- Koalas are largely nocturnal, which decreases their visibility to motorists whilst crossing roads

Vehicle strikes are most likely to occur where busy roads cut through areas of Koala habitat, as Koalas will attempt to cross the road to reach habitat present on the other side of the road. Increased roadkill is associated with increased human population densities.

Current context

There are a number of major roads which occur within or adjacent to habitat areas occupied by the Southern Sydney Koala population. Vehicle strikes are increasingly common on these roads.

The distribution of Koala roadkill records is shown in Map 41. It is recognised that the total number of Koalas killed by vehicle strike is likely to be higher than the number of records, as not every incident would have been recorded.

Analysis of roadkill records shows that the rate has increased over the last few years, and that this increase has corresponded with increasing traffic densities in the region (OEH, 2018d). Roadkill hotspots were recognised to occur where greater than four Koalas are killed within a 2 km stretch of road. They are located in the following places (OEH, 2018d):

- Picton Road between Cordeaux Dam and Wilton
- Macarthur Drive
- Eastern end of Wilton Road
- Appin Road between Appin and Campbelltown
- Hume Highway at the Bargo exit

Transport for NSW (TfNSW) are currently proposing to upgrade a section of Appin Road from Mount Gilead in the south, and the intersection of St Johns Road, Ambarvale in the north (Roads and Maritime Services, 2018). This area occurs partly within and outside of GMAC and comprises one of the Koala roadkill hotspots (between Appin and Campbelltown). As part of this project, TfNSW are proposing to install Koala exclusion fencing on the eastern side of the road (from opposite Noorumba Reserve in the north to the southern end of the upgrade) and fauna fencing along the western side where it intersects with habitat with the aim of reducing fauna mortality. TfNSW are also undertaking targeted safety improvements to parts of Appin Road between Mt Gilead and Brian Road just north of Appin to improve safety for residents, motorists and freight operators, as well as create further traffic efficiencies. This project will also involve installation of fauna fencing on the eastern side and western sides of Appin Road where habitat is present.

How might development under the Plan contribute to vehicle strike?

The Plan will result in significant areas of new development. This will include roads within the nominated areas and broader transport corridors (noting the latter generally occur away from Koala habitat). The increasing population in the vicinity of the Southern Sydney population will:

- Lead to substantial increases in the number of vehicles
- Require road upgrades to a range of roads that are not directly part of the Plan

Without mitigation, the risk of vehicle strike to Koalas will increase substantially as development proceeds. The Plan includes measures to address this risk which are outlined below in Section 30.4.9 and evaluated in Section 30.4.10.

Effects of urban development

Description

Urban development in proximity to Koala habitat poses a number of threats to Koalas. These threats can impact dispersing Koalas which travel through urban areas, in addition to locally resident Koalas which live nearby. Threats include:

- Increased Koala predation by domestic and roaming dogs. This threat occurs both within urban areas (in which dispersing Koalas are at risk), and in bushland adjacent to urban areas (in which locally resident Koalas are at risk)
- Increased landscape hazards such as swimming pools (in which Koalas may become trapped and drown). This threat poses a risk to dispersing Koalas travelling through urban areas
- Habitat degradation due to increased edge effects from land clearing and increased risk of disturbance (e.g. slashing, pollution, illegal dumping). This threat may reduce habitat quality and poses a risk to locally resident Koalas

Current context

The vegetation in the western boundary of the Southern Sydney Koala population has been extensively cleared, for urban development in the north and primarily for agricultural development in the south. Whilst there is limited information available regarding mortality rates, it is likely that the northern Koalas would be under greater pressure from proximity to urban development than Koalas further to the south.

The draft Comprehensive Koala Plan of Management for Campbelltown City Council (Phillips & Biolink, 2016) recognises that urban development poses a significant risk to the local Koala population. The Plan of Management recommends a series of controls (such as urban fencing to control dogs, and pool design standards to minimise the risk of Koalas becoming trapped) to reduce pressure on the local Koala population. It is unclear the extent to which these recommendations have been implemented on the ground.

How might development under the Plan contribute to the effects of urban development?

The Plan will facilitate large scale urban expansion within the nominated areas. Without mitigation, the risk to Koalas associated with urban areas will increase substantially as development proceeds. The Plan includes measures to address this risk which are outlined below in Section 30.4.9 and evaluated in Section 30.4.10.

Disruption of connectivity

Description

Habitat connectivity refers to the degree of connectedness of areas of habitat. Koalas travel through the landscape primarily through wooded areas, spending large amounts of time in trees. Whilst Koalas will descend to the ground level to move between trees, the time they spend on the ground tends to be limited as they are more exposed to predation on the ground.

Well-connected areas of habitat constitute wooded areas to permit the safe passage of Koalas, preferably with feed trees present to meet the physiological needs of the animal. Whilst Koalas are known to move through large distances of open areas, extended travel on the ground increases the risk of exposure to predation. Large open areas are therefore not considered to be suitable habitat to enable safe movement of Koalas.

Greater habitat connectivity allows for unimpeded movement of Koalas, which enables:

- Safe dispersal of juvenile Koalas searching for territory
- Movement of Koalas during the breeding season throughout the landscape, which increases the probability of Koalas successfully finding suitable mates and decreases the risk of inbreeding
- Areas of suitable habitat to be easily accessed
- Escape routes for Koalas in the event of stochastic threats such as bushfire

Habitat connectivity becomes disrupted when barriers to movement are introduced in the landscape. Common examples of movement barriers include cleared areas, busy roads and fences.

Habitat corridors are areas of connectivity which link two or more areas of habitat which would otherwise be separated by barriers. The characteristics of habitat corridors influence the usefulness of the corridor for Koala movements. Thinner corridors have greater exposure to habitat degradation from edge effects and increase the threat of predation by forcing all Koalas to travel through bottleneck points. Corridors with gaps of open space within them also force Koalas to increase the time spent on the ground, which increases vulnerability to predation. Wide, continuous corridors have lesser impacts from edge effects and provide for greater protection of wildlife from predators.

Current context

Disruption of habitat connectivity is an existing threat for Koalas within Wilton and GMAC. Significant areas of land within both nominated areas have already been cleared and there are a number of barriers to movement (e.g. roads). Remaining habitat patches are linked by habitat corridors with varying degrees of connectivity.

As outlined previously, corridor mapping was undertaken in accordance with mapping carried out by EES (2018d). It shows the location and relative importance of Koala habitat corridors in Wilton and GMAC.

Of the corridors that were identified, primary corridors are the most well-connected and important. They are considered important for maintaining the viability of the population. Secondary corridors still provide connectivity, yet are narrow or discontinuous and so are not as important as primary corridors. Tertiary corridors and supporting habitat do not constitute important habitat for landscape connectivity. A more detailed overview of corridor mapping is provided in Section 30.4.5 and in Attachment C.

Map 42 indicates the distribution and location of key habitat corridors within Wilton and southern GMAC. Map 42 shows that primary habitat corridors provide for:

- North-south movements to the east of GMAC
- North-south movements along the Nepean River to the west of GMAC
- North-south and east-west movements through Wilton

Map 42 also shows that east-west movement across GMAC is mostly provided by secondary corridors, interspersed with small areas of supporting and tertiary habitat. The secondary corridors through GMAC connect primary habitat of the Nepean River in the west with the primary habitat associated with the Georges River in the east. These corridors are named as follows:

- Noorumba
- Woodhouse – Menangle
- Mallaty
- Ousedale
- Simpsons - Elladale

The connectivity analysis undertaken by Biolink (2018a) considered how easily Koalas could traverse different landscape types, and then modelled the locations and importance of different habitat corridors in southern GMAC and Wilton. The key findings of the report are as follows:

- North-south connectivity provided by intact habitat to the east of GMAC and Wilton is the most important area of connectivity for the local Koala population
- The Woodhouse – Menangle (referred to as Beulah in the GAPCLoSR report) and Ousedale corridors are recognised as being important for providing east-west connectivity across the southern half of GMAC
- Habitat corridors through Douglas Park (between the Wilton and GMAC nominated area boundaries) are of high importance for habitat connectivity

How might development under the Plan contribute to the disruption of connectivity?

Proposed development under the Plan will not result in the loss of primary or secondary habitat corridors through Wilton or GMAC due to land clearing. However, habitat connectivity has the potential to be impacted through:

- Increased threats posed by the effects of urban development
- Increased risk of vehicle strike
- Additional development concurrent to the Plan, such as the proposed installation of wildlife fencing along Appin Road to decrease the risk of vehicle strike (RMS, 2018)

Proposed measures to mitigate potential impacts to connectivity are outlined in Section 30.4.9 and evaluated in Section 30.4.10.

Fire

Description

Fire poses a threat to Koalas through direct mortality from exposure to fire events, and from starvation due to food shortages immediately following fire events.

The fires which pose the most risk to Koalas are high intensity fires which burn the crowns of trees. The intensity of fire events is impacted by available fuel loads, which are influenced by the length of time between fires, and whether fuel management activities (such as slashing) are carried out.

Fires may be caused by natural (such as lightning strikes) and unnatural (such as cigarette butts, campfires or arson) ignitions. Increased proximity of Koala habitat to developed areas increases the likelihood of more frequent fire events due to an increase in exposure to ignition sources.

The risks posed by fire events to Koalas are significantly increased by habitat fragmentation. Connectivity is required to allow:

- Koalas to escape fire events by moving to areas free from fire until the event has passed
- Koalas to re-colonise habitat following a fire event which may have caused a localised extinction within the area

Current context

The Southern Sydney Koala population occurs in extensive areas of bushland, which spans from Holsworthy in the north down to the Southern Highlands, and east to the coast.

Fire management activities occur in various locations within and on the edges of this bushland, which are conducted by various agencies including the NSW National Parks and Wildlife Service and the Rural Fire Service. However, large areas of bushland remain inaccessible, which limits the capacity for fire management and control. As the forested areas are well connected, there is significant potential for fires to easily grow and spread throughout this region.

The 2019-20 bushfires across NSW provide a clear indication that bushfire is an existing and potentially significant threat to the Southern Sydney Koala population.

Habitat connectivity is important for Koala conservation in Wilton and GMAC, to enable Koalas to access escape routes in the event of fire. Habitat corridors through otherwise cleared areas (such as those within and adjacent to Wilton and GMAC) are also important as such areas can serve as refuge sites for wildlife in the event of a bushfire, because such sites can be more easily protected from fire.

How might development under the Plan contribute to the risks of fire?

The Plan will result in significant urban development, which will increase the exposure of Koala habitat to anthropogenic fire sources. This may increase the frequency of fires occurring within Koala habitat and may result in negative impacts to the species without appropriate mitigation measures. The Plan proposes mitigation measures to manage these risks. These are outlined in Section 30.4.9 and evaluated in Section 30.4.10.

Disease (Chlamydiosis caused by infection with *Chlamydia*)

Description

Chlamydia is a bacterium which has a high infection rate in many Koala populations. However, infection with *Chlamydia* does not always lead to the development of disease symptoms. Some Koalas infected with *Chlamydia* will continue to present and act as healthy Koalas, whereas other Koalas will develop disease symptoms as a result of the infection (known as Chlamydiosis). The reasons why disease develops in some situations yet not in others is still being understood.

Chlamydiosis is a serious disease which results in a range of symptoms and can result in Koala infertility and death. McAlpine et al. (2017) found that proximity to urban development increases the risk that Koalas infected with *Chlamydia* will develop Chlamydiosis. It is thought that increased exposure to environmental pressures results in poorer body condition and weakened immune responses, which increases vulnerability to the disease.

Urban development has the potential to increase the severity of the threat posed by *Chlamydia* to Koala populations, by increasing the occurrence of clinical disease symptoms and therefore increasing infertility and mortality rates of Koalas due to *Chlamydia*.

Current context - Wilton and GMAC

To date, Koalas in the Campbelltown area are thought to be free of infection with *Chlamydia,* whilst Koalas in the Southern Highlands are known to have high rates of infection. Recent research conducted by Saving Our Species (2019) suggests that *Chlamydia* infection is moving northward from the Southern Highlands towards the Campbelltown locality.

It is unknown how Koalas within the Campbelltown locality will respond to infection with *Chlamydia.* There is potential for there to be significant rates of disease development, as:

- The Koalas in this locality have not previously been exposed to *Chlamydia* and therefore may not have resistance to the infection
- The strains of *Chlamydia* in the Southern Highlands are known to be virulent

Overall, infection with *Chlamydia* and the development of Chlamydiosis is considered to be an emerging threat which is likely to place greater pressures on the Southern Sydney Koala population over the next few years.

How might development under the Plan contribute to the risk of disease?

The Plan will introduce a range of pressures associated with urban development to the Koala population of Wilton and GMAC, which increases the susceptibility of Koalas in these localities to developing Chlamydiosis. A range of mitigation measures are recommended to minimise the pressures placed by urban development on Koala populations (as outlined above), in addition to specific measures associated with the monitoring and management of disease. Proposed measures are outlined in Section 30.4.9 and evaluated in Section 30.4.10.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to Koalas from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels

- Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)

Potential impacts from essential infrastructure

In addition to predicted impacts due to urban development, there is the potential for impacts to Koala habitat to occur due to development of essential infrastructure within nominated areas but outside the urban capable lands.

Significant areas of important Koala habitat occur on avoided lands within Wilton and GMAC, but not WSA or GPEC. It is possible that some of this habitat on avoided land within Wilton and GMAC will be impacted by essential infrastructure.

As outlined in Chapter 37, any proposed essential infrastructure developments on avoided lands in the nominated areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values that are present
- Measures to avoid impacts to Koalas through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

The Plan includes two commitments that will limit the potential impacts to Koala habitat from essential infrastructure:

- The first (Commitment 2.4) requires that avoidance of impacts to important Koala corridors within Wilton and GMAC be prioritised in order to maintain their integrity
- The second (Commitment 2.3) relates to the EPBC Act listed TEC Shale Sandstone Transition Forest in the Sydney Basin Bioregion. This TEC occurs extensively on avoided lands in Wilton and GMAC and provides large parts of the important habitat for Koalas. The commitment limits the potential impacts to the TEC to a cumulative maximum over the life of the Plan to no more than 20 ha in Wilton and 20 ha in GMAC

Based on the application of these commitments and the overall requirements of the BAM process, impacts from essential infrastructure are not considered likely to substantially effect the scale, condition or functionality of Koala habitat within Wilton or GMAC. See Section 37.6 in Chapter 37 for more details.

Potential impacts from tunnels

Koala habitat does not occur within the vicinity of the tunnel footprints for transport and is therefore not at risk of additional impacts from tunnels.

30.4.9 OUTCOMES, COMMITMENTS AND ACTIONS TO PROTECT KOALAS

OUTCOMES

The Plan sets out a number of outcomes for biodiversity which are designed to be a "reported or measurable result of the desired goal of the Plan". The outcome for Koalas is contained within overall outcomes for threatened species which is:

> *Populations of targeted threatened species persist and the condition of suitable habitat improves within areas in the Cumberland subregion most likely to support long-term viability*

COMMITMENTS AND ACTIONS

The Plan then provides a series of commitments and actions to deliver the outcome for Koalas (see Table 30-19). These are set out in Sub-Plan B: Koalas which outlines how Koalas and their habitat will be protected and as part of the Plan's conservation program.

In summary, the Plan aims to:

- Mitigate indirect and prescribed impacts from urban, transport and agricultural development on biodiversity values. This includes:

- A number of general actions to mitigate impacts such as the application of development controls to ensure measures to address indirect impacts are applied
- A number of Koala specific actions such as:
  - Installing Koala-exclusion fencing between important Koala habitat and certified urban capable land within GMAC and Wilton
  - In areas where exclusion fencing is not feasible, applying mitigation actions 60 m from the Koala habitat. These actions include implementing controls from the Koala Habitat Protection Guidelines (linked to the new Koala SEPP) and including design requirements in relevant development control plan
  - Establishing an expert working group to provide input on managing Koalas as development proceeds

- Secure and protect habitat and corridors for the species. This includes establishing a new Koala reserve (the Georges River Koala Reserve) to protect north-south movement on the eastern side of Appin Road
- Implement a number of other actions to improve knowledge about Koalas, build awareness in the community, and support ecological restoration measures

Early in the proposed implementation phase of the Plan, the NSW Government has committed $63 million in the first three years. This includes:

- Funding to plant 100,000 trees as part of ecological restoration of Koala habitat including within the Georges River Koala Reserve
- 120 km of Koala exclusion fencing within Wilton and GMAC to protect Koalas from increasing threats such as vehicle strike and dog attacks

Table 30-19: Commitments for Koalas (taken from Sub-Plan B)

COMMITMENTS	ACTIONS
CONSERVATION PROGRAM	
Mitigate indirect and prescribed impacts	
Commitment 7 Mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on the Southern Sydney Koala population to best practice standards and in line with the Chief Scientist Koala Report	1. Install Koala-exclusion fencing between important Koala habitat and certified urban capable land within GMAC and Wilton as identified in Sub-Plan B except where exclusion fencing is not feasible due to slope, heritage or water courses. 2. Ensure all Koala-exclusion fencing is at least 3 metres from Koala habitat trees. 3. In areas where exclusion fencing is not feasible, apply mitigation actions 60 metres from the Koala habitat. These actions include implementing controls from the Koala Habitat Protection Guidelines and including design requirements in relevant development control plans. Specific locations are identified in Sub-Plan B. 4. Install Koala-exclusion fencing on both sides of Appin Road between Rosemeadow and Appin to mitigate Koala vehicle strikes at roadkill hotspots. 5. Where fencing must cross existing or planned linear infrastructure such as gas and electricity transmission, consider appropriate access treatments such as gates to ensure the integrity of the Koala-exclusion fencing. 6. Establish a Koala working group including Koala experts and relevant government agencies to determine priorities for Koala conservation consistent with the objectives of the NSW Koala Strategy
Conserve flora, fauna and habitat	
Commitment 10 Establish a reserve to protect the north-south Koala movement corridor along the Georges River between Appin and Kentlyn.	1. Protect up to 700 hectares of land between Appin and Kentlyn that is currently in ownership of NSW Government as the first stage in establishing the Georges River Koala Reserve. 2. Protect an additional 430 hectares of land between Appin and Kentlyn through the acquisition of land for the Georges River Koala Reserve. 3. Gazette the preliminary stages of the Georges River Koala Reserve as a conservation reserve under the management of National Parks and Wildlife Service. 4. Protect up to 755 hectares of land between Kentlyn and Long Point as future additions to the Georges River Koala reserve. 5. Restore up to 200 hectares of cleared land within the Georges River Koala reserve to strengthen the north-south Koala movement corridor.

COMMITMENTS	ACTIONS
Commitment 12 Secure priority habitat corridors in the Cumberland subregion in perpetuity, to support connectivity for ecological communities and species	1. Undertake ground-truthing within the strategic conservation area to confirm native vegetation extent and condition in areas identified as potential habitat corridors. 2. Secure priority habitat and Koala movement corridors in accordance with the Conservation Lands Implementation Strategy to protect habitat corridors in the Cumberland subregion. 3. Protect avoided Koala habitat through environmental conservation zoning in potential east-west Koala movement corridors between the Georges River and the Nepean River. 4. Through restoration, ensure at least one north-south corridor (the Georges River Koala Reserve) and one east-west corridor are each at least 390 m wide, for Koala viability and movement. 5. Facilitate Koala movement for at least one east-west corridor by constructing a Koala crossing at Appin Road. 6. Construct a Koala passage under Kings Fall Bridge to support north-south Koala movement from the Georges River Koala Reserve to the southern Koala habitat.
Commitment 13 Undertake ecological restoration of up to 25% of the Plan's offset target for native vegetation (Commitment 8) in areas secured for conservation within the Cumberland subregion	4. Plant around 100,000 trees to restore important Koala habitat in o Georges River Koala Reserve o along Ousedale Creek o around Appin o other priority locations in the strategic conservation area. The restoration of important Koala habitat will primarily include the restoration of Cumberland Plain Woodland and Shale/Sandstone Transition Forest.
BUILD KNOWLEDGE AND CAPACITY	
Commitment 21 Provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation including Koala conservation	7. Invest in the *NSW Koala Strategy* (hyperlink) to raise awareness of the Southern Sydney Koala population and encourage community participation in Koala conservation in Western Sydney, consistent with the Plan's education and engagement program.
Commitment 24 Invest in research that will help to secure threatened species and increase understanding of threats and land management issues.	4. Implement the research program with key outcomes including: o research that increases knowledge of population demographics, life-history and ecology of the Southern Sydney Koala population, as part of the *NSW Koala Strategy Research Plan*

COMMITMENTS	ACTIONS
Commitment 25 Support rehabilitation measures to help maintain Koala health and welfare.	1. Invest in the *NSW Koala Strategy* and other potential partners to implement the Koala health and welfare program in South Western Sydney with key deliverables including: o monitoring of Koalas including key threats and effectiveness of mitigation measures as part of the *NSW Koala Strategy Monitoring Framework* o providing enhanced training in wildlife treatment for veterinarians o providing grants for community wildlife organisations for resources and carer recruitment and training o establishing health and welfare programs to support Koalas from threats including vehicle strike, fire, disease and climate change.

STRATEGIC CONSERVATION AREAS

As part of delivering commitments to protect and restore land, the Plan is focusing its efforts into the SCAs. The method for defining these areas is described in Section 8.5 of Chapter 8.

The SCAs (see Map 45) include the proposed Koala park, as well a number of other areas that provide habitat for the species. See Table 30-20 for the areas of habitat in the SCAs. The Koala park is described in detail in Sub-Plan B: Koalas and shown in Figure 4 of Sub-Plan C. The new park would secure large parts of the north-south primary corridor to the east of Appin Road. It is proposed to be implemented in two stages:

- Stage 1 from Appin north encompassing approximately 875 ha of important habitat. This will be protected within the first 5 years of the Plan
- Stage 2 further north adjacent to GMAC encompassing an additional 722 ha of important habitat. This will be protected within the first 10 years of the Plan

The Koala park would also provide for a range of ecological restoration of up to 200 ha of cleared land to increase habitat over time and strengthen the north-south movement corridor.

Table 30-20: Koala habitat (ha) in the Strategic Conservation Areas

STRATEGIC CONSERVATION AREAS	SAA TOTAL	AREA CURRENTLY PROTECTED IN SAA	AREA IN STAGE 1 KOALA PARK	AREA IN STAGE 2 KOALA PARK	AREA REMAINING IN SCAs	TOTAL AREA IN SCAs
CORRIDORS						
PRIMARY CORRIDORS	11,998.9	1,064.9	869.5	721.8	4,635.6	6,226.9
SECONDARY CORRIDORS	2,433.2	115.2	5.5	0.0	1,114.4	1,119.9
IMPORTANT HABITAT SUBTOTAL*	**14,432.1**	**1,180.1**	**875.0**	**721.8**	**5,750.0**	**7,346.8**
TERTIARY CORRIDORS	724.3	0.0	1.1	0.0	154.0	155.1
SUPPORTING HABITAT	4,895.7	998.1	5.8	0.0	302.4	308.2
CORRIDOR TOTAL	**20,052.2**	**2,178.2**	**881.9**	**721.8**	**6,206.4**	**7,810.1**
HABITAT CRITICAL						
HABITAT CRITICAL TOTAL	**14,718.8**	**1,163.2**	**874.7**	**719.7**	**5,836.6**	**7,431.0**

* Important habitat comprises primary and secondary corridors

SUPPORTING MEASURES

In addition to the specific commitments and actions for Koalas, the Plan also includes a number of supporting measures that will be important for successful implementation and achieving a positive outcome for the species. These include:

- Monitoring, evaluation and reporting (MER) which will provide information about:
  - The status of Koalas in the Southern Sydney population
  - The Plan's progress in meeting its commitments and actions
- Adaptive management which will enable improvements to be made to management decisions over the life of the Plan

30.4.10 EVALUATION

The evaluation draws together the information from the Koala assessment to provide a robust way of understanding the predicted outcomes for the Southern Sydney Koala population as a result of implementation of the Plan. It also provides an evaluation against the relevant EPBC Act approval considerations.

The evaluation is based on understanding:

- If the outcomes for Koala specified in the Plan will be delivered?

- If the Plan addresses the EES principles from *Conserving Koalas in Wollondilly and Campbelltown LGAs*?
- If the Plan addresses the EPBC referral guidelines for Koalas?
- If the Plan has had regard for the Koala Conservation Advice?

To address these questions, the evaluation is structured around the following issues:

- Avoidance of impacts
- Extent and quality of habitat
- Landscape connectivity
- Level of threat

AVOIDANCE OF IMPACTS

As outlined in Chapter 14 and in Section 30.4.7, avoidance of impacts to Koala habitat was a key part of the process for developing the Plan. Design of the urban capable footprints in Wilton and GMAC was specifically guided by efforts to avoid impacts to Koala habitat which resulted in:

- More than 91 per cent of important habitat (not including excluded lands) being avoided within the two nominated areas
- Impacts being constrained to the edges of corridors within the nominated areas rather than cutting through any of the corridors

This level of avoidance is considered adequate when combined with the commitments and actions to:

- Mitigate indirect impacts
- Protect important habitat
- Restore habitat

EXTENT AND QUALITY OF HABITAT

As outlined in Section 30.4.8, the Plan will result in the loss of 260.6 ha of important habitat for Koalas within GMAC and Wilton. This equates to 1.8 per cent of the mapped important habitat for the Southern Sydney population.

In part to address these impacts, the Plan commits to protecting and managing a minimum of 610 ha of important Koala habitat. The Plan also commits to protecting and managing a minimum of 1,885 ha of land within the Georges River Koala Reserve (encompassing approximately 1,595 ha of important habitat), and restoring approximately 200 ha of cleared land, which significantly exceeds the 610 ha offset target for Koala. The action to restore land is consistent with Principle 3 of *Conserving Koalas in Wollondilly and Campbelltown LGAs* (OEH, 2018d) which is: "Identify critical revegetation zones that will augment and strengthen core habitat and corridors".

These commitments and actions also support a number of priority management actions from the Conservation Advice (DSEWPC, 2012a). These include:

- *Investigate formal conservation arrangements, management agreements and covenants on private land, and for Crown and private land investigate and/or secure inclusion in reserve tenure if possible*
- *Develop and implement options of vegetation recovery and re-connection in regions containing fragmented Koala populations*

It is noted that ecological restoration of habitat takes a significant amount of time and it will be important for ecological restoration efforts to start as early as possible to ensure the overall carrying capacity of habitat is not substantially reduced for a period of time. In response to this, the Plan commits funding over the first three years to plant at 100,000 trees as part of ecological restoration of Koala habitat including within the Georges River Koala Reserve.

Based on these commitments being met, the overall extent and quality of habitat for the population will be similar at the end of the life of the Plan as it is now. In addition, substantially greater areas of important habitat will be under active management. The outcomes for extent and quality of habitat for Koalas are considered adequate.

LANDSCAPE CONNECTIVITY

As outlined in Section 30.4.8, proposed development under the Plan will not result in the loss of primary or secondary habitat corridors through Wilton or GMAC due to land clearing. However, habitat connectivity has the potential to be impacted through:

- Increased threats posed by the effects of urban development
- Increased risk of vehicle strike
- Additional development concurrent to the Plan, such as the proposed installation of wildlife fencing along Appin Road to decrease the risk of vehicle strike (RMS, 2018)

Both EES (2018d) and Biolink (2018a) discuss the importance of the north-south primary corridor to the east of Appin Road. This will be protected (as a new reserve) and improved (through ecological restoration) under the Plan and is anticipated to play a critical role for the population over the life of the Plan.

East-west connectivity through Douglas Park (between the Wilton and GMAC nominated area boundaries) is also recognised for its importance to connectivity. This area will not be impacted by the Plan and parts of it are included in the SCAs which are targeted for protection.

The main risk to connectivity occurs to the east-west connections through GMAC. These are all secondary corridors and are currently compromised (from a connectivity perspective) in various ways. Biolink (2018a) suggests the most important of these connections are the Woodhouse – Menangle (referred to as Beulah in the GAPCLoSR report) and Ousedale corridors.

In developing the Plan, the Department investigated the viability of these corridors for Koala movement over the long term. The Plan commits to further investigations to determine how a permanent corridor can be implemented. Other relevant actions under Commitment 12 include:

- Protecting avoided Koala habitat through environmental conservation zoning in the potential east-west Koala movement corridors
- Ensuring at least one east-west corridor (at least 390 m wide) is maintained for Koala viability and movement. This is in addition to the north-south corridor to be protected through the Georges River Koala Reserve
- Constructing Koala crossings at:
    - Appin Road for east-west movement
    - Kings Fall Bridge (just to the east of the Strategic Assessment Area) to support north-south Koala movement from the Georges River Koala Reserve to the southern Koala habitat

The outcomes for connectivity are considered adequate as the Plan avoids disruptions to the primary movement corridors, enhances the most important corridor (north-south corridor to the east of Appin Road), and commits to maintaining at least one secondary east-west corridor.

LEVEL OF THREAT

As outlined in Section 30.4.8, development under the Plan has the potential to increase the level of threat to the Southern Sydney Koala population. This includes threats associated with:

- Vehicle strike
- Effects of urban development
- Fire
- Disease

The Plan includes a series of commitments and actions to address these threats.

Exclusion fencing is proposed as the primary control for managing Koalas within Wilton and GMAC. This is recognised in the EPBC Act Koala referral guidelines (DoE, 2014j) as one of the most important mitigation measures. It will be an important tool for separating Koalas from future urbanised areas and will help address many of the threats of urban development. It should be noted that there are a number of cases where fencing will not be possible (e.g. due to topography constraints, or community safety). In these instances, the Plan proposes that alternative controls from the Koala Habitat Protection Guidelines will be applied.

Fencing will also be installed on both sides of Appin Road between Rosemeadow and Appin to mitigate Koala vehicle strikes at roadkill hotspots.

The approach to managing Koalas will be guided by an expert working group that will have an ongoing role over the life of the Plan.

In addition to the specific Koala commitments, the Plan will:

- Require implementation of a range of general planning and development controls to address indirect impacts (these are assessed in detail in Chapter 15)
- Support the implementation of road mitigation measures on selected major roads that are identified roadkill hotspots
- Require the development and implementation of a fire management strategy that will support the management of Koala habitat

These commitments and actions are consistent with the following priority management actions from the Conservation Advice (DSEWPC, 2012a):

- *Develop and implement a management plan to control the adverse impacts of predation on Koalas by dogs in urban, peri-urban and rural environments*
- *Development plans should explicitly address ways to mitigate risk of vehicle strike when development occurs adjacent to, or within, Koala habitat.*

The package of measures to address indirect impacts is considered adequate when combined with the supporting measures around monitoring, evaluation and adaptive management.

30.4.11 OVERALL CONCLUSION

The efforts to avoid impacts to Koala habitat, and the commitments and actions in the Plan provide a strong framework for addressing the risks to the population from development under the Plan. The commitments and actions provide a range of positive contributions to the population (in particular the establishment of the Georges River Koala Reserve). They also address the key risks to the population and are designed to be implementable as development proceeds.

However, given the long timeframes associated with implementation there is uncertainty at this time about the ultimate effectiveness of these measures. This uncertainty can only be addressed in implementation and it will be critical that monitoring, evaluation and adaptive management measures are effective. Ongoing review of the success of the Plan in protecting Koalas will be critical.

SPECIES AT MEDIUM RISK OF DIRECT IMPACTS

30.5 *LATHAMUS DISCOLOR* (SWIFT PARROT)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	*Lathamus discolor* (Swift Parrot) is a medium-sized bright green parrot. It has dark-blue patches on the crown and a red face. It grows to approximately 25 cm in length, with a wingspan of 32-36 cm. It weighs around 65 g (TSSC, 2016d).
ECOLOGY	Swift Parrots breed in Tasmania in summer and migrate to mainland Australia in winter. They forage on flowers and psyllid insects on the mainland. Usually seen in groups of up to 30 birds, or larger flocks when around sources of abundant food. Disperses widely on the mainland to forage. The species shows high site fidelity (at both breeding and non-breeding sites) and return to the same locations on an irregular cyclic basis. (TSSC, 2016d)
DISTRIBUTION AND HABITAT	Can be found in the east and south-east of Tasmania in summer (where it breeds) and migrates to mainland Australia (coast of Victoria, NSW and south-eastern Queensland) during winter. The area of occupancy in Tasmania is estimated to be less than 500 km^2 (Saunders & Tzaros, 2011). Priority habitat areas are identified in the recovery plan (Saunders & Tzaros, 2011) as sites: • Used for nesting • By large proportions of the population • Used repeatedly between seasons (site fidelity) • Used for long periods of time (site persistence) In NSW, the species forages in forests and woodlands throughout the coastal and western slopes regions (TSSC, 2016d). In the Cumberland subregion, the following TECs contain habitat suitable for the Swift Parrot: • Cumberland Plain Woodland • Western Sydney Dry Rainforest and Moist Woodland on Shale • River-Flat Eucalypt Forest on Coastal Floodplains • Shale Sandstone Transition Forests • Shale Gravel Transition Forests

	• Swamp Sclerophyll Forest on Coastal Floodplains (Saunders & Tzaros, 2011)
POPULATIONS	The species occurs as one single, migratory population (Saunders & Tzaros, 2011). The population of swift parrots was estimated to be approximately 2,000 in 2010. It is likely to have declined since then (TSSC, 2016d).
SOS SITES	The following SOS sites for the species have been identified: • Central Coast • Tarcutta Hills – Co-investment site • Riverina None of these occur within the Cumberland subregion.
RELEVANT PLANS AND POLICIES	Conservation Advice for *Lathamus discolor* (Swift Parrot) (TSSC, 2016d) National recovery plan for the swift parrot *Lathamus discolor* (Saunders & Tzaros, 2011) Threat abatement plan for predation by feral cats (DoE, 2015g)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=744

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM)**. Habitat maps for the Swift Parrot were generated using BioNet PCT associations of intact and thinned vegetation, and scattered trees. Under the BAM process, the species was removed as a candidate species credit species in all nominated areas based on the understanding that no important habitat (as defined by the BAM) occurs in the urban capable land. No targeted surveys were undertaken, however, the species was recorded in Wilton in 2019 during surveys for this project. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM)**. As above. No targeted surveys as part of this project were undertaken outside the nominated areas.

POPULATION MAPPING	**RECORD SELECTION** Species records were compiled from BioNet. All available records were considered in the assessment. **POPULATION DEFINITION** The species is considered to be a single migratory population. All records within the Strategic Assessment Area are therefore considered part of the same population. **IMPORTANT POPULATION CRITERIA** The population was considered to be important as the species is critically endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 46.5 for a map of records and habitat across the Strategic Assessment Area. It is important to note that the records for this species are sensitive and have been denatured for representation on the map.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-22 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Swift Parrot in the Strategic Assessment Area. **Records** The species has been recorded throughout the Cumberland subregion and is associated with flowering woodland areas. There are 134 BioNet records within the Strategic Assessment Area. The species is known to occur in five broad locations in the Strategic Assessment Area: • In the area to the north of GPEC: 32 records ranging from 1968 to 2002. The majority of these records are from 1998 • Within and close to GPEC and WSA: 17 records from 1997 to 2014 • On the western side of the Strategic Assessment Area (south of WSA): 7 records from 2006 to 2013 • Immediately north of GMAC: 19 records from 1983 to 2014 • Within or close to Wilton (only 1 record) and GMAC: 8 records from the early 1900s to 2018 These records suggest the species occurs widely and regularly in the Strategic Assessment Area, but less frequently than some coastal areas of NSW. While records within the Cumberland subregion indicate the species uses foraging habitat repeatedly between seasons, it is not identified as a priority area in NSW in the National Recovery Plan (Saunders & Tzaros, 2011). **Potential foraging habitat** Given the Swift Parrot is a highly mobile species, this assessment is focussed on the occurrence of foraging habitat and potential impacts to this habitat. The baseline mapping for this assessment has mapped 59,460 ha of potential foraging habitat within the Strategic Assessment Area (see Table 30-22 for further details). This area is large because of the broad associations the species has with flowering woodland. The Swift Parrot does not breed on the mainland, and the foraging habitat mapped within the Strategic Assessment Area is part of the larger area in which the species forages. Records occur along the NSW coast from Nowra up to Newcastle and further inland near Wollemi National Park.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.5.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 4,627 ha of potential habitat for the Swift Parrot within the nominated areas (not including excluded lands). Approximately 3,513 ha (76 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,620 ha was avoided for biodiversity purposes
- 893 ha was avoided for other purposes

In addition, the Plan includes a specific measure for the Swift Parrot to retain large trees (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction.

A breakdown of avoidance across each nominated area is provided in Table 30-23.

It is important to note that the avoidance calculations in Table 30-23, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-23 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.5.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.5.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to the loss of potential foraging habitat for the species. Given the species breeds only in Tasmania, there will be no impacts to breeding habitat under the Plan.

LOSS OF POTENTIAL FORAGING HABITAT

Approximately 1,285 ha of potential foraging habitat will be lost as a result of the implementation of the Plan (1,114 ha within the nominated areas and 171 ha within transport corridors outside the nominated areas). This habitat represents 2 per cent of mapped potential foraging habitat across the Strategic Assessment Area. It focuses on the poorer condition vegetation, with approximately 63 per cent of the impacted habitat in thinned condition, and only 12 per cent of the area impacted classified as intact.

A summary of these impacts is provided in Table 30-24.

Risk of residual adverse impacts to the species

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be medium. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as possible. There will be moderate impacts to areas of potential foraging habitat where the species has been observed. However, the higher number of records in nearby coastal habitat indicates a relatively lower reliance on the Cumberland subregion, the area impacted represents a small proportion of available foraging habitat, and the mobile nature of the species means that the loss of small areas of the lower condition habitat within the Strategic Assessment Area is less likely to substantially impact the species. Importantly, there will be no impacts to priority sites/regions identified in the National Recovery Plan (Saunders & Tzaros, 2011)
- The consequence of any impacts to the species has been categorised as major. There will be loss of approximately 2 per cent of mapped potential foraging habitat in the Strategic Assessment Area and records occur close to and within areas that will be impacted

30.5.4 FRAGMENTATION OF HABITAT

Given the wide-ranging nature of the species and broad availability of potential habitat, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects.

30.5.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the medium risk of residual adverse impacts to the species, the Plan provides offsets for the Swift Parrot. The Plan commits to protecting 4,470 ha of potential foraging habitat for the Swift Parrot.

Offsets will be located within the SCAs which identify well connected, high quality vegetation across the Strategic Assessment Areas. These areas contain 17,403 ha of potential foraging habitat for the species and provide the best opportunity for improving conservation planning across the subregion and delivering real benefits for the Swift Parrot.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.5.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice and Recovery Plan (and other key documents) for the Swift Parrot identify a range of threats to the species (TSSC, 2016d; Saunders & Tzaros, 2011). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Collision mortality
- Inappropriate fire regimes
- Predation by feral cats

Predation by sugar gliders, competition from honeyeaters, Psittacine Beak and Feather Disease, and illegal wildlife capture and trade are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the threat across the Strategic Assessment Area.

COLLISION MORTALITY

Mortality from collisions with human-made objects in urban areas is an identified threat to the species (TSSC, 2016d). The Conservation Advice states that:

- Continuing urban encroachment into breeding and foraging habitat is increasing the threat
- Collisions are a particular concern in the greater Hobart and Melbourne areas, and the New South Wales central and north coast regions where fatalities have been recorded

There are no records in BioNet of collision mortalities in the Strategic Assessment Area. However, expanding urban development within the nominated areas and development of transport corridors has the potential to increase the threat of collision mortality to the species.

While the threat will remain (and potentially increase), it is unlikely to significantly affect the species in the Strategic Assessment Area because:

- Western Sydney is not identified as a key area of concern
- Large parts of Western Sydney (including the nominated areas) are subject to current development
- The species occurs in the Strategic Assessment Area less frequently than other areas of NSW

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes, in particular frequent fire, is identified as a threat to the species (Saunders & Tzaros, 2011; TSSC, 2016d). Fire can reduce tree flowering events and affect maturation of nectar rich plant species, resulting in reduced foraging resources (Saunders & Tzaros, 2011).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact Swift Parrot habitat. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the Swift Parrot from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential foraging habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the Swift Parrot and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

PREDATION BY FERAL CATS

Predation from feral cats is identified as a threat to the Swift Parrot in the species recovery plan. New urban development within the nominated areas is very likely to increase the number of domestic cats in the local area, which in turn, may lead to an increase in feral cat populations within adjacent areas of potential Swift Parrot habitat.

Existing land use within the nominated areas and surrounding region includes residential areas and farming, which means cats are unlikely to pose a novel threat to the species in the area. However, the extent of proposed new urban development under the Plan means the threat is likely to be exacerbated.

As outlined in Chapter 15, development controls will be implemented under the Plan to:

- Ensure that domestic animals are appropriately contained at urban/bushland interfaces
- Appropriately manage and control pest animals as relevant to the site

These measures are considered to adequately mitigate the threat to the species.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.5.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The Swift Parrot has been recorded in all of the nominated areas, including on avoided land in GMAC and GPEC. Potential foraging habitat has been mapped on avoided lands. As a result, the species may be subject to additional impacts from essential infrastructure. However, the species is highly mobile and wide-ranging, and the scale of impacts is not expected to be significant.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.5.8 POTENTIAL IMPACTS FROM TUNNELS

Potential foraging habitat for the Swift Parrot occurs within the tunnel footprints for the Metro Rail Future Extension (69.6 ha) and the Outer Sydney Orbital (108.2 ha).

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur, including the Mater Dei BioBank site and Camden Airport Registered Property Agreement, as discussed in Chapter 36
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.5.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice and Recovery Plan (and other key documents) identify the following key issues that are likely to have the greatest influence on the long-term viability of the Swift Parrot in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts such as:
  - Collision mortality
  - Inappropriate fire regimes
  - Predation by feral cats

HABITAT LOSS AND FRAGMENTATION

Development under the Plan will lead to the clearing of 1,285 ha of potential Swift Parrot foraging habitat. Some of this clearing will be mitigated by the retention of large trees (≥50cm DBH) during precinct planning. However, all together the impact assessment has concluded that the scale of clearing presents a medium risk of residual adverse impacts to the species, which will need to be addressed through the protection of 4,470 ha of potential foraging habitat.

Importantly, the clearing of potential foraging habitat is unlikely to lead to fragmentation of connectivity for the species given its highly mobile nature and the availability of potential foraging resources throughout the landscape. The loss of potential habitat does not affect any of the priority sites identified in the National Recovery Plan and focuses on the poorer condition woodlands, with intact vegetation comprising only 12 per cent (or around 154 ha) of the impacted areas.

In contrast, the offset areas for the Swift Parrot will focus on the best condition vegetation strategically located to provide an improved conservation outcome within the subregion. These offsets will be located within the SCAs which contain 17,403 ha of potential foraging habitat for the Swift Parrot. It is very likely that areas of suitable Swift Parrot foraging habitat in addition to the 4,470 ha offset will be protected within these SCAs as part of offset commitments for other species and ecological communities under the Plan.

It is relevant to note that the offsets for the Swift Parrot support a management priority included in the species conservation advice to *increase the area of habitat for the species that is secured and managed for conservation.*

In summary, the loss of potential habitat under the Plan is not expected to negatively influence the long-term viability of the species because the impacts:

- Will not fragment landscape connectivity
- Will not affect any of the priority sites/regions identified in the National Recovery Plan
- Focus on poorer condition woodland, and
- Are compensated for through a strategic offset program designed to improve the conservation outcome within the subregion

INDIRECT IMPACTS

The potential indirect impacts associated with collision mortality, inappropriate fire regimes and predation from feral cats have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to potential impacts to Swift Parrot foraging habitat. However, implementation of the Plan is not expected to adversely influence the long-term viability of the species for the following key reasons:

- Direct impacts comprise a small proportion (2 per cent) of available habitat within the subregion. These impacts will not affect any identified priority sites/regions, focus on poorer condition habitat and will not lead to fragmentation
- The Plan commits to the delivery of a 4,470 ha offset for the Swift Parrot which will be located in the SCAs. These areas have been designed to pick-up well-connected vegetation in the best condition in order to improve landscape scale conservation across the subregion
- Potential indirect impacts are addressed through management measures in the Plan

30.5.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan Prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan is to prevent further decline of the Swift Parrot population, and achieve a demonstrable sustained improvement in the quality and quantity of Swift Parrot habitat to increase carrying capacity (Saunders & Tzaros, 2011).

Specific actions have been identified to support the overall objective. These are:

- Identify the extent and quality of habitat
- Manage and protect Swift Parrot habitat at the landscape scale
- Monitor and manage the impact of collisions, competition and disease
- Monitor population and habitat
- Increase community involvement in, and awareness of, the recovery program
- Coordinate, review and report on recovery process

The outcome for the Swift Parrot under the Plan will not make it impossible to the achieve any of the objectives of the Recovery Plan.

Does the Plan prevent implementation of the Recovery Plan actions?

The Recovery Plan identifies a set of actions to be implemented in order to deliver on the objectives. The Plan will not prevent implementation of any of the actions.

The commitment to strategically protect large patches of well connected, high quality vegetation across the Strategic Assessment Area offers real conservation benefits for the Swift Parrot. This process is consistent with one of the main strategies in the Recovery Plan to "manage and protect Swift Parrot habitat at the landscape scale".

30.5.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-21 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-21: Relevant Key Threatening Processes and associated Threat Abatement Plans for Swift Parrot

KEY THREATENING PROCESS	THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-22: Occurrence of the Swift Parrot in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	59,460.4	6,773.0

Table 30-23: Avoidance of Swift Parrot habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,673.6	3,085.0	805.6	3,155.2	8,719.4
HABITAT WITHIN EXCLUDED LANDS (ha)	314.8	989.4	116.8	2,671.8	4,092.8
HABITAT WITHOUT EXCLUDED LANDS (ha)	**1,358.9**	**2,095.6**	**688.8**	**483.4**	**4,626.7**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	934.6	1,384.5	198.2	103.0	2,620.3
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	68.8	66.1	28.8	21.3	56.6
AVOIDANCE FOR OTHER REASONS (ha)	254.0	427.1	160.9	50.8	892.8
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	18.7	20.4	23.4	10.5	19.3
TOTAL AVOIDANCE (ha)	**1,188.6**	**1,811.6**	**359.1**	**153.8**	**3,513.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**87.5**	**86.4**	**52.1**	**31.8**	**75.9**

Table 30-24: Direct impacts to Swift Parrot within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	170.3	284.0	329.7	329.5	171.3	**1,284.9**

SPECIES AT LOW RISK OF DIRECT IMPACTS

30.6 *ANTHOCHAERA PHRYGIA* (REGENT HONEYEATER)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	*Anthochaera phrygia* (Regent Honeyeater) is a predominantly black, medium sized honeyeater with yellow trimming on the tail and wing feathers. Its head and breast are black, transitioning to pale yellow trimming and a pure pale yellow belly (DoE, 2015a, 2016).
ECOLOGY	Breeds mostly throughout spring and summer, from August to January. Breeding times appear to have a correlation with the flowering of certain eucalypt and mistletoe species. Primary food source is nectar from eucalypts and mistletoe as well as invertebrates (DoE, 2015a). Movement patterns have been associated with the regional flowering of certain eucalypt species and the species is capable of travelling large distances (DoE, 2015a). However, there is still a high level of variability with these patterns. Some individuals have been found to return to the same area in successive breeding seasons, while others have not (DoE, 2016). The area of occupancy is approximately 300 km^2 (DoE, 2015a).
DISTRIBUTION AND HABITAT	Endemic to the south-eastern Australian mainland and is patchily distributed. Its distribution extends from south-east Queensland to central Victoria. The species is observed widely across its range, but it is only known to occur regularly to breed and forage at four locations (DoE, 2015a). These are identified in the recovery plan (along with surrounding subsidiary areas) as Bundarra-Barraba (NSW), Capertee Valley (NSW) and Hunter Valley (NSW), and the Chiltern area (VIC) (DoE, 2016). A recent paper on the breeding ecology of the species (Crates, Rayner et al., 2018) also identifies breeding sites at the Severn River (northern NSW) and in the Burragorang Valley in the Blue Mountains to the west of the Strategic Assessment Area. At the end of 2019, a breeding pair was observed near Mulgoa within the Strategic Assessment Area. Mostly associated with box ironbark eucalypt woodland and dry sclerophyll forest and has also been found in riparian corridors with she-oak (*Casuarina* spp.). The species has a preference for trees that are taller and have a larger diameter, as they typically produce more nectar (DoE, 2015a). Nesting generally occurs in the canopy of mature trees. The breeding areas often consist of a nest tree and the food sources surrounding it (DoE, 2015a). The species is thought to prefer larger, better quality patches that support all woodland structural elements, including large trees which are important for breeding and foraging. Better quality patches buffer against the negative impacts of edge effects and provide the necessary productive

	resources. The quality of remnants is also thought to influence the species' ability to undertake large-scale movements, as degraded vegetation is likely to be missing important ecological features, such as the larger trees and/or high quality nectar flows (DoE, 2016). Habitat critical to the survival is defined in the recovery plan (DoE, 2016) as: • *Any breeding or foraging habitat in areas where the species is likely to occur, and* • *Any newly discovered breeding or foraging locations*
POPULATIONS	Occurs as a single population that was estimated to be 350-400 mature individuals in 2010 (DoE, 2016).
SOS SITES	The following SOS sites for the species have been identified: • Capertee Valley • Lower Hunter Valley • Taronga Zoo • Bundarra – Barraba • Mudgee / Wollar • Western Plains Zoo (Proposed)
RELEVANT PLANS AND POLICIES	Conservation Advice *Anthochaera phrygia* Regent Honeyeater (DoE, 2015a) National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia)* (DoE, 2016) Threat abatement plan for competition and land degradation by rabbits (DoEE, 2016a)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for the Regent Honeyeater.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82338

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Knowledge based map. Habitat maps outside the nominated areas for the Regent Honeyeater were generated using BioNet associations of intact and thinned vegetation conditions, and scattered trees. Targeted surveys for this species were not undertaken and the species was not recorded during surveys for this project.				
	OUTSIDE THE NOMINATED AREAS				

	Knowledge based map. As above. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** All available BioNet records were considered in the assessment. **POPULATION DEFINITION** The Regent Honeyeater comprises a single population (DoE, 2016). **IMPORTANT POPULATION CRITERIA** The population was considered to be important as the species is critically endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 46.3 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-26 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Regent Honeyeater in the Strategic Assessment Area. **Records** The Regent Honeyeater occurs throughout the Strategic Assessment Area with the majority of records associated with the larger patches of vegetation towards the north. There is a total of 92 records within the Strategic Assessment Area. Until very recently, all records related to foraging birds. However, at the end of 2019 a pair was observed successfully breeding near Mulgoa at Fernhill Estate, just west of the boundary between the WSA and GPEC. The nest was recorded in vegetation mapped as Shale Sandstone Transition Forest. It is connected to the much broader areas of intact vegetation west of the Strategic Assessment Area; although the nest site itself is towards the interface of this vegetation and cleared rural land. The site is protected and managed in perpetuity under a biobanking agreement. **Potential habitat** The baseline mapping for this assessment has mapped approximately 59,460 ha of potential habitat across the Strategic Assessment Area. This area is so large because of the broad associations the species has with a variety of PCTs. However, it is noted that the actual area of suitable habitat is likely to be smaller given the species preference for larger, high quality patches of woodland which are generally more limited within the subregion due to historical clearing and land degradation. EES has mapped important habitat for the Regent Honeyeater as part of the BAM process. There is no mapped important habitat within the nominated areas or transport corridors for the species. The known breeding site near Mulgoa has been mapped as important as part of this BAM process.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.6.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 4,627 ha of potential habitat for the Regent Honeyeater within the nominated areas (not including excluded lands). Approximately 3,513 ha (76 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,620 ha was avoided for biodiversity purposes
- 893 ha was avoided for other purposes

In addition, the Plan includes a specific measure for the Regent Honeyeater to retain large trees (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction.

A breakdown of avoidance across each nominated area is provided in Table 30-27.

It is important to note that the avoidance calculations in Table 30-27, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-27 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.6.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.6.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to the loss of potential habitat for the species. It will not result in direct impacts to any known breeding habitat or key areas identified in the species recovery plan and conservation advice.

LOSS OF POTENTIAL HABITAT

Approximately 1,285 ha of potential habitat will be lost as a result of the implementation of the Plan (1,114 ha within the nominated areas and 171 ha within transport corridors outside the nominated areas). This habitat represents 2 per cent of mapped potential habitat across the Strategic Assessment Area. As identified below, potential habitat within each of the nominated areas and the transport corridors is unlikely to be used much or at all by the species due to the level of clearing and fragmentation.

Impacts are proposed to occur as follows:

- GPEC: Loss of 330 ha of potential habitat. Most of which occurs as fragmented patches in an existing urbanised environment. Unlikely that the nominated area is used or important to the species. Only one post-1990 record is present which occurs in a cleared location
- WSA: Loss of 330 ha of potential habitat. Most of which occurs as fragmented patches in an existing, heavily cleared rural landscape. Unlikely that the nominated area is important to the species. No records of the species
- GMAC: Loss of 284 ha of potential habitat. Most of which occurs to the edges of vegetated areas. Unlikely that the nominated area is used or important for the species. No records of the species
- Wilton: Loss of 170 ha of potential habitat. Most of which occurs to the edges of vegetated areas. Unlikely that the nominated area is used or important for the species. No records of the species
- Transport outside the nominated areas: Loss of 171 ha of potential habitat. Occurs to mostly fragmented vegetation patches across the Outer Sydney Orbital

A summary of these impacts is provided in Table 30-28.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential habitat is considered to be low. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as unlikely. There will be no impacts to known breeding habitat or key areas identified in the species Recovery Plan or Conservation Advice. While the extent of clearing of mapped potential habitat for the Regent Honeyeater is large, the likely impacts to the species are considered to be minor. Impacts focus on the more fragmented and degraded remnants which are unlikely to provide the ecological elements preferred or needed by the species. This is reflected in the almost complete absence of records within the impacted areas and the lack of important habitat mapping by EES within the nominated areas or transport corridors. The Cumberland subregion more broadly has been subject to large levels of historical clearing and land use practices that have reduced its capacity to support the species and this is again reflected in relatively low number of records across the subregion
- The consequence of any impacts to the species has been categorised as major. There will be loss of approximately 2 per cent of mapped potential foraging habitat in the Strategic Assessment Area, however, there are very few records close to and within areas that will be impacted

30.6.4 FRAGMENTATION OF HABITAT

Given the wide-ranging nature of the species, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects. The lack of records within the nominated areas and transport corridors suggests that these mapped potential habitat areas may already be in too degraded a state to contain enough of the important ecological features needed to support foraging movements (DoE, 2016).

30.6.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for the Regent Honeyeater.

However, it is worth noting that mapped habitat prepared for this project for Regent Honeyeater and the Swift Parrot are the same. And that the offsets that the Plan will provide for Swift Parrot (4,470 ha of potential foraging habitat within the SCAs) may provide benefits for the Regent Honeyeater.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.6.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice and Recovery Plan (and other key documents) for the Regent Honeyeater identify a range of threats to the species (DoE, 2015a, 2016). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts.

The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan: degradation of habitat especially through the removal of large mature trees, firewood collection, spread of weeds, and inappropriate fire regimes.

Eucalypt dieback, grazing by livestock and rabbits, competition with other nectivorous birds and honeybees, increased predation by native nest predators, and loss of genetic diversity are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

The main area of concern for indirect impacts is the Mulgoa region west of GPEC and WSA where the species has recently been observed breeding. Importantly, this site is protected and managed in perpetuity as part of a biobanking agreement. Management of this site will substantially minimise the threat of any indirect impacts on the species associated with development.

More broadly across the Strategic Assessment Area, the level of historical clearing and degrading land uses has reduced the value of habitat. This limits the extent that any threatening processes potentially exacerbated under the Plan, might lead to actual impacts on the species.

However, it is recognised that the package of commitments and actions under the Plan will lead to the protection and management of large areas of the better-quality, better-connected vegetation within the SCAs. Although the protection of these areas is required to compensate for the impacts of development on other threatened species and ecological communities, there is considerable overlap with vegetation types that have the potential to provide foraging resources for the Regent Honeyeater. With greater protection and management, these areas are likely to improve the foraging capacity of the subregion to the species. This means the potential indirect impacts from development on these areas is likely to become more relevant in the future as the species' numbers begin to recover within these areas as they are managed and protected.

REMOVAL OF TREES AND FIREWOOD COLLECTION

Removal of large, mature trees and the collection of firewood are identified in the Conservation Advice and Recovery Plan as threats to the Regent Honeyeater. These threats have the potential to increase within the Strategic Assessment Area due to development within the nominated areas. Habitat considered most at risk are areas that occur in close proximity to new urban development.

The Plan incorporates a range of measures to mitigate the risks associated with these things, including:

- A commitment to retain large trees (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction
- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when assessing development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance to habitat
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will help address issues such as illegal firewood collection in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal activities such as vegetation clearing and firewood collection
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the species from tree removal and firewood collection. This is because:

- Avoided lands that support areas of potential foraging habitat will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction

- Conservation lands will be actively managed which will address disturbance and illegal activities in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

SPREAD OF WEEDS

Invasive weeds are identified as a threat to the Regent Honeyeater as they degrade foraging remnants. Weed incursion in the habitat areas is associated with agricultural activities as well as urban development.

Key weeds that occur within the subregion include: African Olive (*Olea europaea* subsp. *cuspidata*), Fireweed (*Senecio madagascariensis*), Spear Thistle (*Cirsium vulgare*), Cat's Ear (*Hypochaeris radicata*), Pigeon Grass (*Setaria gracilis*), Plantain (*Plantago lanceolata*), Paddy's Lucerne (*Sida rhombifolia*), Bridal Creeper (*Myrsiphyllum asparagoides*), Sow Thistle (*Sonchus oleraceus*), and Broad-leafed and Small-leaf Privet (*Ligustrum lucidum* and *L. Sinense*) in wetter areas.

The most serious threats are from Bridal Creeper and African Olive as they are highly competitive and difficult to manage.

These weeds are already present within the Strategic Assessment Area. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

Foraging habitat is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to the habitat and introduces edge effects.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCAs. This includes a number of key actions:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Weeds will be actively managed within all areas added to conservation as part of the offset program.

The package of measures in the Plan is expected to adequately manage the risk posed to the Regent Honeyeater from invasive weeds. This is because:

- Avoided lands will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program which is expected to provide large areas of potential foraging habitat for the Regent Honeyeater
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes, in particular frequent fire, is identified as a threat to the Regent Honeyeater. Where fire intervals are too frequent, flowering events and maturation of nectar rich plant species can be reducing, leading to a reduction in foraging resources (DoE, 2016).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact Regent Honeyeater habitat. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the Regent Honeyeater from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential foraging habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the Regent Honeyeater and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.6.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

While mapped potential habitat for the Regent Honeyeater occurs on avoided land, and these areas may be subject to impacts from essential infrastructure, it is very unlikely the species will be adversely affected. There are no records of the Regent Honeyeater on avoided land and very few elsewhere in the nominated areas, the species is highly mobile and wide-ranging, and the scale of impacts is not expected to be significant.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.6.8 POTENTIAL IMPACTS FROM TUNNELS

Potential habitat for the Regent Honeyeater occurs within the tunnel footprints for the Metro Rail Future Extension (69.6 ha) and the Outer Sydney Orbital (108.2 ha). These areas are not associated with records and are not considered important to the species.

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur, including protected lands and the Nepean River and associated riparian vegetation, as discussed in Chapter 36
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.6.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice and Recovery Plan identify the following key issues that are likely to have the greatest influence on the long-term viability of the Regent Honeyeater in relation to implementation of the Plan:

- Habitat loss and fragmentation
- Indirect impacts associated with degradation of habitat through the removal of large mature trees, firewood collection, spread of weeds, and inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

Loss and fragmentation of Regent Honeyeater habitat within the Strategic Assessment Area is not likely to be an issue and the risk of residual adverse impacts to the species has been assessed here as low. Although the Plan authorises the clearing of 1,285 ha of potential habitat, this does not relate to any key breeding or foraging areas identified in the Conservation Advice or Recovery Plan and predominantly occurs:

- In already fragmented and degraded areas that offer low habitat value
- In areas where the species has not been recorded recently (or at all)
- In areas that have not been mapped as important habitat by EES as part of the BAM process

More generally, the Cumberland subregion has been subject to extensive historical clearing and land use practices that have reduced its capacity to support the species.

The package of commitments and actions under the Plan will lead to the protection and management of large areas of the better quality, well-connected vegetation within the SCAs. The protection of these areas is required to compensate for the impacts of development on other threatened species and ecological communities (including Swift Parrot which shares the same areas of mapped habitat). With greater protection and management, these areas are likely to improve the foraging capacity of the subregion to the Regent Honeyeater.

This outcome directly supports one of the conservation and management actions in the Conservation Action to *improve the extent and quality of regent honeyeater habitat*, as well as a number of the on ground actions identified to achieve the strategies and objectives in the Recovery Plan.

INDIRECT IMPACTS

The potential indirect impacts associated with degradation of habitat will be managed and mitigated through a specific measure and generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There is a low risk that development under the Plan will adversely impact the Regent Honeyeater and any long-term impacts to viability in the subregion have the potential to be positive for the following key reasons:

- There will be no direct impacts to areas identified as important for breeding or foraging
- The nominated areas and transport corridors offer limited habitat values and the Regent Honeyeater has barely been observed in these areas
- The majority of the Cumberland subregion is currently likely to offer only marginal habitat for the species due to extensive levels of historical vegetation clearing and degrading land use practices. However, the protection and management of large areas (at least 5,470 ha) of vegetation types associated with foraging habitat is expected to improve the capacity of the subregion to support the species
- Potential indirect impacts are addressed through management measures in the Plan

30.6.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?

- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The objectives of the Recovery Plan for the Regent Honeyeater are to:

- Reverse the long-term population trend of decline and increase the numbers of regent honeyeaters to a level where there is a viable, wild breeding population, even in poor breeding years; and to
- Enhance the condition of habitat across the Regent Honeyeater's range to maximise survival and reproductive success, and provide refugia during periods of extreme environmental fluctuation (DoE, 2016)

Specific strategies have been identified to support the overall objectives. These are:

- Improve the extent and quality of Regent Honeyeater habitat
- Bolster the wild population with captive-bred birds until the wild population becomes self-sustaining
- Increase understanding of the size, structure, trajectory and viability of the wild population
- Maintain and increase community awareness, understanding and involvement in the recovery program (DoE, 2016)

The outcome for the Regent Honeyeater under the Plan will not prevent achievement of any of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of strategies in order to deliver on the objectives. The Plan will not prevent implementation of any of the strategies.

The commitment to strategically protect large patches of well connected, high quality vegetation across the Strategic Assessment Area offers potential conservation benefits for the Regent Honeyeater. This process is consistent with one of the main strategies in the Recovery Plan to "improve the extent and quality of regent honeyeater habitat".

30.6.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-25 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-25: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Regent Honeyeater

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Competition and land degradation by rabbits	Threat abatement plan for competition and land degradation by rabbits (DoEE, 2016a)
Land clearance	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-26: Occurrence of the Regent Honeyeater in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	59,460.4	6,773.0

Table 30-27: Avoidance of Regent Honeyeater habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,673.6	3,085.0	805.6	3,155.2	8,719.4
HABITAT WITHIN EXCLUDED LANDS (ha)	314.7	989.4	116.8	2,671.8	4,092.7
HABITAT WITHOUT EXCLUDED LANDS (ha)	**1,358.9**	**2,095.6**	**688.8**	**483.4**	**4,626.7**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	934.6	1,384.5	198.2	103.0	2,620.3
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	68.8	66.1	28.8	21.3	56.6
AVOIDANCE FOR OTHER REASONS (ha)	254.0	427.1	160.9	50.8	892.8
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	18.7	20.4	23.4	10.5	19.3
TOTAL AVOIDANCE (ha)	**1,188.6**	**1,811.6**	**359.1**	**153.8**	**3,513.1**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**87.5**	**86.4**	**52.1**	**31.8**	**75.9**

Table 30-28: Direct impacts to Regent Honeyeater within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	170.4	284.0	329.7	329.5	171.3	**1,284.9**

30.7 *BOTAURUS POICILOPTILUS* (AUSTRALASIAN BITTERN)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Botaurus poiciloptilus* (Australasian Bittern) is a large heron-like bird. It has mottled brown, dark brown to black feathers, a straw yellow bill and pale green to olive legs. The average male weighs 1.4 kg and the average female weighs 0.9 kg (TSSC, 2019a).
ECOLOGY	Breeding occurs from October to February. Females usually lay four to five olive-brown eggs. Nests are built on a bed of reeds in densely-vegetated wetlands, and placed about 30 cm above the water level. (TSSC, 2019a) Feeds mainly at night on fish, eels, frogs, freshwater crayfish and aquatic insects (Garnett, Szabo et al., 2011). The species is mainly solitary but has been seen in pairs or groups of up to 12 birds (TSSC, 2019a).
DISTRIBUTION AND HABITAT	The Australasian Bittern occurs in New Zealand, New Caledonia and Australia. In Australia the species occurs in south-eastern Australia: throughout Tasmania, south east of South Australia, Victoria, NSW (excluding the north west), and up to Yeppoon in Queensland. It also occurs in the south-west of Western Australia between Moora and Cape Arid (TSSC, 2019a). In NSW it occurs along the coast and has been recorded in the Murray-Darling Basin, in the floodplain wetlands of the Murray, Murrumbidgee, Lachlan, Macquarie and Gwydir Rivers. The species has been recorded in the Cumberland subregion. The area of occupancy in Australia is estimated to be 1,150 km^2 (TSSC, 2019a). The species inhabits freshwater or brackish swamps that are shallow and vegetated, with a preference for the presence of sedges, rushes, and reeds (Garnett, Szabo et al., 2011). The species is less often found in estuaries or tidal wetlands (TSSC, 2019a). The species moves between habitats as suitability changes and has been observed to use coastal wetlands during periods of drought and ephemeral wetlands when wet (TSSC, 2019a). All natural habitat where the species is known or likely to occur is considered habitat critical to the survival of the species (TSSC, 2019a).
POPULATIONS	The Australasian Bittern occurs as two sub-populations: one in south-eastern Australia and the other in south-western Australia (TSSC, 2019). The total Australian population is estimated at 1,000 mature individuals (Garnett, Szabo et al., 2011).
SOS SITES	This species has been assigned to the landscape species management stream because it is distributed across large areas and is subject to threatening processes that generally act at the landscape scale rather than at distinct, definable locations (OEH, 2018c).

RELEVANT PLANS AND POLICIES	Conservation Advice *Botaurus poiciloptilus* Australasian Bittern (TSSC, 2019a) Threat abatement plan for predation by the European red fox (DEWHA, 2008n) Threat abatement plan for predation by feral cats (DoE, 2015g)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for the Australian Bittern.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1001

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS** **Knowledge based map (KBM).** Habitat maps were generated using BioNet PCT associations, vegetation condition parameters (intact, thinned), 40 m buffer to hydrolines (based on preferred habitat comprising wetlands, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water) (TSSC, 2019a). No targeted surveys were undertaken as part of this project. **OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM).** As above. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION** Records restricted to post 2007 to account for estimated 11-year lifespan of the species. **POPULATION DEFINITION** The south-eastern Australian subpopulation of the species is considered as one population for this assessment. All records within the Strategic Assessment Area are therefore considered part of the same population. **IMPORTANT POPULATION CRITERIA** All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in *conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.*

MAP	See Map 36.25 for a map of records and habitat across the Strategic Assessment Area
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-30 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Australasian Bittern in the Strategic Assessment Area. **Records** There are five records of the species within the Strategic Assessment Area: • Four occur at Pitt Town Lagoon in the north of the Strategic Assessment Area near to the Hawkesbury River (approximately 15 km from the nearest development area) • One occurs near Wianamatta (South Creek) in Oran Park (approximately 9 km from the nearest development area) **Potential habitat** The baseline mapping for the assessment has mapped 2,524 ha of potential habitat within the Strategic Assessment Area. Based on the limited number of records, this mapping is considered to be highly precautionary as it is based on all mapped streams with the appropriate PCTs. While some records occur in the Strategic Assessment Area, the area is not recognised as a key location for the species. In NSW the species primarily occurs along the coast and is frequently recorded in the Murray Darling Basin, notably in floodplain wetlands of the Murray, Murrumbidgee, Lachlan, Macquarie and Gwydir Rivers (TSSC, 2019a). Notable observations within proximity of the Strategic Assessment Area include Sydney Olympic Park approximately 9 km to the east of the Strategic Assessment Area, and Towra Point Wetlands approximately 20 km from the Strategic Assessment Area.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.7.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 180 ha of potential habitat within the nominated areas (not including excluded lands). Approximately 109 ha (61 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluding lands). Of this:

- 11 ha was avoided for biodiversity purposes
- 99 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-31.

It is important to note that the avoidance calculations in Table 30-31, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-31 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.7.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.7.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will not lead to direct impacts to known habitat. However, it will result in impacts to some potential habitat.

LOSS OF POTENTIAL HABITAT

Approximately 88 ha of potential habitat will be lost as a result of the implementation of the Plan (70 ha within the nominated areas and 18 ha within transport corridors outside the nominated areas). This habitat represents 3.5 per cent of mapped potential habitat across the Strategic Assessment Area. The majority of potential habitat (53 ha) to be impacted occurs within GPEC and is associated with the proposed alignment of the Outer Sydney Orbital within the vicinity of Wianamatta (South Creek).

The Conservation Advice notes that the major threat to the species from habitat loss relates to *the long-term diversion of water away from wetlands and floodplains to support irrigated agriculture and urban water supplies; and the permanent loss of wetlands through conversion to other purposes, such as agricultural and urban development* (TSSC, 2019a). Development under the Plan will not involve any of these types of impacts. The loss of potential habitat relates to clearing of vegetation mapped as potential habitat due to broad PCT associations or development that occurs within the 40 m buffer of hydrolines.

A summary of these impacts is provided in Table 30-32.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be low. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as unlikely. There will be no impacts to areas known to support the species and only minor impacts to potential foraging habitat. The Strategic Assessment Area represents more marginal habitat for the species, which is more frequently recorded along the coast and within the Murray Darling Basin when in NSW. The potential habitat mapping is considered to be highly precautionary
- The consequence of any impacts to the species has been categorised as moderate. There will be loss of approximately 3.5 per cent of mapped potential habitat in the Strategic Assessment Area. There is low confidence that the species occurs in the impact areas

30.7.4 FRAGMENTATION OF HABITAT

Given the lack of records and wide-ranging nature of the species, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects.

30.7.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for the Australasian Bittern.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.7.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the Australasian Bittern identifies a range of threats to the species (TSSC, 2019a). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Hydrological changes
- Predation by introduced vertebrates
- Weed invasion
- Inappropriate fire regimes

Transition from ponded rice to other farming systems, impacts from grazing animals and salinization of coastal wetlands are also identified in the conservation advice as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

HYDROLOGICAL CHANGES

Habitat degradation from increased salinity, siltation and pollution is identified as a threat to the Australasian Bittern (TSSC, 2019a). This is a particular threat where important habitat areas are in the proximity of development and well connected hydrologically. The likelihood of adverse impacts to the species due to development under the Plan is low as mapped potential habitat in the Strategic Assessment Area within the vicinity of development lacks records and is not considered to be critical for the species.

The Plan also incorporates a range of measures to mitigate the risks associated with changes to hydrology and this further minimises the likelihood of impacts on the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application

- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

While the threat to the species is already low, the package of measures in the Plan manages any residual risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

PREDATION BY INTRODUCED VERTEBRATES

Predation by introduced vertebrates such as foxes and cats is a key threat to the Australasian Bittern (noting that the extent of the impacts on this species is unknown) (DSEWPC, 2011a).

Cats and foxes are already well established in the Strategic Assessment Area and are unlikely to pose a novel threat to the species. However, the extent of proposed new urban development under the Plan means that the threat, particularly associated with cats, is likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats in the local area, which, in turn, may lead to an increase in feral cat numbers. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is low.

While the actual impact on the Australasian Bittern is expected to be minimal due to their limited use of the Strategic Assessment Area, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

WEED INVASION

Weed invasion and changes in abundance of certain plant species can reduce wetland productivity, which may impact on the quality of habitat for the Australasian Bittern (DSEWPC, 2011a).

Many weeds are already present within the Strategic Assessment Area and pose a threat to habitat for the Australasian Bittern. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where new development occurs adjacent to habitat areas or connected waterways. However, the extent of impacts on the species is generally expected to be low given the limited use of the Strategic Assessment Area by the species and lack of records within proximity to development.

The Plan also incorporates a range of measures to manage the risk posed by weed invasion and this further minimises the likelihood of impacts on the species. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCAs. This includes a number of actions, of which the following are the most relevant to the outcome for the species:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are identified as a key threat to the Australasian Bittern. Fire can reduce the quality of habitat features that are important to the species (DSEWPC, 2011a).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy

  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.7.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no records and limited potential habitat for the Australasian Bittern on avoided land in the nominated areas.

However, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.7.8 POTENTIAL IMPACTS FROM TUNNELS

Potential habitat for the Australasian Bittern occurs within the tunnel footprints for the Metro Rail Future Extension (4.6 ha) and the Outer Sydney Orbital (8.2 ha). These areas are not associated with records and the habitat mapping for the species is considered to be highly precautionary.

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.7.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DSEWPC, 2011a) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the Australasian Bittern in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts such as:
  - Reduced water quality
  - Predation by introduced vertebrates
  - Weed invasion
  - Inappropriate fire regimes

HABITAT LOSS

This assessment has identified the risk of residual adverse impacts to the Australasian Bittern from habitat loss as being low. Although development under the Plan will lead to the loss of 88 ha of mapped potential habitat, impacts on the species are likely to be minimal given:

- The areas being impacted are not known to support the species and the potential habitat mapping is very precautionary
- The importance of the Strategic Assessment Area more broadly is marginal. When in NSW, the species is more frequently recorded along the coast and within the Murray Darling Basin
- The loss of habitat does not involve the types of impacts or activities identified in the Conservation Advice as particularly problematic, which include *the long-term diversion of water away from wetlands and floodplains to support irrigated agriculture and urban water supplies; and the permanent loss of wetlands through conversion to other purposes, such as agricultural and urban development.* Instead, direct impacts under the Plan relate to clearing of vegetation mapped as potential habitat due to broad PCT associations, or development that occurs within the 40m buffer of hydrolines

As a result, habitat loss under the Plan is not expected to affect the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with the identified threats will be managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will not affect areas known to support the Australasian Bittern but will lead to the loss of a small proportion of areas mapped as potential habitat. However, implementation of the Plan is not expected to adversely influence the long-term viability of the species for the following key reasons:

- Habitat known to support the species within the Strategic Assessment Areas occurs some distance from development and will not be affected by implementation of the Plan
- Areas of potential habitat that will be directly affected has been mapped using highly precautionary assumptions and impacts are not expected to affect the species' use of the Strategic Assessment Area
- Potential indirect impacts will be addressed through management measures in the Plan

30.7.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.7.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-29 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-29: Relevant Key Threatening Processes and associated Threat Abatement Plans for Australasian Bittern

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by European red fox	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-30: Occurrence of the Australasian Bittern in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	2,524.4	306.6

Table 30-31: Avoidance of Australasian Bittern habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	123.0	83.1	444.7	650.8
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	107.7	7.4	356.1	471.2
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**15.3**	**75.7**	**88.6**	**179.6**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	1.9	4.0	4.7	10.6
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	12.7	5.3	5.2	5.9
AVOIDANCE FOR OTHER REASONS (ha)	0.0	9.3	58.1	31.4	98.8
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	61.0	76.7	35.5	55.0
TOTAL AVOIDANCE (ha)	**0.0**	**11.2**	**62.1**	**36.1**	**109.4**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**73.7**	**82.1**	**40.7**	**60.9**

Table 30-32: Direct impacts to Australasian Bittern habitat within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0	4.0	13.6	52.6	17.6	**87.8**

30.8 *CHALINOLOBUS DWYERI* (LARGE-EARED PIED BAT)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Chalinolobus dwyeri* (Large-eared Pied Bat) is a small to medium-sized insectivorous bat with shiny, black fur on its body. Has a total length of up to 10 cm and weighs 7-12 g (DoEE, 2018c).
ECOLOGY	It is a nocturnal species and forages for insects below the canopy and can travel several kilometres from roost sites. Breeding occurs in early winter and young are born in early summer. Females normally carry one or two pups and give birth once a year. The species has been recorded in groups of up to 50 breeding females at maternity roosts (DoEE, 2018). They have high site fidelity and visit the same maternity site over many years (OEH, 2018d).
DISTRIBUTION AND HABITAT	Records are poor for the species but occur from Shoalwater Bay in south Queensland to Ulladulla in south eastern NSW. In NSW it is found in areas of volcanic strata in the north east at Coolah Tops, Mt Kaputar and Warrumbungle National Park and in sandstone areas of the Sydney Basin and the western slopes and plains including Pilliga Nature Reserve (DERM, 2011). The area of occupancy is estimated to be 9,120 km^2 (DoEE, 2018). Inhabits well-timbered areas and low to mid-elevation dry open forests and woodland in close proximity to preferred roosting locations of sandstone caves, crevices in cliffs, old mine workings and disused mud nests of the Fairy Martin (*Petrochelidon ariel*). Requires very specific nursery roosts with deep roofs that allow juveniles to learn to fly and roof indentations, which are likely to capture the heat. The species is not associated with tree hollows. Habitat is associated with the following TECs: • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest • Shale Sandstone Transition Forest • Brigalow (*Acacia harpophylla* dominant and co-dominant) • White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland • Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley • Temperate Highland Peat Swamps on Sandstone • Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia • New England Peppermint (*Eucalyptus nova-anglica*) Grassy Woodlands. (DERM, 2011)

	The species Recovery Plan identifies the following as habitat critical to survival of the Large-eared Pied Bat (DERM, 2011): • Any maternity roosts • Sandstone cliffs and fertile wooded valley habitat within close proximity of each other
POPULATIONS	There is insufficient information to estimate total population. The species is thought to exist in a number of small populations, with colonies containing up to 50 individuals. Important populations in NSW exist in the sandstone escarpments of the Sydney basin and north west slopes of NSW (DERM, 2011).
SOS SITES	There are no SOS sites identified for the species because there is insufficient information available for effective management.
RELEVANT PLANS AND POLICIES	National recovery plan for the Large-eared Pied Bat *Chalinolobus dwyeri* (DERM, 2011)
SPECIES-SPECIFIC GUIDELINES	There are no specific guidelines for this species.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=183

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	Yes	Yes	Yes	Yes

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Knowledge based map (KBM). Habitat maps within the nominated areas for the Large-eared Pied Bat were generated using BioNet associations of intact and thinned vegetation conditions. Mapping was also restricted to sandstone areas and cliffs within 2 km of rocky areas containing caves, overhangs, escarpments, outcrops, or crevices, or within 2 km of old mines/tunnels. No targeted surveys as part of this project were undertaken for this species.
	OUTSIDE THE NOMINATED AREAS
	Knowledge based map (KBM). As above. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION**
	All BioNet records for the Strategic Assessment Area were included in the assessment.
	POPULATION DEFINITION

	The species is known to breed in very few locations across NSW and the distance bats move from the maternity roost to over wintering roosts has not been established, but is likely to be less than 100 km (DoEE, 2018c). As such all records within the Cumberland subregion are considered likely to be from the same breeding population
	IMPORTANT POPULATION CRITERIA
	The population of Large-eared Pied Bats was considered important within the Strategic Assessment Area because it is a population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 46.1 for a map of records and potential habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-34 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Large-eared Pied Bat in the Strategic Assessment Area. **Records** The Large-eared Pied Bat has been recorded in the Strategic Assessment Area and surrounding region. There are 65 records for the species within the Strategic Assessment Area, with the majority of observations from the last 10 years. The records occur along the boundary of the Strategic Assessment Area in the south (where the largest cluster of records occurs within Wilton), east and west and are generally associated with areas of sandstone geology. These records are all considered to form part of a single population and which, more broadly, form part of the important population associated with the sandstone escarpments of the Sydney Basin. **Potential habitat** The baseline mapping for this assessment has mapped approximately 25,555 ha of potential habitat across the Strategic Assessment Area. The majority of the potential habitat occurs in the south of the Strategic Assessment Area and along the western and south-eastern edges, again in association with areas of sandstone. Habitat within the Strategic Assessment Area is likely to be used predominantly for foraging. Interrogation of the observation codes of records for the species indicate there are no known roost or breeding sites for the species within the Strategic Assessment Area. Anabat surveys for the species within a part of the northern section of Wilton did not confirm the presence of breeding habitat or breeding individuals. However, there are a number of suitable caves in the Appin and Wilton areas which may be used for roosting (Bruce Mullins, pers com). The habitat mapped within the Strategic Assessment Area forms part of a much larger area of the species' known distribution. Records occur from Nowra in the south, up the coast to Newcastle and inland to Kanangra-Boyd National Park and Wollemi National Park.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.8.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 3,250 ha of potential habitat for the Large-eared Pied Bat within the nominated areas (not including excluded lands). Approximately 2,937 ha (90 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,236 ha avoided for biodiversity purposes
- 701 ha avoided for other purposes

The majority of avoidance occurs in GMAC (1,723 ha or 90 per cent) and Wilton (1,214 ha or 91 per cent).

A breakdown of avoidance across each nominated area is provided in Table 30-35.

It is important to note that the avoidance calculations in Table 30-35, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-35 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.8.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.8.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to a loss of potential habitat for the species. There will be no impacts to known roosting or breeding areas.

LOSS OF POTENTIAL HABITAT

Approximately 316 ha of potential Large-eared Pied Bat habitat will be lost, predominantly in Wilton and GMAC. This represents 1.2 per cent of potential habitat within the Strategic Assessment Area.

At a broader landscape level, direct impacts are proportionally smaller still, given the areas of foraging habitat within the Strategic Assessment Area forms a relatively small part of much larger and intact areas of habitat to the north and west of the Strategic Assessment Area and to the south of Sydney.

A summary of these impacts is provided in Table 30-36.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be low. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as possible. There will be no impacts to known breeding or roosting areas, and moderate impacts to foraging habitat. However, impacts to foraging habitat relates to small sections on the fringes of habitat corridors. These corridors are associated with canopied vegetation along riparian corridors in an otherwise cleared landscape. The corridors themselves will be maintained which is important as the Recovery Plan notes that narrow connecting riparian strips in otherwise cleared habitat are sometimes quite heavily used. The species is wide-ranging and potential foraging habitat in the Strategic Assessment Area forms part of a much larger area of the species' known distribution

- The consequence of any impacts to the species has been categorised as moderate. There will be loss of approximately 1.2 per cent of mapped potential foraging habitat in the Strategic Assessment Area

30.8.4 FRAGMENTATION OF HABITAT

Loss of potential habitat relates to foraging habitat mainly within GMAC and Wilton and relates to small sections on the fringes of habitat corridors. Development will not increase the level of habitat fragmentation in these areas.

30.8.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for the Large-eared Pied Bat.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.8.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan for the Large-eared Pied Bat identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Disturbance of roosts from human recreational activities
- Fire in the proximity of roosts
- Predation by introduced predators

Mining of roosts, mine induced subsidence of cliff lines, habitat disturbance from livestock, and loss of genetic diversity are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

DISTURBANCE OF ROOSTS FROM HUMAN RECREATIONAL ACTIVITIES

Disturbance of roosts from recreational activities such as bushwalking, caving and abseiling is identified as a threat to the Large-eared Pied Bat. Regular disturbance can lead to bats abandoning roosts or depleting essential fat reserves (DERM, 2011).

Areas considered most at risk from increased disturbance due to recreational activities are those that occur in close proximity to development within Wilton and GMAC. Roosting and maternity caves are most likely to be located within the sandstone areas adjacent to and surrounding the Strategic Assessment Area. Much of this land is protected for conservation or as part of Sydney's drinking water catchment and should have existing management frameworks to prevent inappropriate access and use.

The Plan incorporates a range of measures to mitigate the risks associated with recreational disturbance within the Strategic Assessment Area, including:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- A commitment (Commitment 7) to mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on Koalas. This is relevant to the species because a lot of the mapped habitat for the Large-eared Pied Bat is identified as important Koala habitat. Of particular relevance to habitat disturbance are associated actions around the use of exclusion fencing which will assist in controlling access to Koala habitat. These measures will help minimise inappropriate habitat disturbance to potential habitat within both Wilton and GMAC
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate access and use
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor issues such as illegal access and use
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan, combined with existing management of protected areas adjacent to the Strategic Assessment Area is expected to adequately manage the risk to the species from inappropriate recreational use.

FIRE IN THE PROXIMITY OF ROOSTS

Bushfires and prescribed burning are identified as a key threat to the Large-eared Pied Bat as they are potentially susceptible to direct mortality from heat and smoke if the fire is close to their relatively shallow cave roosts (DERM, 2011). Changes in foraging resources and prey species as a result of altered fire regimes may also impact the species (DERM, 2011).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat.

> While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

PREDATION BY INTRODUCED PREDATORS

Predation by introduced predators such as cats, foxes and rats has been identified in the Recovery Plan as a possible, but unknown, threat to the Large-eared Pied Bat. Concerns relate to predation on individuals where they are forced to roost close to the ground (DERM, 2011).

Roosting within the Strategic Assessment Area is either absent or very limited. However, new urban development within GMAC and Wilton is in close proximity to areas of likely roosting outside the Strategic Assessment Area in surrounding sandstone areas. New urban development within these nominated areas is very likely to increase the number of domestic cats in the local area, which in turn, may lead to an increase in feral cat populations within adjacent areas of likely roosting habitat.

Existing land use within the nominated areas and surrounding region includes residential areas and farming, which means cats are unlikely to pose a novel threat to the species in the area. However, the extent of proposed new urban development under the Plan means the threat is likely to be exacerbated.

As outlined in Chapter 15, development controls will be implemented under the Plan to:

- Ensure that domestic animals are appropriately contained at urban/bushland interfaces
- Appropriately manage and control pest animals as relevant to the site

These measures are considered to adequately mitigate the threat to the species.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.8.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are records of the Large-eared Pied Bat on avoided land in GMAC and potential habitat on avoided land within Wilton and GMAC. Therefore, the species may be subject to impacts from essential infrastructure. However, the species is mobile and wide-ranging, and the scale of impact is not expected to be significant.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.8.8 POTENTIAL IMPACTS FROM TUNNELS

Foraging habitat for the Large-eared Pied Bat occurs within the tunnel footprints for the Metro Rail Future Extension tunnel (24.0 ha). The area is unlikely to support breeding habitat (the site is not within 1 km of areas likely to contain caves, crevices and cliffs - see Map 17) and only a small amount of potential foraging habitat has the potential to be impacted.

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur, including the Mater Dei BioBank site, as discussed in Chapter 36
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.8.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Recovery Plan for the Large-eared Pied Bat describes the species' reliance on very specific maternity roosts with physical characteristics that are uncommon in the landscape as an important limiting factor in the distribution of the species (DERM, 2011). The communal nature of the species when they roost and raise young, means that a reasonable proportion of a local population can be in one location and this makes them more vulnerable to impacts to these sites.

Implementation of the Plan will not directly affect any known roosting sites. Potential indirect impacts to roosting sites have been assessed and the generic management strategies in the Plan are considered adequate in addressing these risks. Altogether, impacts from development under the Plan are not expected to affect roosting or maternity sites and this substantially minimises the potential to adversely influence the species' long-term viability.

However, foraging habitat within proximity to roosting areas will be affected by development. These areas constitute habitat critical to survival, which suggests that any substantial impacts to these areas has the potential to affect the long-term viability of the species.

There are a number of factors relating to the impacts on these foraging areas which minimise the severity of impacts. These factors make it very unlikely that the species long-term viability will be affected by development under the Plan and include:

- Loss of foraging habitat represents a small proportion (1.2 per cent) of potential habitat within the Strategic Assessment Area. At a broader landscape level, these impacts are proportionally smaller still, given the much larger and intact areas of habitat to the north and west of the Strategic Assessment Area and to the south of Sydney
- Loss of potential foraging habitat predominantly occurs within GMAC and Wilton. The potential foraging habitat within these nominated areas is mostly associated with canopied vegetation along riparian corridors in an otherwise cleared landscape. The Recovery Plan notes that these types of corridors can be heavily used by the species. Impacts to this habitat will involve the loss of small sections on the fringes of the corridors. The corridors themselves will be retained, minimising any functional loss on potential foraging habitat. In fact, the planning controls that will establish environmental zoning (E2) on avoided lands are expected to improve the long-term outcome for these areas. This zoning will set out objectives that a consent authority must consider when assessing development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for managing the land and minimising degradation of habitat

In addition, the Plan will lead to the protection and management of large areas of vegetation within the SCA. Two of the reserves currently proposed by the Plan are suitably located to support foraging within proximity of potential sandstone roosting areas. They are:

- The Georges River Koala Reserve which is on the eastern side of the Strategic Assessment Area near GMAC where the Large-eared Pied Bat has been recorded. This will be implemented in two stages over the first 10 years of the Plan and will cover an area of approximately 1,892 ha
- The Gulguer Reserve investigation area which occurs on the western side of the Strategic Assessment Area where the Large-eared Pied Bat has been recorded. The Plan proposes to implement the reserve over the first 20 years of the Plan, and it will cover an area of approximately 1,800 ha

Altogether, it is considered very unlikely that implementation will adversely influence the long-term viability of the Large-eared Pied Bat.

30.8.10 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan is to ensure the persistence of viable populations of the Large-eared Pied Bat throughout its geographic range (DERM, 2011). Specific objectives have been identified to support the overall objective, these are:

- Identify priority roost and maternity sites for protection
- Implement conservation and management strategies for priority sites
- Educate the community and industry to understand and participate in the conservation of the large-eared pied bat
- Research the large-eared pied bat to augment biological and ecological data to enable conservation management
- Determine the meta-population dynamics throughout the distribution of the large-eared pied bat

The outcome for the Large-eared Pied Bat under the Plan will not make it impossible to the achieve any of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions in order to deliver on the objectives. The Plan will not prevent implementation of any of the actions.

The commitment to strategically protect large patches of well connected, high quality vegetation across the Strategic Assessment Area offers potential conservation benefits for the Large-eared Pied Bat. This process is consistent with one of the main actions in the Recovery Plan to "identify priority colonies and sites for conservation management and protection".

30.8.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-33 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For the Large-eared Pied Bat there are no relevant Threat Abatement Plans.

Table 30-33: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Large-eared Pied Bat

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-34: Occurrence of the Large-eared Pied Bat in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	25,555.0	3,295.1

Table 30-35: Avoidance of Large-eared Pied Bat habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,618.8	2,592.8	0.0	68.9	4,280.5
HABITAT WITHIN EXCLUDED LANDS (ha)	281.8	681.2	0.0.	67.9	1,030.9
HABITAT WITHOUT EXCLUDED LANDS (ha)	**1,337.0**	**1,911.6**	**0.0**	**1.0**	**3,249.6**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	924.8	1,310.7	0.0	0.0	2,235.5
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	69.2	68.6	N/A	N/A	68.8
AVOIDANCE FOR OTHER REASONS (ha)	288.7	412.5	0.0	0.0	701.2
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	21.6	21.6	N/A	N/A	21.6
TOTAL AVOIDANCE (ha)	**1,213.5**	**1,723.2**	**0.0**	**0.0**	**2,936.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**90.8**	**90.1**	**N/A**	**N/A**	**90.4**

Table 30-36: Direct impacts to Large-eared Pied Bat within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	123.6	188.4	0.0	0.9	3.5	**316.4**

30.9 *DASYURUS MACULATUS MACULATUS* (SPOT-TAILED QUOLL) – SE MAINLAND POPULATION

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Dasyurus maculatus maculatus* (Spot-tailed Quoll) is a cat sized marsupial. It has reddish-brown fur with a cream-white stomach and irregular sized white spots covering its back, sides and tail. The large size and spotted tail are distinguishing features. (DELWP, 2016) Males grow to around 1.3 m long and weigh up to 7 kg, and females can grow to 85 cm and weigh up to 4 kg (DELWP, 2016).
ECOLOGY	The species is carnivorous and nocturnal. Main source of food is medium sized mammals including gliders, possums, small wallabies, rats and rabbits (OEH, 2018i). It also feeds on a variety of other animals including birds, reptiles, and invertebrates, and hunts on the ground and in trees (DELWP, 2016). Life expectancy in the wild is 3-5 years. Sexual maturity is reached at the age of 11-12 months and females generally produce a litter annually of (on average) five young. (DELWP, 2016) Mating occurs between late May and early August (DSEWPC, 2011b). Adults are solitary and can travel large distances such as 8 km a day and 19 km in a week. Female home ranges can be 88-1,515 ha and do not normally overlap. Male home ranges can be 359-5,512 ha, can overlap and include many female home ranges. They use several dens to rest in during the day and travel between them regularly (DELWP, 2016).
DISTRIBUTION AND HABITAT	Has a wide, patchy distribution in eastern Australia. Its distribution ranges from north-eastern Queensland to Tasmania. The species can be found in a variety of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest. It is mostly found in areas with rainfall of over 600 mm per year. Habitat critical to the survival has been identified in the species' Recovery Plan as large patches of forest with sufficient den sites and adequate densities of medium-sized mammalian prey (DELWP, 2016). Den sites have been recorded in tree hollows, rock crevices, hollow logs, hollow tree buttresses, clumps of vegetation, windrows, caves and boulder tumbles and under buildings. Maternal den sites include rock crevices, caves, boulder tumbles, hollow logs, hollow tree roots and burrows (DELWP, 2016).
POPULATIONS	Has 26 known important populations from Queensland to Victoria. In NSW records are generally confined to within 200 km of the coast and range from the Queensland border to Kosciuszko National Park. Locations include: Hunter Valley, Taree, Port Macquarie and Coffs Harbour through

	to the gorges and escarpments of the New England Tableland, south NSW, Hay and several disjunct populations between the Border Ranges and the Blue Mountains / Illawarra area. It is known to occur in the Cumberland subregion (OEH, 2018i).
SOS SITES	The following SOS sites for the species have been identified: • North Coast – proposed • Northern Tablelands • Jenolan-Kanangra • Wyangala Dam to Gillindich NR • Barren Grounds/Budderoo • Byadbo None of these sites occur within the Cumberland subregion.
RELEVANT PLANS AND POLICIES	National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus* (DELWP, 2016) Threat abatement plan for predation by feral cats (DoE, 2015g) Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
SPECIES-SPECIFIC GUIDELINES	EPBC Act Policy Statement 3.4 Significant impact guidelines for *Dasyurus maculatus maculatus* (DEWHA, 2009c) - noting that this guideline relates only to proposed 1080 baiting programs and is not relevant to the activities under the Plan
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=75184

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Knowledge based map (KBM). Habitat maps for Spot-tailed Quoll were generated using BioNet PCT associations of intact and thinned vegetation in areas with greater than 600 mm rainfall. Patch size of greater than 1,000 ha was used in order to restrict habitat to areas of very large intact bushland remnants around, and connected to the edges of the Cumberland subregion. Under the BAM, the species was removed as a candidate species in in all nominated areas because there are no known breeding sites in the urban capable land.				
	OUTSIDE THE NOMINATED AREAS				
	Knowledge based map (KBM). As above. No targeted surveys as part of this project were undertaken outside the nominated areas.				

POPULATION MAPPING	**RECORD SELECTION** BioNet records from 1999 onwards were considered current for the assessment. **POPULATION DEFINITION** All records within an area covered by the average male home range (up to 5,512 ha) were considered a single population. **IMPORTANT POPULATION CRITERIA** All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 46.4 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-38 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Spot-tailed Quoll in the Strategic Assessment Area. **Records** Records of the Spot-tailed Quoll are widespread in the regions surrounding the Strategic Assessment Area, including from the Blue Mountains to the west, the northern beaches and central coast to the north and the Illawarra/Wollongong area to the south. Within the Strategic Assessment Area, records primarily occur around the edges where some level of landscape connectivity remains with the large areas of surrounding wilderness to the north and west of the Strategic Assessment Area and south of Sydney. Eight populations within or immediately adjacent to the Strategic Assessment Area have broadly been identified from the BioNet records, as follows: • Population #508 - in the north-east of the Strategic Assessment Area, approximately 20 km north of GPEC where there are three BioNet records • Population #200 - on the north-west boundary of the Strategic Assessment Area, almost 20 km north of GPEC near Bowen Mountain where there are three BioNet records • Population #495 - along the western boundary of the Strategic Assessment Area adjacent to and just north of GPEC where there are a large number of records along the Great Western Highway through to the Blue Mountains and following the Nepean River. One record associated with the Nepean River is in the Strategic Assessment Area • Population #509 - two post 1999 records within GPEC – one located in the Wianamatta Regional Park and one in the middle of an existing urban area in Cambridge Park (with a low level of accuracy) • Population #496 - in the west of the Strategic Assessment Area near Orangeville, where there are two BioNet records from 2004 • Population #498 - in the southern section of the Strategic Assessment Area, to the west of Wilton where there are two relatively recent BioNet records • Population #201 – south of Wilton where there are three BioNet records, all outside of the Strategic Assessment Area • Population #500 - east of the southern section of GMAC where there are four relatively recent BioNet records (one within the Strategic Assessment Area and the others adjacent) **Potential habitat** The baseline mapping for this assessment has mapped 32,527 ha of potential habitat within the Strategic Assessment Area. This habitat is predominantly associated with creek lines which the Spot-tailed Quoll may use for dispersal (Bruce Mullins, pers com).

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.9.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 3,756 ha of potential habitat for the Spot-tailed Quoll within the nominated areas (not including excluded lands). Approximately 3,110 ha (83 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 2,337 ha was avoided for biodiversity purposes
- 773 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-39.

It is important to note that the avoidance calculations in Table 30-39, including 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-39 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.9.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred. Avoidance within the transport corridors will occur during the detailed design phase as each project is brought forward. The Plan includes a specific measure to support the Spot-tailed Quoll which is to: design the transport corridors to avoid and minimise impacts to fauna populations and habitat and connectivity, particularly along riparian corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.9.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to the loss of potential habitat for the Spot-tail Quoll. A breakdown of impacts across the Strategic Assessment Area is given in Table 30-40.

The potential for fragmentation of habitat is also discussed below.

LOSS OF POTENTIAL HABITAT

Approximately 676 ha of potential habitat will be lost as a result of the implementation of the Plan, or 2 per cent of potential habitat mapped across the Strategic Assessment Area.

These direct impacts include potential habitat areas within the vicinity of:

- Population #509, where the Outer Sydney Orbital passes through the Wianamatta Regional Park within GPEC. The species primarily uses the much larger areas of intact habitat surrounding the Cumberland subregion. The habitat area within GPEC is not immediately connected to these areas and is unlikely to be as important due to the level of fragmentation associated with existing urban and rural development
- Populations #498 and #201, where urban development in Wilton will lead to the loss of isolated areas of potential habitat on the fringes of riparian corridors. The species may disperse along creek lines within the Strategic Assessment Area (Bruce Mullins, pers com). The corridors and associated vegetation have largely been avoided and the ecological function of each corridor within Wilton in terms of dispersal and connectivity will be maintained
- Population #500, where urban development in GMAC will lead to the loss of isolated areas of potential habitat on the fringes of riparian corridors. Again, the riparian corridors and associated vegetation that may be used for dispersal have largely been avoided and the ecological function of each corridor within GMAC will be maintained

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential habitat is considered to be low. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as possible. There will be moderate impacts to potential habitat. The majority of impacts occur along the edges of habitat corridors ensuring that the corridors themselves are maintained, and the species has access to a much larger network of intact habitat surrounding the Strategic Assessment Area
- The consequence of any impacts to the species has been categorised as minor. There will be loss of approximately 2 per cent of mapped potential habitat in the Strategic Assessment Area

30.9.4 FRAGMENTATION OF HABITAT

The majority of mapped potential habitat is associated with riparian corridors. Corridors such as these may be important landscape components for the species as they are more likely to contain the necessary den and prey resources (DELWP, 2016) and might be used within the Strategic Assessment Area for dispersal.

The urban capable land within the nominated areas has been specifically designed to avoid and minimise impacts to these corridors. Impacts that do occur are associated with small sections of fringing habitat. These corridors are currently unmanaged and vulnerable to edge effects. Under the Plan, planning controls will establish environmental zoning (E2) on these areas and this is expected to improve their long-term outcome. The zoning will set out objectives that a consent authority must consider when assessing development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for managing the land and minimising degradation of habitat.

The transport corridors have the potential to fragment habitat in the following locations:

- Potential habitat within Wianamatta Regional Park due to the development of the OSO. The species has been recorded in this area
- Fragmentation of small areas of potential habitat further south in GPEC, also due to the development of the OSO. There have been no historical records of the species using this area

The Plan includes a specific measure to design the transport corridors to avoid and minimise impacts to Spot-tailed Quoll populations and habitat and connectivity, particularly along riparian corridors. Designing creek crossings in these areas to maintain movement of the Spot-tail Quoll will significantly minimise any effects on the species. The area is also likely to be less important compared with the large areas of intact habitat surrounding the Strategic Assessment Area, due to the extent of existing urban and rural development within GPEC.

Altogether, direct impacts associated with development under the Plan are not expected to interfere with the movement of the Spot-tailed Quoll within the Strategic Assessment Area.

30.9.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, offsets were not considered necessary for the Spot-tailed Quoll.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.9.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Recovery Plan for the Spot-tailed Quoll identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Competition and predation from introduced predators
- Road mortality
- Inappropriate fire regimes

Timber harvesting, poison baiting, deliberate killing, and poisoning by cane toads are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

COMPETITION AND PREDATION FROM INTRODUCED PREDATORS

Competition and predation from introduced vertebrates such as cats and dogs is identified as a key threat to the Spot-tailed Quoll (DELWP, 2016).

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the species.

However, the extent of proposed new urban development under the Plan means that the threat associated with cats and dogs is likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is lower.

The Plan incorporates a range of measures to manage the risks associated with introduced predators. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
    - Preparation of a Pest Animal Control Implementation Strategy
    - A process to enter into written agreements with delivery partners to implement the pest animal control program
    - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans

- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16
- A specific requirement in relation to Commitment 5 to contain domestic cats and dogs in new residential areas at the urban/bushland interface consistent with relevant Council guidelines.

These measures are considered to adequately address any potential increased threat from introduced predators due to implementation of the Plan.

ROAD MORTALITY

The Spot-tailed Quoll is susceptible to vehicle strike, and mortality on roads has been identified as a key threat to the species. The populations of Spot-tailed Quoll within and surrounding the Strategic Assessment Area are already exposed to a number of major roads, including from the Hume Highway, Wilton/Appin Road, Picton Road, Great Western Highway and Bells Line of Road.

Despite this exposure, none of the BioNet records for the area and surrounding region relate to vehicle strikes, which suggests that:

- The species is not regularly moving across existing roads to get from known habitat areas in the south into the more marginal habitat areas within the Strategic Assessment Area, or
- The species is dispersing along creek lines and passing under the roads where the crossings provide suitable conditions for an underpass (such as adequate vegetation cover), or
- Cases of roadkill are not being reported; although given the tendency for people to report Koala vehicle strikes within the area, this factor is unlikely to be the main contributor

Implementation of the Plan will lead to new roads and an increase in the volume of cars on these roads within and surrounding the nominated areas. The potential level of increased risk from these roads is difficult to predict. However, factors that reduce the potential risk include:

- The availability of much larger areas of intact vegetation outside of the Strategic Assessment Area, which is likely to reduce the species' need to cross roads in order to move into potential habitat areas within the Strategic Assessment Area
- The existing corridors of habitat within the nominated areas will be avoided and maintained. The only potential disruption relates to the development of the OSO within GPEC. However, the Plan includes a specific measure to design the transport corridors to avoid and minimise impacts to Spot-tailed Quoll populations and habitat and connectivity, particularly along riparian corridors. This measure should ensure safe passage for the Spot-tailed Quoll under creek crossings in this area

The Plan also incorporates a range of measures to manage the increased threat from road mortality. In summary, these include:

- Development controls that will:
  - Ensure that traffic calming measures are implemented in development areas not subject to Koala exclusion fencing, including speed limit restrictions for areas adjacent to land with biodiversity values, and installation of wildlife signposting and speed humps and audible surfacing in accordance with relevant standards
  - Require fauna-friendly road design structures to be installed and maintained in appropriate areas adjacent to fauna habitat, such as underpasses, fauna bridges and overpasses
- A commitment (Commitment 6) to mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat. This includes mitigation measures to

specifically address impacts on the Spot-tailed Quoll during construction and operation of transport infrastructure as prescribed in Appendix E of the Plan

- A commitment (Commitment 7) to mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on Koalas. This is relevant to the species because a lot of the mapped habitat for the Spot-tailed Quoll is also identified as important Koala habitat. Of particular relevance to road mortality are actions around the use of exclusion fencing. These measures will help minimise the risk of road mortality within both Wilton and GMAC for the species.

These measures are considered to adequately address any potential increased threat from road mortality due to implementation of the Plan.

INAPPROPRIATE FIRE REGIMES

Bushfires and prescribed burning are identified as a key threat to the Spot-tailed Quoll as they can reduce the availability of prey and habitat features that provide protection from predation (DELWP, 2016).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.9.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There is potential habitat on avoided land within Wilton and GMAC. The species may therefore be subject to impacts from essential infrastructure. However, the species is mobile and wide-ranging and the scale of impact is not expected to disrupt habitat use or movement.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.9.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Recovery Plan identifies the major threatening processes relevant to the Spot-tailed Quoll and these should be considered most likely to affect the long-term viability of the species. They include:

- Habitat loss, modification and fragmentation
- Timber harvesting
- Poison baiting
- Competition and predation by introduced predators
- Deliberate killing
- Road mortality
- Bushfire and prescription burning
- Poisoning by cane toads
- Climate change

Of these threats, implementation of the Plan has the potential to lead to habitat loss, modification and fragmentation and exacerbate the threat from competition and predation by introduction predators, road mortality and bushfires.

HABITAT LOSS, MODIFICATION AND FRAGMENTATION

The Recovery Plan describes the aspects of the biology and ecology of the Spot-tailed Quoll that make the species particularly vulnerable to threatening processes. To summarise, Spot-tailed Quoll populations are limited to large, relatively intact patches of forest due to:

- Their generally solitary nature and large home ranges
- Their low population densities
- Their short lifespan and low reproductive output
- Juvenile dispersal being focussed on males, as females tend to remain near their birthplace. This limits the ability of the species to recolonise areas of fragmented habitat

The species is subsequently very sensitive to impacts that reduce, degrade and fragment their habitat (DELWP, 2016).

Development associated with implementation of the Plan will lead to the loss of areas of habitat for the Spot-tailed Quoll, including 656 ha of potential habitat. The risk of residual adverse impacts from this has been assessed as low for the following key reasons:

- Loss of habitat represents a small proportion (2 per cent) of potential habitat within the Strategic Assessment Area. At a broader landscape level, these impacts are proportionally smaller still, given the much larger and intact areas of habitat surrounding the Strategic Assessment Area
- Habitat surrounding the Strategic Assessment Area is vast and intact and therefore considered much more important to the viability of the species. Mapped potential habitat within the Strategic Assessment Area is predominately associated with creek lines within an otherwise cleared landscape. The species may use these creek lines for dispersal
- Where impacts to habitat occur within the nominated areas, they are associated with small sections of habitat that fringes the corridors. The integrity of the corridors themselves will be maintained. These corridors are currently unmanaged and vulnerable to edge effects. Under the Plan, planning controls will establish environmental zoning (E2) on these areas and this is expected to improve the long-term outcome for the biodiversity within the corridors. The zoning will set out objectives that a consent authority must consider when assessing development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for managing the land and minimising degradation of habitat. This is especially important within GMAC and Wilton where these corridors connect to the broader areas of habitat outside the Strategic Assessment Area
- The one exception to this is the potenital for impacts to a habitat corridor within GPEC associated with the OSO. However, there are a number of measures in the Plan to specifically address impats to habitat and movement for the Spot-tailed Quoll during detailed design of this infrastructure. This area of habitat is also considered more marginal due to the extent of existing urban and rural development and disconnection from the surrounding, intact habitat areas

In addition, the Plan will lead to the protection and management of large areas of vegetation within the SCA. Two of the reserves currently proposed by the Plan will protect habitat considered very likely to support the Spot-tailed Quoll, including:

- The Georges River Koala Reserve which is on the eastern side of the Strategic Assessment Area near GMAC where the Spot-tailed Quoll has been recorded. This will be implemented in two stages over the first 10 years of the Plan and will cover an area of approximately 1,892 ha
- The Gulguer Reserve investigation area which occurs on the western side of the Strategic Assessment Area and is connected to areas of habitat where the Spot-tailed Quoll has been recorded. The Plan proposes to implement the reserve over the first 20 years of the Plan and it will cover an area of approximately 1,800 ha

INDIRECT IMPACTS ASSOCIATED WITH INTRODUCED PREDATORS, ROAD MORTALITY AND BUSHFIRES

The potential indirect impacts associated with the identified threats will be managed and mitigated through generic management strategies and species-specific controls.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

Development under the Plan will lead to the loss of a small proportion of areas mapped as potential habitat for the Spot-tailed Quoll. Implementation of the Plan is not expected to adversely influence the long-term viability of the species due to the:

- Level of avoidance and minimisation of impacts to habitat corridors achieved through design of the urban capable lands within the nominated areas
- Marginal value of habitat within the Strategic Assessment Area which is generally fragmented and more degraded compared to the vast, surrounding areas of intact habitat
- The specific measures in the Plan to address potential impacts to dispersal ability from infrastructure design (namely the OSO) and road mortality

30.9.9 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan Prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These questions are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan is to reduce the rate of decline of the Spot-tailed Quoll, and ensure that viable populations remain throughout its current range in eastern Australia (DELWP, 2016). Specific objectives have been identified to support the overall objective. These fit broadly into three groups:

- Investigate and acquire information on distribution, status, and key aspects of the biology and ecology of the species to aid recovery
- Identify key threats and implement threat abatement management practices, those most relevant to the Plan include:
  - Reduce the rate of habitat loss and fragmentation on private land
  - Determine and manage the risk posed by introduced predators (in particular, cats)
  - Reduce the frequency of road mortality
- Increase community awareness of and involvement in the Recovery Plan

The outcome for the Spot-tailed Quoll under the Plan will not make it impossible to the achieve any of the objectives of the Recovery Plan.

DOES THE PLAN PREVENT IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan identifies a set of actions to be implemented in order to deliver on the objectives. The Plan may support these actions, including:

- Target landholders in areas where Spotted-tailed Quolls are known to occur to protect and manage their land in a manner that is compatible with maintenance of Spotted-tailed Quoll habitat through voluntary conservation agreements
- Maintain and restore habitat corridors on unprotected freehold land

The Plan will not prevent implementation of any of the actions.

30.9.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-37 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-37: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Spot-tailed Quoll

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Predation by European red fox	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-38: Occurrence of the Spot-tailed Quoll in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	7	2
(IMPORTANT POPULATIONS)	(7)	(2)
HABITAT MAPPING (Ha)	32,527.0	5,444.8

Table 30-39: Avoidance of Spot-tailed Quoll habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	1,611.4	2,385.3	209.1	2,439.6	6,645.4
HABITAT WITHIN EXCLUDED LANDS (ha)	277.9	554.5	9.1	2,047.4	2,888.9
HABITAT WITHOUT EXCLUDED LANDS (ha)	**1,333.5**	**1,830.8**	**200.0**	**392.2**	**3,756.5**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	925.8	1,277.9	42.0	91.3	2,337.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	69.4	69.8	21.0	23.3	62.2
AVOIDANCE FOR OTHER REASONS (ha)	287.5	395.6	50.5	39.1	772.7
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	21.6	21.6	25.3	10.0	20.6
TOTAL AVOIDANCE (ha)	**1,213.3**	**1,673.5**	**92.5**	**130.4**	**3,109.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**91.0**	**91.4**	**46.3**	**33.2**	**82.8**

Table 30-40: Direct impacts to the Spot-tailed Quoll within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	120.3	157.2	107.5	261.8	28.7	**675.5**

30.10 *PTEROPUS POLIOCEPHALUS* (GREY-HEADED FLYING-FOX)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Pteropus poliocephalus* (Grey-headed Flying-fox [GHFF]) is the largest Australian bat with dark grey fur on the body and an orange/brown collar around the neck. The head is covered with light grey fur. It weighs 600-1,000 g and can grow up to 289 mm in length (DoEE, 2018c).
ECOLOGY	Mating occurs in early autumn, the larger roosting camps then break up and reform in late spring/early summer when food resources start to increase (DoEE, 2018c). Males and females separate in October when females usually give birth to a single young (DoEE, 2018c). The young are carried on their mothers' backs to foraging sites until they are around five weeks old, then left in maternal camps while their mothers forage until they become independent at around 12 weeks old. Following this, the males return to the camps for courting and to form bonds for the next breeding season (DoEE, 2018c). Blossom from *Eucalyptus* and related genera form a large part of the species diet (DoEE, 2018c). It also feeds on commercial fruit crops and on introduced tree species in urban areas (DoEE, 2018c). The species is highly mobile and migrates in response to food shortages (OEH, 2019b).
DISTRIBUTION AND HABITAT	The Grey-headed Flying-fox is usually found within 200 km of the eastern coast of Australia, from Rockhampton in Queensland to Melbourne in Victoria. It requires suitable habitat for both roosting and foraging. **Roosting habitat** The species roosts in groups of various sizes on exposed branches. Roost sites (known as camps) are generally located close to water, such as lakes, rivers, or the coast (DoEE, 2018c). Roost vegetation includes rainforest patches, stands of *Melaleuca*, mangroves and riparian vegetation (DoEE, 2018c). Roosting camps may contain tens of thousands of animals and are used for mating, and for giving birth and rearing young. Site fidelity to roosting camps is high; some have been used for over a century. The species can travel up to 50 km a night from roosting camps to forage but more often the distances are less than 20 km (DoEE, 2018c). **Foraging habitat** Grey-headed Flying-foxes feed on fruit and nectar from the canopy and use a range of vegetation communities, including rainforests, open forests, closed and open woodlands, *Melaleuca* swamps and *Banksia* woodlands (DoEE, 2018c).

	Winter and spring foraging resources are critical for the species. The draft recovery plan (DoEE, 2017a) identifies that the one of the key issues for the species recovery is the "protection and rehabilitation of foraging habitat and the expansion of forested areas that are productive during winter and spring". Important vegetation communities that provide winter and spring foraging resources are those that contain *Eucalyptus tereticornis*, *E. albens*, *E. crebra*, *E. fibrosa*, *E. melliodora*, *E. paniculata*, *E. pilularis*, *E. robusta*, *E. siderophloia*, *Banksia integrifolia*, *Castanospermum australe*, *Corymbia citriodora*, *C. eximia*, *C. maculata* (DoEE, 2017a).
POPULATIONS	There are no separate or distinct populations as there is constant genetic exchange and movement across the species' range. In 2005, the total population was estimated at 674,000 individuals (DoEE, 2018c). In 2008, thirty-nine camps used by Grey-headed Flying-foxes were known in the south-east region of NSW occurring mostly along the coastal lowlands and ranges (Eby & Law, 2008). A small number of the camps found in the Sydney Metropolitan area were occupied continuously. These were thought to have been established due to the increasing volumes of food in the gardens and streetscapes of Sydney. All camps associated with native vegetation were inhabited less consistently and were only occupied occasionally or rarely (Eby & Law, 2008).
SOS SITES	The species has been assigned to the landscape species management stream because it is distributed across large areas and is subject to threatening processes that generally act at the landscape scale rather than at distinct, definable locations (OEH, 2018g).
RELEVANT PLANS AND POLICIES	The SPRAT profile (DoEE, 2018c) for Grey-headed Flying-fox states that there is no: • Approved Conservation Advice for this species • Adopted or made Recovery Plan for this species • Threat Abatement Plan which has been identified as being relevant for this species However, there is a draft Recovery Plan for this species which was published for public comment by the Department of Environment and Energy in 2017. The Plan will be assessed with reference to the draft Recovery Plan.
SPECIES-SPECIFIC GUIDELINES	Referral guideline for management actions in grey-headed and spectacled flying-fox camps (DoE, 2015f)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	Yes	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				

HABITAT MAPPING

Two forms of habitat mapping are used in this analysis:

- A species distribution model developed for the Cumberland subregion for this project
- Foraging habitat mapping developed by Eby and Law (2008)

SPECIES DISTRIBUTION MODEL

Species distribution model (SDM). Potential habitat was mapped using an SDM. The SDM was developed using species records associated with camps. This condition was imposed because this species is known to forage widely, and therefore there was a risk that potential habitat would have been over-predicted by the model if all records had been included.

Consistent with the approach taken for other EPBC Category 1 species, impacts are calculated using the SDM.

During surveys for this assessment the species was recorded twice in GMAC and once in GPEC.

FORAGING HABITAT

Foraging habitat. Eby and Law (2008) mapped foraging habitat for the species across its range. As part of this work they ranked native vegetation according the nectar resources it provides. Habitat is ranked from a score of 1-4 where 1 is the highest nectar rank, and 4 is the lowest.

The mapping is used in the analysis for context and to enable a consideration of foraging resources outside the Cumberland Plain (which were not mapped by the SDM).

CAMP MAPPING

The National Flying Fox Monitoring Program provides monitoring data for camps across the range of the Grey-headed Flying-fox. Data is available about the number of individuals at camps from 2012 to 2019.

The importance of camps is categorised as follows:

CAMP CATEGORY	DESCRIPTION
Nationally important	Camps that have contained ≥ 10,000 GHFF in more than one year in the last 10 years, or have been occupied by more than 2,500 GHFF permanently or seasonally every year for the last 10 years (DoE, 2015f)
High priority	> 2,500 in at least 4 of last 8 surveys
Medium priority	Any records in the last 2 years
No GHFF in last 2 years	No records in the last 2 years
No GHFF since 2011	No records since 2011

POPULATION MAPPING

RECORD SELECTION

Based on other bat species, the life expectancy is likely to be between two and ten years. BioNet records have been taken from 2008 onwards.

POPULATION DEFINITION

The records of Grey-headed Flying-fox are considered to be part of a single population across their range (DoEE, 2017a)

IMPORTANT POPULATION CRITERIA

The population of Grey-headed Flying-foxes was considered important within the Strategic Assessment Area because it met the following criteria: a population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.32 for a map of records and habitat across the Strategic Assessment Area. See Map 36.33 for a map of Grey-headed Flying-fox camp sites and Eby and Law (2008) foraging habitat
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-42 and Table 30-43 at the end of this species assessment for a breakdown of the occurrence of Grey-headed Flying-fox records, habitat and camps in the Strategic Assessment Area. The Strategic Assessment Area supports foraging and roosting habitat for the species. **Foraging habitat** As outlined above, two types of mapping for foraging habitat are used in this assessment: • Baseline mapping for this assessment which was done through an SDM process • Eby and Law (2008) foraging habitat mapping The baseline mapping for the assessment mapped approximately 26,873 ha of potential and known foraging habitat within the Strategic Assessment Area (Map 36.32). Habitat is mapped in association with a range of woodland communities and generally occurs where native remnants are present. Foraging habitat within 20 km of camps is considered important due to the common distance the species can travel to feed. All potential habitat in the Strategic Assessment Area is within 20 km of a camp. Map 36.33 shows GHFF camps with a 20 km buffer in relation to the Eby and Law (2008) foraging habitat. This mapping extends beyond the boundary of the Strategic Assessment Area to provide context about the amount of habitat within the surrounding region. **Roosting habitat** The Strategic Assessment Area supports 11 Grey-headed Flying-fox camps. Categorisation of camps is discussed above in the approach to baseline data section. Of the 11 camps: • One is nationally important (Macquarie Fields). It occurs at Bingara Reserve in Macquarie Fields, and is located within the northern part of GMAC close to an existing urban area. Campbelltown City Council is in the process of developing a Management Plan for the camp. It is approximately 1.5 km from the nearest urban capable land • One is high priority (Picton), it occurs outside the nominated areas • Six are medium priority. Two of these (Campbelltown and Ropes Creek) occur within the nominated areas but outside the urban capable lands (GMAC and GPEC respectively), and another (Emu Plains) is close to the western boundary of GPEC • Three have had no records of GHFF since 2011 The nationally important camp and high priority camp have significant mapped foraging resources (highest nectar rank) within 20 km. Much of this occurs outside the Strategic Assessment Area and is unlikely to be impacted (e.g. defence land, protected land). In addition to these camps, there are 14 camps that occur within 20 km of the Strategic Assessment Area. Three of these are nationally important.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.10.1 NOMINATED AREAS

None of the three camps that occur within the nominated areas will be directly impacted. They include:

- Macquarie fields and Campbelltown in GMAC
- Ropes Creek in GPEC

The baseline mapping for this assessment has mapped 1,805 ha of potential habitat for the Grey-headed Flying-fox within the nominated areas (not including excluded lands). Approximately 1,231 ha (68 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 749 ha was avoided for biodiversity purposes
- 482 ha was avoided for other purposes

Avoidance in WSA, GMAC and Wilton ranges between 57 per cent and 88 per cent. Avoidance is lower in GPEC, with 36 per cent of potential habitat avoided (117 ha avoided of 325 ha of potential habitat).

In addition, the Plan includes a specific mitigation measure (as part of Commitment 5) to retain large trees (≥50cm DBH) within urban capable lands during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction. This measure may provide additional avoidance of significant foraging trees for the Grey-headed Flying-fox within the nominated areas.

A breakdown of avoidance across each nominated area is provided in Table 30-44.

It is important to note that the avoidance calculations in Table 30-44, including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-44 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.10.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred. It is important to note that there are no camps within the transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

There will be no direct impacts to Grey-headed Flying-fox camps. However, implementation of the Plan will lead to the loss of potential foraging habitat. A breakdown of impacts across the Strategic Assessment Area is given in Table 30-45.

Given the wide-ranging nature of the species, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects.

30.10.3 LOSS OF POTENTIAL HABITAT

LOSS OF POTENTIAL FORAGING HABITAT

Approximately 723 ha of potential foraging habitat will be lost as a result of implementation of the Plan, or 2.7 per cent of potential foraging habitat mapped across the Strategic Assessment Area.

While it is impossible to know the rate that habitat will be lost, it is clear that development will proceed in a staged way over the life of the Plan. If clearing was to occur progressively over the life of the Plan at an even rate, approximately 20 ha of potential foraging habitat would be lost each year. The rate and scale of clearing are considered unlikely to lead to dispersal from existing camp sites. Particularly within the context of the Plan's conservation program (see Section 30.10.4 below).

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of substantial impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be low. As outlined in Section 30.3.5 which describes the risk assessment for wide-ranging species, "substantial" in this case is defined as impacts that could materially affect the species' use of the Strategic Assessment Area.

The risk rating of low was determined because:

- The likelihood of actual impacts occurring to the species has been categorised as possible. This is because:
  - There will be no impacts to known camps
  - The scale of impacts to foraging habitat is considered to be moderate. The species is highly mobile, feeds on fruit and nectar from a variety of vegetation communities and has access to large areas of intact vegetation surrounding the Strategic Assessment Area
- The consequence of any impacts to the species (if they did occur) has been categorised as minor as there will be loss of approximately 2.7 per cent of mapped potential foraging habitat in the Strategic Assessment Area

30.10.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the low risk of residual adverse impacts to the species, specific offsets were not considered necessary for the Grey-headed Flying-fox.

However, it is worth noting that the Plan's conservation program will provide substantial offsets for native vegetation. Much of which will provide potential foraging habitat for the species. Key components of the conservation program that will benefit Grey-headed Flying-fox include:

- Commitment 8 which will lead to the protection of at least 5,475 ha of native vegetation in the Cumberland subregion. At least 75 per cent of this target will be achieved by protecting existing native vegetation, and up to 25 per cent (or approximately 1,365 ha) will relate to ecological restoration
- A range of commitments that will help manage landscape threats across the Strategic Assessment Area. These will help maintain and improve the condition of foraging habitat for the species across the landscape over the life of the Plan and include commitments to manage weeds (Commitment 16), pest animals (Commitment 17), fire (Commitment 18), disease (Commitment 19), and support adaptation to climate change (Commitment 20)

Ecological restoration will be particularly beneficial to the species given the loss of potential foraging habitat. Ecological restoration is being prioritised early in implementation of the Plan which will help counteract the predicted progressive loss of potential foraging habitat over the life of the Plan. The NSW Government has committed $63 million in the first three years for a range of actions which include funding to plant 100,000 trees as part of ecological restoration of Koala habitat including within the Georges River Koala Reserve. These areas will provide benefits to the Grey-headed Flying-fox.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.10.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The draft Recovery Plan for the Grey-headed Flying-fox identifies a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impact (identified as a threat) is considered relevant to implementation of the Plan: camp disturbance.

Climate change is also a relevant threat to each species. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

A range of other threats are identified in the draft recovery plan which are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risks across the Strategic Assessment Area. They include: deliberate destruction associated with commercial horticulture; competition with Black Flying-foxes; electrocution on powerlines, entanglement in netting and on barbed-wire; and disease.

CAMP DISTURBANCE

The draft Recovery Plan notes that conflicts between people and flying fox camps is an ongoing problem. It typically occurs where camps are surrounded by urban and rural residential development, and people request relocation of the camp.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Camps that are considered most at risk are those that occur in or close to the nominated areas.

There are three camps within or close to GMAC:

- Macquarie Fields – nationally important, surrounded by existing development, being managed by Campbelltown City Council
- Campbelltown – medium priority, near the Campbelltown town centre and surrounded by existing development
- Menangle – no records since 2011, adjacent to the Nepean River just to the west of GMAC

There are four camps within or close to GPEC:

- Ropes Creek – medium priority, surrounded by existing development
- Emu Plains – medium priority, close to the Nepean River to the west of GPEC, significant development and disturbed areas in the vicinity
- Penrith – no records since 2011, close to the Nepean River to the west of GPEC, significant development and disturbed areas in the vicinity
- Emu Plains (2007) - no records since 2011, close to the Nepean River to the west of GPEC, significant development and disturbed areas in the vicinity

There are no camps within or close to Wilton or WSA.

All of these camps are close to (or surrounded by) existing development and are not located adjacent to any of the proposed urban capable lands. It is considered unlikely that:

- Additional development within the nominated areas will substantially increase the risk of disturbance beyond what is currently occurring
- Implementation of the Plan will result in dispersal from existing camps

However, in order to ensure that any future camp disturbance is avoided, the Plan includes a precautionary requirement (as part of Commitment 5) to establish ecological setbacks in accordance with distances in the DCP to provide a buffer to adjacent development for any Grey-headed Flying-Fox camps. If it becomes relevant, this measure is considered adequate for protecting camps.

Nevertheless, the Plan does incorporate a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the species. In relation to the Grey-headed Flying-fox these would be applicable to areas of potential foraging habitat in various locations. In summary, the measures include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance to vegetation
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the draft recovery plan around educating the community about the species

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.10.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are records of the Grey-headed Flying-fox on avoided land in Wilton and GMAC and potential habitat on avoided land in all nominated areas. The species may be subject to impacts from essential infrastructure. However, the species is mobile and wide-ranging, and the scale of impact is not expected to be significant.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.10.7 POTENTIAL IMPACTS FROM TUNNELS

Foraging habitat for the species occurs within the tunnel footprints for both the Metro Rail Future Extension (61.7 ha) and the Outer Sydney Orbital (88.2 ha). There are no Grey-headed Flying-fox camps in these areas.

The Plan includes commitments to:

- Avoid and minimise impacts to the key areas of biodiversity within the tunnel footprints (Commitment 4). This would include the vast majority of potential foraging habitat for the Grey-headed Flying-fox
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.10.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The draft Recovery Plan identifies the following key issues that are likely to have the greatest influence on the long-term viability of the Grey-headed Flying-fox in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts associated with camp disturbance

In addition, this section provides a brief discussion about the implications to the species of the 2019-20 bushfires.

HABITAT LOSS

Implementation of the Plan will not lead to impacts to any of the known camp sites for the species across the Strategic Assessment Area. In addition, there is a commitment to provide buffers around any camps if it becomes relevant during future planning.

However, the Plan authorises the clearing of 723 ha of potential foraging habitat which will be minimised in some locations by a commitment to retain large trees during precinct planning. The overall risk of substantial impacts occurring to the species as a result of habitat loss is low.

Habitat loss is not expected to adversely influence the long-term viability of the species because:

- The scale of clearing within the context of the available habitat both within and near to the Strategic Assessment Area is relatively minor. For example, there is currently 26,873 ha of mapped habitat in the Strategic Assessment Area
- Clearing is likely to occur progressively over the life of the Plan
- The Plan includes a range of commitments to protect and manage vegetation which will provide benefits to the species. These include a commitment to restore up to 1,365 ha of vegetation. It is also noted that restoring vegetation early in the life of the Plan is prioritised as part of an initial $63 million funding commitment
- The Plan includes a range of commitments to help manage landscape scale threats across the Strategic Assessment Area. These will provide a benefit to the species over the life of the Plan

The process of protecting land in the Strategic Assessment Area is likely to support actions from the draft recovery plan to increase the area of habitat for the species that is secured and managed for conservation.

INDIRECT IMPACTS

The potential indirect impacts associated with camp disturbance are not expected to substantially change from the current situation, and will not influence the long-term viability of the species.

IMPLICATIONS OF THE 2019-20 BUSHFIRES

As outlined in Part 1 of this report, the 2019-20 bushfires in NSW are unprecedented in their extent and intensity. As of 28 January 2020, the fires had burnt 5.3 million ha (6.7 per cent of NSW), including 2.7 million ha in national parks (37 per cent of the national park estate) and over 80 per cent of the Greater Blue Mountains World Heritage Area (EES, 2020).

The full impact of the fires will not be understood for some time (EES, 2020). This includes the potential impacts to the Grey-headed Flying-fox.

However, it should be noted that the initial analysis undertaken of the implications of the fires for this report (Part 1, Attachment A) did not identify Grey-headed Flying-fox as a species that may need additional commitments in the Plan. This is because it did not meet all of the following criteria (see Part 1 Attachment A for explanation):

- A high percentage (>10 per cent) of NSW records have been affected by fires of the 2019-2020 period, and
- The Cumberland subregion is already important for species persistence in NSW and/or has the potential to become more important for persistence because of the impacts of the fires to other areas of habitat, and
- The Plan has known or likely impacts to the species

CONCLUSION

There will be no direct impacts to known camps. There are large areas of potential habitat (26,873 ha) and impacts to this are relatively minor (723 ha) given the larger areas of intact habitat surrounding the Strategic Assessment Area.

Potential indirect impacts are addressed through a species-specific control defined in the Plan and implementation of the conservation program will protect large areas associated with potential habitat for the species.

Collectively these will ensure that the implementation of the Plan does not adversely influence the long-term viability of the Grey-headed Flying-fox.

30.10.9 CONSISTENCY WITH RECOVERY PLAN

There is no made or adopted recovery plan under the EPBC Act. However, there is a draft recovery plan that is addressed in this section.

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the draft Recovery Plan?
- Does the Plan prevent implementation of the draft Recovery Plan actions?

These are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE DRAFT RECOVERY PLAN?

The overall objectives of the draft Recovery Plan are to:

- Improve the Grey-headed Flying-foxes national population trend by reducing the impact of threatening processes on Grey-headed Flying-foxes through habitat identification, protection, restoration and monitoring, and
- Assist communities and Grey-headed Flying-foxes to coexist through better education, stakeholder engagement, research, policy and continued support to fruit growers

In addition to the overall objectives, the draft Recovery Plan has a range of specific objectives, including:

- Identify, protect and enhance native foraging and roosting habitat for the Grey-headed Flying-fox
- Determine population trends in Grey-headed Flying-foxes so as to monitor the species' national distribution and conservation status

- Build community capacity to coexist with flying-foxes and minimise the impacts on urban settlements from existing camps without resorting to dispersal
- Increase public awareness and understanding of Grey-headed Flying-foxes and the recovery program
- Improve the management of Grey-headed Flying-fox camps in sensitive areas
- Assess and reduce the impact on Grey-headed Flying-foxes of electrocution on power lines, and entanglement in netting and on barbed-wire

The outcome for the Grey-headed Flying-fox under the Plan will not make it impossible to the achieve any of the objectives of the draft Recovery Plan.

Does the Plan prevent implementation of the draft Recovery Plan actions?

The draft Recovery Plan includes a number of actions to help achieve its objectives. The Plan will not prevent implementation of any of the actions.

30.10.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-41 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For the Grey-headed Flying-fox there are no relevant Threat Abatement Plans.

Table 30-41: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Grey-headed Flying-fox

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-42: Occurrence of the Grey-headed Flying-fox in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	26,873.3	3,580.4

Table 30-43: Grey-headed Flying-fox Camps in the Strategic Assessment Area

CAMP NAME	CATEGORY	MAX RECORDS FOR A CAMP IN A SINGLE YEAR*							
		2012	2013	2014	2015	2016	2017	2018	2019
CABRAMATTA	Medium priority	3,000	3,500	6,740	14,130	7,500	5,000	5,000	-
CAMDEN, BROWNLOW HILL	Medium priority	-	2,600	5,800	6,300	6,000	800	-	3,300
CAMPBELLTOWN	Medium priority	500	1,554	1,533	3,299	3,276	3,039	669	7,915
EMU PLAINS	Medium priority	850	3,609	1,540	20,000	8,000	1,150	2,200	-
EMU PLAINS (2007)	No GHFF since 2011	-	-	-	-	-	-	-	-
MACQUARIE FIELDS	Nationally important	2,500	5,420	4,810	17,000	10,050	4,900	4,930	1,731
MENANGLE	No GHFF since 2011	-	-	-	-	-	-	-	-
PENRITH	No GHFF since 2011	-	-	-	-	-	-	-	-
PICTON	High priority	-	-	190	5,335	5,934	8,760	6,100	9,820
ROPES CREEK	Medium priority	-	900	1,500	6,780	3,620	600	1,248	2,500
YARRAMUNDI	Medium priority	500	2,566	900	2,500	-	-	850	2,751

Table 30-44: Avoidance of Grey-headed Flying-fox habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	121.8	1,497.8	602.6	2,449.4	4,671.6
HABITAT WITHIN EXCLUDED LANDS (ha)	36.6	629.3	76.7	2,124.3	2,866.9
HABITAT WITHOUT EXCLUDED LANDS (ha)	**85.2**	**868.5**	**525.9**	**325.1**	**1,804.7**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	35.2	486.8	154.0	73.4	749.4
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	41.3	56.0	29.3	22.6	41.5

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
AVOIDANCE FOR OTHER REASONS (ha)	19.2	275.3	144.2	43.3	482.0
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	22.5	31.7	27.4	13.3	26.7
TOTAL AVOIDANCE (ha)	**54.4**	**762.1**	**298.2**	**116.7**	**1,231.4**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**63.8**	**87.7**	**56.7**	**35.9**	**68.2**

Table 30-45: Direct impacts to the Grey-headed Flying-fox within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	30.9	106.4	227.7	208.4	149.7	**723.1**

SPECIES AT VERY LOW RISK OF DIRECT IMPACTS

30.11 *HELEIOPORUS AUSTRALIACUS* (GIANT BURROWING FROG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Heleioporus australiacus* (Giant Burrowing Frog) is a large, rotund frog that ranges from steely blue-grey to dark brown and black in colour with white/yellowish spots on its sides. It grows to approximately 10 cm in length. Tadpoles are plump, slow-moving and can grow up to 7.5 cm long. (DoE, 2014b)
ECOLOGY	The species feeds on ground-dwelling invertebrates including ants and spiders (DoEE, 2018c). Breeding occurs throughout the year with peaks in late summer or autumn. Individuals move into breeding habitat just before or just after heavy rain and can stay there for up to 10 days. Egg masses are foamy and can contain 500-800 eggs. They are laid in burrows or under vegetation in small pools. Tadpoles take 3-12 months to develop into frogs. The species spends most of their time (more than 95 per cent) in non-breeding habitats where they burrow below the soil surface or leaf litter. (DoE, 2014b)
DISTRIBUTION AND HABITAT	The species occurs in NSW and Victoria, along the coast and nearby ranges (DoE, 2014b). The species inhabits heath, woodland and open sclerophyll forest on a variety of soil types except those that are clay based. They are not restricted to watercourses but can be found in hanging swamps on sandstone shelves, by creeks, on sand or rock-based streams, dams, drainage ditches and culverts. (DoEE, 2018c). Breeding habitat tends to be in soaks or pools within first and second order streams. Breeding has also been recorded in ephemeral or permanent artificial drainage areas and culverts on roadsides (DoE, 2014b). Non-breeding habitat consist of areas up to 300 m from breeding sites. The species has rarely been recorded on cleared land (DoEE, 2018c).
POPULATIONS	Records possibly occur as two distinct populations. The northern population occurs from the Sydney Basin to Ulladulla with the southern population occurring from north of Narooma to Walhalla in Victoria. There are no population estimates for this species (DoE, 2014b).

SOS SITES	This species has been assigned to the landscape species management stream because it is distributed across large areas and is subject to threatening processes that generally act at the landscape scale rather than at distinct, definable locations (OEH, 2018f). No SOS sites for the species have been identified due to data deficiencies.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Heleioporus australiacus* (giant burrowing frog) (DoE, 2014b) Threat abatement plan for predation by feral cats (DoE, 2015g) Threat abatement plan for predation by the European red fox (DEWHA, 2008n) Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE, 2016b)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines for the Giant Burrowing Frog
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1973

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

<table>
<tr><td rowspan="3">NOMINATED AREA CANDIDATE SPECIES
(BCAR PROCESS)</td><td>ECOSYSTEM CREDIT SPECIES</td><td colspan="4">CANDIDATE SPECIES CREDIT SPECIES</td></tr>
<tr><td rowspan="2">No</td><td>WILTON</td><td>GMAC</td><td>WSA</td><td>GPEC</td></tr>
<tr><td>Yes</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>EXPERT REPORT
(BCAR PROCESS)</td><td colspan="5">There is no expert report for this species.</td></tr>
<tr><td rowspan="4">HABITAT MAPPING</td><td colspan="5">WITHIN THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). Habitat maps within the nominated areas for the Giant Burrowing Frog were generated using:
BioNet PCT associations of intact vegetation
Patch sizes of larger than 5 ha were to exclude small isolated patches of vegetation from the model
Areas within 300 m of 1st and 2nd order watercourses, excluding overlapping areas within 300 m from a 3rd (or higher) order watercourse
Rock units in ‘Hawkesbury Sandstone’ and ‘Minchinbury Sandstone’ and excluded soils in 'Blacktown', 'Glenorie', 'Luddenham', 'Picton', 'West Pennant Hills'
Targeted habitat assessments were undertaken for this species, the species was not recorded however suitable habitat was found to occur.</td></tr>
<tr><td colspan="5">OUTSIDE THE NOMINATED AREAS</td></tr>
<tr><td colspan="5">Knowledge based map (KBM). As above. No targeted surveys as part of this project were undertaken outside the nominated areas.</td></tr>
</table>

POPULATION MAPPING	**RECORD SELECTION** BioNet records were used from 2008 onwards based on the approximate 10 year life-span of the species (noting that this only excluded two records from the assessment – both with limited accuracy from 1974 and 1913). **POPULATION DEFINITION** Records within 300 m were considered to be a population. **IMPORTANT POPULATION CRITERIA** The populations of Giant Burrowing Frog were considered important within the Strategic Assessment Area because they met the following criteria: a population within a conservation reserve

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.29 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-47 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Giant Burrowing Frog in the Strategic Assessment Area. **Records** There are limited records for the Giant Burrowing Frog within the Strategic Assessment Area. This reflects the lack of suitable habitat across the Cumberland subregion generally and the relative extent of clearing compared with surrounding areas. The species occurs more commonly to the south-east of the Strategic Assessment Area between Campbelltown and Helensburgh, as well as to the north-west, north and north-east of the Strategic Assessment Area. Two populations from five records have been mapped within the Strategic Assessment Area – one in the Castlereagh area in the north, and a second in the Gulguer Nature Reserve in Greendale towards the western boundary of the Strategic Assessment Area. The population from the Castlereagh area is considered not important. It comprises a single record located within a largely cleared landscape containing large housing lots. The second population (comprising four records) is considered to be important on the basis of its occurrence within a protected area; the premise being that populations within protected areas have a greater chance of persistence, and therefore make a significant contribution to the conservation and recovery of the species. **Potential habitat** The baseline mapping for this assessment has mapped 4,075 ha of potential habitat within the Strategic Assessment Area. This primarily occurs in the south of the Strategic Assessment Area, with scattered patches in the west and along parts of the eastern boundary of the Strategic Assessment Area. Potential habitat within the Strategic Assessment Area occurs along the interface between broad areas of intact vegetation surrounding the Cumberland subregion and land that has been cleared for farming or houses within the Strategic Assessment Area. It is likely to be marginal when compared to available habitat in the region.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.11.1 NOMINATED AREAS

The baseline mapping for the assessment mapped 317.3 ha of potential habitat for the Giant Burrowing Frog within the nominated areas (not including excluded lands). Nearly all of this habitat has been avoided as part of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 223.7 ha was avoided for biodiversity purposes
- 93.0 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-48.

It is important to note that the avoidance calculations in Table 30-48, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-48 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.11.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.11.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will result in very small impacts to potential habitat.

LOSS OF POTENTIAL HABITAT

Approximately 0.6 ha of potential Giant Burrowing Frog habitat will be lost as a result of the implementation of the Plan (within Wilton and GMAC). This habitat represents <0.1 per cent of potential habitat within the Strategic Assessment Area. No direct impacts will occur to locations where the species has been recorded.

A summary of these impacts is provided in Table 30-49.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be very low. This is because:

- The likelihood of substantial impacts occurring to the species has been categorised as unlikely. There will be no direct impacts to known populations and small impacts to potential habitat. The species has not been recorded within the region associated with direct impacts and is unlikely to be found there. Impacts are to small and fragmented areas and avoid direct impacts to first and second order streams within the distribution of mapped potential habitat
- The consequence of any impacts to the species has been categorised as negligible. There will be loss of approximately <0.1 per cent of mapped potential foraging habitat in the Strategic Assessment Area

30.11.4 FRAGMENTATION OF HABITAT

Development within the nominated areas or transport corridors will not lead to fragmentation of potential habitat for the species.

30.11.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for the Giant Burrowing Frog.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.11.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the Giant Burrowing Frog identifies a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Changes to hydrology and water quality
- Inappropriate fire regimes
- Predation by foxes and cats
- Vehicle strike
- Infection with amphibian chytrid fungus

The Conservation Advice identifies a number of other key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

HYDROLOGICAL CHANGES

Hydrological changes caused by stormwater run-off, water extraction and sedimentation has been identified as a threat to the species (DoE, 2014b).

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council’s requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets

- Soil erosion and sedimentation. For example:
  - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
  - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to habitat for the species
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are identified as a threat to the Giant Burrowing Frog (DoE, 2014b).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat

- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

PREDATION BY CATS

Predation by cats and other pest animals is recognised as a threat to the Giant Burrowing Frog, although the conservation advice states that the level of impact is unknown (DoE, 2014b). New urban development under the Plan is likely to increase the number of domestic cats in the local area, which in turn, may lead to an increase in feral cat populations.

The Plan incorporates a range of measures to manage the risks associated with cats. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
    - Preparation of a Pest Animal Control Implementation Strategy
    - A process to enter into written agreements with delivery partners to implement the pest animal control program
    - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
    - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
    - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
    - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

VEHICLE STRIKE

Vehicle strike as a result of increased traffic frequency is an identified potential threat to the species (DoE, 2014b).

Expanding urban development within the nominated areas and development of transport corridors will increase the traffic within and surrounding these areas. However, the Giant Burrowing Frog is unlikely to be affected by this increase given the lack of historical records within proximity to development and the location of the known populations in areas that are unlikely to see any change in vehicle movements due to development under the Plan.

INFECTION WITH AMPHIBIAN CHYTRID FUNGUS

Amphibian chytrid fungus, which causes the infection known as chytridiomycosis, is identified as a key threat to the Giant Burrowing Frog (DoE, 2014b).

Chytrid fungus is already present in the Cumberland subregion, although there may be pockets of disease free areas that are inhospitable to the growth of the disease (for example, due to salinity levels or elevated concentrations of trace metals). The potential for dispersing chytridiomycosis in wild frog populations increases with urbanisation around streams. This comes from growing potential for human interaction, more water flow (urban run-off) and reduced optimal habitat.

The Plan incorporates a range of measures to manage the risks associated with this issue. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise the spread of disease

The package of measures in the Plan is expected to adequately manage the risk associated with chytrid fungus because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

It is noted that there is no mapped potential habitat, and no known records of the species, within either the OSO tunnel footprint or the Metro Rail Future Extension tunnel footprint. It is therefore considered unlikely that development within the tunnel footprints will negatively impact the Giant Burrowing Frog.

30.11.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no known records of the Giant Burrowing Frog within avoided lands in any of the nominated areas. However, there is 316.7 ha of potential habitat mapped for the species within avoided lands within Wilton and GMAC, and therefore it is considered to be possible that the species may occur within avoided lands in these nominated areas.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.11.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014b) identifies the following key issues relevant to implementation of the Plan that are likely to have the greatest influence on the long-term viability of the Giant Burrowing Frog:

- Habitat loss
- Indirect impacts such as:
  - Hydrological changes
  - Inappropriate fire regimes
  - Predation by cats
  - Vehicle strike
  - Infection with amphibian chytrid fungus

However, it is unlikely that any of these issues will be a problem within the Strategic Assessment Area. The key reasons for this are as follows:

- There are only two identified populations within the Strategic Assessment Area, one of which is important. The important population and associated habitat is separated by a distance of almost 6 km from the nearest urban capable land and is within an area already managed for conservation. The non-important population is based on one record located within a largely cleared landscape containing large housing lots
- While potential habitat in the south of the Strategic Assessment Area within Wilton and GMAC may be subject to indirect impacts, the species has not been recorded in this area and it is unlikely to be important to the viability of the populations in the region given the extent of adjacent wilderness known to support the species
- While there is a possibility that indirect impacts may affect the nearest records for the species to the east of the Strategic Assessment Area, potential impacts are likely to be minor and incremental given the distance from the nearest urban capable land (approximately 4 km) and the extent of existing development within the Campbelltown area

In addition, the Plan is very likely to lead to the protection and management of important areas for the species within the SCA. Two of the reserves currently proposed by the Plan are with known or have the potential to support the species. They are:

- The Gulguer Reserve investigation area which occurs on the western side of the Strategic Assessment Area where the Giant Burrowing frog has been recorded. The Plan proposes to implement the reserve over the first 20 years of the Plan and it will cover an area of approximately 1,800 ha
- The Georges River Koala Reserve which is on the eastern side of the Strategic Assessment Area near GMAC and which contains substantial areas of potential habitat. This will be implemented in two stages over the first 10 years of the Plan and will cover an area of approximately 1,892 ha

CONCLUSION

There is a very low risk of residual adverse impacts from habitat loss under the Plan and potential indirect impacts are managed and unlikely to affect the species.

Implementation of the Plan will not adversely influence the long-term viability of the Giant Burrowing Frog.

30.11.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.11.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in (DoE, 2014b) where they relate to:

- The potential direct impacts of the Plan, or

- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-46: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Giant Burrowing Frog

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE, 2016b)
Land clearance	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by European red fox	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-47: Occurrence of the Giant Burrowing Frog in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	2	1
(IMPORTANT POPULATIONS)	(1)	(1)
HABITAT MAPPING (Ha)	4,074.7	566.5

Table 30-48: Avoidance of Giant Burrowing Frog habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	290.4	108.0	0.0	0.0	398.4
HABITAT WITHIN EXCLUDED LANDS (ha)	48.5	32.6	0.0	0.0	81.1
HABITAT WITHOUT EXCLUDED LANDS (ha)	**241.8**	**75.4**	**0.0**	**0.0**	**317.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	181.4	42.2	0.0	0.0	223.7
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	75.0	56.0	N/A	N/A	70.5
AVOIDANCE FOR OTHER REASONS (ha)	60.1	32.9	0.0	0.0	93.0
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	24.9	43.6	N/A	N/A	29.3
TOTAL AVOIDANCE (ha)	**241.5**	**75.1**	**0.0**	**0.0**	**316.7**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**99.9**	**99.6**	**N/A**	**N/A**	**99.8**

Table 30-49: Direct impacts to the Giant Burrowing Frog within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.3	0.3	0.0	0.0	0.0	**0.6**

30.12 *LITORIA AUREA* (GREEN AND GOLDEN BELL FROG)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Litoria aurea* (Green and Golden Bell Frog) is a large dull olive to bright emerald-green frog with large irregular golden-bronze blotches on its back.
ECOLOGY	The Green and Golden Bell Frog has a diverse diet which includes invertebrates such as insect larvae, crickets, cockroaches, dragonflies, earthworms, flies, grasshoppers, mosquito wrigglers, isopods, freshwater crayfish and slugs (DEWHA, 2009b). Tadpoles feed on algal or bacterial scum growing on submerged rocks (DEWHA, 2009b). The species is active by day, although males call mostly at night. While they retain a close association with water bodies and appear to generally be faithful to a single water body for their general activities, records suggest that the species is highly mobile and can move some distance as part of migrations to and from breeding sites (Lemckert, 2019). Movements of up to 5 km may be common and the frog may disperse up to 10 km (DoEE, 2018c). Breeding occurs generally between September and February after heavy rains or storms and spawn is laid among aquatic vegetation (DEWHA, 2009b). The species has high fecundity and clutch sizes have been known to contain 2463-11,682 eggs (DEWHA, 2009b).
DISTRIBUTION AND HABITAT	Records of the Green and Golden Bell Frog are widely separated and isolated, occurring along coastal lowland areas of eastern NSW and Victoria ranging from Yuraygir National Park in the north to Lake Wellington in the south. In NSW, several records occur around Sydney and the species is known to occur in the Cumberland subregion. Nearly all current known populations of the Green and Golden Bell Frog are located with 10 km of the coast. This is most likely due to the fact that the species is susceptible to the amphibian chytrid fungus and the fungus is intolerant of salt. These locations therefore provide some refuge from the impacts of chytrid (Lemckert, 2019). Habitat comprises one or more water bodies, and associated terrestrial habitats with grassy areas and low vegetation (DEWHA, 2009b). The species uses water bodies that are still, shallow, temporary, unshaded, with aquatic plants and free of mosquito fish for breeding (DEWHA, 2009b). A range of water bodies are suitable for the species, as long as they are not fast flowing, including ponds, wetlands, farm dams, creek lines and irrigation channels (DEWHA, 2009b). Ephemeral water bodies are important habitat for the species as: • Flooding of these water bodies can trigger breeding • They can provide habitat stepping stones between otherwise disconnected areas

	• They are less likely to contain mosquito fish. In NSW, the species is known to occupy disturbed habitats such as abandoned mines and quarries (DEWHA, 2009b). Non-breeding habitat is usually closely associated with water bodies (often within 50 m) (Lemckert, 2019). These terrestrial habitats immediately adjacent to water bodies are used for foraging and shelter and preferably contain grassy areas and vegetation including a range of shelter sites such as logs, rocks or dense vegetation (DEWHA, 2009b). Shelter sites are used when the species is inactive and therefore vulnerable to predation. The species is more likely to be present, and habitat more likely to be important, where: • Multiple suitable breeding sites are within a close enough proximity for individuals to migrate between them • Multiple non-breeding water bodies are present in an area and within close enough proximity to allow migration between them (and breeding sites) with relative ease • The connectivity of breeding and non- breeding habitat contains vegetation and shelter that facilitates migration • There are other individuals occupying waterbodies in close proximity (Lemckert, 2019)
POPULATIONS	In 2008, 30 populations were known in NSW and records are clustered around the following areas: • Yuraygir National Park • Gosford • Greater Sydney • Kempsey-Port Macquarie • Hexham-Newcastle-Ravensworth-Mungo Brush • Illawarra-Batemans Bay • Eden-East Gippsland (DoE, 2014d) Most populations have fewer than 20 adults, however, a population in Captains Flat has around 100 adults and over 1,000 were recorded at Kooragang Island, Broughton Island and Homebush (DoEE, 2018c). A population is considered a separate population if it is located more than 10 km from a known or nearby population (DEWHA, 2009b).
SOS SITES	Eight SOS sites for the species have been identified: • Yuraygir National Park • Crescent Head • Broughton Island • Kooragang Island • Homebush/Sydney Olympic Park • Crookhaven • Molonglo Floodplain • Meroo The closest site to the Strategic Assessment Area is the Homebush/Sydney Olympic Park site.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Litoria aurea* (Green and Golden Bell Frog) (DoE, 2014d) EPBC Act Policy Statement 3.19. Significant impact guidelines for the vulnerable green and golden bell frog (*Litoria aurea*) (DEWHA, 2009d) Threat abatement plan for predation by feral cats (DoE, 2015g) Threat abatement plan for predation by the European red fox (DEWHA, 2008n) Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE, 2016b)

SPECIES-SPECIFIC GUIDELINES	The EPBC Act Policy Statement 3.19 - Significant Impact Guidelines for the Vulnerable Green and Golden Bell Frog (*Litoria aurea*) (DEWHA, 2009d) provides guidance about how to determine whether a proposed action is likely to have a significant impact on the Green and Golden Bell Frog. The guidelines describe an action as having a significant impact on the Green and Golden Bell Frog if it directly or indirectly alters or interferes with the breeding or dispersal of the species. Specifically, a referral under the EPBC Act should be considered if the action results in: 1. The removal or degradation of aquatic or ephemeral habitat either where the Green and Golden Bell Frog has been recorded since 1995 or habitat that has been assessed as being suitable according to these guidelines. This can include impacts from chytrid and *Gambusia* originating off-site 2. The removal or degradation of terrestrial habitat within 200 m of habitat identified in threshold 1 3. Breaking the continuity of vegetation fringing ephemeral or permanent waterways or other vegetated corridors linking habitats meeting the criteria in threshold 1 Only one threshold needs to be met to be considered a significant impact.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1870

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	Yes	Yes	Yes	Yes
EXPERT REPORT (BCAR PROCESS)	Yes (Lemckert, 2019). Available at Supporting Document C.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Expert report polygons. Predicted polygons for the Green and Golden Bell Frog were provided for GMAC and GPEC only, as these are the only two nominated areas supporting extant populations of the species. The species polygons cover the locations of known records, the riparian corridor joining those records and a buffer of 1,000 m around the riparian corridor and records. This is the area deemed likely to be used for foraging, shelter, breeding and as migratory habitat as they move between water bodies and riparian corridors (Lemckert, 2019). Targeted habitat assessments were not undertaken as part of this project.				
	OUTSIDE THE NOMINATED AREAS				
	Species distribution model (SDM). Potential habitat outside the nominated areas was mapped using an SDM. The report for this process notes that there are important factors driving the species' distribution for which appropriate predictors were not available. For example, Chytridiomycosis is known to impact where the species occurs. In addition, the Green and Golden Bell Frog is known not to be restricted to areas surrounded by native vegetation and has been found in quarries,				

	constructed ponds, and small bodies of the water on the ground. Therefore, the resulting predictions should be used with some caution. No targeted surveys as part of this project were undertaken outside the nominated areas.
	MAPPING TO ADDRESS SIGNIFICANT IMPACT GUIDELINES
	Additional mapping was generated to enable an assessment of impacts against the criteria set out in EPBC Act Policy Statement 3.19 (DEWHA, 2009d). This mapping identifies: • Aquatic habitat based on the overlap between habitat identified through the expert polygon process and species distribution model with buffers applied to mapped drainage and water bodies (those defined by the Guidelines for riparian corridors on waterfront land (NOW, 2012)). The buffers were applied to both sides of the mapped drainage and were based on the Strahler stream order. A standard 40 m buffer was applied to water bodies • Terrestrial habitat, comprising potential habitat identified through the Expert report polygon process and species distribution model within 200 m of the aquatic habitat identified in (1)
POPULATION MAPPING	**RECORD SELECTION**
	All available BioNet records from 1995 onwards were included in the assessment, based on the guidance in the EPBC Act Policy Statement 3.19 (DEWHA, 2009d).
	POPULATION DEFINITION
	Populations were considered separate if records were more than 10 km apart OR where landscape features interrupted connectivity, based on the guidance in the EPBC Act Policy Statement 3.19 (DEWHA, 2009d).
	IMPORTANT POPULATION CRITERIA
	The populations of Green and Golden Bell Frog were considered important within the Strategic Assessment Area because they met the following criteria: a population identified or inferred in a Commonwealth conservation advice, plan, final determination, or other relevant policy document as being important

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.31 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-51 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Green and Golden Bell Frog in the Strategic Assessment Area. **Records** The Green and Golden Bell Frog has been recorded within the Strategic Assessment Area, although current records (from 1995 onwards) are limited. Four populations have been identified: • One population within GPEC associated with Ropes Creek • One population restricted to a small area around Blair Athol in GMAC. These records are of frogs that escaped a captive colony. No natural population has been identified, and while a population could potentially have established in that location, no records have been obtained after 2014 indicating that the population has disappeared (Lemckert, 2019) • One population identified at Gow Park in Mulgoa, approximately 2.4 km south of the nearest urban capable land within GPEC. This population was recorded in 1999 in a non-permanent creek • One population along the eastern boundary of the Strategic Assessment Area, approximately 17 km east of WSA

	There are a relatively large number of BioNet records for the Cumberland subregion. However, these are dominated by records from Sydney Olympic Park (outside of the Strategic Assessment Area) with over 95 per cent of the records located within the eastern third of the Cumberland subregion; again, primarily outside of the Strategic Assessment Area (Lemckert, 2019). The expert report for this species notes that the Green and Golden Bell Frog is unlikely to have been common across the majority of the Cumberland subregion, reflecting the fact that the region is over 10 km from the coast so chytrid fungus is more likely to be present (Lemckert, 2019). **Potential habitat** The baseline mapping for this assessment has mapped 5,501 ha of potential habitat within the Strategic Assessment Area. This habitat is concentrated towards the eastern most boundary of the Strategic Assessment Area, with some large areas identified north of GPEC and small, scattered areas along the western edge. Potential habitat within GPEC and GMAC is associated with the location of known records in these nominated areas. There is no potential habitat within Wilton and WSA. It is expected that survey effort has been sufficient to reasonably indicate likely presence across all four nominated areas (Lemckert, 2019).

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.12.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 25 ha of potential habitat for the Green and Golden Bell Frog within the nominated areas (not including excluded lands). Approximately 11 ha (46 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors. All of the avoidance occurred in GPEC and for biodiversity purposes.

A breakdown of avoidance across each nominated area is provided in Table 30-52.

It is important to note that the avoidance calculations in Table 30-52, including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-52 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.12.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

However, the Plan includes a specific measure to support the Green and Golden Bell Frog: to design the transport corridors to avoid and minimise impacts to populations and habitat and connectivity, particularly along riparian corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Offsets are provided for species that are considered to be at <u>medium</u> or <u>high</u> risk of residual adverse impacts. Offsets are not provided for species that are considered to be at <u>low</u> or <u>very low</u> risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.12.3 LOSS OF KNOWN AND POTENTIAL HABITAT

Implementation of the Plan will lead to impacts to potential habitat. The majority of these impacts relate to habitat within GPEC where the species has previously been recorded. A very small area of mapped potential habitat will be affected within transport corridors outside the nominated areas.

A breakdown of impacts across the Strategic Assessment Area is given in Table 30-53.

IMPACTS TO HABITAT WITHIN GPEC

The urban capable lands and transport corridors within GPEC intersect just over 13 ha of habitat within and adjacent to the Ropes Creek corridor. This habitat is known to have supported a population of the Green and Golden Bell Frog, with 6 BioNet records made between 1998 and 2012.

It has not been confirmed whether this population still exists. However, there are a series of other records for this population from nearby habitat associated with Ropes Creek (both current from 1995 onwards and a number of older records) and areas of suitable habitat remain along the corridor in the form of a high density of water bodies within undeveloped lands (Lemckert, 2019). It is likely that the population persists in the area. It is also noted that the clustering of records into several discrete areas that occurs along Ropes Creek is typical of the species. The species requires a series of supporting and interacting sub-populations (in this case based around water bodies) for long-term success (Lemckert, 2019).

The impacts include 1.7 ha of aquatic habitat and 7.1 ha of terrestrial habitat within 200 m of aquatic habitat. If confirmed present, this population would be important and the loss of associated water bodies, suitable nearby terrestrial habitat or habitat that provides connectivity value may be significant. To address this risk, there is a species-specific measure in the Plan to undertake targeted surveys within potential habitat along Ropes Creek and if confirmed present, to avoid, protect and enhance key habitat features identified within and adjacent to the Ropes Creek corridor.

The standard risk assessment method described in Section 30.3 was not seen as applicable to the Green and Golden Bell Frog due to the species-specific measure to undertake targeted surveys and protect all habitat if the species is confirmed to be present. This measure addresses any uncertainty relating to presence and will lead to a total avoidance outcome if confirmed. The mitigated risk to the species from loss of habitat in this area is necessarily very low.

IMPACTS TO HABITAT OUTSIDE THE NOMINATED AREAS

Two very small areas of mapped potential habitat (totalling 0.7 ha) will be intersected by transport corridors outside the nominated areas. There are no records associated with these areas. The risk to the species from these impacts is considered to be very low as:

- The lack of historical records within the two impacted areas and connected habitats provides a good indication that they are unlikely to support the species given the reasonable level of survey effort in the region
- The Plan includes a commitment (Commitment 6) to mitigate indirect and prescribed impacts on the Green and Golden Bell Frog from major infrastructure (transport) development. This will involve:
  - An assessment of the impacts on biodiversity and other environmental values based on detailed design
  - Implementing mitigation measures based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines
  - Identifying potential design options for major watercourse crossings to reduce disruption to connectivity and the risk of vehicle strikes
  - Undertaking ongoing monitoring of high-value environmental areas, and review and adjust mitigation measures (where practical) in response to monitoring outcomes

30.12.4 FRAGMENTATION OF HABITAT

Development under the Plan will not lead to any further fragmentation of Green and Golden Bell Frog populations. If presence of the population is confirmed within habitat associated with the Ropes Creek corridor, all relevant habitat will be avoided and protected.

30.12.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for the Green and Golden Bell Frog.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.12.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the Green and Golden Bell Frog identifies a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. They include:

- Changes to the structure and diversity of aquatic vegetation
- Changes to hydrology and water quality
- Intensification of public access to habitat
- Predation by foxes, cats, dogs and rats
- Inappropriate fire regimes
- Infection with amphibian chytrid fungus
- Road mortality

Predation of eggs and tadpoles, interaction with cane toads and grazing are also identified as potential threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

CHANGES TO THE STRUCTURE AND DIVERSITY OF AQUATIC VEGETATION

Changes to the structure and diversity of aquatic vegetation from weed invasion is a key threat to the Green and Golden Bell Frog. Weeds are already present within the Strategic Assessment Area. However, urban, transport and agricultural development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or inadvertently changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where new urban growth or transport occurs adjacent to known populations or habitat, in particular adjacent to the OSO and close to North St Marys along Ropes Creek in GPEC.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCAs. This includes a number of key actions:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans

   - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
   - Require proponents to undertake the following when applying for/undertaking development:
      - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
      - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
      - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
   - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk posed to the Green and Golden Bell Frog from invasive weeds. This is because:

- Avoided lands will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

CHANGES TO HYDROLOGY AND WATER QUALITY

A reduction in water quality and changes to hydrology are recognised as a principal threat to the species (DEWHA, 2009d). Key issues relate to changes to drainage patterns and stormwater runoff, soil erosion and sedimentation and increased pollutants.

Development under the Plan has the potential to alter water quality and hydrology in areas of known and potential habitat for the Green and Golden Bell Frog. The areas at risk include:

- The population associated with Ropes Creek where development of the Western Sydney Freight Line (transport corridor to the east of WSA) intersects an upstream section of the creek
- The population at Gow Park in Mulgoa, which is located downstream of development within WSA

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
   - Water cycle management. For example:
      - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
      - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
   - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets

- Soil erosion and sedimentation. For example:
  - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
  - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to habitat for the species
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

INTENSIFICATION OF PUBLIC ACCESS TO HABITAT

Intensification of public access to habitat is identified as a threat to the species. However, populations of the Green and Golden Bell Frog adjacent to or within proximity of proposed development are already subject to this threat as they are located within highly urbanised areas. Implementation of the Plan is unlikely to change the current level of disturbance.

The Plan also incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the species. In summary, these include:

- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate access and use by the public
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal activities
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas.
- A specific measure in relation to Commitment 5 to ensure key habitat features are protected and enhanced if the Green and Golden Bell Frog is confirmed present along Ropes Creek following targeted surveys

The package of measures in the Plan is expected to adequately manage the risk to the species from increased public access to habitat areas as a result of development. This is because:

- The Ropes Creek corridor will be protected and managed if the species is confirmed to occur there
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

PREDATION BY CATS AND OTHER PEST ANIMALS

Predation by cats and other pest animals is recognised as a threat to the Green and Golden Bell Frog. New urban development under the Plan is likely to increase the number of domestic cats in the local area. However, areas of habitat within proximity of proposed development already occur within highly urbanised areas. Any increase in the risk of predation from cats on populations of the Green and Golden Bell Frog as a result of the Plan is expected to be minimal.

The Plan also incorporates a range of measures to manage this issue across throughout the nominated areas. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes are identified as a potential threat to the Green and Golden Bell Frog (DoE, 2014d).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity across the Strategic Assessment Area. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

INFECTION WITH AMPHIBIAN CHYTRID FUNGUS

Amphibian chytrid fungus, which causes the infection known as chytridiomycosis, is likely to impact on populations of the Green and Golden Bell Frog. The threat to the species from chytrid fungus is not well understood, with the risk of extinction from the disease categorised as low to moderate (DEWHA, 2009b; DoEE, 2016b). However, the suitability of habitat is influenced by the presence of chytrid fungus.

Chytrid fungus is already present in the Cumberland subregion, although there may be pockets of disease free areas that are inhospitable to the growth of the disease (for example, due to salinity levels or elevated concentrations of trace metals). The potential for dispersing chytridiomycosis in wild frog populations increases with urbanisation around streams. This comes from growing potential for human interaction, more water flow (urban run-off) and reduced optimal habitat. Increased risks associated with development under the Plan are minimal, however, as habitat areas are already highly urbanised.

The Plan also incorporates a range of measures to manage the risks associated with this issue. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion (this measure specifically relates to chytrid fungus)
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures to protect the environment during construction, including best practice site hygiene protocols to minimise the spread of disease
- A specific measure in relation to Commitments 5 and 6 to incorporate best practice site hygiene protocols to manage the potential spread of chytrid fungus within construction environmental management plans, if the Green and Golden Bell Frog is confirmed present along Ropes Creek. This measure is consistent with the following priority action in the Conservation Advice (DoE, 2014d): “develop and implement suitable hygiene protocols to protect known sites from further outbreaks of chytrid fungus”

The package of measures in the Plan is expected to adequately manage the risk associated with chytrid fungus because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction, including a species specific measure for the Ropes Creek corridor

ROAD MORTALITY

Road mortality is identified as a potential threat to the Green and Golden Bell Frog (DoE, 2014d). This is not a novel threat to the species within the Strategic Assessment Area as roads have already been developed in proximity to habitat areas. However, implementation of the Plan will lead to new roads and an increase in the volume of cars on existing roads within and surrounding the nominated areas. The main areas of concern relate to:

- The development of the Outer Sydney Orbital downstream of habitat associated with the Ropes Creek corridor
- Development of the Western Sydney Freight Line (transport corridor to the east of WSA) which intersects a creek line upstream of Ropes Creek

The Plan incorporates a range of measures to manage the increased threat from road mortality. In summary, these include:

- Development controls that will require fauna-friendly road design structures to be installed and maintained in appropriate areas adjacent to fauna habitat, such as underpasses, fauna bridges and overpasses
- A commitment (Commitment 6) to mitigate indirect and prescribed impacts on threatened species from major infrastructure (transport) development on threatened species and their habitat. This includes an action to identify potential design options for major watercourse crossings to reduce disruption to connectivity and the risk of vehicle strikes, with specific reference to the Green and Golden Bell Frog

These measures are considered to adequately address any potential increased threat from road mortality due to implementation of the Plan.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

There is no habitat for the Green and Golden Bell Frog within tunnel footprints and the species will not be impacted in these locations.

30.12.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The species may be subject to impacts to potential habitat from essential infrastructure on avoided land within GPEC associated with the Ropes Creek corridor. However, the Plan includes a specific commitment to survey this area and if the species is found, avoid, protect and enhance key habitat features identified within and adjacent to the corridor.

In addition, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.12.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014d) identifies the following key issues relevant to implementation of the Plan that are likely to have the greatest influence on the long-term viability of the Green and Golden Bell Frog:

- Habitat loss
- Indirect impacts including:
  - Changes to the structure and diversity of aquatic vegetation
  - Changes to hydrology and water quality
  - Intensification of public access to habitat
  - Predation by cats and other pest animals
  - Inappropriate fire regimes
  - Infection with amphibian chytrid fungus
  - Road mortality

HABITAT LOSS

The main issue relating to habitat loss for the Green and Golden Bell Frog occurs in GPEC where the urban capable lands and transport corridors intersect just over 13 ha of habitat within and adjacent to the Ropes Creek corridor. This habitat is known to have supported a population of the Green and Golden Bell Frog, with 6 BioNet records made between 1998 and 2012.

It has not been confirmed whether this population still exists. However, if it is present, it would be important and the loss of associated water bodies, suitable nearby terrestrial habitat or habitat that provides connectivity value may be significant. To address this risk, there is a species-specific measure in the Plan to undertake targeted surveys within potential habitat along Ropes Creek. If confirmed, key habitat features identified within and adjacent to the Ropes Creek corridor will be avoided, protected and enhanced. This habitat is not currently managed to protect the Green and Golden Bell Frog. An outcome that leads to its protection and ongoing management would therefore improve the long-term viability of the population. This would support a number of the priority actions in the Conservation Advice.

Any loss of potential habitat as a result of development is not expected to adversely affect the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with development under the Plan will all be adequately managed and mitigated through a combination of species-specific and generic management strategies.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

This assessment has identified the potential for significant impacts to the Green and Golden Bell Frog as a result of development within GPEC. The Plan has responded with a number of specific measures to address these risks. These measures will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

30.12.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.12.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-50 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-50: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Green and Golden Bell Frog

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE, 2016b)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by European red fox	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-51: Occurrence of the Green and Golden Bell Frog in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	6	0
(IMPORTANT POPULATIONS)	(6)	(0)
HABITAT MAPPING (Ha)	5,500.9	340.0

Table 30-52: Avoidance of Green and Golden Bell Frog habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	0.0	232.9	0.0	1,421.6	1,654.5
HABITAT WITHIN EXCLUDED LANDS (ha)	0.0	232.9	0.0	1,397.0	1,629.9
HABITAT WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**0.0**	**24.6**	**24.6**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	0.0	11.2	11.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	45.7	45.7
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.0	<0.1	<0.1
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	N/A	N/A	N/A	0.1	0.1
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**0.0**	**11.3**	**11.3**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**N/A**	**45.8**	**45.8**

Table 30-53: Direct impacts to the Green and Golden Bell Frog within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	13.3	0.7	**14.0**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	1	0	**1**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(1)	(0)	**(1)**

30.13 *PETAUROIDES VOLANS* (GREATER GLIDER)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Petauroides volans* (Greater Glider) is the largest gliding possum in Australia. It has thick fur which is dusky brown or dark to mottled grey on top and white or cream underneath. It can have a head and body length of 35-46 cm and 45-60 cm long tail. (TSSC, 2016e)
ECOLOGY	An arboreal nocturnal marsupial. Its diet consists of eucalypt leaves and sometimes flowers. It relies on trees with large hollows to shelter in during the day. Females reach sexual maturity in their second year and give birth to one offspring from March to June. They are estimated to live for 15 years. The home range is larger for males than for females and varies from 1-4 ha up to 16 ha in less productive forests and open woodlands. Male home ranges don't tend to overlap. They have low dispersal ability. (TSSC, 2016e)
DISTRIBUTION AND HABITAT	Restricted to eastern Australia, from the Windsor Tableland in north Queensland through to central Victoria. Isolated inland subpopulations have been found in western Townsville and the Einasleigh uplands. The species can be found in taller, montane, moist eucalypt forests containing old trees and large hollows. (TSSC, 2016e)
POPULATIONS	In 2014, the estimated population size was 100,000. The area of occupancy is estimated to be 16,164 km^2. Modelling suggests that the species requires at least 160 km^2 of native forest patches to maintain viable populations. (TSSC, 2016e)
SOS SITES	Key SOS management sites are being identified by EES, currently there are none.
RELEVANT PLANS AND POLICIES	Conservation Advice for *Petauroides volans* (Greater Glider) (TSSC, 2016e) Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines for the Greater Glider.

SPRAT LINK	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=254

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**				
	Knowledge based map (KBM). Habitat maps for the Greater Glider were generated using BioNet PCT associations of intact vegetation in areas with a patch size of greater than 25 ha. This patch size was chosen because smaller patch sizes were returning many areas of unsuitable habitat in the modelling.				
	OUTSIDE THE NOMINATED AREAS				
	Knowledge based map (KBM). As above.				
POPULATION MAPPING	**RECORD SELECTION**				
	BioNet records were restricted to post 2003 to account for the average 15 year lifespan of the species				
	POPULATION DEFINITION				
	The species occupies a relatively small home range with an average size of 1 to 3 ha and they have a low dispersal ability. Records separated by several kilometres and/or cleared developed areas were identified as separate populations.				
	IMPORTANT POPULATION CRITERIA				
	The populations of Greater Glider were considered important within the Strategic Assessment Area because they met the following criteria: a population within a conservation reserve				

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.30 for a map of records and habitat across the Strategic Assessment Area.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-55 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Greater Glider in the Strategic Assessment Area. **Records** Records for the Greater Glider are limited within the Strategic Assessment Area. There are thirteen known populations, of which four are considered important due to their location within a conservation reserve, including: • In the west of the Strategic Assessment Area, in Gulguer Nature Reserve. Approximately 5 km from the nearest transport corridor and WSA (important population #209) • In the south of the Strategic Assessment Area, between GMAC and Wilton. Records occur between 500 m and 2 km from urban capable lands (important population #207) • South west of Wilton towards the boundary of the Strategic Assessment Area. Near Couridjah, in the Thirlmere Lakes National Park (important population #210) • In the east of GMAC, on the boundary of the nominated area (important population #526) **Potential habitat** The baseline mapping for this assessment has mapped 25,763 ha of potential habitat within the Strategic Assessment Area. Due to the level of historical land clearing, potential habitat within the Strategic Assessment Area is more fragmented compared to surrounding areas of vegetation. The species is considered to be particularly sensitive to fragmentation, with a low dispersal ability and a requirement for large native patches of vegetation containing a high enough density of tree hollows. Potential habitat within the Strategic Assessment Area is therefore likely to be marginal compared to the much broader and intact areas of habitat to the north and west of the Strategic Assessment Area and to the south of Sydney.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.13.1 NOMINATED AREAS

The baseline mapping for the assessment mapped 2,400 ha of potential habitat for the Greater Glider within the nominated areas (not including excluded lands). Approximately 2,295 ha (96 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,633 ha was avoided for biodiversity purposes
- 662 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-56.

It is important to note that the avoidance calculations in Table 30-56, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-56 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.13.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.13.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to loss and fragmentation of potential habitat. A breakdown of impacts across the Strategic Assessment Area is given in Table 30-57.

LOSS OF POTENTIAL HABITAT

Approximately 134 ha of potential Greater Glider habitat will be lost as a result of the implementation of the Plan (105 ha within the nominated areas and 29 ha within transport corridors outside the nominated areas). This habitat represents 0.5 per cent of potential habitat within the Strategic Assessment Area. There are no records of the species in these areas to be impacted.

The main impact areas include:

- GMAC: Loss of 48 ha of potential habitat on the edges of riparian corridors adjacent to the urban capable land
- GPEC: Loss of 31 ha where the OSO intersects Wianamatta Regional Park
- Wilton: Loss of 16 ha of potential habitat on the edges of riparian corridors adjacent to the urban capable land

There will also be impacts close to three locations where the species has been recorded that are not mapped as habitat within the nominated. Each record occurs in small, fragmented patches of vegetation adjacent to urban capable lands. They are:

- Population 528 in Wilton
- Population 585 in WSA
- Population 584 in GPEC

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be very low. This is because:

- The likelihood of actual impacts occurring to the species has been categorised as possible. There will be impacts to potential habitat with a moderate confidence that the species occurs in the impact area. For example, in Wilton there will be some impacts to the edges of vegetation patches that are connected to an area with a known population (population 207). It is possible, although not certain that the species is present in some of the impact areas
- The consequence of any impacts to the species (if they did occur) has been categorised as negligible. There will be loss of approximately 0.5 per cent of mapped potential habitat in the Strategic Assessment Area

30.13.4 FRAGMENTATION OF HABITAT

FRAGMENTATION IMPACTS

The Plan will lead to fragmentation of potential habitat due to the development of the OSO within Wianamatta Regional Park.

RISK OF RESIDUAL ADVERSE IMPACTS

The risk of residual adverse impacts occurring to the species as a result of the loss of fragmentation is considered to be very low. This is because:

- The likelihood of fragmentation has been categorised as possible. This is because:
  - The likelihood that development presents a barrier to dispersal of the species is likely. The OSO transport corridor fragments habitat that could be used by the Greater Glider for dispersal
  - The type of fragmentation is impact to mapped habitat only. There are no records in the vicinity of the fragmentation
- The consequence of fragmentation has been categorised as negligible. This is because the area to be fragmented consists of a small area of potential habitat with no associated records

30.13.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for the Greater Glider.

However, it is worth noting that the Plan's conservation program is likely to provide substantial benefits for the species. In particular, the following reserves are likely to protect important populations:

- The Georges River Koala Reserve which occurs to the east of GMAC. It will cover up to 1,800 ha of land and include significant areas that are mapped as habitat for the Greater Glider
- The Gulguer Reserve Investigation Area which is on the western side of the Strategic Assessment Area. This area covers approximately 1,800 ha and has the potential to support the east-west connection between Burragorang State Conservation Area and Gulguer Nature Reserve (where population 209 has been recorded)

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.13.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (and other key documents) for the Greater Glider identify a range of threats to the species (TSSC, 2016e). Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Too intense or frequent fires
- Habitat loss or degradation from *Phytophthora* root fungus

Timber production, entanglement in barbed wire fencing, hyper-predation by owls and competition from Sulphur-crested Cockatoos are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

TOO INTENSE OR FREQUENT FIRES

Bushfires and prescribed burning are identified as key threats to the Greater Glider (TSSC, 2016e).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species or result in direct mortality. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- A landscape scale approach to fire management (including in reserves) will be applied with a focus on biodiversity values
- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

HABITAT LOSS OR DEGRADATION FROM PHYTOPHTHORA ROOT FUNGUS

Potential habitat for the Greater Glider is threatened by exposure to *Phytophthora cinnamomi*, a soil-borne water mould which is fatal to many flora species.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust
- A specific requirement in relation to Commitment 5 to incorporate best practice site hygiene protocols to manage the potential spread of pathogens, such as *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to potential habitat from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.13.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are records of the Greater Glider on avoided land in GPEC, WSA and GMAC and potential habitat on avoided land within all nominated areas. Therefore, the species may be subject to impacts from essential infrastructure. However, the species is mobile and the scale of impact is not expected to be significant.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.13.8 POTENTIAL IMPACTS FROM TUNNELS

Potential habitat for the Greater Glider occurs within the tunnel footprints for the Metro Rail Future Extension (31 ha) and the Outer Sydney Orbital (54 ha). These habitat areas are not associated with records.

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.13.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2015d) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the Greater Glider in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts such as:
  - Too intense or frequent fires
  - Habitat loss or degradation from *Phytophthora* root fungus

HABITAT LOSS AND FRAGMENTATION

The risk of residual adverse impacts to the species from habitat loss and fragmentation is <u>very low</u>. While the Plan authorises the clearing of 134 ha of potential habitat (0.5 per cent of potential habitat within the Strategic Assessment Area), this is considered unlikely to have a significant effect on the species because:

- There are no direct impacts to areas with known records of the species or important populations
- The majority of direct impacts occur on the edges of habitat corridors and to areas that are already highly fragmented
- The areas of foraging habitat within the Strategic Assessment Area are connected to a much larger network of intact habitat to the north, west and south. In this regional context, implementation of the Plan impacts a very small proportion of the habitat available to the species

In addition, the conservation program is likely to provide significant benefits to the species within the Strategic Assessment Area.

Habitat loss and fragmentation are not expected to adversely influence the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with too intense or frequent fires, and habitat loss or degradation from *Phytophthora* root rot fungus will be managed and mitigated through the generic and species-specific management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There are large areas of potential habitat (25,763 ha) and impacts to this are relatively minor (134 ha) given the larger areas of intact habitat surrounding the Strategic Assessment Area.

Potential indirect impacts are addressed through general management strategies and species-specific controls defined in the Plan and implementation of the conservation program will protect large areas associated with potential habitat for the species.

Collectively these will ensure that the implementation of the Plan does not adversely influence the long-term viability of the Greater Glider.

30.13.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.13.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-54 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan has been developed to ensure that it is not inconsistent with any relevant TAPs. This analysis around consistency is presented in Chapter 15.

Table 30-54: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Greater Glider

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gasses	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-55: Occurrence of the Greater Glider in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	13	4
(IMPORTANT POPULATIONS)	(4)	(4)
HABITAT MAPPING (Ha)	25,762.9	4,697.6

Table 30-56: Avoidance of Greater Glider habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	992.0	1,871.1	33.3	867.7	3,764.2
HABITAT WITHIN EXCLUDED LANDS (ha)	173.4	360.2	0.9	830.0	1,364.5
HABITAT WITHOUT EXCLUDED LANDS (ha)	**818.7**	**1,510.9**	**32.5**	**37.7**	**2,399.7**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	532.8	1,078.7	15.1	6.2	1,632.8
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	65.1	71.4	46.4	16.5	68.0
AVOIDANCE FOR OTHER REASONS (ha)	270.1	383.8	7.8	<0.1	661.7
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	33.0	25.4	24.0	<0.1	27.6
TOTAL AVOIDANCE (ha)	**802.9**	**1,462.5**	**22.9**	**6.2**	**2,294.5**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**98.1**	**96.8**	**70.4**	**16.5**	**95.6**

Table 30-57: Direct impacts to the Greater Glider within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	15.8	48.4	9.6	31.4	28.8	**134.0**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

30.14 *POMMERHELIX DURALENSIS* (DURAL LAND SNAIL)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Pommerhelix duralensis* (Dural Land Snail) is a medium sized snail with a dark brown to black semi-translucent, almost spherical shaped, shell. Adults grow approximately 10-23 mm in height and 14-23 mm in width. (DoE, 2015d)
ECOLOGY	Individuals are solitary. The species is nocturnal and typically active approximately one hour after dusk until dawn. Migration and dispersal are limited, overnight straight-line distances are less than one metre. Reproduction rates are low with about 32 eggs per season. Offspring mortality is high at 90 per cent in the first year. Life expectancy is approximately five years. Main food source is native fungi. The ranges of individuals are adjacent to each other but do not overlap significantly (DoE, 2015d).
DISTRIBUTION AND HABITAT	Endemic to NSW. Until recently, known records occurred predominantly along the north-east fringes of the Cumberland subregion on shale-sandstone transitional landscape, where the distribution is dependent on the shale availability (DoE, 2015d). Within the last year, new records for the species have been found near Silverdale and St Helens Park, which significantly increase the known southern range of the species. Inhabits forested areas with good native cover and woody debris. It favours sheltering under rocks or inside curled-up bark (OEH, 2019b). It is thought to be intolerant of highly disturbed and weedy habitats (DoE, 2015d). The species is found within the following EPBC listed TECs: • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest • Turpentine-Ironbark Forest in the Sydney Basin Bioregion • Shale Sandstone Transition Forest of the Sydney Basin Bioregion The species' habitat is severely fragmented, almost all links between the species' shale transition habitat and adjoining Cumberland Plain have been lost through land clearance. (DoE, 2015d) Shale-influenced habitats along the north west fringes of the Cumberland Plain are considered important for the species (DoE, 2015d).
POPULATIONS	Long term population trends are unknown. A number of populations are now isolated into remnants under five hectares in size (DoE, 2015d).
SOS SITES	No SOS sites for the species have been identified due to data deficiencies.

RELEVANT PLANS AND POLICIES	Conservation advice for *Pommerhelix duralensis* (Dural Land Snail) (DoE, 2015d)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85268

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
	ACROSS THE STRATEGIC ASSESSMENT AREA
HABITAT MAPPING	**Species distribution model (SDM).** An SDM for the species was prepared across the Cumberland subregion. Given the species was determined not to be a candidate species credit species in the nominated areas, any mapped habitat within the nominated areas was removed. The report for this process, published in 2018 (Supporting Document F), used known information and records about the species to model the distribution of habitat for the Dural Land Snail. However (as outlined in the following section), additional records of the Dural Land Snail have recently been discovered which significantly extend the known southern range of the species. It is therefore recognised that the SDM was produced without knowledge of the full current extent of the species' records. The report for this process mapped some areas of habitat in the locality of the new southern records of the species. Based on available records at the time, analysis within the report suggests that the model for the species overestimated the available habitat for the species, due to an absence of known records in those localities. However, the recent discovery of new records now suggests that the habitat mapped in these areas is likely to constitute real habitat. It is further recognised that additional habitat may be present for this species within the southern portion of the Strategic Assessment Area, and that future research may provide greater clarity regarding the extent of occurrence and habitat preferences for the Dural Land Snail.
	RECORD SELECTION
POPULATION MAPPING	Species records were compiled from BioNet and surveys undertaken for the project. Records were downloaded for the purposes of this assessment in September 2019, and assessments of species have been conducted primarily based on this dataset. However, it is noted (based on a review of the BioNet Atlas in July 2020) that there are new records in BioNet which significantly expand the known range of the species when compared to the original downloaded records.

	The Conservation Advice notes that the Dural Land Snail is morphologically similar to, and can be mistaken for, other species within the *Pommerhelix* and *Meridolum* genera which occur adjacent to the range of the Dural Land Snail. Expert review may therefore be required to confirm the authenticity of the new southern records. However, for the purposes of this report, it is assumed on a precautionary basis that the new species records have been correctly identified as the Dural Land Snail, and the records have been assessed accordingly. At the time of writing, it was too late to include the additional populations into the population database generated for this report, and as such these populations have not been assigned population numbers or included in the maps associated with this report, nor are they considered in impact statistics. However, these records have still been considered when assessing impacts to the species within the written body of this report. This assessment therefore includes consideration of all available BioNet records as of July 2020.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. Records have been grouped into populations based on geographic restrictions and connectivity between patches of suitable vegetation.
	IMPORTANT POPULATION CRITERIA
	Populations of the Dural Land Snail were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.28 for a map of records and habitat across the Strategic Assessment Area. Note that the map of records for the Dural Land Snail represents records within the database prepared for this report (compiled September 2019). Additional records for this species are now available on BioNet and have also been considered within this report.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-59 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Dural Land Snail in the Strategic Assessment Area. **Records** *Records within the population database for this report (compiled September 2019)* The majority of known records of the Dural Land Snail occur in the north and north east of the Cumberland subregion, ranging between Parramatta and Macquarie Park in the south, through to South Maroota and Sackville in the north. Within this dataset, all records except one is outside the Strategic Assessment Area. The record is located along the northern boundary of the Strategic Assessment Area, near Tennyson. *New records identified on BioNet as of July 2020* Within the Strategic Assessment Area, four new records are present, which significantly expand the known range of the species. These are as follows: • Two records to the north of GPEC, one at Agnes Banks and one to the east of Wianamatta Nature Reserve • One record between Silverdale township and the Gulguer Nature Reserve • One record directly adjacent to the boundary of GMAC, near the Georges River at St Helens Park. It is noted that this record occurs within the footprint of the proposed Georges River Koala Reserve

	The new records at Silverdale and St Helens Park are the southernmost known records of the Dural Land Snail. **Potential habitat** The baseline mapping for this assessment has mapped 25,503 ha of potential habitat within the Strategic Assessment Area. The majority of mapped potential habitat occurs in the north of the Strategic Assessment Area, with scattered patches along the Western fringes and across the centre.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.14.1 NOMINATED AREAS

There is no mapped habitat for the species within the nominated areas.

30.14.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.14.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will not lead to direct impacts to records or populations. However, it will lead to the loss of some potential habitat within the transport corridors. A breakdown of impacts across the Strategic Assessment Area is given in Table 30-60.

LOSS OF POTENTIAL HABITAT

Approximately 46 ha of potential habitat will be directly impacted. This loss is associated with the transport corridors outside the nominated areas, including development of the M7/Ropes Crossing Link Road at the north-east corner of GPEC, and development of the OSO to the west and south of WSA. It is noted that there are no known records of the species in the vicinity of impacted habitat.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be very low. This is because:

- The likelihood of actual impacts occurring to the species has been categorised as possible. There will be moderate impacts to potential foraging habitat

- The consequence of any impacts to the species (if they did occur) has been categorised as minor. There will be loss of approximately 0.2 per cent of mapped potential foraging habitat in the Strategic Assessment Area, however, there are very few records close to and within areas that will be impacted

30.14.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for the Dural Land Snail.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.14.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DoE, 2015d) for the Dural Land Snail (and other key documents) identifies a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes and habitat modification for bushfire asset protection
- Disturbance due to weed control activities, including slashing and burning activities

Predation, habitat modification, low fecundity and high mortality, use of garden pesticides to control snails and slugs, and competition with the common garden snail are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES AND HABITAT MODIFICATION FOR BUSHFIRE ASSET PROTECTION

Inappropriate fire regimes and habitat modification for bushfire asset protection are identified as key threats to the Dural Land Snail (DoE, 2015d).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans

- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

It is further noted that one of the new BioNet records for the Dural Land Snail occurs within the footprint of the proposed Georges River Koala Reserve (Commitment 10). The establishment of the Koala Reserve is a major focus of the Plan and will be managed for conservation purposes, which will include fire management measures to protect the biodiversity values of the reserve.

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- A known record at the southernmost extent of the species will be protected through establishment and management of the Georges River Koala Reserve (Commitment 10) which will undertake fire management practices to protect biodiversity values
- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

DISTURBANCE DUE TO WEED CONTROL ACTIVITIES INCLUDING SLASHING AND BURNING ACTIVITIES

Disturbance due to weed control activities is identified as a key threat to the Dural Land Snail (DoE, 2015d). In particular, the species is threatened by weed control which involves mechanical damage to the understorey, and by the burning of composted weed materials (as the snail is attracted to the compost piles which subsequently are burnt).

There is no potential habitat for the Dural Land Snail within the nominated areas. Therefore, the main risk areas for this species include known populations and mapped potential habitat outside of the nominated areas. The majority of habitat for the species occurs within the northern portion of the Strategic Assessment Area.

The Plan includes a commitment (Commitment 16) to manage priority weeds in strategic locations within the Cumberland subregion. Action 3 associated with this commitment is as follows: prepare a Weed Control Implementation Strategy to establish a coordinated weed control program, that:

- Identifies priority weed species and priority locations for weed control to maximise benefits to biodiversity in the SCA
- Identifies the training, extension and resource needs to address threats
- Provides guidance on weed control methods
- Identifies roles, responsibilities, delivery partners and other stakeholders, including Bushcare and Landcare groups, and Local Aboriginal Land Councils
- Provides guidance on funding decisions under the weed control program

Through provision of training, extension and resources, and through providing guidance on appropriate weed control measures at key sites throughout the Cumberland subregion, it is considered that the Plan will enable implementation of appropriate weed control measures which will not result in damage to biodiversity values. This measure is considered to provide protection to the Dural Land Snail from inappropriate weed control methods.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to tunnels associated with transport projects

30.14.6 POTENTIAL IMPACTS FROM TUNNELS

Potential habitat for the Dural Land Snail occurs within the tunnel footprints for the Metro Rail Future Extension (20.0 ha) and the Outer Sydney Orbital (60.3 ha). However, whilst habitat has been mapped for this species in this locality, it is noted that there are no known records of the species in the vicinity of the tunnel footprints. The Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur, including the Mater Dei BioBank site, as discussed in Chapter 36
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.14.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice for the Dural Land Snail (DoE, 2015d) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the species in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts such as:
  - Inappropriate fire regimes and habitat modification for bushfire asset protection
  - Disturbance due to weed control activities, including slashing and burning activities

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan will lead to loss of potential habitat within transport corridors. While the Plan facilitates the clearing of 45.8 ha of potential habitat, this is only a small proportion (0.2 per cent) of potential habitat within the Strategic Assessment Area. It is noted that the Plan will not impact shale-influenced habitats along the northwest fringes of the Cumberland subregion which are considered to be important for the species' survival (DoE, 2015d).

Based on the application of the risk assessment method, the overall risk of residual adverse impacts associated with these direct impacts is very low. Impacts will only occur within foraging habitat, and no known records of the species will be impacted.

The Plan includes a broader set of commitments and actions which are likely to benefit the species, which includes commitments to protect land within the SCAs which contain approximately 3,480.9 ha of potential habitat for the Dural Land Snail. It is also noted that the southernmost known record of the Dural Land Snail occurs within the footprint of the proposed Georges River Koala Reserve, which will be protected and managed for conservation under Commitment 10 of the Plan.

On balance, direct impacts associated with implementation of the Plan are not expected to threaten the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes and habitat modification for bushfire asset protection and disturbance due to weed control activities, including slashing and burning activities have been analysed and determined to be adequately managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

The limited scale of direct impacts to the species habitat and the management measures in the Plan to address potential indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

30.14.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.14.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in (DoE, 2015d) where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For the Dural Land Snail, there are no relevant Threat Abatement Plans.

Table 30-58: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Dural Land Snail

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-59: Occurrence of the Dural Land Snail in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	0
(IMPORTANT POPULATIONS)	(1)	(0)
HABITAT MAPPING (Ha)	25,503.4	2,801.8

Table 30-60: Direct impacts to the Dural Land Snail within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.0	0.0	0.0	0.0	45.8	**45.8**
DIRECT IMPACTS TO POPULATIONS (Number)	0	0	0	0	0	**0**
DIRECT IMPACTS TO IMPORTANT POPULATIONS (Number)	(0)	(0)	(0)	(0)	(0)	**(0)**

30.15 *ROSTRATULA AUSTRALIS* (AUSTRALIAN PAINTED SNIPE)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered, marine
DESCRIPTION	*Rostratula australis* (Australian Painted Snipe) is a medium sized stocky wading bird with blue-green legs and a long orange-pink bill. It has a brown head, nape and chest with comma shaped white markings around the eyes, white belly and a white harness shape marking from its breast to back. Its plumage is barred olive green and black (DSEWPC, 2013).
ECOLOGY	The species breeds all year round depending on available suitable wetland conditions. It has been known to lay up to four clutches of 2 to 6 eggs per year. Females mostly breed every two years. (DoEE, 2018c). The species feeds on vegetation, seeds and invertebrates such as insects, worms, molluscs and crustaceans. It is mostly active at dawn, dusk and throughout the night (DoEE, 2018c; Garnett, Szabo et al., 2011). It is generally seen singly or in pairs. Movement patterns are not well understood, the species may be dispersive or migratory (DoEE, 2018c).
DISTRIBUTION AND HABITAT	The species is only found in Australia and mainly occurs in the Murray Darling Basin. It is widespread across Australia (DoEE, 2018c; DSEWPC, 2013). It is associated with the following EPBC Act listed TECs: • Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains • Upland Wetlands of the New England Tablelands The species inhabits ephemeral and permanent shallow freshwater wetlands, occasionally brackish wetlands. It favours a dense cover of grass and reeds. Important areas for the species include the Murray Darling Basin, Queensland Channel Country, Fitzroy Basin of Central Queensland, south eastern South Australia and adjacent parts of Victoria. (DSEWPC, 2013)
POPULATIONS	The species occurs as a single sub-population and estimated at between 100 and 1,500 individuals (Garnett, Szabo et al., 2011).
SOS SITES	One SOS site has been identified for the species: Far West NSW It does not occur within the Cumberland IBRA subregion.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Rostratula australis* (Australian painted snipe) (DSEWPC, 2013) Threat abatement plan for predation by feral cats (DoE, 2015g)

	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines for the Australian Painted Snipe.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=77037

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Knowledge based map (KBM). Habitat maps were generated using vegetation classes derived from BioNet PCT associations, vegetation condition parameters (intact), 40 m buffer to waterways (based on preferred habitat comprising freshwater wetlands). No targeted surveys were undertaken as part of this project.
	OUTSIDE THE NOMINATED AREAS
	Knowledge based map (KBM). As above. No targeted surveys as part of this project were undertaken outside the nominated areas.
POPULATION MAPPING	**RECORD SELECTION**
	Records restricted to post 2002 to account for estimated 16 year lifespan of the species.
	POPULATION DEFINITION
	Biological populations of were defined using the records dataset and available information about the nature of the species. All records within the Cumberland subregion are representative of a portion of the east coast population and therefore records in the Strategic Assessment Area have been grouped as one single population.
	IMPORTANT POPULATION CRITERIA
	Populations of the Australian Painted Snipe were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.26 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-62 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Australian Painted Snipe in the Strategic Assessment Area. **Records** There are two records for the Australian Painted Snipe within the Strategic Assessment Area in the last sixteen years: • One is within GPEC from an unnamed water body outside of the urban capable land near to Wianamatta (South Creek) • The other is from the north of the Strategic Assessment Area in the floodplain of the Hawkesbury River While two records occur in the Strategic Assessment Area, the area is not recognised as a key location for the species and the nominated areas include only one record (within GPEC). The only other recent record in the Cumberland subregion (outside the Strategic Assessment Area) is from the former wastewater ponds associated with the old Riverstone Meatworks in the Marsden Park North Precinct of the North West Growth Centre (approximately 5.6 km from the nearest development area). **Potential habitat** The baseline mapping for this assessment has mapped 2,231 ha of potential habitat within the Strategic Assessment Area. This mapping is considered to be highly precautionary as it is based on all mapped waterways with the appropriate PCTs.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.15.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 106 ha of potential habitat for the Australian Painted Snipe within the nominated areas (not including excluded lands). Approximately 72 ha (68 per cent) of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 14 ha was avoided for biodiversity purposes
- 57 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-63.

It is important to note that the avoidance calculations in Table 30-63, including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-63 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.15.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

30.15.3 LOSS OF POTENTIAL HABITAT

Implementation of the Plan will lead to impacts to some potential habitat. Given the wide-ranging nature of the species, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects.

LOSS OF POTENTIAL HABITAT

Approximately 40 ha of potential habitat will be lost as a result of the implementation of the Plan. This habitat represents 1.8 per cent of mapped potential habitat across the Strategic Assessment Area. The majority of impacts to potential habitat occur in WSA (17 ha) and GPEC (10 ha), consisting of multiple small potential habitat areas.

A summary of these impacts is provided in Table 30-64.

RISK OF RESIDUAL ADVERSE IMPACTS TO THE SPECIES

The risk of residual adverse impacts occurring to the species as a result of the loss of potential foraging habitat is considered to be very low. This is because:

- The likelihood of actual impacts occurring to the species has been categorised as unlikely. There will be minor impacts to potential foraging habitat and it is considered unlikely for the species to be present in these areas. The Strategic Assessment Area is not recognised as a key location for the species and the mapping is considered to be highly precautionary
- The consequence of any impacts to the species (if they did occur) has been categorised as minor. There will be loss of approximately 1.8 per cent of mapped potential habitat in the Strategic Assessment Area and very few records close to or within impacted areas

30.15.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given the very low risk of residual adverse impacts to the species, offsets were not considered necessary for the Australian Painted Snipe.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.15.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the Australian Painted Snipe identifies a range of threats to the species. Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Loss or degradation of wetlands
- Predation by feral animals
- Vegetation changes caused by introduced plants
- Inappropriate fire regimes

Grazing, coastal port and infrastructure development, and shale oil mining are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

LOSS OR DEGRADATION OF WETLANDS

Loss and degradation of wetlands through drainage and diversion of water is identified as a threat to the Australian Painted Snipe (DSEWPC, 2013). This is a particular threat where important habitat areas are in the proximity of development and well connected hydrologically. The majority of habitat in the Strategic Assessment Area within the vicinity of development lacks records and is not considered to be critical for the species.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the species from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to habitat for the species
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to habitat for the species

The commitments and actions under the Plan are consistent with the following regional priority action in the conservation advice (DSEWPC, 2013): "manage any changes to hydrology that may result in changes to water table levels, run-off, salinity, algal blooms, sedimentation or pollution".

PREDATION BY FERAL ANIMALS

Predation by feral animals such as foxes and cats is identified as a potential threat to the Australian Painted Snipe, however, the Conservation Advice states that there is no evidence for this (DSEWPC, 2013).

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the species.

However, the extent of proposed new urban development under the Plan means that the threat associated with cats is likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats in the local area, which, in turn, may lead to an increase in feral cat numbers. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is low.

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

VEGETATION CHANGES CAUSED BY INTRODUCED PLANTS

Vegetation changes caused by introduced plants is identified as a threat to the Australian Painted Snipe (DSEWPC, 2013).

Many weeds are already present within the Strategic Assessment Area and pose a threat to habitat for the Australian Painted Snipe. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The species is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to habitat areas and introduces edge effects.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the SCAs. This includes a number of actions, of which the following are the most relevant to the outcome for the species:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program

  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk posed to the species from weed invasion. This is because:

- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

INAPPROPRIATE FIRE REGIMES

Altered fire regimes are identified as a potential threat to the Australian Painted Snipe, however, the conservation advice states that the impacts are unknown (DSEWPC, 2013).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

The commitments and actions under the Plan are consistent with the following regional priority action in the conservation advice (DSEWPC, 2013) to: "develop and implement a suitable fire management strategy for the habitat of the Australian Painted Snipe".

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

30.15.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no records and limited potential habitat for the Australian Painted Snipe on avoided land in the nominated areas.

However, as outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to biodiversity through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

30.15.7 POTENTIAL IMPACTS FROM TUNNELS

Foraging habitat for the Australian Painted Snipe occurs within the tunnel footprints for the Metro Rail Future Extension (6.8 ha) and the Outer Sydney Orbital (5.7 ha). These areas are not associated with records and the habitat mapping for the species is considered to be highly precautionary

However, the Plan includes commitments to:

- Avoid any direct impacts to the areas where the species could occur
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the species from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.15.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DSEWPC, 2013) identifies the following key issues that are likely to have the greatest influence on the long-term viability of Australian Painted Snipe in relation to implementation of the Plan:

- Habitat loss
- Indirect impacts such as:
  - Loss or degradation of wetlands
  - Predation by introduced vertebrates
  - Vegetation changes caused by introduced plants
  - Inappropriate fire regimes

HABITAT LOSS AND FRAGMENTATION

The risk of residual adverse impacts to the species from habitat loss is very low. Although the Plan authorises the clearing of 40 ha of potential habitat, this is only a small proportion (1.8 per cent) of potential habitat within the Strategic Assessment Area.

There are no specific commitments for the Australia Painted Snipe included in the Plan. This reflects the low level of risk to the species.

However, the Plan includes broader commitments and actions that are likely to benefit the species. In particular:

- The SCAs contain approximately 231 ha of mapped potential habitat for the species. Although the final extent of potential habitat that will be secured in these areas is unclear, the opportunity to secure large, well connected and high quality vegetation that provides potential habitat makes it likely that the conservation program will deliver benefits for this species
- Implementation of the conservation program will protect 5 ha of PCTs associated with habitat for the species

The process of protecting land in the Strategic Assessment Area is likely to support a management priority from the conservation advice to increase the area of habitat for the species that is secured and managed for conservation.

As a result, habitat loss under the Plan is not expected to influence the long-term viability of the species.

INDIRECT IMPACTS

The potential indirect impacts associated with the identified threats will be managed and mitigated through the generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There will be no direct impacts to known populations. There are large areas of potential habitat (2,231 ha) and impacts to this are relatively minor (40 ha).

Potential indirect impacts are addressed through management measures in the Plan.

Collectively these will ensure that the implementation of the Plan does not adversely influence the long-term viability of the Australian Painted Snipe.

30.15.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.15.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-61 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any of the Threat Abatement Plans.

Table 30-61: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Australian Painted Snipe

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by European red fox	Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-62: Occurrence of the Australian Painted Snipe in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	0
(IMPORTANT POPULATIONS)	(1)	(0)
HABITAT MAPPING (Ha)	2,230.9	83.1

Table 30-63: Avoidance of Australian Painted Snipe habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	16.8	27.3	77.5	211.0	332.6
HABITAT WITHIN EXCLUDED LANDS (ha)	0.5	15.3	11.2	199.7	226.7
HABITAT WITHOUT EXCLUDED LANDS (ha)	**16.3**	**12.0**	**66.3**	**11.3**	**105.9**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.4	0.1	13.8	0.0	14.3
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	2.2	1.1	20.9	0.0	13.5
AVOIDANCE FOR OTHER REASONS (ha)	15.0	5.4	35.8	1.1	57.3
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	92.0	44.7	54.0	9.5	54.0
TOTAL AVOIDANCE (ha)	**15.4**	**5.5**	**49.6**	**1.1**	**71.6**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**94.2**	**45.8**	**74.9**	**9.5**	**67.5**

Table 30-64: Direct impacts to the Australian Painted Snipe within the nominated areas and transport corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO HABITAT (ha)	0.9	6.5	16.7	10.2	5.2	**39.5**

SPECIES AT NO RISK OF DIRECT IMPACTS

30.16 *HIRUNDAPUS CAUDACUTUS* (WHITE-THROATED NEEDLETAIL)

This species assessment provides an impact assessment for the White-throated Needletail. The species is also a listed migratory species and assessed in Chapter 32 which should be read in conjunction with the assessment in this section.

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable, migratory **NB:** *An assessment of this species as a migratory species is provided in Chapter 32*
DESCRIPTION	*Hirundapus caudacutus* (White-throated Needletail) is a large swift, weighing up to 120 g. It has a thickset body up to around 20cm in length and long pointed wings. Plumage is generally olive green on the head and neck, grey and brown on the wings and body, with a white patch under the tail. (TSSC, 2019b)
ECOLOGY	There is limited information about the ecology of the White-throated Needletail. The species has two subspecies of which only one (*Hirundapus caudacutus caudacutus*) occurs in Australia. This subspecies is migratory. It breeds in northeast Asia (from central Siberia through to Northern China, Sakhalin and Japan) and migrates to Australia for the non-breeding season. The species typically arrives in northern Australia between September and early November before dispersing south along both sides of the Great Dividing Range. The species typically departs Australia between mid-March and April. (TSSC, 2019b) In Australia, the species has been recorded eating a wide range of insects. It is mostly aerial but has been recorded roosting. The species is typically gregarious and has been recorded in large flocks of hundreds or thousands of birds, including mixed flocks with Fork-tailed Swift (*Apus pacificus*) and Fairy Martins (*Hirundo ariel*). (DoEE, 2018c)
DISTRIBUTION AND HABITAT	In Australia, the species is widespread across eastern and south-eastern Australia. It has been recorded between Queensland and the south-east of South Australia in coastal regions and inland as far as the western side of the Great Dividing Range (DoEE, 2018c). The species is almost always observed in flight and has been recorded over a wide range of habitats at altitudes between 1 m above ground up to below cloud level (TSSC, 2019b). It is most commonly recorded above wooded areas and less commonly above treeless areas, but has been recorded above urban areas, farmland, coastal areas, and islands well out to sea (DoEE, 2018c). There are limited records of the species roosting in Australia, but it seems to prefer trees in forests and woodlands with dense foliage or hollows (TSSC, 2019b).

POPULATIONS	The White-throated Needletail occurs as a single, mobile population. The total population that migrates to Australia is unknown, but is estimated at 10,000 individuals (DoE, 2015e).
SOS SITES	No SOS Sites have been identified.
RELEVANT PLANS AND POLICIES	Conservation Advice *Hirundapus caudacutus* (White-throated Needletail) (TSSC, 2019b)
SPECIES-SPECIFIC GUIDELINES	Referral guideline for 14 birds listed as migratory species under the EPBC Act (DoE, 2015e)
SPRAT LINK	https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	No	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				
HABITAT MAPPING	Due to the aerial nature of the species and the limited information about its ecology, it was not possible to produce meaningful habitat mapping. The species appears to prefer certain geographic and meteorological conditions, rather than relying on particular kinds of vegetation or habitat features.				
POPULATION MAPPING	**RECORD SELECTION**				
	Records of the species were collated from Birdlife Australia, the Atlas of Living Australia, and BioNet Atlas. These records reflect observations as well as organised surveys. The analysis used a conservative estimate of individuals based on the total recorded sightings of the species per year across the Cumberland subregion.				
	POPULATION DEFINITION				
	As outlined above, there is a single population of the species. All records within the Strategic Assessment Area are therefore considered part of the same population.				
	IMPORTANT POPULATION CRITERIA				
	The population is an important population.				

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	There are numerous records of the White-throated Needletail within the Strategic Assessment Area. See the record data below which shows the ten years with the highest records of the species since 1980. Records occur from spring to early autumn and the species has been recorded in ecologically significant numbers (based on the definition in the *Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DoE, 2015e) with over 2,000 records in 2016-17 and 2012-13, and at least 350 records every year since the 2009-10 austral summer. Records are more frequent over urban areas in the north and east of the Strategic Assessment Area. This may reflect the increased population of birdwatchers in this area, rather than any preference for this area by the species. It is likely that the species is also regularly present above less disturbed areas but is not recorded.

Ranked year of highest number of records (number of individuals/year)									
First	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**	**Seventh**	**Eighth**	**Ninth**	**Tenth**
2,576 (2016-17)	2,208 (2012-13)	1,472 (2017-18)	884 (2015-16)	739 (2014-15)	676 (2011-12)	644 (2013-14)	593 (2010-11)	356 (2009-10)	233 (1986-87)

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

Avoidance of habitat has not been calculated for this species as it was not to possible prepare meaningful habitat mapping.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. Due to the nature of the data for this species, a risk assessment using the methodology set out in Section 30.3 was not undertaken.

30.16.1 LOSS OF POTENTIAL HABITAT

Potential impacts associated with implementation of the Plan are discussed in relation to foraging and roosting habitat.

LOSS OF POTENTIAL FORAGING HABITAT

The species has been observed foraging over a wide range of habitats. The Atlas of Living Australia, Birdlife Australia and BioNet Atlas contain numerous records in or above heavily modified and urban environments. The species is aerial while foraging and is often observed in areas of updraughts (e.g. above cliffs, ridges, and dunes, in the smoke of bushfires, in whirlwinds, or along the edges of low pressure systems) (DoEE, 2018c).

It is unlikely that modification of habitat from implementation of the Plan will substantially alter the species' use of the Strategic Assessment Area. There are no anticipated impacts to foraging habitat from the Plan.

LOSS OF POTENTIAL ROOSTING HABITAT

There are limited records of the White-throated Needletail roosting and it was previously thought that the species was exclusively aerial in Australia. Records now suggest that the species can roost in tall trees and may prefer roosting sites on ridgelines. There is some evidence that the species uses traditional roosting sites although there are no records of these sites in the Cumberland subregion.

The risk to the species from the impact of the Plan on roosting habitat is low. The species is wide-ranging and not known to roost within the Strategic Assessment Area. The Plan will conserve large areas of high-quality woodland, which will ensure species has continued access to potential roosting sites within the Cumberland subregion.

30.16.2 FRAGMENTATION OF HABITAT

Given the wide-ranging nature of the species, it is considered unlikely that development within the nominated areas or transport corridors would lead to any fragmentation effects.

30.16.3 OFFSETS FOR RESIDUAL DIRECT IMPACTS

Given there is no risk of residual adverse impacts to the species, offsets were not considered necessary for the White-throated Needletail.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.16.4 RELEVANT POTENTIAL INDIRECT IMPACTS

Direct mortality (wind turbines and overhead wires) and poisoning (organochlorides) are identified as key threats to the White-throated Needletail in the Conservation Advice. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to substantially exacerbate the risks across the Strategic Assessment Area.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.16.5 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (TSSC, 2019b) identifies threats to the White-throated Needletail within Australia. However, these threats in the context of the Strategic Assessment Area are unlikely to influence the long-term viability of the species.

30.16.6 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.16.7 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Given the lack of direct and indirect impacts, there are no relevant Key Threatening Processes (KTPs) or associated Threat Abatement Plans (TAPs).

30.17 *HOPLOCEPHALUS BUNGAROIDES* (BROAD-HEADED SNAKE)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*
- *Data tables*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable
DESCRIPTION	*Hoplocephalus bungaroides* (Broad-headed Snake) is black with yellow spots forming narrow irregular cross-bands on its back, and a grey-black belly. It has a flattened head and can grow to 60-150 cm long. (DoE, 2014c)
ECOLOGY	The species is active at dusk and is an ambush predator, spending long periods of time (up to four weeks) in the same place, preying on small reptiles and mammals. Female snakes mature at six years old and males at five years old. Females reproduce every other year. Mating occurs from autumn to spring and females give birth to 4-12 live young between January and April. The average home range of the species in woodland is 3.43 ha. Male home ranges do not overlap, and individuals show a preference for sites they have previously used. (DoEE, 2018c)
DISTRIBUTION AND HABITAT	Records are restricted to the sandstone ranges in the Sydney Basin, within a 200 km radius of Sydney. There are four main areas of occurrence: • Blue Mountains • Southern Sydney • An area outside of the Cumberland Plain, to the north-west • The Nowra hinterland (DoE, 2014c) Adults shelter in rocky outcrops during autumn, winter and early spring, then move to adjacent sclerophyll woodland during late spring and summer. In woodland areas, the species can be found in large trees, with multiple hollows and in dead trees. Individual snakes use between one and nine trees. Pregnant females and juveniles remain in rocky habitat, using cooler, shaded rocks and crevices (DoEE, 2018c). They can spend long periods of inactivity (up to 48 days) in a single hollow (DoEE, 2018c).
POPULATIONS	There are no current population estimates.
SOS SITES	The following SOS sites for the species have been identified: • Woronora Plateau • Morton National Park

	• Royal National Park None of these sites occur within the Cumberland IBRA subregion.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Hoplocephalus bungaroides* (Broad-headed Snake) (DoE, 2014c) Threat abatement plan for competition and land degradation by unmanaged goats (DEWHA, 2008m) Threat abatement plan for predation by feral cats (DoE, 2015g) Threat abatement plan for predation by the European red fox (DEWHA, 2008n)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines for the Broad-headed Snake.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1182

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	**ECOSYSTEM CREDIT SPECIES**	**CANDIDATE SPECIES CREDIT SPECIES**			
		WILTON	**GMAC**	**WSA**	**GPEC**
	Yes	No	No	No	No
EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.				

HABITAT MAPPING	**WITHIN THE NOMINATED AREAS**
	Knowledge based map (KBM). Habitat maps for the Broad-headed Snake were generated using BioNet PCT associations of intact vegetation. Patch sizes of larger than 5 ha were used to exclude small isolated patches of vegetation from the model.
	OUTSIDE THE NOMINATED AREAS
	Knowledge based map (KBM). As above.
POPULATION MAPPING	**RECORD SELECTION**
	Species records were compiled from BioNet and surveys undertaken for the project. The BioNet records were cleaned using a process that interrogated the likelihood of persistence based on the historical removal of, or disturbance to, habitat. Where it was considered unlikely that a record still existed, it was removed from the dataset.
	POPULATION DEFINITION
	Biological populations were defined using the records dataset and available information about the nature of the species. There is only one record of this species within the Strategic Assessment Area, which has been identified as a single population.
	IMPORTANT POPULATION CRITERIA

	Populations of the Broad-headed Snake were then categorised as important or not-important based on the methodology set out in Section 11.5.3 of Chapter 11. No important populations have been identified for this species (all non-important).

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 36.27 for a map of records and habitat across the Strategic Assessment Area. It is important to note that the records for this species are sensitive and have been denatured for representation on the map.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	See Table 30-66 at the end of this species assessment for a breakdown of the occurrence of records and habitat for the Broad-headed Snake in the Strategic Assessment Area. **Records** There is a single current record of the Broad-headed Snake within the Strategic Assessment Area, reflecting the largely unsuitable habitat across most of the area. The record is dated from 2014 located in the southern section of the Strategic Assessment Area, near Buxton. The species is known from surrounding areas, with numerous records located in the broad areas of intact vegetation: • To the south of Sydney, south east of the Strategic Assessment Area • In the Blue Mountains to the north west of the Strategic Assessment Area **Potential habitat** The baseline mapping for this assessment has mapped 6,735 ha of potential Broad-headed Snake habitat within the Strategic Assessment Area. This is primarily associated with the vegetation along riparian corridors that occur over sandstone geology in the very south of the Strategic Assessment Area and along the eastern boundary. Some potential habitat has been mapped within Wilton and the southern parts of GMAC. Mapped potential habitat may support the species. However, it is likely to be less important than surrounding areas given the small number of records within the Strategic Assessment Area. There are large areas of more suitable, intact habitat adjacent to the Strategic Assessment Area, while potential habitat within the Strategic Assessment Area is limited and at the interface between bushland and cleared farmland or urban areas.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

30.17.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 699 ha of potential habitat for the Broad-headed Snake within the nominated areas (not including excluded lands). All of this habitat has been avoided as part of the urban capable lands and transport corridors (not including excluded land). Of this:

- 303 ha was avoided for biodiversity purposes
- 396 ha was avoided for other purposes

A breakdown of avoidance across each nominated area is provided in Table 30-67.

It is important to note that the avoidance calculations in Table 30-67, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 30-67 shows the amounts of habitat within excluded lands for context only, and Chapter 14 defines the land types that are excluded.

30.17.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

Direct impacts are assessed in relation to known populations, loss of potential habitat, or fragmentation of habitat. The risk of residual adverse impacts to the species occurring as a result of any direct impacts is characterised as per the methodology set out in Section 30.3.

Offsets are provided for species that are considered to be at medium or high risk of residual adverse impacts. Offsets are not provided for species that are considered to be at low or very low risk of residual adverse impacts. The rationale and process for setting offset targets for species is set out in Section 8.5.2 of Chapter 8.

There will be no direct impacts to the species as a result of implementation of the Plan and offsets are not considered necessary.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.17.3 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice for the Broad-headed Snake identifies a range of threats to the species (DoE, 2014c). Where these threats are relevant to the implementation of the Plan, the Plan includes management strategies to mitigate their impacts. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Bush rock removal
- Inappropriate fire regimes
- Predation by cats
- Road mortality

Development of ridgetops, pine plantation development, illegal collection, vehicle strike and disturbance by feral goats are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

Potential indirect impacts are considered relevant to populations of the Broad-headed Snake to the south of Sydney, south east of the Strategic Assessment Area.

BUSH ROCK REMOVAL

Bush rock removal has been identified as a threat to the Broad-headed Snake as rocks are used as retreat sites by the species (DoEE, 2018c). Bush rock 'collectors' are known to favour the same type and size of rocks as the Broad-Headed Snake, their gecko prey and the spiders preyed on by geckos (DoEE, 2018c).

Development in GMAC and Wilton may lead to an increase in human activity and landscaping of gardens which could increase this threat in accessible areas of the surrounding bushland where the species is known to occur. The risk areas primarily relate to the Dharawal National Park (noting that large areas of bushland near to Wilton and the southern half of GMAC are designated as 'Special Areas' within Sydney's drinking water catchment and access is restricted).

The Dharawal National Park Plan of Management acknowledges the threat of bush rock removal to the Broad-headed Snake and undertakes to protect exfoliating rock from all avoidance disturbance (NSW NPWS, New South Wales et al., 2006).

These measures are considered to adequately mitigate the level of risk to the Broad-headed Snake.

INAPPROPRIATE FIRE REGIMES

Bushfires are identified as a threat to the Broad-headed Snake as they can reduce the availability of hollows or prey, and may endanger snakes sheltering in hollows (DoEE, 2018c).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact habitat for the species. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the species from increased fire frequency as a result of development. This is because:

- Avoided lands supporting potential habitat will be zoned appropriately to enable an adequate framework for management

- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting habitat
- Fire management authorities will be engaged to ensure they understand the values relevant to the species and incorporate these values into their fire management practices. This will include specific fire management approaches for conservation areas

PREDATION BY CATS

Cats are a potential predator of Broad-headed Snakes (DoEE, 2018c).

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the species.

However, the extent of proposed new urban development under the Plan means that the threat associated with cats is likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats in the local area, which, in turn, may lead to an increase in feral cat numbers. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is low.

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the SCAs. This includes a number of actions with the most relevant to the outcome for the species being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
    - Preparation of a Pest Animal Control Implementation Strategy
    - A process to enter into written agreements with delivery partners to implement the pest animal control program
    - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
    - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
    - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
    - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16
- A specific requirement to support other species in the region to contain domestic cats in new residential areas at the urban/bushland interface which is likely to be of benefit to the Broad-headed Snake
- Existing pest management within the Dharawal, Heathcote and Royal National Parks

The package of measures in the Plan is expected to adequately mitigate the level of risk to the Broad-headed Snake

ROAD MORTALITY

The Broad-headed Snake is susceptible to vehicle strike, and mortality on roads has been identified as a potential threat to the species (DoE, 2014c). Implementation of the Plan will lead to new roads and an increase in the volume of cars on existing roads within and surrounding Wilton and GMAC.

The development of new roads will not intersect any potential habitat for the Broad-headed Snake and is unlikely to increase the level of threat to the species. Increased traffic on existing roads outside of the Strategic Assessment Area may present more of a risk to the species. For instance, along the Hume Highway, Picton Road and Appin Road. It is noted that this will represent an incremental change to an existing threat rather than a novel one, and while it is difficult to predict, any potential increase in road mortality along these existing roads as a direct result of development under the Plan is expected to minor in this context.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the species to occur due to the development of essential infrastructure within nominated areas but outside the urban capable lands.

It is noted that there is no mapped potential habitat, and no known records of the species, within either the OSO tunnel footprint or the Metro Rail Future Extension tunnel footprint. It is therefore considered unlikely that development within the tunnel footprints will negatively impact the Broad-headed Snake.

30.17.4 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

There are no known records of the Broad-headed Snake within avoided lands in any of the nominated areas. However, there is 699 ha of potential habitat mapped for the species within avoided lands within Wilton and GMAC, and therefore it is considered to be possible that the species may occur within avoided lands in these nominated areas.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area
- Measures to avoid impacts to the species through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the species will occur as a result of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15

30.17.5 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014c) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the Broad-headed Snake in relation to implementation of the Plan:

- Indirect impacts, such as:
  - Bush rock removal
  - Inappropriate fire regimes

- Predation by cats
- Road mortality

INDIRECT IMPACTS

The potential indirect impacts associated with bush rock removal, inappropriate fire regimes, predation by cats and road mortality will be managed and mitigated through generic management strategies in the Plan.

Indirect impacts are not expected to influence the long-term viability of the species.

CONCLUSION

There will be no direct impacts to the species as a result of implementation of the Plan.

Potential indirect impacts are addressed through general management strategies

Collectively these will ensure that the implementation of the Plan does not adversely influence the long-term viability of the Broad-headed Snake.

30.17.6 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the species.

30.17.7 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-65 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The consistency of the Plan with relevant Threat Abatement Plans is discussed in detail in Chapter 15. The Plan is not inconsistent with any of the Threat Abatement Plans.

Table 30-65: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Broad-headed Snake

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 30-66: Occurrence of the Broad-headed Snake in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL POPULATIONS	1	0
(IMPORTANT POPULATIONS)	(0)	(0)
HABITAT MAPPING (Ha)	6,735.2	748.7

Table 30-67: Avoidance of Broad-headed Snake habitat within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL HABITAT ACROSS NOMINATED AREA (ha)	443.6	432.5	0.0	0.0	876.0
HABITAT WITHIN EXCLUDED LANDS (ha)	101.9	75.1	0.0	0.0	177.0
HABITAT WITHOUT EXCLUDED LANDS (ha)	**341.7**	**357.4**	**0.0**	**0.0**	**699.0**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	129.6	173.2	0.0	0.0	302.7
AVOIDANCE FOR BIODIVERSITY PURPOSE (% HABITAT WITHOUT EXCLUDED LANDS)	37.9	48.5	N/A	N/A	43.3
AVOIDANCE FOR OTHER REASONS (ha)	212.1	184.2	0.0	0.0	396.3
AVOIDANCE FOR OTHER REASONS (% HABITAT WITHOUT EXCLUDED LANDS)	62.1	51.5	N/A	N/A	56.7
TOTAL AVOIDANCE (ha)	**341.7**	**357.4**	**0.0**	**0.0**	**699.0**
TOTAL AVOIDANCE (% HABITAT WITHOUT EXCLUDED LANDS)	**100.0**	**100.0**	**N/A**	**N/A**	**100.0**

30.18 *MACQUARIA AUSTRALASICA* (MACQUARIE PERCH)

This species assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- *Species background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the species*

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	*Macquaria australasica* (Macquarie Perch) is a moderately sized, elongated oval shaped, freshwater fish. Mature adults are either black-grey, blue-grey, or olive-brown on the dorsal side and off-white on the ventral side (DoE, 2013b).
ECOLOGY	The Macquarie Perch is a nocturnal species. Males reach maturity at two years of age and females at three years of age. Spawning occurs immediately upstream of stretches of shallow running water over gravel beds from the middle of spring to early summer (DoE, 2013b). Feeds on insects and larvae. Some fish use the same river each year for spawning (DoEE, 2018c).
DISTRIBUTION AND HABITAT	Distribution extends from southern NSW, through the ACT, to northern Victoria (DoE, 2013b). Current NSW populations exist in catchments of the Hawkesbury-Nepean river system and the Georges River, the upper reaches of the Lachlan and Murrumbidgee Rivers, Mongarlowe River, and Queanbeyan River. In Victoria populations occur in the upper reaches of the Mitta Mitta River, Ovens River, Broken River, Campaspe River, Goulburn River, Yarra River, and in Lake Eildon. (DoEE, 2018c) A riverine schooling species typically found in the cool upper reaches of rivers. It has a preference for clear water and deep, rocky holes with vegetation, overhanging banks and debris providing coverage (DoE, 2013b; DoEE, 2018c).
POPULATIONS	Populations are often small and geographically separated (DoE, 2013b). There is currently no estimate of total population.
SOS SITES	Not applicable. This species is listed under the NSW *Fisheries Management Act 1994* and is not addressed under the SOS program.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for *Macquaria australasica* (Macquarie Perch) (DoE, 2013b) National Recovery Plan for the Macquarie Perch (*Macquaria australasica*) (DoEE & DPI, 2018)
SPECIES-SPECIFIC GUIDELINES	There are no species-specific guidelines for the Macquarie Perch.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66632

APPROACH TO BASELINE DATA

This section provides a summary of the baseline information used in the assessment. It sets out:

- *If the species is a candidate species under the BCAR process*
- *If an expert report was prepared for the species under the BCAR process*
- *An overview of the habitat mapping for the species within and outside the nominated areas*
- *An overview of the population mapping for the species*

Please refer to Section 11.5 in Chapter 11 for further details about the threatened species baseline data, including the various approaches to habitat and population mapping.

NOMINATED AREA CANDIDATE SPECIES (BCAR PROCESS)	ECOSYSTEM CREDIT SPECIES	CANDIDATE SPECIES CREDIT SPECIES			
		WILTON	GMAC	WSA	GPEC
	No	No	No	No	No

EXPERT REPORT (BCAR PROCESS)	There is no expert report for this species.
HABITAT MAPPING	**WITHIN AND OUTSIDE THE NOMINATED AREAS** **Knowledge based map (KBM)**. Habitat mapping for the Macquarie Perch was generated by mapping: • The waterways identified in the recovery plan (DoEE & DPI, 2018) that occur within and close to the Strategic Assessment Area that support: o Self-sustaining native populations, or o Translocated and stocked populations • Any additional waterways within the Strategic Assessment Area that support records of the species since 2000
POPULATION MAPPING	**RECORD SELECTION** All BioNet records since 2000 have been included in the assessment. **POPULATION DEFINITION** Populations in distinct rivers and streams are considered separate populations. **IMPORTANT POPULATION CRITERIA** All populations were considered to be important as the species is endangered.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area. It includes reference to a map of records and habitat which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where records and habitat occur.

MAP	See Map 46.2 for a map of records and habitat across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The species' recovery plan identifies a number of self-sustaining native populations of the Macquarie Perch in stretches of river within and near to the Strategic Assessment Area as follows: • The Grose River, north west of the Strategic Assessment Area boundary, in the Blue Mountains National Park, near Yarramundi. It is approximately 11 km from the northern boundary of GPEC

	• Erskine Creek, west of the Strategic Assessment Area boundary, in the Blue Mountains National Park, near Warragamba. It is approximately 9.7 km from GPEC in the Hawkesbury-Nepean catchment • The Warragamba dam to the west of the Strategic Assessment Area boundary • The upper reaches of the Nepean River to the south of the Strategic Assessment Area • Cordeaux River, where there is a single BioNet record approximately 600 m south of Wilton • Cataract River (below Cataract Dam) which flows from the south east to the north west in between Wilton and GMAC up to the Nepean river • The Georges River, which follows the eastern boundary of GMAC from Gilead to Appin. it is between 130 m and 1.6 km from the GMAC urban capable land in the Georges/Cooks catchment There are also a number of waterways that have BioNet records that are not identified in the recovery plan. They are: • Little Wheeny Creek, near kurrajong in the north west. This record is located approximately 20 km from the closest urban capable land in GPEC • Glenbrook Creek, where there is a single BioNet record approximately 7.6 km west of GPEC • Nattai and Little Rivers which occur to the south west of the Strategic Assessment Area

AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

All riparian corridors and waterways that are potential habitat for the species were avoided as part of the planning process within the nominated areas. No potential habitat occurs within proposed transport corridors.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. Direct impacts are assessed in relation to impacts to mapped habitat.

Due to the nature of the data for this species, a risk assessment using the methodology set out in Section 30.3 was not undertaken.

There will be no direct impacts to known populations or areas of potential habitat for the Macquarie Perch as a result of the Plan and offsets are not considered necessary.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice, or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

30.18.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice and Recovery Plan for Macquarie Perch identify a range of threats to the species. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. The following potential indirect impacts (identified as threats) are considered relevant to implementation of the Plan:

- Hydrological changes
- Habitat degradation caused by bushfires
- Recreational fishing

Competition and predation from introduced fish species (including carp, gambusia, redfin perch and trout), barriers to fish movement, introduced diseases, and cold water pollution are also identified as key threats. However, these are not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

HYDROLOGICAL CHANGES

Hydrological changes, including river siltation, as a result of the removal of riparian vegetation, land use changes and construction activities is identified as a key threat to the Macquarie Perch (DoEE, 2018c; DoEE & DPI, 2018). Increased sediment loads can fill in deep holes and cover gravel beds, which are important spawning habitats, and can affect the composition of the benthic fauna, which form the majority of the species' diet (DoEE, 2018c).

There is no possibility of hydrological changes in the majority of waterways that occur within and near to the Strategic Assessment Area as they are not hydrologically connected to areas of development. However, there are two areas that have some limited potential to be affected. They are:

- The population and habitat along the Georges River which is within the same catchment as a very small section of the urban capable land in GMAC. There is minimal risk of hydrological changes within this section of the River as a result of development. However, measures are included in the Plan to protect water ways and water quality (see below)
- The population/s and habitat along the Cordeaux River and upper reaches of the Nepean River which have the potential to be affected by hydrological changes as a result of development as they are within the same catchment as the majority of Wilton

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the species. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the TfNSW Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

These measures are considered to adequately mitigate the level of risk to the Macquarie Perch.

HABITAT DEGRADATION CAUSED BY BUSHFIRES

Bushfires are identified as a threat to the Macquarie Perch as they can increase water temperatures, increase pH, reduce the foliage cover of streams, and increase the sediment load of rivers (DoEE, 2018c; DoEE & DPI, 2018).

Increased human activity within the nominated areas increases the risk of fire within adjacent areas of potential Macquarie Perch habitat. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant including:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the SCAs that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from potential foraging habitat. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

These measures are considered to adequately mitigate the level of risk to the Macquarie Perch.

RECREATIONAL FISHING

Recreational fishing is identified as a threat to the Macquarie Perch. Urban development may lead to increased recreational fishing within nearby areas known to support the species. Fishing Macquarie Perch is prohibited in Australia and comes with heavy penalties for harming, possessing, buying or selling them or for damaging their habitat (DoEE & DPI, 2018; NSW DPI, 2017). Despite this, a potential increase in the rate of recreational fishing presents a greater risk to the populations within proximity of the nominated areas.

The Plan incorporates the following specific management measures (as part of Commitment 5) to address this issue: consult with relevant resource managers to consider:

- Prohibiting recreational fishing along the stretches of habitat associated with Erskine Creek, Glenbrook Creek, Georges River and Cordeaux River known to support the species
- Installing signs/interpretive displays at appropriate sites used to access fishing locations at Erskine Creek, Glenbrook Creek, Georges River and Cordeaux River to assist with identification and awareness of threats

These measures are expected to adequately mitigate the level of risk to the Macquarie Perch.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the species. The assessment of viability has regard for the guidance in the Conservation Advice and (if applicable) the Recovery Plan, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also discusses the consistency of the Plan with any Recovery Plans and relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

30.18.2 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2013b) and Recovery Plan (DoEE & DPI, 2018) identify the key issues that are likely to have the greatest influence on the long-term viability of the Macquarie Perch in relation to implementation of the Plan. They are indirect impacts associated with:

- Hydrological changes
- Habitat degradation caused by bushfires
- Recreational fishing

Direct impacts are not relevant to this species

INDIRECT IMPACTS

The potential indirect impacts associated with hydrological changes, habitat degradation caused by bushfires, and recreational fishing will be managed and mitigated through a number of commitments and actions in the Plan (see Chapter 15 for details). Indirect impacts will not adversely influence the long-term viability of the species.

IMPLICATIONS OF THE 2019-20 BUSHFIRES

As outlined in Part 1 of this report, the 2019-20 bushfires in NSW are unprecedented in their extent and intensity. As of 28 January 2020, the fires had burnt 5.3 million ha (6.7 per cent of NSW), including 2.7 million ha in national parks (37 per cent of the national park estate) and over 80 per cent of the Greater Blue Mountains World Heritage Area (EES, 2020).

The full impact of the fires will not be understood for some time (EES, 2020). This includes the potential impacts to the Macquarie Perch. However, it appears that fish populations in some waterways outside the Strategic Assessment Area may have been severely affected.

It should be noted that the initial analysis undertaken of the implications of the fires for this report (Part 1, Attachment A) did not identify Macquarie Perch as a species that may need additional commitments in the Plan. This is because it did not meet all of the following criteria (see Part 1 Attachment A for explanation):

- A high percentage (>10 per cent) of NSW records have been affected by fires of the 2019-2020 period, and
- The Cumberland subregion is already important for species persistence in NSW and/or has the potential to become more important for persistence because of the impacts of the fires to other areas of habitat, and
- The Plan has known or likely impacts to the species

CONCLUSION

The Plan will not lead to direct impacts to this species, while the management strategies for indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the species.

30.18.3 CONSISTENCY WITH RECOVERY PLAN

In accordance with Section 146K of the EPBC Act, this section considers whether the implementation of the Plan is not inconsistent with the species' Recovery Plan. It considers two questions:

- Does the Plan prevent achievement of the objectives of the Recovery Plan?
- Does the Plan prevent implementation of the Recovery Plan actions?

These are discussed below.

DOES THE PLAN PREVENT ACHIEVEMENT OF THE OBJECTIVES OF THE RECOVERY PLAN?

The overall objective of the Recovery Plan is to: ensure the recovery and ongoing viability of Macquarie perch populations throughout the species' range (including historically translocated populations in Cataract Reservoir and the Mongarlowe and Yarra rivers).

The Recovery Plan also includes a range of strategies to achieve the objective. These are:

- Conserve existing Macquarie perch (including historically translocated populations in Cataract Reservoir and the Mongarlowe and Yarra rivers);
- Protect and restore Macquarie perch habitat;
- Understand and address threats to Macquarie perch populations and habitats;
- Establish additional Macquarie perch populations within the species' natural range;
- Improve understanding of the biology and ecology of the Macquarie perch and its distribution and abundance; and
- Increase participation by community groups in Macquarie perch conservation.

The outcome for the Macquarie Perch under the Plan will not make it impossible to the achieve the objective or implement the strategies of the Recovery Plan.

DOES THE PLAN PREVENT IMPLEMENTATION OF THE RECOVERY PLAN ACTIONS?

The Recovery Plan includes a number of actions to help achieve its objective. The Plan will not prevent implementation of any of the actions.

30.18.4 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 30-68 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

For Macquarie Perch, there are no relevant Threat Abatement Plans.

Table 30-68: Relevant Key Threatening Processes and associated Threat Abatement Plans for the Macquarie Perch

RELEVANT KEY THREATENING PROCESS	ASSOCIATED THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP

30.19 THREATENED MIGRATORY SHOREBIRDS

This section provides an impact analysis for the five migratory shorebirds that are also listed as threatened. It draws on the detailed analysis in Section 32.2 of Chapter 32 which addresses the 21 listed migratory shorebirds that have been recorded in the Cumberland subregion. Chapter 32 should be read in conjunction with the assessments in this section.

The five species are:

- *Calidris canutus* (Red Knot)
- *Calidris ferruginea* (Curlew Sandpiper)
- *Charadrius leschenaultii* (Greater Sand Plover)
- *Limosa lapponica bauera* (Bar-tailed Godwit)
- *Numenius madagascariensis* (Eastern Curlew)

They are addressed in the same section because they:

- Share similar habitat requirements
- Are assessed using the same baseline data
- Are very similar in terms of potential impacts

The assessment of the five species in this section analyses the implications of implementation of the Cumberland Plain Conservation Plan in accordance with the EPBC Terms of Reference. It sets out:

- The approach to baseline data for migratory shorebirds
- A background to each species including its occurrence in the Strategic Assessment Area
- Avoidance of impacts
- Direct impacts and offsets
- Potential indirect impacts and mitigation
- Potential additional impacts from essential infrastructure and tunnels
- Likely effects of implementation of the Planon the long-term viability for each species

30.19.1 THE APPROACH TO BASELINE DATA FOR MIGRATORY SHOREBIRDS

The approach to developing baseline data for migratory shorebirds is described in detail in Section 32.2.2 of Chapter 32. It is summarised here.

The baseline data includes:

- Compilation of available records for shorebird species
- Habitat mapping (including the identification of important habitat) across the Cumberland subregion

None of the species were candidate species under the BCAR process.

COMPILATION OF RECORDS

Records were compiled from the Birdlife Australia Database and the OEH BioNet Database. This is considered to be the most complete data for shorebirds in the Cumberland subregion.

APPROACH TO HABITAT MAPPING WITHIN THE CUMBERLAND SUBREGION

Given the similarity in habitat requirements between migratory shorebirds, habitat was mapped for all species through a single process which identified habitat sites across the Cumberland subregion.

The habitat mapping was undertaken broadly in accordance with the approach outlined in the *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DoEE, 2017b) (referred to as the Guidelines from this point). However, the method applied was more precautionary than required under the Guidelines to ensure that no important habitat sites were missed (see ‘limitations in the baseline data’ below).

See Section 32.2.1 for an explanation of the Guidelines and how they treat habitat for migratory shorebirds.

The process involved the following steps:

Step 1: Analysis of records across the Cumberland subregion

Records were compiled and examined across the whole of the Cumberland subregion. The initial step considered the subregion as a single habitat unit to determine which species exceeded the thresholds outlined in the Guidelines for important habitat across the whole area (i.e. which species occur in numbers greater than the threshold when records are summed across the whole subregion).

Step 2: Identification of important migratory shorebird habitat sites

The spatial distribution of records was then assessed to identify the individual wetland and waterbody (or wetland mosaic) where the thresholds were exceeded at a site level. Each wetland that was identified as important for migratory shorebirds had its boundary marked and a 250 m buffer applied. This buffer distance is consistent with the Guidelines which suggest buffer distances ranging from 165 to 255 m to mitigate against disturbance (DoEE, 2017b).

For ephemeral wetlands the threshold was considered across every year where records were held.

For permanent wetlands, the guidelines suggest considering the last five years. The approach taken for this assessment was to look at records for the last 20 years for sites that were thought to be permanent. This acknowledges the uncertainty in determining if habitat sites are permanent or ephemeral across the Strategic Assessment Area.

Step 3: Identification of potential migratory shorebird habitat

The remaining potential migratory shorebird habitat in the subregion was determined based on the presence of suitable wetlands throughout the landscape that exceed 1.5 ha in area. This 1.5 ha threshold was used as a proxy for the minimum disturbance distance for shorebirds of 150 m.

Wetland mapping layers were interrogated from the Directory of Important Wetlands (DoEE, 2018b) and the LPI topographical data Hydro Area layer (LPI, 2016) to identify areas of potential habitat.

LIMITATIONS IN THE BASELINE DATA

The data used in the habitat mapping is the best available across the Cumberland subregion. It incorporates:

- Historical records from both BioNet and Birdlife Australia
- Wetland and waterbody mapping from DAWE and LPI

However, there has not been a systematic survey for migratory shorebirds across the subregion and it is likely that shorebirds visit a number of sites where there are no records.

To address uncertainty in the data a precautionary approach was taken. This involved:

- Considering the whole of the Cumberland subregion to determine what species occurred in numbers greater than the important habitat thresholds when their records were summed for all sites
- Mapping potential habitat using wetland and waterway mapping

OVERVIEW OF SHOREBIRD HABITAT

A total of 11 important sites occur for migratory shorebirds across the subregion (see Table 30-69 and Map 49). None of these sites will be directly impacted by development under the Plan.

Table 30-69: Summary of migratory shorebird habitat sites

Habitat type	Number of sites	Total area of habitat (ha)
Important habitat within the Strategic Assessment Area	5	182.3
Important habitat within the broader Cumberland subregion	6	54.5

The important habitat sites can be broadly placed into five groups based on their location:

- Sites in the Strategic Assessment Area:
  - Sites 7, 9, 17 and 21 all occur near to the Hawkesbury River in the north of the Strategic Assessment Area
  - Site 19 occurs in the Mt Annan Botanic Gardens to the west of GMAC
- Sites outside the Strategic Assessment Area in the broader Cumberland subregion:
  - Sites 1 and 11 occur in the Marsden Park North Precinct of the existing North West Growth Area
  - Sites 3, 13 and 15 all occur within the vicinity of Sydney Olympic Park
  - Site 5 occurs outside in the suburb of Panania

It is important to note that important migratory shorebird habitat has been mapped for use in BAM assessments. No important migratory shorebird habitat has been identified within the Strategic Assessment Area.

A number of sites are subject to existing management (e.g. as a nature reserve). A profile for each site is provided in Section 32.2.3 of Chapter 32.

30.19.2 BACKGROUND TO EACH SPECIES INCLUDING ITS OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

CALIDRIS CANUTUS (RED KNOT)

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Endangered, marine, migratory ***NB:** An assessment of this species as a migratory species is provided in Chapter 32*
DESCRIPTION	*Calidris canutus* (Red Knot) is a small to medium migratory shorebird. It has a length of 23-25 cm, a wingspan of 45-54 cm, a short neck, a short straight bill, short legs, and wings that extend beyond its tail (TSSC, 2016b).
ECOLOGY	There are six recognised subspecies of the Red Knot, of which three have been recorded in Australia: • *Calidris canutus piersmai* regularly occurs in Australia, almost exclusively in the north west • *C. c. rogersi* regularly occurs in Australia, mostly in the east • *C. c. canutus* occurs as a vagrant The species breeds at a range of locations around the Arctic. It is thought that the vast majority of the population migrates to Australia in the non-breeding season. Individuals typically arrive in Australia from late August. The species returns to the northern hemisphere between February and May. (TSSC, 2016b)
DISTRIBUTION AND HABITAT	In Australia, the species mainly inhabits coastal environments and saline wetlands near the coast. The Red Knot is rarely observed in or around freshwater swamps or inland aquatic habitats. The species: • Forages in soft substrate near the edge of intertidal mudflats or sandflats exposed by low time, or in nearby lakes, sewage ponds and floodwaters • Roosts on sandy beaches, spits, and islets; mudflats; or shallow saline ponds. The species prefers roosting habitat in open areas away from potential cover for predators (TSSC, 2016b)
POPULATIONS	The species occurs as a single population in Australia. An estimated 135,000 individuals are present in Australia during the austral summer.
SOS SITES	No SOS Sites have been identified.

RELEVANT PLANS AND POLICIES	Conservation Advice. *Calidris canutus*. Red Knot (TSSC, 2016b)
SPECIES-SPECIFIC GUIDELINES	Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DoEE, 2017b) Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=855

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The Red Knot has been recorded at one important habitat site, the Mason Park Wetlands (Site 3). This site is outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion, close to Sydney Olympic Park. The species has not been recorded in the Cumberland subregion in numbers above the 0.1 per cent threshold for important habitat (as defined in the migratory shorebird Guidelines) when the subregion is considered a single habitat unit.

CALIDRIS FERRUGINEA (CURLEW SANDPIPER)

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Critically endangered, migratory ***NB:*** *An assessment of this species as a migratory species is provided in Chapter 32*
DESCRIPTION	*Calidris ferruginea* (Curlew Sandpiper) is a small, slim migratory bird with long legs and a long black bill (TSSC, 2015a).
ECOLOGY	The species breeds in the Russian Arctic before migrating to the southern hemisphere. A relatively small proportion of the species (thought to be less than 13 per cent) migrates to Australia for the for the austral summer. Most immature birds do not return to the northern hemisphere for two years following their first arrival in Australia.
DISTRIBUTION AND HABITAT	In Australia, the species occurs along the coast but is also widespread inland (although in lower and variable numbers). The species uses a range of freshwater and brackish coastal and estuarine areas and inland waterbodies, where it: • Forages on mudflats and in nearby shallow water, and occasionally low, sparse vegetation • Roosts in open areas with damp substrates, especially on shingle, shell or sand beaches, spits and islets (TSSC, 2015a)
POPULATIONS	The species occurs as a single population in Australia.
SOS SITES	Five SOS Sites have been identified for the Curlew Sandpiper: • Clarence River Estuary • Hunter Estuary and Port Stephens • Manning River Estuary • Richmond River Estuary • Shoalhaven Estuary

	They are all outside the Strategic Assessment Area. The closest SOS Site is in the Shoalhaven Estuary, north of Jervis Bay.
RELEVANT PLANS AND POLICIES	Conservation Advice. *Calidris ferruginea*. Curlew Sandpiper (TSSC, 2015a)
SPECIES-SPECIFIC GUIDELINES	Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DoEE, 2017b) Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=856

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The Curlew Sandpiper has been recorded in small numbers in a range of wetlands and waterbodies across the Strategic Assessment Area. These include:
	• Six sites which are identified as important habitat for migratory shorebirds:
	  o Site 1 – which is comprised of ponds at the old Riverstone Meatworks. It occurs outside the Strategic Assessment Area (in the Marsden Park North Precinct of the North West Growth Centre)
	  o Sites 3 and 13 – which both occur within the vicinity of Sydney Olympic Park outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion
	  o Site 7 – which is Bushell's Lagoon in the north of the Strategic Assessment Area (to the north of the Hawkesbury River)
	  o Site 9 – which is Pitt Town Lagoon in the north of the Strategic Assessment Area (to the east of the Hawkesbury River)
	  o Site 21 – which is McGraths Hill Wetland in the north of the Strategic Assessment Area (to the south of the Hawkesbury River)
	• A small number of other sites close to the Hawkesbury River and in proximity to Sites 7, 9 and 21
	• One record within GPEC outside urban capable land
	The number of records from these sites is low. Considered as a single habitat unit, the Cumberland subregion has not exceeded 0.1 per cent of the total flyway population for this species in a single year.

CHARADRIUS LESCHENAULTII (GREATER SAND PLOVER)

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Vulnerable, migratory, marine ***NB:** An assessment of this species as a migratory species is provided in Chapter 32*
DESCRIPTION	*Charadrius leschenaultii* (Greater Sand Plover) is a medium sized brown and white plover. It is similar in appearance to the Lesser Sand-plover although distinctly bigger (TSSC, 2016c).
ECOLOGY	The Greater Sand Plover is a migratory shorebird. The species breeds in China, Mongolia and nearby parts of Russia. During the non-breeding season, the species migrates south, with records

	from Australia and the south Pacific across the coast of the Indian Ocean to the eastern and southern coasts of Africa and the south eastern shores of the Mediterranean. (TSSC, 2016c) Only the subspecies *C. l. leschenaultia* occurs in Australia. Almost three quarters of the subspecies is present in Australia during the austral summer. Birds typically arrive between mid-July and November and leave in late February. Most immature birds remain in Australia during the breeding season. (TSSC, 2016c)
DISTRIBUTION AND HABITAT	During the austral summer the species is widespread but more common in northern Australia. It is found in coastal areas in every Australian state. In NSW, the species is common north of the Northern Rivers region, with occasional records south to around Shoalhaven Heads. (TSSC, 2016c) While in Australia the species is almost entirely coastal. It inhabits sheltered beaches, intertidal mudflats, sandbanks, salt marshes, estuaries, coral reefs, rocky islands or platforms, tidal lagoons and dunes near the coast. They typically forage in wet sand or mud, and roost on sand-spits or high on banks near beaches. (TSSC, 2016c)
POPULATIONS	The species occurs as a single (important) population in Australia.
SOS SITES	Five SOS Sites have been identified for the Curlew Sandpiper. They are all outside the Strategic Assessment Area. The closest SOS Site is in the Shoalhaven Estuary, north of Jervis Bay.
RELEVANT PLANS AND POLICIES	Conservation Advice. *Charadrius leschenaultia*. Greater sand plover (TSSC, 2016c)
SPECIES-SPECIFIC GUIDELINES	Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DoEE, 2017b) Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=877

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The Greater Sand Plover has been recorded at one important habitat site, the Mason Park Wetlands (Site 3). This site is outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion, close to Sydney Olympic Park. The species has not been recorded in the Cumberland subregion in numbers above the 0.1 per cent threshold for important habitat when the subregion is considered a single habitat unit.

LIMOSA LAPPONICA BAUERA (BAR-TAILED GODWIT)

SPECIES BACKGROUND

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

EPBC ACT LISTING	Vulnerable, migratory ***NB:*** *An assessment of this species as a migratory species is provided in Chapter 32*
DESCRIPTION	*Limosa lapponica bauera* (Bar-tailed Godwit) is a large migratory bird with a long neck and very long upturned bill. It has dark barring on the lower white rump, upper tail and lining of the underwing (TSSC, 2016g).
ECOLOGY	Two subspecies of *L. lapponica* regularly occur in Australia:

	• In the non-breeding season, *L. l. baueri* (listed as migratory and vulnerable) occurs along the north and east coasts of Australia (TSSC, 2016g) • *L. l. menzbieri* (listed as migratory and critically endangered) occurs predominately in Western Australia (TSSC, 2016h) and is not considered likely to occur in the Cumberland subregion This assessment considers impacts to *L. lapponica baueri*. The subspecies breeds in northern Siberia and Alaska before migrating through the Yellow Sea to Australia and New Zealand. Immature birds often remain in Australia for one or two austral winters before returning to their breeding grounds in the Northern Hemisphere. The Bar-tailed Godwit has one of the longest non-stop migratory routes recorded for any bird. This makes the species sensitive to changes in intertidal habitats used for feeding to create fuel stores prior to migration.
DISTRIBUTION AND HABITAT	In Australia, the species: • Mainly occurs along the north and east coasts • Typically forages in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays • Typically roosts on sandy beaches, sandbars, spits and in near-coastal saltmarsh The Bar-tailed Godwit is thought to have high site fidelity in the non-breeding season (TSSC, 2016g).
POPULATIONS	The species occurs as a single (important) population in Australia.
SOS SITES	No SOS Sites have been identified.
RELEVANT PLANS AND POLICIES	Conservation Advice. *Limosa lapponica baueri*. Bar-tailed godwit (western Alaskan) (TSSC, 2016g)
SPECIES-SPECIFIC GUIDELINES	Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DoEE, 2017b) Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=86380

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The species has been recorded in the Cumberland subregion in numbers above the 0.1 per cent threshold for important habitat when the subregion is considered a single habitat unit. However, it does not exceed the threshold at any individual site. It has been recorded at three of the important habitat sites: • Site 9 – which is Pitt Town Lagoon in the north of the Strategic Assessment Area (to the east of the Hawkesbury River) • Sites 13 and 15 – which both occur in Sydney Olympic Park outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion There are no records within the nominated areas or transport corridors.

NUMENIUS MADAGASCARIENSIS (EASTERN CURLEW)

SPECIES BACKGROUND

This section sets out the basic information about the species. It provides an overview of the species' ecology, distribution, habitat, and populations. These provide context for the impact assessment. At the end of the section are links to key species' documents that provide additional background information.

EPBC ACT LISTING	Critically endangered, migratory ***NB:*** *An assessment of this species as a migratory species is provided in Chapter 32*

DESCRIPTION	*Numenius madagascariensis* (Eastern Curlew) is the largest migratory shorebird in the world. It has a long neck and legs, and a very long downcurved bill (TSSC, 2015b).
ECOLOGY	The species breeds in Russia, Mongolia and north-eastern China. It is thought that approximately 73 per cent of the population migrates to Australia in the non-breeding season. Individuals arrive in Australia as early as July, with the majority of birds arriving in mid-to-late August. Migration north typically starts in late February and continues until March or April. Immature individuals may spend as many as three austral winters in Australia before returning to the Northern Hemisphere to breed. (TSSC, 2015b)
DISTRIBUTION AND HABITAT	In Australia, the species: • Is typically distributed across coastal areas and is rarely found inland • Typically forages in sheltered intertidal sandflats or mudflats that are either open or vegetated with seagrass, or near mangroves, saltflats or saltmarshes • Typically roosts during high tide periods on sandy spits, sandbars and islets, either on sand near the high-water mark or among coastal vegetation • Is rarely found on near-coastal lakes or in grassy areas (TSSC, 2015b)
POPULATIONS	The species occurs as a single population in Australia.
SOS SITES	No SOS Sites have been identified.
RELEVANT PLANS AND POLICIES	Conservation Advice. *Numenius madagascariensis*. Eastern Curlew (TSSC, 2015b)
SPECIES-SPECIFIC GUIDELINES	Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (DoEE, 2017b) Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=847

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the species in the Strategic Assessment Area and provides a qualitative description of where records and habitat occur.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The Eastern Curlew has been recorded at one important habitat site, Wanngal Wetland (Site 13). This site is outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion. It is part of the Newington Nature Reserve within Sydney Olympic Park. The species has not been recorded in the Cumberland subregion in numbers above the 0.1 per cent threshold for important habitat when the subregion is considered a single habitat unit.

30.19.3 AVOIDANCE OF IMPACTS

This section provides an overview of the area of potential habitat that was avoided for the species through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

No important habitat for any of the five species occurs within the nominated areas or transport corridors. Avoidance of impacts was therefore not necessary.

30.19.4 DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts.

There are no direct impacts to important habitat for any of the five species. Offsets were therefore not considered necessary.

30.19.5 POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the five species that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the species if:

- *The indirect impact is identified as a threat in a relevant profile or conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

The Conservation Advices identify a common range of threats to each of the five species along their migratory pathways and in Australia. Threats along their migratory pathways (i.e. outside Australia) are not considered further.

Threats in Australia include:

- Ongoing human disturbance
- Habitat loss and degradation from pollution
- Changes to the water regime
- Invasive plants

Climate change is also a relevant threat to each species. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Section 32.2.4 in Chapter 32 provides a detailed analysis of the potential for these threats to occur as indirect impacts to migratory shorebirds as a result of implementation of the Plan. This analysis (which should be read in conjunction with this assessment) concludes that the risks to important habitat from these threats are considered to be negligible across the Strategic Assessment Area. In summary, this is because none of the important habitat sites are:

- In close proximity to the nominated areas or transport corridors
- Hydrologically well connected (e.g. downstream) to development areas

It is relevant to note that even though implementation of the Plan is considered unlikely to indirectly impact migratory shorebird habitat, the Plan includes a range of measures that may provide a benefit to these areas. These measures include landscape scale approaches to:

- Conserving and managing land
- Managing fire
- Managing weeds
- Managing pest animals

30.19.6 POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to each species from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

No important habitat for any of the five species occurs within the nominated areas or transport corridors. Potential additional impacts from essential infrastructure and tunnels are therefore not relevant.

30.19.7 LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY FOR EACH SPECIES

This section considers the likely effects of implementation of the Plan on the long-term viability of the five species. The analysis has regard for the guidance in the Conservation Advices (there are no Recovery Plan for the species), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

As outlined above, implementation of the Plan will not lead to any direct or indirect impacts to important habitat for any of the species. This will ensure that the implementation of the Plan does not adversely influence their long-term viability.

CONSISTENCY WITH RECOVERY PLANS

There are no recovery plans for the species.

KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Given the lack of direct and indirect impacts, there are no relevant Key Threatening Processes (KTPs) or associated Threat Abatement Plans (TAPs).

31 Threatened Ecological Communities impact assessment

31.1 INTRODUCTION

There are eight Category 1 Threatened Ecological Communities (TECs) and one ecological community nominated for listing in the Finalised Priority Assessment List (FPAL) that are assessed in this Chapter. These ecological communities were identified as needing detailed assessment (see Part 3 for the approach, and Chapter 28 for the results) as they are reliant on the Cumberland subregion and have some potential to be impacted directly, indirectly or cumulatively.

The Chapter is structured around the level of direct impacts likely to occur to each TEC (see Table 31-1). TECs subject to the largest direct impacts are discussed first, with TECs at lower levels of direct impact discussed subsequently. The ecological community nominated for listing is assessed last.

The overall assessment approach for TECs is presented below in Section 31.2. To support the TEC assessment three additional pieces of technical analysis were undertaken. These were:

- A patch size analysis to calculate the number and sizes of patches of each TEC across the Strategic Assessment Area. See Section 31.3 for a description of the approach with the results presented in each TEC assessment
- A viability analysis to identify the patches of each TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term. The methodology for the viability analysis is presented below in Section 31.4 with the results presented in each TEC assessment
- A trend analysis undertaken by RMIT University (A Gordon & Peterson, 2019) that examined the extent and condition of a component (PCT 849) of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest. The trend analysis examined the potential impacts of development and offsetting under various scenarios on PCT 849 over the life of the Plan. A report for the trend analysis is provided at Supporting Document D. A summary of the approach and results is provided in Section 31.6 as part of the assessment of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest

The analysis in this chapter concludes that the avoidance, mitigation and offset measures in the Plan will ensure that the long-term viability of the TECs and the nominated ecological community will not be adversely influenced.

Table 31-1: Ecological communities assessed in this chapter categorised according to the scale of direct impacts

Direct impacts to TECs	Number of TECs	TEC names
TECs subject to direct impacts	4	• Shale Sandstone Transition Forest of the Sydney Basin Bioregion • Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest • Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion • Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community
TECs not directly impacted	4	• Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion • Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion • Turpentine-Ironbark Forest of the Sydney Basin Bioregion • Western Sydney Dry Rainforest and Moist Woodland on Shale
Nominated ecological community	1	• Coastal Floodplain Eucalypt Forest of Eastern Australia (nominated for listing under the EPBC Act)

31.2 TEC ASSESSMENT APPROACH

The assessments for TECs follow a standard format. However, the content is tailored for the specific context of each TEC.

There are nine sections to the assessments. They are described below and include:

- TEC background
- Approach to baseline data
- Occurrence in the Strategic Assessment Area
- Avoidance of impacts
- Direct impacts and offsets
- Potential indirect impacts and mitigation
- Potential additional impacts from essential infrastructure and tunnels
- Likely effects of implementation of the Plan on the long-term viability of the TEC
- Data tables

To assist the reader, standard explanatory text about the purpose and content of each section is provided throughout the assessments in *blue italics text*. The text is repeated for each TEC. It enables the reader to quickly understand the content of each section and where in the broader report more detailed information is available about a particular issue.

31.2.1 TEC BACKGROUND

Sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

31.2.2 APPROACH TO BASELINE DATA

Provides an overview of the approach to baseline data for the TEC. It:

- Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping
- Outlines the vegetation condition states used in the mapping
- Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC
- Summarises the approach to mapping the EPBC TEC at the scale of the Strategic Assessment Area
- Summarises the approach to the patch size analysis for the ecological community
- Summarises the approach to identifying areas of likely higher long-term viability for the TEC in the Strategic Assessment Area

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

31.2.3 OCCURRENCE IN THE STRATEGIC ASESSMENT AREA

Describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map of the TEC which can be viewed as a separate file (layered PDF). The map provides critical context for the assessment and should be viewed in conjunction with the text presented in the assessments. This section also provides a qualitative description of where the TEC occurs.

31.2.4 AVOIDANCE OF IMPACTS

Provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan.

The definition of what constitutes avoidance has been adopted from the BCAR process. Under the BAM, avoidance refers to land that is suitable for development and included in the area proposed for development or biodiversity certification, but has been avoided because of its biodiversity value. This is referred to as avoided for 'biodiversity purposes' in this assessment.

Land not impacted because it is not suitable for development or biodiversity certification, or land that has been excluded from the area proposed for development is not considered to have been avoided under the BAM. This land is referred to as avoidance for 'other purposes' and includes:

- Riparian corridors consistent with the *Water Management Act 2000*:
  - Strahler stream order 2 - buffer 20 m either side
  - Strahler stream order 3 - buffer 30 m either side
  - Strahler stream order 4 and above - buffer 40 m either side
- State protected land (>18 degrees slope, considered too steep for urban development)

Some land within the nominated areas was not considered for inclusion in the area proposed for development and has therefore been identified as 'excluded' land. These lands include:

- Existing protected land, including reserves and established offset sites
- Council owned land which is zoned for environmental conservation, environmental management or recreation
- Commonwealth land, such as Defence Establishment Orchard Hills
- Lands within the nominated areas already assessed as part of another development approval (Bingara Gorge), or lands progressing through an alternate assessment (Mount Gilead, Menangle Park, Sydney Metro Stage 1)
- Lands already developed (existing urban areas, urban land zones and roads)

A further, detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.2.5 DIRECT IMPACTS AND OFFSETS

Provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. Direct impacts are assessed in relation to the loss of the mapped TEC.

Direct impacts were determined based on an intersect of the urban capable lands and transport corridors with the baseline mapping generated for each TEC. It has been assumed that total permanent clearing will occur within the urban capable lands and transport corridors for the purposes of the assessment. However, it is important to note that in reality:

- Further avoidance will be undertaken within the transport corridors (see Chapter 7)
- Direct impacts will occur progressively over the life of the Plan, which reduces the severity of impacts

The analysis considers direct impacts within the context of the information provided through the patch size analysis and viability analysis (i.e. which patches are considered most likely to be viable in the long term).

The Plan provides offsets for TECs that are impacted directly. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

31.2.6 POTENTIAL INDIRECT IMPACTS AND MITIGATION

Identifies and discusses the potential indirect impacts to each TEC that may occur as a result of development under the Plan. They were identified as being relevant to the TEC if:

- The indirect impact is identified as a threat in a relevant profile or conservation advice, and
- The threat is present in the Cumberland subregion, and
- The Plan has the potential to exacerbate the threat

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

Where relevant to each TEC, indirect impacts are discussed in relation to the following categories which encapsulate the various ways threats to TECs are discussed in Conservation and Listing Advices:

- Inappropriate fire regimes
- Weed invasion

- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

31.2.7 POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

Considers the potential additional impacts to TECs due to essential infrastructure projects that are needed to support development within the nominated areas. These might include projects such as water and electricity utilities, communications facilities, stormwater management systems, and waste or resource management systems. The assessment covers projects that may need to be located outside urban capable lands and on areas that are identified as avoided lands within the nominated areas.

This section also assesses the likelihood of potential additional impacts to TECs due to the tunnel sections of the transport corridors. The impacts of tunnels were assessed separately to the rest of the transport corridors as only small areas of the footprints will be disturbed and it is not possible to determine at this stage the nature and extent of those impacts.

Please refer to the following chapters for details about these development types:

- Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels
- Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)

31.2.8 LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

Considers the likely effects of implementation of the Plan on the long-term viability of the TEC. This assessment has regard for the guidance in the Conservation Advice for each TEC (none of the TECs have EPBC Recovery Plans), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation.

Where applicable, this section also discusses the consistency of the Plan with any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.2.9 DATA TABLES

Sets out the data tables for occurrence, avoidance and direct impacts for each TEC.

31.3 PATCH SIZE ANALYSIS

A patch size analysis was undertaken for each TEC. This process used the mapping undertaken for the strategic assessment to identify and calculate the size of each patch of the TEC. This information was then used to calculate:

- The total number of patches of each TEC
- The distribution of patch sizes across three categories:
  - 0.5-5 ha
  - 5-20 ha
  - >20 ha

31.4 ASSESSMENT OF VIABILITY FOR TECS

For TECs, the consideration of likely effects on long-term viability took into account an analysis undertaken as part of the strategic assessment to identify areas of likely higher long-term viability in the Strategic Assessment Area.

31.4.1 PURPOSE

The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches".

31.4.2 APPROACH

The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included:

- Larger patches are generally more viable than smaller patches
- Better condition patches are generally more viable than poorer condition patches
- Connected patches are generally more viable than poorer connected patches
- Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

While the Conservation Advices identified several more factors as being important for viability or conservation significance, spatial data at the scale of the Strategic Assessment Area was not available on TECs to include these factors in the analysis.

A single rule-set was developed for all TECs to identify patches more likely to be of higher viability. To meet this requirement, patches needed to:

- Have a minimum patch size of 20 ha
- Be in intact condition
- Be well connected to other patches of native vegetation (this was defined as having greater than 30 per cent native vegetation cover in surrounding 550 m and 1750 m buffers)
- Have a good edge to area ratio (this was defined as "an edge to area ratio of the patch of native vegetation is smaller than an equivalent 100 m wide patch of the same size")

It is important to note that patches of the TEC that do not meet this rule-set are not necessarily of lower conservation value. Small patches are often of high conservation significance, particularly in over-cleared landscapes such as the Cumberland subregion, and if managed appropriately, can persist in the long-term (Wintle et al, 2019). The purpose of this analysis was to distinguish between different patches of the TEC based on guidance in Conservation Advices to enable a more meaningful evaluation of impacts and overall outcomes of the Plan based on available data.

31.4.3 RESULTS

The results of the TEC viability analysis are presented throughout this chapter for each TEC assessment.

TECS SUBJECT TO DIRECT IMPACTS

31.5 SHALE SANDSTONE TRANSITION FOREST OF THE SYDNEY BASIN BIOREGION

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC is a forest or open woodland with an overstorey dominated by various Eucalypt species and an understorey comprising sclerophyll shrubs, grasses and herbs. It occurs primarily on soils derived from shale substrates and is also found on weathered sandstone substrates. The TEC occurs in the transition zone between the Wianamatta Group shale that underlies the Cumberland Plain and the sandstone-dominated Hawkesbury Group of the surrounding subregions. The canopy is usually a mix of two or more of the following native tree species: Grey Gum (*Eucalyptus punctata*), Narrow-leaved Ironbark (*E. crebra*), Broad-leaved Ironbark (*E. fibrosa* subsp. *fibrosa*), Forest Red Gum (*E. tereticornis* subsp. *tereticornis*), Red Mahogany (*E. resinifera* subsp. *resinifera*), one or more stringybarks (*E. eugenioides* or *E. globoidea*), and Narrow-leaved Apple (*Angophora bakeri*). The mid-layer is commonly dominated by eucalypt species and Black She-oak (*Allocasuarina littoralis*). If a shrub layer is present, it is typically well-developed, diverse and dominated by *Bursaria spinosa* (blackthorn) in areas with low sandstone influence. The ground layer is diverse and dominated by grasses, graminoids and herbs. (DoE, 2014h) The following PCTs are associated with the TEC: • 792 Deane's Gum - Mountain Grey Gum - Turpentine tall moist forest on shale, Sydney Basin Bioregion • 1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion • 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion A range of fauna species occur in the TEC, including reptiles, amphibians, birds, micro-bats, and marsupials. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, adjacent wetlands, grasslands, woodlands and forests. The TEC is equivalent to the NSW BC Act listed TEC Shale Sandstone Transition Forest where key diagnostic and condition thresholds are met (DoE, 2014h).

EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the Conservation Advice (DoE, 2014h).
DISTRIBUTION	The TEC is confined to the Sydney Basin bioregion, on the edge of the Cumberland subregion and the adjacent Hornsby, Woronora, and Lower Blue Mountains Plateau. The TEC primarily occurs at elevations below 200 m (but may occur up to 350 m in the Blue Mountains and 600 m in the Southern Highlands) with mean annual rainfall of 800 - 1100 mm. The TEC generally occurs on soils that are primarily derived from shale substrates with some influence from weathered sandstone substrates. It is also strongly associated with the Mittagong Formation (DoE, 2014h).
SOS SITES	The TEC has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Currently no management sites have been identified for this TEC.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice (including listing advice) for Shale Sandstone Transition Forest of the Sydney Basin Bioregion (EC25R) (DoE, 2014h) Key Threatening Processes relevant to the TEC are identified in Section 2.1 of the Conservation Advice There is no adopted or made Commonwealth Recovery Plan for the TEC Threat Abatement Plans relevant to the TEC are identified in Table 31-2
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=146

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site

	based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are: • **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed • **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	The following PCTs are associated with the TEC: • 792 Deane's Gum - Mountain Grey Gum - Turpentine tall moist forest on shale, Sydney Basin Bioregion • 1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion • 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based on applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 0.5 ha, AND • > 50% of the perennial understorey vegetation cover is made up of native species (based on field verification), • Rainfall 800-1100 mm pa, AND • Growing on Shale or sandstone soil substrates OR • Patch size ≥ 2 ha, AND • > 50% of the perennial understorey vegetation cover is made up of native species (based on field verification), AND • Rainfall 800-1100 mm pa, AND • Growing on Shale or sandstone soil substrates OR • Patch size ≥ 0.5 ha, AND • ≥ 30% perennial understorey vegetation made up of natives, AND • The patch has at least one tree with hollows per ha or at least one large tree (≥ 80 cm dbh) per ha (based on field verification), OR, the patch is contiguous with a native vegetation remnant ≥1 ha • Rainfall 800-1100 mm pa, AND • Growing on Shale or sandstone soil substrates

	OR • Patch size ≥ 0.5 ha, AND • ≥ 50% perennial understorey vegetation made up of natives (based on field verification), AND • Rainfall 800-1100 mm pa, AND • Growing on Shale or sandstone soil substrates
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included: • Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.6 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment mapped approximately 8,214 ha of the TEC within the Strategic Assessment Area (see Table 31-3 for further details). Of this, approximately 5,899 ha has been identified as higher viability through the viability analysis. The TEC occurs in the following main locations within the Strategic Assessment Area: • In the north west, around North Richmond • In the mid-west, near Silverdale, Oakdale and Werombi • In the south, around Wilton and the southern part of GMAC It occurs in the following nominated areas: • Wilton – 1,006.5 ha total, 522.7 ha of this identified as higher viability • GMAC – 1,719.6 ha total, 1,127.4 ha of this identified as higher viability • GPEC – 1.7 ha total, 0 ha of this identified as higher viability It does not occur in WSA or the transport corridors outside the nominated areas. The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. The Conservation Advice states that all areas that meet the minimum condition thresholds as defined in the advice (categories A to D) are considered habitat critical to the survival of the TEC. These are generally: • Patch size (≥ 0.5 ha) with ≥ 30% native understory • Well-connected patches ≥ 1 ha in area or the patch has at least one tree with hollows or at least one large locally indigenous tree (> 80 cm dbh)

	The Conservation Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or a high area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Evidence of recruitment of key plant species/range of age cohorts • High native species richness • Presence of threatened species • Low level of weeds and pest animals The TEC is highly fragmented across the Strategic Assessment Area, comprising 817 patches with an average patch size of 10 ha.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.5.1 NOMINATED AREAS

The baseline mapping for this assessment mapped 2,138 ha of the TEC within the nominated areas (not including excluded lands). Approximately 1,947 ha (91 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 1,691 ha was avoided for biodiversity purposes
- 255 ha was avoided for other purposes

An additional 589.6 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-4.

It is important to note that the avoidance calculations in Table 31-4, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-4 shows the amounts of habitat within excluded lands for context only.

31.5.2 TRANSPORT

Avoidance results are only reported for urban development within the nominated areas, as detailed design of the footprint within the Transport Corridors has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will lead to direct impacts to the TEC (see Section 31.5.3 for discussion) but will not generally increase fragmentation (see Section 31.5.4 for discussion).

31.5.3 DIRECT IMPACTS TO THE TEC

Implementation of the Plan will lead to a loss of a total of 191.8 ha of the TEC within Wilton and GMAC. There will be no direct impacts within WSA, GPEC or transport corridors outside the nominated areas. These impacts represent approximately 2.3 per cent of the remaining TEC in the Strategic Assessment Area and 7 per cent of the TEC in the nominated areas. A breakdown of direct impacts is provided in Table 31-5.

The majority of the TEC that will be impacted within Wilton and southern GMAC:

- Is in thinned condition (135.7 ha), with only 22.5 per cent of direct impacts occurring to patches in intact condition
- Comprises small patches (less than 5 ha) (approximately 62 per cent)
- Is not mapped as higher viability, with only 33.7 ha of higher viability TEC being directly impacted

The most notable direct impacts to the TEC occur in Wilton and southern GMAC due to urban development. The threat to the TEC in these locations is reduced because:

- Impacts generally occur only to the edges of patches of the TEC that remain connected to larger patches of native vegetation associated with the gullies and gorges of Wilton and GMAC, and will not generally fragment or isolate patches of the TEC
- Potential habitat corridors along waterways that may be used by species associated with the TEC will be maintained
- The impact in the context of the amount remaining in the Strategic Assessment Area is relatively minor

31.5.4 FRAGMENTATION OF THE TEC

As outlined above, impacts largely occur to the edges of patches within Wilton and GMAC and will not result in a loss of connectivity (and therefore will not lead to fragmentation). Areas of the TEC that will not be impacted within these two nominated areas generally provide important habitat for Koalas and often form part of primary and secondary corridors for the species. As outlined in Chapter 30, a significant focus of the Plan is protecting these Koala corridors and maintaining connectivity for Koalas. These processes have helped avoid any notable fragmentation to the TEC.

31.5.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the TEC, the Plan includes a commitment (Commitment 8.1) to secure 715 ha of the TEC as part of the conservation program. This would:

- Lead to the protection and management of an additional 8.7 per cent of the ecological community within the Strategic Assessment Area
- Increase the level of protection and management of the ecological community by approximately 98.1 per cent on top of what is currently secured in the Strategic Assessment Area

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile or conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.5.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DoE, 2014h) identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from inappropriate grazing regimes, soil salinisation, and mining were also identified in the Conservation Advice as key threats. However, none of these are considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these risks across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC (DoE, 2014h). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in and around Wilton and the southern part of GMAC where significant areas of the TEC are present.

The key factors that influence the appropriateness of a fire regime are fire frequency, intensity and season of occurrence (DECCW, 2011). The Conservation Advice (DoE, 2014h) and the Cumberland Plain Recovery Plan (DECCW, 2011) provide information on fire regimes suitable for the TEC.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
  - Preparation of a fire management strategy for the Strategic Conservation Areas (SCAs) that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
  - A process to work with delivery partners to implement the fire management strategy
  - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas

- Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes.

Also relevant for the TEC is the fact that it largely overlaps with Koala habitat which is a key focus of the Plan in terms of protection and management. Significant areas of Koala habitat will be managed which will include the application of the fire management strategy and a set of measures to control access to bushland which will help minimise risks around arson and accidental fires.

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas
- The measures in the Plan for Koalas in terms of protecting and managing habitat, and constraining access to bushland will help protect the TEC

The commitments and actions under the Plan are consistent with a number of high priority actions in the Conservation Advice (DoE, 2014h). For example:

- To "integrate fire…management regimes"
- To "implement appropriate fire management regimes that take into account results from research"

WEED INVASION

The TEC is threatened with invasion of weeds. Weeds can displace native plants and reduce the diversity and regenerative capacity of the TEC (DoE, 2014h). Weed incursion in the TEC is associated with agricultural activities as well as urban development.

Key weeds that can occur in the TEC include: African Olive (*Olea europaea* subsp. *cuspidata*), Fireweed (*Senecio madagascariensis*), Spear Thistle (*Cirsium vulgare*), Cat's Ear (*Hypochaeris radicata*), Pigeon Grass (*Setaria gracilis*), Plantain (*Plantago lanceolata*), Paddy's Lucerne (*Sida rhombifolia*), Bridal Creeper (*Myrsiphyllum asparagoides*), Sow Thistle (*Sonchus oleraceus*), and Broad-leafed and Small-leaf Privet (*Ligustrum lucidum* and *L. Sinense*) in wetter areas.

The most serious threats to the TEC are from Bridal Creeper and African Olive as they are highly competitive and difficult to manage (DoE, 2014h).

These weeds are already present within the Strategic Assessment Area and pose a threat to the TEC. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to the TEC and introduces edge effects. Key risk areas include:

- In north and north west of Wilton, where the urban capable land impacts the edges of patches of the TEC connected to gorges and gullies on the edge of the nominated area
- In the southern part of GMAC, where the urban capable land impacts the edges of patches of the TEC connected to gorges and gullies on the edge and middle of the nominated area

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Importantly for the TEC, weeds will be actively managed within the 715 ha to be added to conservation as part of the offset program.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

These controls are consistent with a number of threat abatement actions in the Conservation Advice about the management of invasive species.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice (DoE, 2014h) as a threat to the TEC. This relates to a wide range of different mechanisms for disturbance including:

- Inappropriate mowing, slashing or scrubbing of the understorey for reasons such as bushfire fuel reduction, grazing and perceived aesthetics
- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants

- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of wood which changes the structure and habitat features of the TEC
- Inadvertent disturbance during construction which has the potential to directly impact the TEC outside approved development areas

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those that occur in close proximity to development within Wilton and GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- A commitment (Commitment 7) to mitigate indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on Koalas. This is relevant to the TEC because the vast majority of the TEC is identified as important Koala habitat. Of particular relevance to habitat disturbance are associated actions around the use of exclusion fencing which will assist in controlling access to Koala habitat. These measures will help minimise inappropriate habitat disturbance to the TEC within both Wilton and GMAC
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 715 ha for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas. This commitment is consistent with a number of actions in the Conservation Advice around educating the community about the TEC

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where large areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- The measures in the Plan for Koalas in terms of protecting and managing habitat, and constraining access to bushland will help protect the TEC
- A program of education for the community will be run to help them understand the biodiversity values they live near

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the

TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause erosion (DoE, 2014h).

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are:

- In north and north west of Wilton
- In the southern part of GMAC

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the RMS Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

The commitments and actions under the Plan are consistent with the following high priority action in the Conservation Advice (DoE, 2014h): "Manage any changes to hydrology or disruptions to water flows that may result in changes to water table levels and/or increased run-off, salinity, sedimentation or pollution".

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust and dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

The commitments and actions under the Plan are consistent with a number of high priority actions in the Conservation Advice (DoE, 2014h). For example:

- To "manage any other known, potential or emerging threats such as rural tree dieback"
- To "use appropriate hygiene to minimise the introduction or spread of plant diseases and weeds at susceptible sites"

INVASIVE FAUNA

The Conservation Advice (DoE, 2014h) identifies introduced animals and aggressive native species as a threat to the TEC. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the introduced Indian myna, and native species such as the sulphur-crested cockatoo

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers. The main areas of concern relate to new urban development in Wilton and the southern section of GMAC, where the current density of houses is low.

Agricultural development within Wilton and GMAC is not part of the Plan. As a result a substantial increase in pest species (other than feral cats or wild dogs) is not expected to occur as a result of implementation of the Plan.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above in the analysis of direct impacts, the Plan is considered unlikely to lead to any notable fragmentation to the TEC and as such is not considered an issue

- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

The commitments and actions under the Plan are consistent with the following high priority action in the Conservation Advice (DoE, 2014h): "Control introduced pest animals, including domestic pets, to allow natural regeneration and to manage threats, especially to threatened species".

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts due to urban development analysed above, there is the potential for impacts to the TEC to occur due to development of essential infrastructure within nominated areas but outside the urban capable lands.

The TEC does not occur within the vicinity of the tunnel footprints for transport and is therefore not at risk of additional impacts from tunnels.

31.5.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The TEC occurs on avoided land within Wilton (753.7 ha) and GMAC (1,192.8 ha), but not WSA or GPEC. It is possible that some of the areas on avoided land within Wilton and GMAC will be impacted by essential infrastructure. Impacts to the TEC are probable as the majority of the TEC occurs within lands avoided for biodiversity purposes between urban capable lands and on the edge of GMAC bordering with Wilton.

To limit the potential impacts to the TEC from essential infrastructure, the guidelines for essential infrastructure development include the following requirements: "Limit the total cumulative direct impacts within avoided lands to Shale Sandstone Transition Forest in the Sydney Basin Bioregion over the life of the Plan to no more than 20 ha in Wilton and 20 ha in GMAC".

As outlined in Chapter 37, any proposed essential infrastructure developments on avoided lands in the nominated areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine if the TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

The maximum additional impact to the TEC from essential infrastructure will be 40 ha. It is likely that the actual impacts will be less due to the proposed avoidance processes. In addition, any impacts that do occur will be adequately mitigated and offset through the application of the BAM. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.5.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2014h) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the TEC in relation to implementation of the Plan. They are:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Inappropriate habitat disturbance
  - Changes to hydrology
  - Diseases, pathogens and dieback
  - Invasive fauna

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan may lead to the loss of 191.8 ha of the TEC within the urban capable lands within the nominated areas, and potentially an additional 40 ha within avoided lands due to essential infrastructure. However, it is not considered likely that this will threaten the long-term viability of the TEC because:

- The majority of the remaining areas of higher viability TEC in the nominated areas have been avoided and are not impacted by the Plan, including:
  - 1,141 ha avoided for biodiversity purposes
  - 205 ha avoided for other purposes
- The majority of impacts are to lower viability areas of the TEC:
  - 0.6 per cent of higher viability TEC in the Strategic Assessment Area
  - 2.0 per cent of higher viability TEC in the nominated areas
- The impacts are unlikely to increase the level of fragmentation

- The offsets proposed by the Plan (715 ha of the TEC) will provide a substantial addition to the level of protection of the TEC and will support a key high priority action in the Conservation Advice to increase the area of larger, high quality patches of TEC that is secured and managed for conservation

It is worth noting that two of the reserves proposed by the Plan contain substantial areas of the TEC. They are:

- The Georges River Koala Reserve which is on the eastern side of the Strategic Assessment Area near GMAC. This will be implemented in two stages over the first 10 years of the Plan and contains approximately 375 ha of the TEC
- The Gulguer Reserve investigation area which occurs on the western side of the Strategic Assessment Area. The Plan proposes to implement the reserve over the first 20 years of the Plan. The area contains approximately 600 ha of the TEC

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, inappropriate habitat disturbance, changes to hydrology, diseases, pathogens and dieback, and invasive fauna will be managed and mitigated through a number of commitments and actions in the Plan.

Indirect impacts are not expected to influence the long-term viability of the TEC.

CONCLUSION

The nature of the impacts to the TEC combined with the commitments to protect 715 ha of the TEC and manage indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.5.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.5.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-2 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-2: Key Threatening Processes and relevant Threat Abatement Plans for Shale Sandstone Transition Forest of the Sydney Basin Bioregion

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)	There is no relevant TAP
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi)*	There is no relevant TAP
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-3: Occurrence of Shale Sandstone Transition Forest of the Sydney Basin Bioregion in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	8,214.1	728.7
Intact	6,598.5	685.7
Thinned	1,553.4	43.0
Scattered Trees	62.1	0.0
Higher Viability TEC	5,899.2	626.9

Table 31-4: Avoidance of impacts to Shale Sandstone Transition Forest of the Sydney Basin Bioregion within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL TEC IN NOMINATED AREA (ha)	**1,006.5**	**1,719.6**	**0.0**	**1.7**	**2,727.9**
Intact	540.4	1,258.8	0.0	0.0	1,799.2
Higher Viability TEC	522.7	1,127.4	0.0	0.0	1,650.1
TEC WITHIN EXCLUDED LANDS (ha)	164.7	423.2	0.0	1.7	589.6
TEC WITHOUT EXCLUDED LANDS (ha)	**841.8**	**1,296.5**	**0.0**	**0.0**	**2,138.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	683.9	1,007.4	0.0	0.0	1,691.3
Intact	399.8	812.6	0.0	0.0	1,212.3
Higher Viability TEC	389.4	751.6	0.0	0.0	1,141.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% TEC WITHOUT EXCLUDED LANDS)	**81.2**	**77.7**	**N/A**	**N/A**	**79.1**
AVOIDANCE FOR OTHER REASONS (ha)	69.8	185.4	0.0	0.0	255.2
Intact	55.7	169.3	0.0	0.0	225.0
Higher Viability TEC	55.3	149.8	0.0	0.0	205.1
AVOIDANCE FOR OTHER REASONS (% TEC WITHOUT EXCLUDED LANDS)	**8.3**	**14.3**	**N/A**	**N/A**	**11.9**
TOTAL AVOIDANCE (ha)	**753.7**	**1,192.8**	**0.0**	**0.0**	**1,946.5**
Intact	455.5	981.9	0.0	0.0	1,437.4
Higher Viability TEC	444.8	901.4	0.0	0.0	1,346.1
TOTAL AVOIDANCE (% TEC WITHOUT EXCLUDED LANDS)	**89.5**	**92.0**	**N/A**	**N/A**	**91.0**

Table 31-5: Direct impacts to Shale Sandstone Transition Forest of the Sydney Basin Bioregion

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO TEC (ha)	**88.1**	**103.7**	**0.0**	**0.0**	**0.0**	**191.8**
Intact	13.8	29.3	0.0	0.0	0.0	43.1
Thinned	71.0	64.7	0.0	0.0	0.0	135.7
Scattered Trees	3.4	9.6	0.0	0.0	0.0	13.0
Higher Viability TEC	10.7	23.0	0.0	0.0	0.0	33.7

31.6 CUMBERLAND PLAIN SHALE WOODLANDS AND SHALE-GRAVEL TRANSITION FOREST

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC is a temperate eucalypt woodland which is endemic to the shale hills and plains of the Sydney Basin bioregion and is mostly found within the Cumberland subregion. The TEC ranges from grassy woodland to forest, with the understorey ranging from mostly grassy to mostly shrubby. Occasional stands of this TEC are dense, particularly in shale-gravel transition areas. The TEC may have an upper tree layer, lower tree layer, shrub layer and a ground layer, although one or more layers may be sparse or absent. It must have an upper tree layer present, in addition to either a ground or shrub layer, to meet the EPBC definition of the TEC. The upper tree canopy is often dominated by *Eucalyptus moluccana*, *E. tereticornis*, *E. fibrosa*, *E. crebra* or other canopy species that may be locally dominant in some areas. The lower tree layer may include *Acacia* species, *Melaleuca* species, *Exocarpos* and young eucalypts. Shrub layers may be present and are often dominated by *Bursaria spinosa*, with a number of other species present. Ground layers comprise perennial native grasses, graminoids and non-woody plants. A range of fauna species occur in the TEC, including reptiles, amphibians, birds, micro-bats, and marsupials. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, other native vegetation in the Cumberland subregion. The TEC correlates to two NSW BC Act listed TECs (Cumberland Plain Woodland, and Shale Gravel Transition Forest) where key diagnostic and condition thresholds are met. (DEWHA, 2009a)
EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as projected foliage cover percentage, patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the listing advice (TSSC, 2009).

DISTRIBUTION	The TEC is confined to the Sydney Basin bioregion and mostly restricted to the Cumberland subregion. The TEC is scattered across the subregion. The TEC primarily occurs in a coastal valley rain shadow, with mean annual rainfall of 700 to 900 mm (TSSC, 2009) and may occur in some elevated areas with higher (orogenic) rainfall. It occurs on flat to undulating or hilly terrain, up to 350 m or slightly higher, and is mostly found on clay soils derived from the Wianamatta Group geological unit (DEWHA, 2009a).
SOS SITES	The two TECs listed under the BC Act that correlate to the TEC are being managed under the Saving our Species program. The management programs for these TECs are still being developed. Currently, no management sites have been identified for this TEC.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (DEWHA, 2009a) Listing Advice for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (TSSC, 2009) Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest Policy Statement 3.31 (DEWHA, 2010) There is no adopted or made Commonwealth Recovery Plan for the TEC. The TEC is included in the Cumberland Plain Recovery Plan (NSW) (DECCW, 2011) Key Threatening Processes and Threat Abatement Plans relevant to the TEC are identified in Table 31-6.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=112

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.

VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are:
	• **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present
	• **Thinned:** This condition state was assigned to native vegetation in various states of modification, including:
	  o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT
	  o Wooded vegetation that has been under scrubbed
	• **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed
	• **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands
	• **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species

ASSOCIATED PCTs	The following PCTs are associated with the TEC: • 724 Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion • 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion • 850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based on applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 0.5 ha, AND • > 10% canopy cover • > 50% perennial understorey vegetation made up of natives (based on field verification), AND • Generally below 350 m elevation, AND • Growing on clay soils derived from Wianamatta OR • Patch size ≥ 5 ha, AND • > 10% canopy cover • > 30% perennial understorey made up of natives (based on field verification), AND • Generally below 350 m elevation, AND • Growing on clay soils derived from Wianamatta OR • Patch size ≥ 0.5 ha, AND • > 30% perennial understorey vegetation made up of natives, AND • The patch is contiguous with a native vegetation remnant ≥ 0.5 ha, AND • Generally below 350 m elevation, AND • Growing on clay soils derived from Wianamatta

	OR • Patch size ≥ 0.5 ha, AND • > 30% perennial understorey vegetation made up of natives, AND • The patch has at least one tree with hollows per ha or at least one large tree (≥80 cm) per ha (based on field verification), AND • Generally below 350 m elevation, AND • Growing on clay soils derived from Wianamatta
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included: • Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.4 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 9,737 ha of the TEC within the Strategic Assessment Area (see Table 31-7 for further details). Of this, approximately 4,310 ha has been identified as higher viability through the viability analysis. The TEC occurs in the following main locations in the Strategic Assessment Area: • Scheyville National Park (474 ha) • Orchard Hills (426.6 ha) • Holsworthy (patch size 238 ha) • Wianamatta Regional Park (185 ha) • Cobbitty (145 ha) • Agnes Banks (138 ha) • Bringelly (137 ha) It occurs in the following nominated areas: • Wilton – 11.5 ha including 1.2 ha that is higher viability • GMAC – 92.0 ha including 8.1 ha that is higher viability • WSA – 85.9 ha including 0.1 ha that is higher viability • GPEC – 1,014.3 ha including 314.0 ha that is higher viability

	43.8 ha also occurs in transport corridors outside the nominated areas. Of this, 5.8 ha is higher viability. The Listing Advice (TSSC, 2009) does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. It states that all patches meeting the minimum condition thresholds as defined in the advice are considered habitat critical to the survival of the TEC. These are generally: • Patches ≥ 0.5 ha with a predominately native understory • Patches that are well-connected to other large (≥ 5 ha) native vegetation remnants in the landscape • Patches that have large mature trees (≥ 80 cm dbh) or trees with hollows The Listing Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or a high area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Evidence of recruitment of key plant species/range of age cohorts • Low level of weeds and pest animals • High native species richness, particularly in the ground layer • Presence of threatened species The TEC is highly fragmented across the Strategic Assessment Area, comprising over 1,900 patches with an average patch size of 4.9 ha. A total of six patches are greater than 100 ha, and 26 patches are greater than 50 ha in size. A number of patches are connected to areas of other vegetation types, which improves vegetation connectivity and provides some buffer from potential impacts associated with edge effects that would otherwise be expected with such a scattered distribution.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.6.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 204 ha of the TEC within the nominated areas (not including excluded lands). Approximately 94 ha (46 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 74 ha was avoided for biodiversity purposes
- 19 ha was avoided for other purposes

An additional 999 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-8.

It is important to note that the avoidance calculations in Table 31-8, including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-8 shows the amounts of habitat within excluded lands for context only.

31.6.2 TRANSPORT

Avoidance results are only reported for urban development within the nominated areas, as detailed design of the footprint within the Transport Corridors has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will lead to direct impacts to the TEC (see Section 31.6.3 for discussion) but will not generally increase fragmentation (see Section 31.6.4 for discussion).

31.6.3 DIRECT IMPACTS TO THE TEC

Implementation of the Plan will lead to a loss of a total of 154.7 ha of the TEC within the nominated areas and transport corridors. This loss represents approximately 1.6 per cent of the remaining TEC in the Strategic Assessment Area and 12.9 per cent of the TEC in the nominated areas. A breakdown of direct impacts is provided in Table 31-9.

The majority of the TEC impacted:

- Is in thinned condition (128.1 ha), with only 14.6 per cent of direct impacts occurring to patches in intact condition
- Comprises small patches (0.5-5 ha)
- Is not mapped as higher viability, with only 12.1 ha of higher viability TEC being impacted

The most notable direct impacts to the TEC occur in the following locations:

- Within GPEC, which will result in the loss of several small (0.5-5 ha) generally isolated patches of the TEC and reduces the size of a few larger patches. Less than 0.1 ha of these impacted areas is mapped as higher viability
- The loss of an area of partially connected patches associated with a riparian corridor in the southern portion of WSA near Luddenham and Bringelly. Less than 0.1 ha of these impacted areas is mapped as higher viability
- At Cobbitty due to the OSO and Shanes Park due to the M7 link

The threat to the TEC in these locations is reduced because:

- The Plan mainly impacts patches of the TEC that are generally isolated and exposed to edge effects
- The amount of impact in the context of the amount remaining in the Strategic Assessment Area is relatively minor
- Impacts account for less than 0.3 per cent of mapped higher viability TEC across the Strategic Assessment Area

31.6.4 FRAGMENTATION OF THE TEC

As outlined above, impacts largely occur to small, isolated patches or to the edge of patches and are not expected to further fragment the TEC.

31.6.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the TEC, the Plan includes a commitment to secure 575 ha of the TEC as part of the conservation program. This would:

- Lead to the protection and management of an additional 5.9 per cent of the ecological community within the Strategic Assessment Area
- Increase the level of protection and management of the ecological community by approximately 28.5 per cent on top of what is currently secured in the Strategic Assessment Area

These offsets also help address an identified threat in the Conservation Advice around the low level of protection of the TEC in reserves.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile or conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.6.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice (DEWHA, 2009a) identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance

In addition to the threats identified in the Conservation Advice, the following potential indirect impacts are considered relevant to the TEC:

- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from inappropriate grazing regimes were also identified in the Conservation Advice as a key threat. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate this risks across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC. This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Altered fire regimes can affect the structure and species composition of the TEC, particularly the understorey layers. Fire intervals of 4 to 12 years are likely to maintain most understorey species within the TEC. Fire intervals which are too short are associated with reduced native plant diversity (NSW Scientific Committee, 2009).

An absence of fire for extended periods of time can also result in proliferation of Blackthorn (*Bursaria spinosa*). Dense occurrences occur when fire has been absent from the TEC for a number of decades. Blackthorn has been recorded in densities of up to 1,000 plants per ha in unburnt patches of this TEC, leading to the decline of ground layer species. High densities of Blackthorn currently occur in many TEC remnants (TSSC, 2009).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The key factors that influence the appropriateness of a fire regime are fire frequency, intensity and season of occurrence (DECCW, 2011).

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

WEED INVASION

The TEC is threatened with invasion of weeds. Weeds can displace native plants and reduce the diversity and regenerative capacity of the TEC. The most serious threats to the TEC include African Olive (O*lea europa* subsp. *cuspidata*), Bridal Creeper (*Asparagus asparagoides*) and a range of exotic grasses (DEWHA, 2009a).

These weeds are already present within the Strategic Assessment Area and pose a threat to the TEC. However, urban development and transport have the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development occurs adjacent to the TEC and introduces edge effects. Key risk areas include in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Importantly for the TEC, weeds will be actively managed within the 575 ha to be added to conservation as part of the offset program.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

These controls are consistent with a number of threat abatement actions in the Conservation Advice about the management of invasive weeds.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice as a threat to the TEC. This relates to a wide range of different mechanisms for disturbance including:

- Inappropriate mowing, slashing or scrubbing of the understorey for reasons such as bushfire fuel reduction, grazing and perceived aesthetics
- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of wood which changes the structure and habitat features of the TEC
- Inadvertent disturbance during construction which has the potential to directly impact the TEC outside approved development areas

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 575 ha for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause erosion.

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas include in and around GPEC, WSA and GMAC, and to a lesser degree in Wilton where the TEC is much less extensive.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the RMS Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust and dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the introduced Indian myna, and native species such as the sulphur-crested cockatoo

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above in the analysis of direct impacts, the Plan is considered unlikely to lead to any notable fragmentation to the TEC and as such is not considered an issue
- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites

- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the TEC to occur due to:

- Development of essential infrastructure within nominated areas but outside the urban capable lands (see Section 31.6.7 for discussion)
- Development of tunnels within the transport corridors (see Section 31.6.8 for discussion)

31.6.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The TEC occurs on avoided land within GMAC (22.5 ha), WSA (20.1 ha) and GPEC (51.1 ha). It is possible that some of these areas will be impacted by essential infrastructure as the majority of the avoided TEC occurs on lands avoided for biodiversity purposes (74.4 ha). Impacts are more likely where the TEC occurs on avoided lands between urban capable lands.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine if the TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the TEC will occur as a results of essential infrastructure as every effort should be made to avoid and minimise impacts. Any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

31.1.1 POTENTIAL IMPACTS FROM TUNNELS

The TEC occurs within the tunnel footprints for the Metro Rail Future Extension (39.6 ha) and the Outer Sydney Orbital (58.4 ha). The Plan includes commitments to:

- Avoid any direct impacts associated with tunnels to the areas where the TEC occurs
- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the TEC from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above. It also discusses the results of the trend analysis that was undertaken to understand how one of the PCTs that comprise the TEC (PCT 849) is likely to fare over the life of the Plan.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.6.8 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DEWHA, 2009a) and other relevant TEC documents identify the following key issues that are likely to have the greatest influence on the long-term viability of the TEC in relation to implementation of the Plan. They are:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Inappropriate habitat disturbance
  - Changes to hydrology
  - Diseases, pathogens and dieback
  - Invasive fauna

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan may lead to the loss of 154.7 ha of the TEC. However, it is not considered likely that this will threaten the long-term viability of the TEC because:

- The scale of impacts are relatively minor when considering the mapped extent of the TEC across the Strategic Assessment Area (less than 1.6 per cent)
- The majority of impacts are to lower viability areas of the TEC:
  - Less than 0.3 per cent of higher viability TEC in the Strategic Assessment Area
  - Approximately 3.7 per cent of higher viability TEC in the nominated areas
- The impacts are unlikely to increase the level of fragmentation
- The offsets proposed by the Plan (575 ha of the TEC) will provide a substantial addition to the level of protection of the TEC and address a key threat identified in the Conservation Advice around its current low level of protection

It is worth noting that two of the reserves proposed by the Plan contain substantial areas of the TEC. They are:

- The Georges River Koala Reserve which is on the eastern side of the Strategic Assessment Area near GMAC. This will be implemented in two stages over the first 10 years of the Plan and contains approximately 60 ha of the TEC
- The Gulguer Reserve investigation area which occurs on the western side of the Strategic Assessment Area. The Plan proposes to implement the reserve over the first 20 years of the Plan. The area contains approximately 200 ha of the TEC

Trend analysis

This conclusion is supported by the trend analysis that was undertaken by RMIT University (A Gordon & Peterson, 2019) that examined the predicted extent and condition of PCT 849 over the life of the Plan under various scenarios. PCT 849 is one of several PCTs that make up the EPBC listed TEC and the results of the analysis provide valuable information about the long-term viability of the TEC as a whole.

The trend analysis examined the potential impacts of development and offsetting under various scenarios on PCT 849 in the Cumberland subregion over the life of the Plan. This is an important analysis because the typical impact assessment approach considers impacts and offsets largely in a static sense (i.e. they are unable to consider quantitative trends in biodiversity values because of the complexity involved). The trend analysis provided the opportunity to model how a key part of the TEC would fare over time and included consideration of the baseline pressures on vegetation. It was informed by expert elicitation with a range of well-regarded experts in the vegetation of the Cumberland subregion and is a robust analysis.

The scenarios analysed through the project are largely consistent with commitments in the Plan. Key findings were:

- Existing landscape scale threats across the Cumberland subregion (e.g. weeds) are significant and will result in an approximate 5.8 per cent decline in the extent and condition of the PCT over the life of the Plan unless additional areas are managed. These threats will operate with or without the Plan
- The proposed impacts of development under the Plan that were modelled in the analysis (noting that further avoidance has occurred since that time) will lead to approximately the same magnitude of losses (~5.8 per cent) to the PCT that will occur due to existing landscape threats
- High intensity management (as occurs in reserves and biodiversity stewardship sites) and early offsetting will provide the greatest benefits to the outcomes of the PCT over the life of the Plan
- Securing approximately 1,605 ha of offsets for PCT 849 (it is important to note that the actual target in the Plan is 2,325 ha which is substantially greater than the amount modelled in the trend analysis) will compensate for the impacts of development where earlier offsetting and higher intensity management is preferenced by improving the extent and condition of the PCT over the life of the Plan. This was measured by considering the extent and condition of the PCT over time. This approach also has the potential to contribute significantly to addressing the predicted declines across the subregion due to existing landscape scale threats

This last point is a critical one. Not only will the offsets in the Plan compensate for the impacts, but they have the potential to address the predicted declines in the PCT that are occurring across the Strategic Assessment Area due to current threats.

Supporting Document D provides further details regarding the methodology and results of the trend analysis.

Strategic priority

The Conservation Advice sets out a strategic priority for the TEC which is to take “an appropriate broad scale landscape approach” to ensure the TEC is “given adequate consideration in decision making”. This is one of the key premises behind the Plan which is taking a landscape scale approach to both development planning and conservation.

Two key points raised in the Conservation Advice about the strategic priority are:

- “The program should therefore identify those remnants that are most important for long-term conservation and recovery of the community. Consideration should be given to position inside and out of planned urban growth areas, proximity of smaller remnants to larger native vegetation remnants, conserving habitat values (e.g. large trees with hollows) and functionality as corridors or 'stepping stones' for fauna and flora”
- “Whilst the connectivity of remnants that meet the Description and Condition Thresholds in the listing advice for the national ecological community is a high priority, reconnection to lower-quality remnants, other ecological communities or native plantings should also be considered in order to optimise biodiversity outcomes across the landscape”

Both the avoidance processes used to define the urban capable lands (see Chapter 14) and the conservation program have specifically addressed these points. Key areas of the TEC have been avoided in the design of the urban capable lands, and the conservation program is applying a process to identify:

- Remnants that are the most important for long-term conservation
- Corridors and connectivity for biodiversity
- Areas that are suitable for restoration including lower-quality remnants of the TEC and derived grasslands

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, inappropriate habitat disturbance, changes to hydrology, diseases, pathogens and dieback, and invasive fauna will be managed and mitigated through a number of commitments and actions in the Plan.

Indirect impacts are not expected to influence the long-term viability of the TEC.

Conclusion

The nature of the impacts to the TEC combined with the commitments to protect 575 ha of the TEC and manage indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.6.9 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.6.10 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-6 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-6: Key Threatening Processes and relevant Threat Abatement Plans for Cumberland Plain Shale Woodlands and Shale-gravel Transition Forest

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-7: Occurrence of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**9,737.2**	**2,012.6**
Intact	6,406.5	1,482.0
Thinned	3,311.2	530.2
Scattered Trees	19.6	0.43
Higher Viability TEC	4,309.6	1,228.6

Table 31-8: Avoidance of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL TEC IN NOMINATED AREA (ha)	**11.5**	**92.0**	**85.9**	**1,014.3**	**1,203.7**
Intact	1.2	29.3	1.2	370.7	402.5
Higher Viability TEC	1.2	8.1	0.1	314.0	323.4
TEC WITHIN EXCLUDED LANDS (ha)	4.6	52.5	8.3	933.9	999.3
TEC WITHOUT EXCLUDED LANDS (ha)	7.0	39.5	77.7	80.4	204.4
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	20.6	8.4	45.4	74.4
Intact	0.0	9.7	0.0	7.4	17.1
Higher Viability TEC	0.0	0.2	0.0	0.0	0.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% TEC WITHOUT EXCLUDED LANDS)	**0.0**	**52.2**	**10.8**	**56.5**	**36.4**
AVOIDANCE FOR OTHER REASONS (ha)	0.0	1.9	11.7	5.7	19.3
Intact	0.0	0.7	0.2	0.0	0.9
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR OTHER REASONS (% TEC WITHOUT EXCLUDED LANDS)	**0.0**	**4.8**	**15.1**	**7.1**	**9.4**
TOTAL AVOIDANCE (ha)	**0.0**	**22.5**	**20.1**	**51.1**	**93.7**
Intact	0.0	10.3	0.2	7.4	18.0
Higher Viability TEC	0.0	0.2	0.0	0.0	0.2
TOTAL AVOIDANCE (% TEC WITHOUT EXCLUDED LANDS)	**0.0**	**57.0**	**25.8**	**63.6**	**45.8**

Table 31-9: Direct impacts to Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest within the nominated areas and Transport Corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO TEC (ha)	**7.0**	**17.0**	**57.6**	**29.4**	**43.8**	**154.7**
Intact	1.2	6.1	0.9	0.6	13.8	**22.6**
Thinned	3.2	10.1	56.0	28.8	30.0	**128.1**
Scattered Trees	2.5	0.8	0.7	<0.1	0.0	**4.1**
Higher Viability TEC	1.2	5.0	<0.1	<0.1	5.8	**12.1**

31.7 COOKS RIVER/CASTLEREAGH IRONBARK FOREST OF THE SYDNEY BASIN BIOREGION

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC is a dry sclerophyll open forest to low woodland community with an overstorey dominated by *Eucalyptus fibrosa* and *Melaleuca decora*. *Eucalyptus longifolia* is also often present. The midstorey is usually moderate to dense, commonly including *Melaleuca nodosa* and *Lissanthe strigosa*, and to a lesser extent *Melaleuca decora.* The ground layer is variable and generally sparse with a mix of grasses and other graminoids, forbs, and low shrubs. The TEC can intergrade into Shale-Gravel Transition Forest (where the alluvium is shallow), Castlereagh Swamp Woodland (in moist depressions) and Castlereagh Scribbly Gum Woodland (on sandier soils). The following PCT is associated with the TEC: 725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin bioregion. A range of fauna species occur in the TEC, including reptiles, amphibians, birds, micro-bats, and marsupials. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, other native vegetation in the Cumberland subregion. Most plant species in the TEC are able to regenerate from lignotubers and buds beneath the bark as well as seeds stored in the soil (OEH, 2019d). The TEC is equivalent to the NSW BC Act listed TEC Cooks River/Castlereagh Ironbark Forest where key diagnostic and condition thresholds are met. The EPBC conditions include a treeless, shrubby state that is not included in the NSW-listed TEC. (DoE, 2015)
EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the Conservation Advice (DoE, 2015).
DISTRIBUTION	The TEC is confined to the Sydney Basin bioregion and mostly restricted to the Cumberland subregion.

	The majority of the TEC is found in larger patches in the north-west part of the subregion in the Castlereagh area between Penrith and Richmond. Other significant patches occur in the Kemps Creek and Holsworthy areas. Smaller patches of the TEC occur in the eastern part of the subregion, such as the upper Cooks River valley. The TEC primarily occurs in elevations below 100 m with mean annual rainfall of 800-1000 mm. It generally occurs on clay soils derived from Tertiary alluvium and on Wianamatta Shale soils found next to Tertiary alluvium. In the eastern areas of its distribution, the TEC can be found on soils with a sandstone influence. (DoE, 2015c)
SOS SITES	The TEC has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Currently no management sites have been identified for this TEC.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice (including listing advice) for Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion (DoE, 2015c) Key Threatening Processes relevant to the TEC are identified in the Conservation Advice There is no adopted or made Commonwealth Recovery Plan for the TEC. The TEC is included in the Cumberland Plain Recovery Plan (NSW) (DECCW, 2011) Threat Abatement Plans relevant to the TEC are identified in Table 31-14
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=129

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.

VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are: • **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed • **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	The following PCT is associated with the TEC: • 725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin bioregion.
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based on applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone), AND • ≥ 30% of perennial understorey vegetation cover is native (field verification), AND • Below 100 m elevation, AND • Rainfall 800-1000 mm per year, AND • Growing on Clay rich soils derived from tertiary alluvium and on Wianamatta derived shale soils found next to tertiary alluvium, AND • Patch is contiguous with native vegetation remnant >1ha, OR the patch has at least one tree with hollows or at least one large locally indigenous tree (>80 cm) (based on field verification) OR • Patch size ≥ 0.5 ha (Patch size > 0.1 ha in areas east of Riverstone), AND • ≥ 50% of perennial understorey vegetation cover is native (based on field verification), AND • Below 100 m elevation, AND • Rainfall 800-1000 mm per year, AND • Growing on clay rich soils derived from tertiary alluvium and on Wianamatta derived shale soils found next to tertiary alluvium
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.

VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included: • Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.3 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 791 ha of the TEC within the Strategic Assessment Area (see Table 31-11 for further details). Of this, approximately 592 ha has been identified as higher viability through the viability analysis. The TEC occurs in the following main locations within the Strategic Assessment Area: • Northern part of the Strategic Assessment Area between Windsor Downs, Llandilo and Agnes Banks associated with larger remnants of native vegetation in this locality • Northern part of GPEC within Wianamatta Regional Park and near Ropes Crossing • Southern part of WSA near Kemps Creek It occurs in the following nominated areas: • WSA – 33.6 ha. None of this is mapped as higher viability • GPEC – 96.8 ha including 39.2 ha that is higher viability The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. It states that all patches that meet the minimum condition categories as defined in the advice are considered habitat critical to the survival of the TEC. The Conservation Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or a high area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Evidence of recruitment of key plant species/range of age cohorts • High native species richness • Presence of threatened species • Low level of weeds and pest animals The TEC is highly fragmented across the Strategic Assessment Area, comprising approximately 153 patches most of which (120) are less than 5 ha. Only seven patches are greater than 20 ha. However, the TEC intergrades into other native vegetation types, and many patches of the TEC are surrounded by or connected to larger areas of native vegetation, providing a buffer to edge effects.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.7.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 52 ha of the TEC within the nominated areas (not including excluded lands). Approximately 26 ha (50 per cent) was avoided as part of the urban capable lands and transport corridors (not including excluded lands). All of this was avoided for biodiversity purposes.

An additional 78 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-12.

It is important to note that the avoidance calculations in Table 31-12, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-12 shows the amounts of habitat within excluded lands for context only.

31.7.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred. Avoidance within the transport corridors will occur during the detailed design phase as each project is brought forward.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will lead to direct impacts to the TEC (see Section 31.7.3 for discussion) and increase fragmentation in one location (see Section 31.7.4 for discussion).

31.7.3 DIRECT IMPACTS TO THE TEC

Implementation of the Plan will lead to loss of a total of 26.3 ha of the TEC within GPEC and WSA. This loss represents approximately 3 per cent of the remaining TEC in the Strategic Assessment Area and 20 per cent of the TEC in the nominated areas. A breakdown of direct impacts is provided in Table 31-13.

The majority of the TEC impacted within GPEC and WSA:

- Is in thinned condition (13 ha)
- Comprises small patches (less than 5 ha) (14 out of the 17 impacted patches)
- Is not mapped as higher viability. Impacts will occur to 10.8 ha of higher viability TEC

The majority of the loss of the TEC (15 ha) is due to the Outer Sydney Orbital in the northern part of GPEC.

The most notable direct impacts to the TEC occur to patches impacted by the Outer Sydney Orbital in the northern part of GPEC within Wianamatta Regional Park (19.3 ha). Impacts in this location will occur to patches that:

- Are of moderate size (> 5 ha)
- Are mostly in intact condition and that are known to contain several threatened flora species (see Chapter 29), which (consistent with the Conservation Advice) makes them of higher conservation value
- Form part of a larger, well-connected patch of native vegetation associated with the Wianamatta Regional Park

However, the Plan includes a specific commitment (Commitment 3) to avoid and minimise impacts to the TEC due to the construction of the Outer Sydney Orbital within the Wianamatta Regional Park.

Impacts in WSA (7.0 ha) will occur to a number of small patches that are predominately in thinned condition.

31.1.2 FRAGMENTATION OF THE TEC

The Conservation Advice identifies fragmentation as a key threat to the TEC (DoE, 2015).

Fragmentation of the TEC will occur due to the direct impacts from the Outer Sydney Orbital in Wianamatta Regional Park (GPEC). In this area, the Outer Sydney Orbital will intersect the middle of several patches of the TEC that form part of a larger, well-connected patch of native vegetation to the west and Ropes Creek riparian corridor to the south. The TEC is also marginally connected to a larger patch of the TEC to the east at Ropes Crossing.

Fragmentation of the TEC may increase the susceptibility of the TEC to weed invasion and other edge effects and has the potential to reduce its long-term viability in this location.

Fragmentation is not expected to occur to the TEC in WSA.

31.7.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the TEC, the Plan includes a commitment to secure 105 ha of the TEC as part of the conservation program. This would:

- Lead to the protection and management of an additional 13.3 per cent of the TEC within the Strategic Assessment Area
- Increase the level of protection and management of the ecological community by approximately 25 per cent on top of what is currently secured in the Strategic Assessment Area

These offsets are consistent with the following two high priority actions in the Conservation Advice:

- “Protect and conserve patches of this ecological community…”
- “Promote formal conservation arrangements, management agreements and covenants on private land. For crown and private land, promote inclusion in reserve tenure”

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile or conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.7.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

To help address these potential indirect impacts, the Plan includes a requirement to undertake mitigation in accordance with the *Best Practice Guidelines: Cooks River/Castlereagh Ironbark Forest* (DECC, 2008a) within and adjacent to the TEC. These are discussed further below in relation to specific indirect impacts.

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from dryland salinity due to historical clearing and uncontrolled grazing were also identified in the Conservation Advice as key threats. However, none of these are considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these risks across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC (DoE, 2015c). This can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Altered fire regimes, particularly increased fire frequency due to arson, can affect the structure and species composition of the TEC by altering the mid and ground layers. This is despite most plant species in the TEC being able to regenerate after fire from lignotubers and buds beneath the bark, as well as seeds stored in the soil (OEH, 2019d). While most impacts to the TEC are associated with increased fire, in some areas the TEC is threatened due to a lack of fire (DoE, 2015c).

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in the north of GPEC, and the south east of WSA.

The key factors that influence the appropriateness of a fire regime are fire frequency, intensity and season of occurrence (DECCW, 2011).

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy

  - o Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
  - o Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
  - o Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes
- A specific requirement in relation to two commitments (Commitments 5 and 6) to apply the best practice guidelines for managing the TEC (DECC, 2008a). This includes specifics around fire management and is consistent with a high priority action in the Conservation Advice

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands in WSA where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas
- The fire management requirements for the TEC specified in the best practice guidelines will be applied

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of fire.

WEED INVASION

The TEC is threatened with invasion and competition by weeds. It typically occurs on soils that are richer in nutrients compared to other soil types in the Sydney Basin bioregion, which means it is particularly susceptible to threats from weeds (DECC, 2008a).

The most serious threats are:

- Mid-storey weeds:
  - o Green cestrum (*Cestrum parqui*), which is dispersed by birds and water
  - o Mickey mouse bush (*Ochna serrulata*), which is dispersed by birds and dumped garden waste. This weed can establish in undisturbed bushland
- Ground-layer weeds: Ground Asparagus (*Asparagus aethiopicus*), dispersed by birds and dumped garden waste. This weed affects availability of nutrients and water
- Grassy weeds:
  - o Panic veldt grass (*Ehrharta erecta*), which is dispersed by water, birds, contaminated soil and dumped garden waste
  - o Kikuyu (*Cenchrus clandestinus*), which is dispersed by dumped garden waste
  - o Common couch (*Cynodon dactylon*), which can escape from pastures and lawns
- Vines: Bridal creeper (*Asparagus asparagoides*)

These weeds are already present within the Strategic Assessment Area and pose a threat to the TEC. However, urban and transport development within the northern half of the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development or transport corridors occur adjacent to the TEC and/or fragments patches of the TEC into smaller patches and introduces edge effects. Key risk areas include:

- Northern part of GPEC where the Outer Sydney Orbital corridor fragments TEC patches
- South-eastern part of WSA where urban development occurs immediately adjacent to several connected TEC patches

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas
- A specific requirement in relation to two commitments (Commitments 5 and 6) to apply the best practice guidelines for managing the TEC (DECC, 2008a). This includes specifics around weed management and is consistent with a high priority action in the Conservation Advice

Importantly for the TEC, weeds will be actively managed within the 105 ha to be added to conservation as part of the offset program.

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction
- The weed management requirements for the TEC specified in the best practice guidelines will be applied

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of weeds.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice as a threat to the TEC. This relates to a wide range of different mechanisms for disturbance including:

- Inappropriate mowing, slashing or scrubbing of the understorey for reasons such as bushfire fuel reduction, grazing and perceived aesthetics
- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of wood which changes the structure and habitat features of the TEC
- Inadvertent disturbance during construction which has the potential to directly impact the TEC outside approved development areas

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those to the north of GPEC, and the south-east of WSA.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations (including the 105 ha for the TEC)
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of disturbance.

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause erosion.

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are those in the north of GPEC and the south east of WSA.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the RMS Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust and dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
    - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
    - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the introduced Indian myna, and native species such as the sulphur-crested cockatoo

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above in the analysis of direct impacts, fragmentation is likely to occur in the vicinity of the Wianamatta Regional Park but not in other areas of the TEC
- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan

- Preparation of a Pest Animal Control Implementation Strategy
- A process to enter into written agreements with delivery partners to implement the pest animal control program
- Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans

- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the TEC to occur due to development of essential infrastructure within the avoided lands of WSA.

The TEC does not occur within the vicinity of the tunnel footprints for transport and is therefore not at risk of additional impacts from tunnels.

31.7.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Areas of the TEC occur within the avoided lands of WSA. Of the 26.1 ha, 19.4 ha is in good (intact) condition and 6.7 ha is in moderate (thinned) condition. It is possible that some of these areas will be impacted by essential infrastructure where it occurs between urban capable lands.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine if the TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the TEC will occur as a results of essential infrastructure as every effort should be made to avoid and minimise impacts. Any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.7.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoE, 2015c) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the TEC:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Inappropriate habitat disturbance
  - Changes to hydrology
  - Diseases, pathogens and dieback
  - Invasive fauna

Habitat loss and fragmentation

As outlined above, implementation of the Plan may lead to the loss of 26.3 ha of the TEC (7.0 ha in WSA and 19.3 ha in GPEC). This equates to 3.3 per cent of the remaining TEC in the Strategic Assessment Area.

The impacts in WSA are not expected to threaten the long-term viability of the TEC because:

- Impacts are to a number of smaller already fragmented patches
- Of the 7.0 ha to be impacted, only 0.2 ha is in intact condition and none of it is mapped as higher viability
- The impacts are unlikely to increase the level of fragmentation of the TEC

The impacts in GPEC are more complex in relation to the implications for the long-term viability of the TEC. This is because:

- The impacts from the Outer Sydney Orbital will lead to fragmentation within the Wianamatta Regional Park
- Of the 19.3 ha to be impacted, 10.8 ha is mapped as higher viability. This represents 1.8 per cent of the higher viability TEC in the Strategic Assessment Area (592 ha)

It is noted that the Plan commits (Commitment 3) to avoid and minimise impacts to the TEC due to the construction of the Outer Sydney Orbital in GPEC. It will be critical that this process avoids and minimise impacts as far as possible to reduce the scale of impacts. As part of this process, Transport for NSW will report to the Department on avoidance achieved within the transport corridors. The Department will use this information to track impacts and adjust offset requirements through the Plan's reconciliation accounting process. This process provides an incentive for Transport for NSW to avoid impacts to this TEC and reduce offset requirements.

To address the overall residual risks associated with direct impacts the Plan commits to protecting 105 ha of the TEC. This will provide a substantial contribution to the area of the TEC that is protected within the Strategic Assessment Area (an additional 13.3 per cent), and supports a number of high priority actions in the Conservation Advice.

As part of this commitment, the Plan is also prioritising restoration of up to 25 per cent of the offset target for the TEC. Restoration provides the potential for substantial improvements in the long-term viability of the TEC by:

- Adding to the known extent of TEC by rehabilitating degraded areas of vegetation that do not currently meet the EPBC listing criteria
- Improving the resilience of patches of the TEC where restoration occurs in strategic locations (e.g. by increasing the size of an existing patch, or connecting existing patches)

Given the extent of impacts from the Outer Sydney Orbital, the timing of offsetting will be critical for the TEC. Offsets should be provided early during the implementation of the Plan and ideally be in place before the construction of the Outer Sydney Orbital. If this were to occur, the long-term viability of the TEC will not be adversely affected.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, inappropriate habitat disturbance, changes to hydrology, diseases, pathogens and dieback, and invasive fauna will be managed and mitigated through a number of commitments and actions in the Plan.

Indirect impacts are not expected to influence the long-term viability of the TEC.

CONCLUSION

Implementation of the Plan is not expected to adversely influence the long-term viability of the TEC where offsetting occurs early and restoration of the TEC is successful.

31.7.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.7.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-10 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-10: Key Threatening Processes and relevant Threat Abatement Plans for Cooks River/Castlereagh Ironbark Forest

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-11: Occurrence of Cooks River/Castlereagh Ironbark Forest in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**790.7**	**413.8**
Intact	702.2	407.7
Thinned	86.7	6.1
Scattered Trees	1.7	0.0
Higher Viability TEC	592.0	347.2

Table 31-12: Avoidance of impacts to Cooks River/Castlereagh Ironbark Forest within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL TEC IN NOMINATED AREA (ha)	**0.0**	**0.0**	**33.6**	**96.8**	**130.4**
Intact	0.0	0.0	19.7	82.8	102.5
Higher Viability TEC	0.0	0.0	0.0	39.2	39.2
TEC WITHIN EXCLUDED LANDS (ha)	0.0	0.0	0.5	77.5	78.0
TEC WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**33.1**	**19.2**	**52.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	26.0	0.0	26.0
Intact	0.0	0.0	19.4	0.0	19.4
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**78.6**	**0.0**	**49.7**
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	0.1	0.0	0.1
Intact	0.0	0.0	0.0	0.0	0.0
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR OTHER REASONS (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**0.3**	**0.0**	**0.2**
TOTAL AVOIDANCE (ha)	**0.0**	**0.0**	**26.1**	**0.0**	**26.1**
Intact	0.0	0.0	19.4	0.0	19.4
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
TOTAL AVOIDANCE (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**78.9**	**0.0**	**49.9**

Table 31-13: Direct impacts to Cooks River/Castlereagh Ironbark Forest

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO TEC (ha)	**0.0**	**0.0**	**7.0**	**19.3**	**0.0**	**26.3**
Intact	0.0	0.0	0.2	11.4	0.0	**11.6**
Thinned	0.0	0.0	5.0	7.9	0.0	**12.9**
Scattered Trees	0.0	0.0	1.7	0.0	0.0	**1.7**
Higher Viability TEC	0.0	0.0	0.0	10.8	0.0	**10.8**

31.8 COASTAL SWAMP OAK (*CASUARINA GLAUCA*) FOREST OF NSW AND SOUTH EAST QUEENSLAND

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	The TEC varies from open forest to low woodlands, depending on landscape location and disturbance history, with an overstorey dominated by *Casuarina glauca* (swamp oak, swamp she-oak). *Eucalyptus* species may also be present. *Melaleuca* species may also occur in the overstorey, midstorey or as emergent in freshwater patches of the TEC. The midstorey is not always present in occurrences of the TEC. Instead, a sub-canopy of smaller trees may often be present. This sub-canopy typically consists of juvenile canopy species. The climbing plant species that is most commonly found in the TEC is *Parsonsia straminea*. The ground layer is typically a contiguous to semi-contiguous layer of forbs, ferns, sedges, grasses and plant litter. The composition of this ground layer is influenced by groundwater salinity. The following PCT is associated with the TEC: 1800 Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley. A range of fauna species occur in the TEC, including reptiles, amphibians, birds, micro-bats, and marsupials. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, adjacent wetlands, grasslands, woodlands and forests. The TEC is equivalent to the NSW BC Act listed TEC Swamp Oak Floodplain Forest where key diagnostic and condition thresholds are met. (DoEE, 2018a)
EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the Conservation Advice (DoEE, 2018a)
DISTRIBUTION	The TEC has a broad extent of occurrence along the east coast of Australia from Curtis Island in Queensland to Bermagui in NSW. However, its area of occupancy is limited. It occurs within the subregion from Cranebrook in the north to Bow Bowing in the south. The TEC primarily occurs in coastal catchments at elevations of less than 50 m, typically within 30 km of the coast. It generally occurs on unconsolidated sediments including alluvium deposits.

	The soils are hydrosols that are grey-black clay-loam and/or sandy loam soils and are saturated with water for long periods of time. It can also occur on peaty soils. (DoEE, 2018a)
SOS SITES	The TEC has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. A priority management site for the TEC has been proposed at Eurobodalla on the NSW south coast (OEH, 2018j).
RELEVANT PLANS AND POLICIES	Conservation Advice (including listing advice) for Coastal Swamp Oak *(Casuarina glauca)* Forest of New South Wales and South East Queensland ecological community (DoEE, 2018a). Key Threatening Processes relevant to the TEC are identified in Table 8 of the Conservation Advice. There is no Recovery Plan for the TEC. Threat Abatement Plans relevant to the TEC are identified in Chapter 15.
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=142

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11. It is also important to note that limited mapping exists for PCT 1800 outside of the nominated areas as the PCT has historically been included in mapping for other PCTs. It is expected that more PCT 1800 exists outside of the nominated areas than identified in the best available data.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are:

	• **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed • **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	The following PCT is associated with the TEC: • 1800 Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based on applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 5 ha, OR • Patch size at least 2 ha and < 5 ha, OR • Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha, AND • Non-native species comprise < 20% of total understorey vegetation cover OR • Patch size ≥ 5 ha, OR • Patch size at least 2 ha and < 5 ha, OR • Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha, AND • Non-native species comprise < 50% of total understorey vegetation cover OR • Patch size ≥ 5 ha, OR • Patch size at least 2 ha and < 5 ha, OR • Patch is at least 0.5 ha and < 2 ha and is connected to a larger area of native vegetation of at least 5 ha, AND • Non-native species comprise < 80% of total understorey vegetation cover
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included:

	• Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.2 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 272 ha of the TEC within the Strategic Assessment Area (see Table 31-15 for further details). None of the TEC is identified as higher viability. This is because none of the mapped TEC occurs in intact condition which is one of the criteria that must be met to be mapped as higher viability. The TEC occurs mainly along waterways and is scattered within and outside the nominated areas in the northern half of the Strategic Assessment Area. The TEC occurs in GPEC, WSA and GMAC. The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. The Conservation Advice states that all patches of a reasonable size and in the highest condition categories as defined in the advice (categories A and B) are considered habitat critical to the survival of the TEC. These are generally: • Large (≥ 5 ha) or moderate patches (≥ 2 ha and < 5 ha) with a predominately native understory • Well-connected smaller patches (< 2 ha and ≥ 0.5 ha) with a predominately native understory The Conservation Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or a high area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Patches in catchments or tidal areas with minimal modification to natural hydrology • Evidence of recruitment of key plant species/range of age cohorts • High native species richness • Presence of threatened species • Low level of weeds and pest animals The TEC is highly fragmented across the Strategic Assessment Area, comprising 109 patches with an average patch size of 2.5 ha. The TEC mostly occurs as long and narrow patches along riparian corridors surrounded by either urban development or farming.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.8.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped approximately 34 ha of the TEC within the nominated areas (not including excluded lands). Approximately 32 ha (96 per cent) has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 5 ha was avoided for biodiversity purposes

- 28 ha was avoided for other purposes

An additional 64 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-16.

It is important to note that the avoidance calculations in Table 31-16, including for ‘avoidance for biodiversity purposes’, ‘avoidance for other reasons’, and ‘total avoidance’, have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-16 shows the amounts of habitat within excluded lands for context only.

31.8.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will lead to direct impacts to the TEC (see Section 31.8.3 for discussion) but will not generally increase fragmentation (see Section 31.8.4 for discussion).

31.8.3 DIRECT IMPACTS TO THE TEC

Implementation of the Plan will lead to the loss of 1.8 ha of the TEC predominantly within transport corridors in WSA. This loss represents less than 1 per cent of the remaining TEC in the Strategic Assessment Area and 1.8 per cent of the TEC in the nominated areas. A breakdown of direct impacts is provided in Table 31-17.

The majority of the TEC impacted within WSA:

- Is in thinned condition (1.7 ha)
- Comprises small patches (less than 5 ha) (6 of 7 impacted patches)

The majority of the loss in WSA is from transport within the nominated area. The threat to the TEC in relation to the TEC is reduced because:

- Only small areas of the TEC will be impacted
- Impacts are to patches in thinned or scattered condition. There are no impacts to intact patches
- Impacts generally occur to the edges of patches that are isolated and not well connected to native vegetation

31.1.3 FRAGMENTATION OF THE TEC

As outlined above, impacts largely occur to the edges of patches and will not result in a loss of connectivity and therefore will not lead to fragmentation.

31.8.4 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the TEC, the Plan includes a commitment to secure 5 ha of the TEC as part of the conservation program. This would:

- Lead to the protection and management of an additional 1.8 per cent of the ecological community within the Strategic Assessment Area
- Increase the level of protection and management of the ecological community by approximately 25.1 per cent on top of what is currently secured in the Strategic Assessment Area

These offsets are consistent with a number of high priority actions in the Conservation Advice to protect the TEC.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile or conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.8.5 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Invasive fauna

In addition to the threats identified in the Conservation Advice, the following potential indirect impacts are considered relevant to the TEC:

- Diseases, pathogens and dieback

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from agricultural activities, including grazing were also identified in the Conservation Advice as key threats. However, none of these are considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these risks across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

The TEC occurs in fire adapted landscapes and may be affected by fires that are too frequent or not frequent enough. However, the impact of inappropriate fire regimes are not well understood (DoEE, 2018a). Inappropriate fire regimes can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas in GPEC, WSA, and the northern part of GMAC.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

These controls are consistent with a number of priority actions in the Conservation Advice about the management of fire.

WEED INVASION

The TEC is threatened with invasion and competition by weeds. Weed incursions in this TEC are caused by (DoEE, 2018a):

- Physical disturbance to vegetation within the community (the predominant cause of weed incursions), such as through landfill, waste dumping and soil disturbance
- Encroachment of garden plants
- Altered hydrology and polluted runoff from urban and agricultural areas which alters conditions within the TEC to favour weed growth
- Grazing from feral animals
- Inappropriate fire regimes

Key weeds include Bridal Creeper (*Asparagus asparagoides*), Bitou Bush (*Chrysanthemoides monilifera*), Camphor Laurel (*Cinnamomum camphora*), Umbrella Tree (*Schefflera actinophylla*), Privets (*Ligustrum* spp.), Winter Senna (*Senna pendula*), invasive grasses (*Pennisetum* spp. and *Stenotaphrum secundatum*), and Lantana (*Lantana camara*). The TEC is also threatened by aquatic weeds such as Water Hyacinth (*Eichhornia crassipes*), *Ludwigia* spp. and Salvinia (*Salvinia molesta*) (DoEE, 2018a).

Urban and transport development within the Strategic Assessment Area has the potential to increase the spread of weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds. However, all mapped areas of this TEC within the Strategic Assessment Area are considered to have significant edge effects and occur in close proximity to urban development or farming and are already significantly exposed to weed incursion.

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development or transport corridors occur adjacent to the TEC and/or fragments patches of the TEC into smaller patches and introduces edge effects. Key risk areas include parts of GPEC, WSA, and the northern part of GMAC:

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
    - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
    - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
    - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
    - Require proponents to undertake the following when applying for/undertaking development:
        - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
        - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
        - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of weeds.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice as a threat to the TEC, with impacts resulting from recreational activity identified as a particular issue. As discussed for the other TECs in this Chapter, inappropriate habitat disturbance may also occur through other mechanisms such as:

- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inadvertent disturbance during construction which has the potential to directly impact the TEC outside approved development areas

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those that occur in GPEC, WSA, and the northern part of GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of disturbance.

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threats to the TEC are associated with reduced water quality, sedimentation and eutrophication (DoEE, 2018a).

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban or transport development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are those that occur in GPEC, WSA, and the northern part of GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the RMS Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the TEC

These controls are consistent with a number of priority conservation actions in the Conservation Advice about hydrology.

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as feral pigs, foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the Noisy Miner

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that the majority of these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that (in particular) the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above in the analysis of direct impacts, fragmentation is not considered likely to occur
- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of invasive fauna.

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust and dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:

- Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
- Entering into written agreements with delivery partners to implement priority disease control programs

- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the TEC to occur due to development of essential infrastructure within the avoided lands of WSA.

The TEC does not occur within the vicinity of the tunnel footprints for transport and is therefore not at risk of additional impacts from tunnels.

31.8.6 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Areas of the TEC occur within the avoided lands of WSA (29.1 ha) and GPEC (3.3 ha). Impacts to the TEC are possible where it occurs within land avoided for biodiversity purposes (~4.6 ha). The likelihood of impact is reduced where the TEC occurs in riparian corridors (~27.9 ha).

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine if the TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the TEC will occur as a results of essential infrastructure as every effort should be made to avoid and minimise impacts. Any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.8.7 IMPLICATIONS FOR LONG-TERM VIABILITY

The Conservation Advice (DoEE, 2018a) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the TEC in relation to implementation of the Plan. They are:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Inappropriate habitat disturbance
  - Changes to hydrology
  - Invasive fauna

HABITAT LOSS AND FRAGMENTATION

As outlined above, implementation of the Plan may lead to the loss of 1.8 ha of the TEC. However, it is not considered likely that this will threaten the long-term viability of the TEC because:

- The scale of impacts are minor when considering the mapped extent of the TEC across the Strategic Assessment Area (less than 0.7 per cent) and more broadly within the context of the entire range of the TEC
- There is no mapped higher viability TEC in the Strategic Assessment Area and all impacts occur to thinned or scattered condition vegetation
- There will be no fragmentation
- The offsets proposed by the Plan (5 ha of the TEC) will increase the level of protection of the TEC and address a number of actions in the Conservation Advice about improving the area of the TEC that is protected and managed

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, inappropriate habitat disturbance, changes to hydrology, and invasive fauna will be managed and mitigated through a number of commitments and actions in the Plan.

Indirect impacts are not expected to influence the long-term viability of the TEC.

CONCLUSION

The nature of the impacts to the TEC combined with the commitments to protect 5 ha of the TEC and manage indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.8.8 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.8.9 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-14 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-14: Key Threatening Processes and relevant Threat Abatement Plans for Coastal Swamp Oak (*Casuarina Glauca*) Forest of NSW and South East Queensland

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)	There is no relevant TAP
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)
Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-15: Occurrence of Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**271.4**	**19.1**
Intact	0.0	0.0
Thinned	269.8	19.1
Scattered Trees	1.7	0.0
Higher Viability TEC	0.0	0.0

Table 31-16: Avoidance of impacts to Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL TEC IN NOMINATED AREA (ha)	**0.0**	**3.2**	**37.1**	**57.4**	**97.7**
Intact	0.0	0.0	0.0	0.0	0.0
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
TEC WITHIN EXCLUDED LANDS (ha)	0.0	3.2	6.7	53.6	63.5
TEC WITHOUT EXCLUDED LANDS (ha)	**0.0**	**0.0**	**30.4**	**3.8**	**34.2**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	0.0	4.3	0.3	4.6
Intact	0.0	0.0	0.0	0.0	0.0
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**14.0**	**7.9**	**13.3**
AVOIDANCE FOR OTHER REASONS (ha)	0.0	0.0	24.8	3.0	27.9
Intact	0.0	0.0	0.0	0.0	0.0
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR OTHER REASONS (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**81.5**	**80.7**	**81.4**
TOTAL AVOIDANCE (ha)	0.0	0.0	29.1	3.3	32.4
Intact	0.0	0.0	0.0	0.0	0.0
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
TOTAL AVOIDANCE (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**N/A**	**95.5**	**88.5**	**94.7**

Table 31-17: Direct impacts to Coastal Swamp Oak *(Casuarina glauca)* Forest of New South Wales and South East Queensland

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO TEC (ha)	**0.0**	**0.0**	**1.4**	**0.4**	**0.0**	**1.8**
Intact	0.0	0.0	0.0	0.0	0.0	**0.0**
Thinned	0.0	0.0	1.2	0.4	0.0	**1.7**
Scattered Trees	0.0	0.0	0.1	0.0	0.0	**0.1**
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0	**0.0**

TECS NOT DIRECTLY IMPACTED

31.9 CASTLEREAGH SCRIBBLY GUM AND AGNES BANKS WOODLANDS OF THE SYDNEY BASIN BIOREGION

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Endangered
DESCRIPTION	The TEC is a low woodland community with an overstorey dominated by *Angophora bakeri*, *Eucalyptus racemosa*, *E. parramattensis* subsp. *parramattensis*. *Melaleuca decora* and *Eucalyptus fibrosa* may also be present and prominent (DoE, 2015b). The midstorey is a shrub layer that commonly includes *Banksia* and *Melaleuca* species and to a lesser extent *Leptospermum trinervium*, *Dillwynia sericea*, *Monotoca scoparia*, *Platysace ericoides*, *Persoonia nutans*, *Pimelea linifolia* subsp. *linifolia* and *Hakea sericea*. The ground layer consists of a mix of grasses, other graminoids and forbs (DoE, 2015b). The TEC can intergrade into Cooks River/Castlereagh Ironbark Forest (on gravel-clay soils), Castlereagh Swamp Woodland (in moist depressions) and Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (on clay soils) (DoE, 2015b). The following PCTs are associated with the TEC: • 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion • 958 Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion A range of fauna species occur in the TEC, including reptiles, amphibians, birds, micro-bats, marsupials and invertebrates. Most of these species are not restricted to the TEC and also occur in, and are likely to rely on, other native vegetation in the Cumberland subregion (DoE, 2015b). Most plant species in the TEC are able to regenerate from lignotubers and buds beneath the bark as well as seeds stored in the soil (OEH, 2010). The TEC is equivalent to two NSW BC Act listed TECs (Castlereagh Scribbly Gum Woodland and Agnes Banks Woodland) where key diagnostic and condition thresholds are met (DoE, 2015b).

EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the Conservation Advice (DoE, 2015b).
DISTRIBUTION	The TEC is confined to the Sydney Basin bioregion and occurs across the Cumberland subregion, and on the margins of Sydney Cataract, Wollemi and Burragorang subregions. The majority of the TEC is found in larger patches in the north-west part of the Cumberland subregion in the Castlereagh area between Richmond and Llandilo. Other significant patches occur in the Holsworthy area with smaller occurrences at Tahmoor, Kemps Creek and Longneck Lagoon. The TEC primarily occurs in elevations below 80 m with mean annual rainfall of 700-900 mm. It generally occurs on Tertiary sands and gravels of the Hawkesbury-Nepean river system. At Agnes Banks, the TEC primarily occurs aeolian sands overlying Tertiary alluvium. (DoE, 2015b)
SOS SITES	Part of this TEC (PCT 883) has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Currently no management sites have been identified for this TEC. The Agnes Banks component of the TEC (PCT 958) is in the 'range-restricted' category and has a cluster of management sites near to and including Agnes Banks Nature Reserve.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice (including listing advice) for Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion (DoE, 2015b) Key Threatening Processes relevant to the TEC are identified in Appendix D of the Conservation Advice There is no adopted or made Commonwealth Recovery Plan for the TEC. The TEC is included in the Cumberland Plain Recovery Plan (NSW) (DECCW, 2011)
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=119

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area.

	It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are: • **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed • **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	The following PCTs are associated with the TEC: • 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion • 958 Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based on applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 0.5 ha, AND • ≥ 30% (< 50%) of the perennial understorey vegetation cover is made up of native species (based on field verification), AND • The patch is contiguous with a native vegetation remnant >1 ha in area, AND • Growing on tertiary sands and gravels of the Hawkesbury-Nepean river system OR • Patch size ≥ 0.5 ha, AND • ≥ 70% of the perennial understorey vegetation cover is made up of native species, AND • Elevations below 80 m, AND • Growing on tertiary sands and gravels of the Hawkesbury-Nepean river system OR • Patch size is ≥ 2 ha, AND • ≥ 50% of the perennial understorey vegetation cover is made up of native species (based on field verification)
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.

VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included: • Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.1 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 2,769 ha of the TEC within the Strategic Assessment Area (see Table 31-19 for further details). Of this, 2,606 ha has been identified as higher viability through the viability analysis. The TEC occurs in the following main locations within the Strategic Assessment Area: • The vast majority occurs outside the nominated areas north of GPEC between Castlereagh and Windsor Downs where it is connected with larger remnants of native vegetation • Two smaller patches occur to the south of WSA near Kemps Creek • Several patches occur outside the nominated areas around Holsworthy and Pitt Town It does not occur in any of the nominated areas or transport corridors. The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. It states that all patches that meet the minimum (moderate class) condition thresholds as defined in the advice (categories A and B) are considered habitat critical to the survival of the TEC. These are generally: • Patch sizes ≥ 0.5 ha with ≥ 30% native understorey and patches that are well-connected to a native vegetation remnant of ≥ 1 ha in area • Patch sizes ≥ 0.5 ha with ≥ 50% native understorey The Conservation Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or large area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Evidence of recruitment of key plant species/range of age cohorts • Good faunal habitat • High native species richness • Presence of threatened species • Low level of weeds and pest animals

	The TEC is highly fragmented across the Strategic Assessment Area, comprising approximately 145 patches with an average patch size of approximately 19 ha. Because the TEC intergrades into other vegetation types, many patches of the TEC are surrounded by larger areas of native vegetation, which provides some buffer from potential impacts associated with edge effects.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

None of the TEC was mapped within the nominated areas or transport corridors. Avoidance of the TEC was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will not lead to direct impacts or fragmentation of the TEC. As a result the Plan does not provide offsets for the TEC.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.9.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion

- Inappropriate habitat disturbance
- Diseases, pathogens and dieback
- Invasive fauna

Climate change is a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

A number of other threats were identified in the Conservation Advice. However, none of these are considered likely to impact the TEC. They are:

- Changes to hydrology. The distance of the TEC away from urban and transport development areas means that changes in hydrology is not a relevant indirect impact
- Grazing. Implementation of the Plan will not exacerbate this risk across the Strategic Assessment Area

INAPPROPRIATE FIRE REGIMES

Inappropriate fire regimes can affect the structure and species composition of the TEC by altering the mid and ground layers. Low seedling recruitment has been observed in the TEC, which is thought to be associated with extended dry periods and too frequent fire. Many plant species in the TEC can survive for decades as seeds stored in the soil, bulbs, corms, rhizomes, rootstocks or lignotubers (DoE, 2015b).

While most impacts to the TEC are associated with increased fire, in some areas the TEC is threatened due to a lack of fire because of its proximity to residential areas. This generally occurs where the TEC has not been burnt for over 30 years (DoE, 2015b).

Inappropriate fire regimes can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

While it is noted that the TEC does not occur in any of the nominated areas, increased human activity across the Strategic Assessment Area may increase the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. For the TEC, the closest areas are to the north of GPEC (Londonderry area) and to the south of WSA (near Kemps Creek).

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, the relevant measures for this TEC include a commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:

- Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
- Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
- A process to work with delivery partners to implement the fire management strategy
- Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans

The measures in the Plan are expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas.

These controls are consistent with a high priority conservation action in the Conservation Advice to “Undertake appropriate fire management practices…”.

WEED INVASION

The TEC is threatened with invasion and competition by weeds. Weed incursion in the TEC is associated with agricultural activities as well as urban development. The most serious threats are: Cootamundra wattle (*Acacia baileyana*), Flat weed (*Hypochaeris radicata*), African love grass (*Eragrostis curvula*), Kikuyu (*Cenchrus clandestinus*) and several other grasses and vines (DoE, 2015b).

These weeds are already present within the Strategic Assessment Area and pose a threat to the TEC. However, the development has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

While it is noted that the TEC does not occur in any of the nominated areas, the TEC may be susceptible to the landscape threat of weeds driven by new urban development.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, the relevant measures for this TEC include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because the Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC.

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of weeds.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice as a threat to the TEC. This relates to a wide range of different mechanisms for disturbance including:

- Inappropriate mowing, slashing or scrubbing of the understorey for reasons such as bushfire fuel reduction, grazing and perceived aesthetics
- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of wood which changes the structure and habitat features of the TEC

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust and dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

While many of these disease pathways are not relevant to the TEC given the distance it occurs from the nominated areas, the Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the introduced Indian myna, and native species such as the sulphur-crested cockatoo

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above there will be no direct impacts due to implementation of the Plan and no fragmentation of the TEC
- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy
  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the TEC does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.9.2 IMPLICATIONS FOR LONG-TERM VIABILITY

As outlined above, implementation of the Plan will not lead to any direct impacts to the TEC and potential indirect impacts will be managed. This will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.9.3 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.9.4 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-18 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-18: Key Threatening Processes and relevant Threat Abatement Plans for Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data table for occurrence. Cross references to the table are provided throughout the text above.

Table 31-19: Occurrence of Castlereagh Scribbly Gum and Agnes Banks Woodlands in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**2,769.3**	**491.8**
Intact	2,658.3	488.7
Thinned	111.1	3.0
Scattered Trees	0.0	0.0
Higher Viability TEC	2,605.7	456.8

31.10 ELDERSLIE BANKSIA SCRUB FOREST IN THE SYDNEY BASIN BIOREGION

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC is a type of scrubby forest or woodland limited to sandy substrates associated with deep Tertiary sand deposits on the Nepean River floodplain (DAWE, 2020). The canopy may include *Banksia intergrifolia* subsp. *intergrifolia* (Coast Banksia), *Angophora subvelutina*, *Eucalyptus botryoides* x *E. saligna* and other *Eucalyptus* species, with a subcanopy of Coast Banksia, or *Melaleuca decora* and *M. linariifolia* in wetter areas (DAWE, 2020). The midstorey is a shrub layer that commonly includes *Acacia* species, *Aotus ericoides*, *Brachyloma daphnoides*, *Dillwynia glaberrima*, and *Persoonia linearis* (DAWE, 2020). In some areas, the TEC has elements associated with dry rainforest and riverflat forest, including *Clematis* species, *Clerodendrum tomentosum*, *Duboisia myoporoides*, *Kunzea ambigua* and *Platysace lanceolate*. The ground layer consists of a mix of ferns, graminoids and forbs. A range of fauna species may occur in the TEC, including amphibians, reptiles, birds and mammals. However, as a result of historical modifications to the structure of the TEC and a loss of important habitat features, remnants of the TEC are likely to be of value only to the more disturbance-tolerant or highly mobile species (DAWE, 2020). The TEC is equivalent to the BC Act listed TEC of the same name, which is equivalent to PCT 774. It also includes areas that intergrade with surrounding forest described in NSW as either River Flat Eucalypt Forest (PCT 835), Moist Shale Woodland (PCT 830) or Cumberland Plain Woodland (PCT 849 or 850), provided that the key diagnostic characteristics are met (DAWE, 2020).
EPBC DEFINITION	Condition thresholds have not been applied to this TEC because of the very small size of patches and extent of the TEC remaining. All remaining patches are considered to comprise the TEC and are critical to the survival of the community, including degraded patches (DAWE, 2020).
DISTRIBUTION	The TEC is restricted to the Cumberland subregion within the Sydney Basin bioregion. It is only known from the Camden LGA. Known patches are small and occur in an extensively cleared and mined Tertiary sand deposit at Spring Farm, near Elderslie (DAWE, 2020). The TEC primarily occurs in elevations of 60-100 m with mean annual rainfall of approximately 750 mm (DAWE, 2020).
SOS SITES	Currently one management site has been identified for this TEC: Spring Farm in Camden

RELEVANT PLANS AND POLICIES	Conservation Advice for the Elderslie Banksia Scrub Forest in the Sydney Basin Bioregion (DAWE, 2020). Key Threatening Processes relevant to the TEC are identified in Appendix C of the Conservation Advice. There is no adopted or made Commonwealth Recovery Plan for the TEC.
SPRAT LINK	https://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=145

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are: • **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed

	• **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	The TEC is equivalent to Elderslie Banksia Scrub Forest listed under the BC Act, which is equivalent to PCT 774 (Coast Banksia scrub on sand in the Elderslie area). Note that the TEC also includes areas that intergrade with surrounding River Flat Eucalypt Forest (PCT 835), Moist Shale Woodland (PCT 830) or Cumberland Plain Woodland (PCT 849 or 850), provided that the key diagnostic characteristics are met (DAWE, 2020).
MAPPING APPROACH	PCT 774 was used to map the TEC. Note that as no condition thresholds have been applied to the TEC under the Conservation Advice, all patches of PCT 774 would comprise the EPBC TEC provided that the key diagnostic characteristics are met
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	A viability assessment wasn't undertaken due to the late listing of this TEC. In addition, the TEC is very restricted within the subregion and all remaining patches are considered critical to its survival.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.9 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 11.4 ha of the TEC within the Strategic Assessment Area (see Table 31-19 for further details). The TEC occurs in the one location within the Strategic Assessment Area – in Spring Farm, north of the Nepean River and south-east of Camden. The TEC does not occur in any of the nominated areas or transport corridors. The closest urban capable land occurs in GMAC approximately 3 km to the east. The OSO tunnel occurs approximately 4.5 km to the west, and the Metro Rail Future Extension tunnel occurs approximately 1.8 km to the north-east. The Conservation Advice states that, due to the very small size of patches and extent of the TEC remaining, all remaining patches are considered habitat critical to the survival of the TEC. The TEC is fragmented and comprises seven patches with an average patch size of approximately 1.6 ha. Because the TEC intergrades into other vegetation types, some patches of the TEC are surrounded by larger areas of native vegetation, which provides some buffer from potential impacts associated with edge effects.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

None of the TEC was mapped within the nominated areas or transport corridors. Avoidance of the TEC was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will not lead to direct impacts or fragmentation of the TEC. As a result the Plan does not provide offsets for the TEC.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.10.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. As outlined in Chapter 15 (Section 15.5 and Attachment A), consideration was given to the potential relevance of these threats as indirect impacts that may result from implementation of the Plan.

Given the limited extent of the TEC in the Strategic Assessment Area, the distance that it occurs from the nominated areas and transport corridors, and its location within and immediately adjacent to existing urban areas, it is considered unlikely that implementation of the Plan would exacerbate most of the identified threats and would therefore not generally result in indirect impacts on the TEC. However, there is some potential for the OSO and Metro Rail Future Extension tunnels to cause hydrological impacts that may affect the TEC.

CHANGES TO HYDROLOGY

The Conservation Advice identifies changes to hydrology as a threat to the TEC. The main hydrology-related threat identified in the advice is increased runoff into patches of the TEC from surrounding urban development, carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause erosion (DAWE, 2020). The Plan is unlikely to exacerbate this threat to the TEC.

However, the OSO and Metro Rail Future Extension tunnels have the potential to cause groundwater level drawdown into the tunnel void and water quality impacts from the disposal of poor quality groundwater and surface water drainage from the tunnels during operation. While the tunnels occur some distance from the TEC, there is potential for this to affect groundwater flows in the area, which may affect the TEC. The Conservation Advice identifies that groundwater discharge may be the cause of the some of the wetter areas within the TEC (DAWE, 2020).

The Metro Rail Future Extension tunnel is also near the top of the sub-catchment of Spring Creek. The Conservation Advice identifies that remnants of the TEC occur along Spring Creek, and further pollution of this waterway risks additional contamination of its riparian soils (DAWE, 2020).

The Plan includes a commitment to mitigate indirect and prescribed impacts from the transport corridors (Commitment 6). This commitment will be delivered through NSW environmental assessment and approval processes. As described in Part 2, each transport project will be subject to future strategic planning and detailed design and a process of environmental assessment and approval. For the transport corridors outside the nominated areas (where biodiversity impacts have not been assessed under the BC Act - see Part 1), including the OSO and Metro Rail Future Extension tunnels, this process will involve assessment under both:

- State Significant Infrastructure approval process (or equivalent)
- BC Act and BAM (or equivalent)

The process under the BC Act and BAM will address the potential indirect impacts of the tunnels on biodiversity values and the State Significant Infrastructure approval process (or equivalent) will assess the other environmental impacts and matters that need to be considered prior to construction and operation of the transport project. These processes will include an assessment of risks to the environment and the identification of mitigation measures to manage these risks from impacts related to hydrology and water quality, including groundwater drawdown.

This commitment and process to assess and mitigate the indirect impacts of the tunnels through a future environmental assessment and approval processes is considered adequate to address any risk of hydrology impacts to the TEC.

Climate change is a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

It is also worth noting that the Plan includes a range of landscape scale measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, and pest animal control implementation strategy). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this TEC.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the TEC does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure. The OSO and Metro Rail Future Extension tunnels have the potential to cause hydrological impacts. This is discussed above.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.10.2 IMPLICATIONS FOR LONG-TERM VIABILITY

As outlined above, implementation of the Plan will not lead to any direct impacts to the TEC and potential indirect impacts associated with the OSO and Metro Rail Future Extension tunnels are considered to be adequately managed. This will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.10.3 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.10.4 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Given the lack of direct impacts and limited indirect impacts, there are no relevant Key Threatening Processes (KTPs) or associated Threat Abatement Plans (TAPs).

DATA TABLES

This section sets out the data table for occurrence. Cross references to the table are provided throughout the text above.

Table 31-20: Occurrence of Elderslie Banksia Scrub Forest in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**11.4**	**2.5**
Intact	9.4	2.5
Thinned	0.3	0
Scattered Trees	1.7	0
Higher Viability TEC	N/A	N/A

31.11 TURPENTINE-IRONBARK FOREST OF THE SYDNEY BASIN BIOREGION

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC is an open forest with a canopy of eucalypts and other trees that can reach 30 m tall. The midstorey comprises shrubs and small trees with a ground layer of herbs and grasses. The canopy is normally dominated by Turpentine (*Syncarpia glomulifera*) and a variety of eucalypt species. The midstorey may include small trees such as Sweet Pittosporum (*Pittosporum undulatum*), Native peach (*Trema aspera*) and Parramatta Wattle (*Acacia parramattensis*), and a shrub layer with Elderberry Panax (*Polyscias sambucifolia*), Mock Olive (*Notelaea longifolia*), and Prickly Beard-heath (*Leucopogon juniperinus*) amongst others. The ground layer may include Forest Hedgehog-grass (*Echinopogon ovatus*), Weeping Grass (*Microlaena stipoides*) and Kangaroo Grass (*Themeda triandra*).(DoE, 2014g)(DoE, 2014g)(DoE, 2014d)(DoE, 2014a)(DoE, 2014g)(DoE, 2014a) The occurrence of the TEC is transitional between Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in drier areas, and Blue Gum High Forest in higher rainfall areas. The following PCTs are associated with the TEC: • 792 Deane's Gum - Mountain Grey Gum - Turpentine tall moist forest on shale, Sydney Basin Bioregion • 1183 Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion • 1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion • 1284 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion A range of fauna species occur in the TEC, including small mammals, birds, reptiles, amphibians and a large range of invertebrates. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, other native vegetation in the Cumberland subregion. The TEC is equivalent to two NSW BC Act listed TECs – Sydney Turpentine-Ironbark Forest, and Blue Mountains Shale Cap Forest – where key diagnostic and condition thresholds are met. (DoE, 2014g)

EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, understorey native vegetation cover, number of tree hollows, or whether the patch is contiguous with other native vegetation patches. Details of the thresholds are provided in the Conservation Advice (DoE, 2014g).
DISTRIBUTION	The TEC is confined to the Sydney Basin bioregion and mostly restricted to the Cumberland subregion and immediate surrounds. It has a scattered distribution to the west of Richmond, Penrith and Picton and in the north east of the subregion. The TEC primarily occurs in the Cumberland subregion and up to 750 m on shale caps of the Woronora, Blue Mountains and Hornsby Plateaux, with mean annual rainfall of 800 - 1100 mm per year. It generally occurs on fertile clay soils derived from Wianamatta shale, and clay of shale lenses within Hawkesbury Sandstone (DoE, 2014g).
SOS SITES	The TEC has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Currently no management sites have been identified for this TEC.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for Turpentine–Ironbark Forest in the Sydney Basin Bioregion (DoE, 2014g) Key Threatening Processes relevant to the TEC are identified in Page 4 of the Conservation Advice There is no Recovery Plan for the TEC
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=38

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.

VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are:
	• **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present
	• **Thinned:** This condition state was assigned to native vegetation in various states of modification, including:
	  o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT
	  o Wooded vegetation that has been under scrubbed
	• **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed
	• **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands
	• **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species

ASSOCIATED PCTs	The following PCTs are associated with the TEC: • 792 Deane's Gum - Mountain Grey Gum - Turpentine tall moist forest on shale, Sydney Basin Bioregion • 1183 Smooth-barked Apple - Sydney Peppermint - Turpentine heathy open forest on plateaux areas of the Sydney Basin Bioregion • 1281 Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion • 1284 Turpentine - Smooth-barked Apple moist shrubby forest of the lower Blue Mountains, Sydney Basin Bioregion
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based applying the condition thresholds at a landscape scale to the available data: • Condition class (A or B, low and moderate), AND • Patch > 1 ha, AND • Tree canopy cover > 10% (field verification) OR • Condition class (A or B, low and moderate), AND • Patch > 1 ha, AND • Tree canopy cover < 10% (field verification), AND • Part of a remnant of native vegetation > 5 ha
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included:

	• Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

MAP	See Map 48.7 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment has mapped approximately 44 ha of the TEC within the Strategic Assessment Area (see Table 31-21 for further details). Of this, approximately 6 ha has been identified as higher viability through the viability analysis. The TEC occurs in the following main locations within the Strategic Assessment Area: • In the north-west, next to the Blue Mountains National Park, 16.4 km from GPEC • In the southeast, near Minto Heights: o 1 km from the boundary of GMAC o 5.2 km from the GMAC urban capable footprint There are no mapped occurrences of the TEC within the nominated areas or transport corridors. The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. The Conservation Advice states that all patches meeting the condition thresholds in the listing advice are eligible to be considered under the EPBC Act for actions that may require referral. These are generally: • Patches > 1 ha with tree canopy cover of > 10% • Patches > 1 ha with tree canopy < 10% only if they are part of a remnant of native vegetation ≥ 5 ha in area The TEC is fragmented across the Strategic Assessment Area, comprising 13 patches with an average patch size of 3.4 ha.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

None of the TEC was mapped within the nominated areas or transport corridors. Avoidance of the TEC was therefore not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*

- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will not lead to direct impacts or fragmentation of the TEC. As a result the Plan does not provide offsets for the TEC.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.11.1 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. As outlined in Chapter 15 (Section 15.5 and Attachment A), consideration was given to the potential relevance of these threats as indirect impacts that may result from implementation of the Plan.

Given the limited extent of the TEC in the Strategic Assessment Area and the distance that it occurs from the nominated areas, it was considered unlikely that implementation of the Plan would exacerbate any of the identified threats and would therefore not result in any indirect impacts.

Climate change is a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

It is worth noting that the Plan includes a range of landscape scale measures that will protect biodiversity (e.g. protection of large areas of land, fire management strategy, weed control implementation strategy, and pest animal control implementation strategy). These measures will benefit all biodiversity in the Cumberland subregion and may potentially relate to this TEC.

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

Given the TEC does not occur within the nominated areas or transport corridors, there is no risk of additional impacts from essential infrastructure or tunnels.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.11.2 IMPLICATIONS FOR LONG-TERM VIABILITY

As outlined above, implementation of the Plan will not lead to any direct or indirect impacts to the TEC. This will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.11.3 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.11.4 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Given the lack of direct and indirect impacts, there are no relevant Key Threatening Processes (KTPs) or associated Threat Abatement Plans (TAPs).

DATA TABLES

This section sets out the data table for occurrence. Cross references to the table are provided throughout the text above.

Table 31-21: Occurrence of Turpentine–Ironbark Forest in the Sydney Basin Bioregion in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**44.4**	**1.3**
Intact	6.4	<0.1
Thinned	36.9	1.3
Scattered Trees	1.1	0.0
Higher Viability TEC	6.4	<0.1

31.12 WESTERN SYDNEY DRY RAINFOREST AND MOIST WOODLAND ON SHALE

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the TEC in accordance with the EPBC Terms of Reference. It sets out:

- *TEC background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the TEC*
- *Data tables*

THREATENED ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the TEC. It provides a description of the TEC, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

EPBC ACT LISTING	Critically Endangered
DESCRIPTION	The TEC varies from low closed rainforest on lower slopes and in gullies, to more open, moist woodland on upper slopes and in disturbed sites. The rainforest form of this TEC is dominated by non-eucalypts including Prickly-leaved Paperbark (*Melaleuca styphelioides*), Hickory Wattle (*Acacia implexa*), Native Quince (*Alectryon subcinereus*) and White Euodia (*Melicope micrococca*). The woodland form has a more open canopy dominated by eucalypts, including Forest Red Gum (*Eucalyptus tereticornis*) and Coastal Grey Box (*E. moluccana*). The lower layers of the TEC may include shrubs of varying density, and a sparse groundcover of grasses, herbs and forbs. Vines and scramblers may also be present. This TEC is also characterised by a number of moisture-dependent plants such as ferns and broad-leaved shrubs. The following PCTs are associated with the TEC: • 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion • 877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion Vine thickets within this TEC provide good habitat for birds and mammals. A range of fauna species occur in the TEC, including small mammals (particularly microbats), birds, reptiles, frogs and a large range of invertebrates. Most of these fauna species are not restricted to the TEC and also occur in, and are likely to rely on, other native vegetation in the Cumberland subregion. The TEC is equivalent to the NSW BC Act listed Western Sydney Dry Rainforest and Moist Shale Woodland TECs where key diagnostic and condition thresholds are met. (DoE, 2015h; DSEWPC, 2012b; OEH, 2019j; TSSC, 2013)
EPBC DEFINITION	Only patches of the TEC that meet minimum size and condition thresholds are considered part of the TEC under the EPBC Act. Thresholds relate to factors such as patch size, species richness and weed cover. Details of the thresholds are provided in the listing advice (TSSC, 2013).
DISTRIBUTION	The TEC has a highly restricted distribution, and is confined to the Sydney Basin bioregion, with most occurrences within the Cumberland subregion. Remnants of this TEC occur in the Wollondilly, Camden, Campbelltown, Holroyd, Fairfield, Liverpool, Penrith, Hawkesbury and The Hills LGAs.

	The TEC is restricted to shale soils of the Wianamatta Group, and is found in sheltered slopes, gullies and steep land. It is generally limited to elevations below 300 m. Only approximately 28 per cent of the pre-European extent of the TEC remains. Remnants of the TEC are highly fragmented, with 99 per cent of patches under 10 ha in size, and 60 per cent of fragments under 1 ha in size. It is estimated that the TEC has a total remaining area of 950 ha. (DSEWPC, 2012b; TSSC, 2013)
SOS SITES	The TEC has been categorised under the 'widespread' management stream for both NSW-listed TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Currently no management sites have been identified for this TEC.
RELEVANT PLANS AND POLICIES	Approved Conservation Advice for Western Sydney Dry Rainforest and Moist Woodland on Shale (DSEWPC, 2012b) Listing advice for Western Sydney Dry Rainforest and Moist Woodland on Shale (TSSC, 2013) Key Threatening Processes relevant to the TEC are identified in Page 3 of the Conservation Advice There is no Recovery Plan for the TEC Threat Abatement Plans relevant to the TEC are identified in Table 31-22
SPRAT LINK	http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=106

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the TEC. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the TEC mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the TEC*
- *Summarises the approach to mapping the EPBC TEC*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to translate the site based condition thresholds for the EPBC TEC so that it could be mapped at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are:

	• **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present
	• **Thinned:** This condition state was assigned to native vegetation in various states of modification, including:
	  o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT
	  o Wooded vegetation that has been under scrubbed
	• **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed
	• **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands
	• **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species

ASSOCIATED PCTs	The following PCTs are associated with the TEC: • 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion • 877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
MAPPING APPROACH	Mapping of the TEC across the Strategic Assessment Area used the following criteria which are based applying the condition thresholds at a landscape scale to the available data: • Patch size ≥ 0.1 ha, AND • At least 20 native species present in sample 0.04 ha plot (based on field verification), AND • Non-native perennial plants no more than 50 per cent of total vegetation cover (based on field verification), AND • Below 300 m elevation, AND • Growing on clay soils derived from Wianamatta Group sediments
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	As outlined in Section 31.4, an analysis was undertaken to identify areas of likely higher long-term viability for the TEC in the Strategic Assessment Area The purpose of the analysis was to identify the patches of the TEC within the Strategic Assessment Area that are more likely to be viable in the longer-term to inform the evaluation of the overall outcome of the Plan for the TEC. Viability is defined in a qualitative sense as the "probability of long-term survival of TEC patches". The approach involved reviewing Conservation Advices for each TEC to identify the factors that influence the long-term viability or conservation significance of a patch of the TEC. This review found that Conservation Advices generally identify a similar set of factors that influence long-term viability. Key factors included: • Larger patches are generally more viable than smaller patches • Better condition patches are generally more viable than poorer condition patches • Connected patches are generally more viable than poorer connected patches • Patches with a lower edge/area ratio are generally more viable than patches with a higher edge/area ratio

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the TEC in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the TEC occurs.

<table>
<tr><td>MAP</td><td>See Map 48.8 for a map of the TEC across the Strategic Assessment Area.</td></tr>
<tr><td>OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA</td><td>The baseline mapping for this assessment has mapped approximately 961 ha of the TEC within the Strategic Assessment Area (see Table 31-23 for further details). Of this, approximately 657 ha has been identified as higher viability through the viability analysis.
The majority of the TEC occurs in the southern part of the Strategic Assessment Area around Picton, in a landscape that has been heavily cleared for farming. In this locality, the TEC often occurs as small to moderate patches along the edges of escarpments surrounded by farmland.
It the nominated areas it occurs within:
• GMAC (15.5 ha) in the central portion near to Rosemeadow
• GPEC (2.4 ha) on the western side near the Mulgoa Nature Reserve
It does not occur in the other nominated areas or transport corridors.
The Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the TEC. The Conservation Advice states that all patches of a reasonable size and in the highest condition categories as defined in the advice (categories A and B) are considered habitat critical to the survival of the TEC. These are generally:
• Large (≥ 5 ha) or moderate patches (≥ 2 ha and < 5 ha) with a predominately native understory
• Well-connected smaller patches (< 2 ha and ≥ 0.5 ha) with a predominately native understory
The Conservation Advice also identifies several factors affecting the value of a patch, including:
• A larger size and/or a high area to boundary ratio
• Part of a larger remnant of native vegetation or linking other remnants
• Evidence of recruitment of key plant species/range of age cohorts
• High native species richness
• Presence of threatened species
• Low level of weeds and pest animals
The TEC is highly fragmented across the Strategic Assessment Area, comprising 294 patches with an average patch size of 3.2 ha. Only 10 patches are greater than 20 ha. A large number of patches occur in close proximity to existing urban development or farmland and are likely to be exposed to substantial edge effects.</td></tr>
</table>

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the TEC that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.12.1 NOMINATED AREAS

The baseline mapping for this assessment mapped 15 ha of the TEC within the nominated areas (not including excluded lands). All of this has been avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 11 ha was avoided for biodiversity purposes
- 4 ha was avoided for other purposes

An additional 3 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-24.

It is important to note that the avoidance calculations in Table 31-24, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-24 shows the amounts of habitat within excluded lands for context only.

31.12.2 TRANSPORT

None of the TEC occurs in transport corridors so avoidance of impacts is not necessary.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts. The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will not lead to direct impacts or fragmentation of the TEC. As a result the Plan does not provide offsets for the TEC.

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the TEC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the TEC if:

- *The indirect impact is identified as a threat in a relevant profile, conservation advice or recovery plan, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.12.3 RELEVANT POTENTIAL INDIRECT IMPACTS

The Conservation Advice identifies a range of threats to the TEC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from logging and inappropriate grazing were also identified in the Conservation Advice as key threats. However, neither of these are considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate these risks across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

The TEC contains rainforest and mesic plants which are not well-adapted to fire, and the TEC is negatively impacted by fire events. The existing fragmentation of the landscape means that fire events may lead to localised extinctions of the TEC, as recolonisation of a burnt area by neighbouring populations may not be possible (TSSC, 2013).

Increased fire frequency can be caused by:

- Arson and accidental lighting of fires
- Application of fire by authorities to manage fire risk

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the TEC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes the areas in GMAC.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the TEC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the TEC from altered fire regimes as a result of development. This is because:

- Avoided lands in GMAC where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the TEC
- Fire management authorities will be engaged to ensure they understand the requirements of the TEC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas
- The fire management requirements for the TEC specified in the best practice guidelines will be applied

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of fire.

WEED INVASION

The TEC is threatened with invasion and competition by weeds. Notable weeds which threaten this TEC include Lantana (*Lantana camara*) and African Olive (*Olea europa* subsp. *cuspidata*). These weeds are already present in the Cumberland subregion and threaten the TEC (DSEWPC, 2012b).

The TEC is most susceptible to the threat of weeds from development under the Plan where new urban development or transport corridors occur adjacent to the TEC and/or fragments patches of the TEC into smaller patches and introduces edge effects. Key risk areas include the central portion of GMAC where it occurs adjacent to urban capable lands.

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the TEC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

The package of measures in the Plan is expected to adequately manage the risk posed to the TEC from weed invasion. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the TEC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of weeds.

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Conservation Advice as a threat to the TEC. This relates to a wide range of different mechanisms for disturbance including:

- Dumping of rubbish and garden waste which can directly impact areas of the TEC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the TEC and facilitate processes such as erosion
- Removal of wood which changes the structure and habitat features of the TEC
- Inadvertent disturbance during construction which has the potential to directly impact the TEC outside approved development areas

Each of these mechanisms have the potential to alter the structure and floristic composition of the TEC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the TEC considered most at risk are those within GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the TEC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the TEC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance
- A program of education for the community will be run to help them understand the biodiversity values they live near

These controls are consistent with a number of priority conservation actions in the Conservation Advice about the management of disturbance.

CHANGES TO HYDROLOGY

The creation of hard surfaces associated with urban development and transport results in changes to the hydrology of surrounding areas. The main threat to the TEC associated with altered hydrology is increased runoff into patches of the

TEC carrying high nutrient and sediment loads, as well as weed seeds or propagules. This can both encourage weed invasion and cause erosion.

The TEC is most susceptible to the threat of increased runoff from development under the Plan where new urban development occurs adjacent (and upstream or upslope) to the TEC. Key risk areas are those in GMAC. The TEC is not threatened by transport projects because it does not occur within the vicinity of any of the transport corridors.

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the TEC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through development controls in the nominated areas in relation to:

- Water cycle management. For example:
  - Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles
  - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
- Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
- Soil erosion and sedimentation. For example:
  - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
  - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application

The package of measures in the Plan is expected to adequately manage the risk to the TEC from changes to hydrology because development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the TEC.

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include myrtle rust.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the TEC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the TEC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers. The main areas of concern relate to new urban development in GMAC.

In relation to aggressive bird species, the two main drivers for increasing the threat within the TEC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above in the analysis of direct impacts, the Plan is considered unlikely to lead to any notable fragmentation to the TEC and as such is not considered an issue
- Habitat disturbance through inappropriate land management which can change the structure of the TEC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the TEC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the TEC being:
    - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
    - Preparation of a Pest Animal Control Implementation Strategy
    - A process to enter into written agreements with delivery partners to implement the pest animal control program
    - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
    - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
    - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
    - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the TEC from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the TEC to occur due to development of essential infrastructure within the avoided lands of GMAC.

The TEC does not occur within the vicinity of the tunnel footprints for transport and is therefore not at risk of additional impacts from tunnels.

31.12.4 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

Areas of the TEC occur within the avoided lands of GMAC. Of the 15.4 ha, 2.2 ha is in good (intact) condition and 13.2 ha is in moderate (thinned) condition. Impacts to the TEC are possible where it occurs within land avoided for biodiversity purposes (~11.2 ha). The likelihood of impact is reduced where the TEC occurs in riparian corridors or steep slopes (~4.2 ha).

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine if the TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the TEC will occur as a results of essential infrastructure as every effort should be made to avoid and minimise impacts. Any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE TEC

This section considers the likely effects of implementation of the Plan on the long-term viability of the TEC. The analysis has regard for the guidance in the Conservation Advice (there is no Recovery Plan for the TEC), and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.12.5 IMPLICATIONS FOR LONG-TERM VIABILITY

As outlined above, implementation of the Plan will not lead to any direct impacts to the TEC and potential indirect impacts will be managed. This will ensure that the implementation of the Plan does not adversely influence the long-term viability of the TEC.

31.12.6 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the TEC.

31.12.7 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-22 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-22: Key Threatening Processes and relevant Threat Abatement Plans for Western Sydney Dry Rainforest and Moist Woodland on Shale

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-23: Occurrence of Western Sydney Dry Rainforest and Moist Woodland on Shale in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL TEC MAPPING (ha)	**960.8**	**139.0**
Intact	795.1	105.3
Thinned	165.7	33.6
Scattered Trees	0.0	0.0
Higher Viability TEC	657.0	86.3

Table 31-24: Avoidance of impacts to Western Sydney Dry Rainforest and Moist Woodland on Shale within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL TEC IN NOMINATED AREA (ha)	**0.0**	**15.5**	**0.0**	**2.4**	**17.9**
Intact	0.0	2.2	0.0	2.4	4.6
Higher Viability TEC	0.0	0.0	0.0	1.9	1.9
TEC WITHIN EXCLUDED LANDS (ha)	0.0	0.1	0.0	2.4	2.5
TEC WITHOUT EXCLUDED LANDS (ha)	0.0	**15.4**	0.0	**0.0**	**15.4**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	11.2	0.0	0.0	11.2
Intact	0.0	1.4	0.0	0.0	1.4
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR BIODIVERSITY PURPOSE (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**72.4**	**N/A**	**N/A**	**72.4**
AVOIDANCE FOR OTHER REASONS (ha)	0.0	4.2	0.0	0.0	4.2
Intact	0.0	0.7	0.0	0.0	0.7
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0
AVOIDANCE FOR OTHER REASONS (% TEC WITHOUT EXCLUDED LANDS)	**N/A**	**27.6**	**N/A**	**N/A**	**27.6**
TOTAL AVOIDANCE (ha)	0.0	15.4	0.0	0.0	15.4
Intact	0.0	2.2	0.0	0.0	2.2
Higher Viability TEC	0.0	0.0	0.0	0.0	0.0

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL AVOIDANCE (% TEC WITHOUT EXCLUDED LANDS)	N/A	100.0	N/A	N/A	100.0

NOMINATED ECOLOGICAL COMMUNITY

31.13 COASTAL FLOODPLAIN EUCALYPT FOREST OF EASTERN AUSTRALIA

This assessment analyses the implications of implementation of the Cumberland Plain Conservation Plan on the ecological community in accordance with the EPBC Terms of Reference. It sets out:

- *Ecological community background*
- *Approach to baseline data*
- *Occurrence in the Strategic Assessment Area*
- *Avoidance of impacts*
- *Direct impacts and offsets*
- *Potential indirect impacts and mitigation*
- *Potential additional impacts from essential infrastructure and tunnels*
- *Likely effects of implementation of the Plan on the long-term viability of the ecological community*
- *Data tables*

ECOLOGICAL COMMUNITY BACKGROUND

This section sets out the basic information about the ecological community. It provides a description of the ecological community, and an overview of the listing definition and its distribution. These provide context for the impact assessment. At the end of the section are links to key documents that provide additional background information.

NAME	Coastal Floodplain Eucalypt Forest of Eastern Australia
EPBC ACT LISTING	Not currently listed. Nominated for listing as under the EPBC Act an endangered ecological community in the Finalised Priority Assessment List (FPAL)
DESCRIPTION	The nominated TEC (referred to as EC from this point) is a eucalypt forest that occurs on quaternary alluvial soils on coastal floodplains on the east coast of Australia in warm to hot and sub-tropical climate zones. The EC generally ranges from tall open forest to woodland. Occasional localised stands of the EC are closed forest and/or low forest. The EC occurs in a lower and less dense structure on the open floodplains and taller, denser forest on the upper floodplains that include stream flats in the surrounding hills of the floodplain. The EC may have a canopy layer, mid-layer, climbing species and scramblers and understorey. While there is regional variation and intergradation of key species, the structure and function of the ecological community stays largely similar throughout its extent. The canopy layer is generally dominated by *Eucalyptus*, *Angophora*, and *Corymbia* as a single species or a mix of several species. The mid-layer is characterised over its entire range by a number of paperbarks including *Melaleuca linariifolia* (Flax-leaved Paperbark) and *M. styphelioides* (Prickly-leaved Paperbark) and other species including *Acacia floribunda*, *Breynia oblongifolia* (Breynia, Coffee Bush), *Bursaria spinosa* (Sweet Bursaria Blackthorn, Kurwan-D'harawal), *Goodenia ovata* (Hop Goodenia), *Pittosporum revolutum* (Hairy Pittosporum) and *Plectranthus parviflorus* (Cockspur flower). Other paperbarks and species occur in the mid-layer on a local or regional basis. Scrambling species that occur in the ground layer are *Desmodium varians* (Slender Trefoil) and *Veronica plebeia* (Trailing Speedwell) while *Glycine clandestine* (Twining Glycine) and *Stephania japonica* var. *discolor* (Snake Vine) may be found in the sub-canopy and mid-layer. The understory layer is dominated by species that have adapted to a higher level of soil moisture and include perennial forbs, grasses, sedges, rushes and ferns. The following PCT is associated with the EC and has been used to map the EC in the Strategic Assessment Area: 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion.

	A range of fauna species occur in the EC, including mammals (arboreal, ground and burrowing), marsupials, birds, frogs, reptiles and invertebrates. The EC provides important habitat for fauna species in terms of food, nesting, roosting or hunting. The fauna in turn also play an important role in the ecology of the EC through pollination, seed dispersal and soil turnover. In the southern part of its distribution, the EC correlates to parts of one NSW BC Act listed TEC (River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions). The southern part of the EC also form parts of Victorian listed ecological communities. The parts of the TEC's range that extend into Queensland and Victoria also form parts of ecological communities listed in other states. (TSSC, 2019c)
EPBC DEFINITION	Only patches of the EC that meet minimum size and condition thresholds will be considered part of the TEC (presuming it becomes listed under the EPBC Act). Thresholds generally relate to factors such as patch size, understorey native vegetation cover, ground cover richness, number of large trees or tree hollows per hectare, evidence of particular mammal species, or whether the patch is contiguous with other native vegetation patches. Details of the proposed thresholds are provided in the Draft Conservation Advice (TSSC, 2019c).
DISTRIBUTION	The EC's extent of occurrence stretches from Sale in Victoria to Gladstone in Queensland. It extends through four IBRA Bioregions: South East Corner, Sydney Basin, NSW North Coast, and South East Queensland. It generally occurs along water courses and drainage lines. The community is important in maintaining river ecosystems and riverbank stability. The EC primarily occurs on elevations below 50 m but may occur on localised floodplain pockets up to and occasionally beyond 250 m. It occurs in riparian corridors, floodplains prone to inundation, older floodplain terraces, and floodplain depressions. The community forms mosaics with other floodplain forest communities and wetlands. (OEH, 2019i; TSSC, 2019c)
SOS SITES	The NSW BC Act listed River-Flat Eucalypt Forest on Coastal Floodplains has been categorised under the 'widespread' management stream for TECs under the SOS program. Management of this category of TECs focuses on planning and regulatory processes, policy and programs, and private land conservation and reservation of land. Three management sites have been identified for this TEC on the Lower and Upper Deua River and Burra Creek Catchment in Eurobodella LGA, south of Ulladulla on the south coast.
RELEVANT PLANS AND POLICIES	Draft Conservation Advice (incorporating listing advice) for Coastal floodplain eucalypt forest of eastern Australia (TSSC, 2019c) Key Threatening Processes relevant to the EC are identified in Table 9 of the draft Conservation Advice There is no Draft Recovery Plan for the EC. However, the NSW BC Act-listed TEC, River-flat Eucalypt Forest, is included within the Cumberland Plain Recovery Plan Threat Abatement Plans relevant to the EC are identified in Table 9 of the Draft Conservation Advice
SPRAT LINK	There is currently no SPRAT profile as the EC is still undergoing assessment.

APPROACH TO BASELINE DATA

This section provides an overview of the approach to baseline data for the ecological community. It:

- *Provides a summary of the approach to vegetation mapping for the strategic assessment which forms the baseline for the ecological community mapping*
- *Outlines the vegetation condition states used in the mapping*
- *Identifies the NSW Plant Community Types (PCTs) that are associated with the ecological community*
- *Summarises the approach to mapping the EPBC ecological community*
- *Summarises the approach to the patch size analysis for the ecological community*
- *Summarises the approach to identifying areas of likely higher long-term viability in the Strategic Assessment Area*

Please refer to Section 11.3 (in Chapter 11) for details about the methods for mapping native vegetation, and Section 11.4.3 for details about the mapping methods for EPBC TECs.

APPROACH TO VEGETATION MAPPING	Native vegetation was mapped at two levels for the strategic assessment. Within the nominated areas, native vegetation was mapped using a method consistent with the BAM. This involved using a combination of API, existing desktop mapping, previous surveys and studies, rapid assessment ground-truthing, and field surveys (including floristic plot surveys). This process resulted in detailed maps of PCTs categorised by condition. Outside the nominated areas, native vegetation was mapped using the best available data integrated into a single dataset. Vegetation condition states were also applied across the broader area. It should be noted that comprehensive on-ground surveys across all native vegetation within the nominated areas was not possible and no surveys were undertaken outside the nominated areas. This means that a set of assumptions around the available data was required to map the nominated EC at the scale of the Strategic Assessment Area. These assumptions are summarised below and explained in detail in Section 11.4.3 of Chapter 11.
VEGETATION CONDITION STATES	Vegetation condition was mapped using the following five condition states. These states generally range from better (intact) to worse (urban native/exotic) condition and are: • **Intact:** This condition state was assigned to areas of wooded vegetation community, including regrowth, that displays a range of structural layers and habitat features (e.g. tree hollows and large trees, fallen timber, leaf litter) with a largely unmodified canopy density and a range of age classes and species present • **Thinned:** This condition state was assigned to native vegetation in various states of modification, including: o Wooded vegetation with a partly-cleared canopy and a more open structure compared to the intact PCT o Wooded vegetation that has been under scrubbed • **Scattered trees:** This condition state includes a single tree or small group of trees surrounded by native or exotic pasture or areas of cultivation. Other structural components of the vegetation have typically been removed • **Grasslands:** Grasslands included two separate state zones – exotic grassland and native grasslands • **Urban native/exotic:** This condition type was assigned to areas of vegetation within urban areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species
ASSOCIATED PCTs	PCT 835 (Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion) is associated with the EC.
MAPPING APPROACH	Given the EC is not yet listed, there were no approved condition thresholds or final definition to use in the mapping. In order to take a precautionary approach to the mapping, PCT 835 was used as a surrogate. It is expected that this mapping will over-estimate the actual occurrence of the future listed TEC, which is expected to have a more restricted definition based on condition thresholds than PCT 835.
PATCH SIZE ANALYSIS	As outlined in Section 31.3, a patch size analysis for the ecological community was undertaken to identify the number and size of patches across the Strategic Assessment Area.
VIABILITY ASSESSMENT	Given the EC has not yet been listed and approved condition thresholds are not available, a viability assessment was not conducted for the EC.

OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA

This section describes the occurrence of the ecological community in the Strategic Assessment Area. It includes reference to a map which can be viewed as a separate file. The map provides critical context for the assessment and should be viewed in conjunction with the text presented in this assessment. This section also provides a qualitative description of where the ecological community occurs.

MAP	See Map 48.5 for a map of the TEC across the Strategic Assessment Area.
OCCURRENCE IN THE STRATEGIC ASSESSMENT AREA	The baseline mapping for this assessment mapped approximately 6,944 ha of the EC within the Strategic Assessment Area (see Table 31-26 for further details). The EC is relatively evenly spread throughout the Strategic Assessment Area. It occurs mainly in GPEC and WSA, with smaller amounts in GMAC. There is no EC mapped in Wilton. The EC mainly occurs as long and narrow patches of vegetation along riparian corridors throughout the Strategic Assessment Area, which may or may not be connected with broader areas of native vegetation. Where the EC is not buffered by the wider presence of native vegetation it is likely to be exposed to significant edge effects, particularly where it occurs in urban areas. The Draft Conservation Advice does not specifically identify any sites in the Strategic Assessment Area that are important to the EC. Rather, it states that all patches of a reasonable size and in the highest condition categories as defined in the advice (categories A and B) are considered habitat critical to the survival of the EC. These are generally: • Patch sizes of ≥ 0.5 ha or well-connected patches with a predominantly native understorey and ≥ 20 large trees (> 45 cm dbh) or tree hollows per hectare • Large patch sizes (≥ 2 ha) or well-connected patches with a predominately native understorey and ≥ 10 large trees (> 45 cm dbh) or tree hollows per hectare The Draft Conservation Advice also identifies several factors affecting the value of a patch, including: • A larger size and/or a high area to boundary ratio • Part of a larger remnant of native vegetation or linking other remnants • Evidence of recruitment of key plant species/range of age cohorts • High native species richness • Presence of threatened species • Low level of weeds and pest animals • Heavily cleared or degraded patches, or patches at the edge of its range The EC is highly fragmented across the Strategic Assessment Area, comprising 1,392 patches (greater than 0.5 ha) with an average patch size of 5.5 ha.

AVOIDANCE OF IMPACTS

This section provides an overview of the area of the ecological community that was avoided through the design of the urban capable lands within the nominated areas. Avoidance of impacts to biodiversity was a critical part of the process to develop the Plan. A detailed explanation of the avoidance process and terminology is provided in Chapter 14.

31.13.1 NOMINATED AREAS

The baseline mapping for this assessment has mapped 335 ha of the EC within the nominated areas (not including excluded lands). Approximately 170 ha (51 per cent) was avoided as part of the design of the urban capable lands and transport corridors (not including excluded lands). Of this:

- 61 ha was avoided for biodiversity purposes
- 110 ha was avoided for other purposes

An additional 835 ha occurs on excluded lands.

A breakdown of avoidance across each nominated area is provided in Table 31-27.

It is important to note that the avoidance calculations in Table 31-27, including for 'avoidance for biodiversity purposes', 'avoidance for other reasons', and 'total avoidance', have been calculated without including excluded lands as these lands are not covered by the Plan. Table 31-27 shows the amounts of habitat within excluded lands for context only.

31.13.2 TRANSPORT

Results are only reported for the nominated areas, as detailed planning within the transport corridors outside the nominated areas has not yet occurred.

DIRECT IMPACTS AND OFFSETS

This section provides an analysis of any direct impacts and (if appropriate) identifies the need for any offsets to compensate for these direct impacts. It considers:

- *Predicted impacts within urban capable lands and transport corridors*
- *Potential issues associated with fragmentation*
- *Potential additional impacts from essential infrastructure (within nominated areas but outside the urban capable lands) and tunnels associated with transport projects*

Offsets are provided for any TECs that are subject to direct impacts (this includes the nominated EC). The rationale and process for setting offset targets for TECs is set out in Section 8.5.2 of Chapter 8, and explained in detail in the Conservation Priorities Method that supports the Plan.

Implementation of the Plan will lead to direct impacts to the EC (see Section 31.12.3 for discussion) and increase fragmentation in a number of locations (see Section 31.12.4 for discussion).

31.13.3 DIRECT IMPACTS TO THE EC

Implementation of the Plan will lead to a loss of a total of 210.2 ha of the EC within the nominated areas and transport corridors (see Table 31-28 for detailed stats). This loss represents approximately 3 per cent of the remaining EC in the Strategic Assessment Area and 18 per cent of the EC in the nominated areas.

The majority of the EC impacted:

- Is in thinned or scattered condition (181.7 ha), with 13.6 per cent of direct impacts occurring to patches in intact condition
- Comprises small patches (0.5-5 ha) (45 of the 54 patches impacted, approximately 83 per cent)

The urban footprint within the nominated areas has generally avoided riparian corridors, and therefore avoids the majority of areas mapped as potential TEC.

The most notable direct impacts to the EC occur in the following locations:

- Within the Outer Sydney Orbital Transport Corridor outside the nominated areas, which will impact several small (0.5-5 ha) and medium (5-20 ha) patches and reduce the size of a few larger patches
- Within the Outer Sydney Orbital Transport Corridor within WSA and GPEC, which will impact sections of riparian corridors along Cosgroves Creek, Wianamatta (South Creek) and Ropes Creek. These areas of EC are connected along the corridors, as well as to larger areas of the EC within Wianamatta Regional Park

The potential scale of impacts to the mapped EC is relatively large. However, it should be noted that mapping of the EC is based on PCT 835 and is considered to be conservative. The future listed TEC is expected to have a more restricted distribution based on the application of condition thresholds and actual direct impacts to the listed EC are likely to be smaller.

The risks to the EC from direct impacts are mitigated to a degree because development will impact:

- Patches of the EC that are generally isolated and exposed to edge effects
- Areas that are generally in lower condition (thinned or scattered)

31.13.4 FRAGMENTATION OF THE EC

The Draft Conservation Advice identifies fragmentation as a threat to the EC (TSSC, 2019c).

The most notable fragmentation impacts are associated with the direct impacts from the Outer Sydney Orbital in GPEC. In this area:

- The Outer Sydney Orbital will intersect the middle of several patches of the EC in Wianamatta Regional Park that form part of a larger, well connected patch of native vegetation to the west and Ropes Creek riparian corridor to the south
- The Outer Sydney Orbital will impact the connectivity of a large area of the riparian corridor around Wianamatta (South Creek), north and south of the Western Motorway near St Marys

Fragmentation of the EC will increase its susceptibility to weed invasion and other edge effects and has the potential to reduce its long-term viability in these locations.

31.13.5 OFFSETS FOR RESIDUAL DIRECT IMPACTS

To compensate for the predicted direct impacts to the ecological community, the Plan includes a commitment to secure 575 ha of PCT 835 as part of the conservation program. This would:

- Lead to the protection and management of an additional 8.3 per cent of the ecological community within the Strategic Assessment Area
- Increase the level of protection and management of the ecological community by approximately 79 per cent on top of what is currently secured in the Strategic Assessment Area

POTENTIAL INDIRECT IMPACTS AND MITIGATION

This section identifies the relevant potential indirect impacts to the EC that may occur as a result of development under the Plan. Indirect impacts were identified as being relevant to the EC if:

- *The indirect impact is identified as a threat in a relevant profile or draft conservation advice, and*
- *The threat is present in the Cumberland subregion, and*
- *The Plan has the potential to exacerbate the threat*

It discusses each relevant potential indirect impact in detail and outlines how the Plan addresses it.

Please refer to Chapter 15 for a detailed discussion and analysis of indirect impacts and mitigation measures included in the Plan. It is critical to read Chapter 15 in order to understand the conclusions reached in this section.

31.13.6 RELEVANT POTENTIAL INDIRECT IMPACTS

The Draft Conservation Advice identifies a range of threats to the EC. Where these threats are present in the Strategic Assessment Area and have the potential to be exacerbated under the Plan, the Plan includes management strategies to mitigate their impacts. As outlined in Chapter 15 (Section 15.5 and Attachment A), the following potential indirect impacts (identified as threats in the Draft Conservation Advice) are considered relevant to implementation of the Plan:

- Inappropriate fire regimes
- Weed invasion
- Inappropriate habitat disturbance
- Changes to hydrology
- Diseases, pathogens and dieback
- Invasive fauna

Climate change is also a relevant threat to the ecological community. The extent to which the Plan has considered adaptation to climate change impacts is addressed in Chapter 41.

Impacts from agricultural activities, including grazing and nutrient enrichment was also identified in the Draft Conservation Advice as a key threat. However, this is not considered relevant to implementation of the Plan as the Plan is unlikely to exacerbate the risk across the Strategic Assessment Area.

INAPPROPRIATE FIRE REGIMES

High frequency fires are identified as a key threat to the NSW BC Act listed TEC, particularly where the TEC occurs in urban areas (OEH, 2004). Further information with regards to the threats posed by increased fire frequencies, and recommended fire management methodologies, is limited.

Inappropriate fire regimes can be caused by:

- Increased fire frequency due to arson and accidental lighting of fires
- Increased fire frequency due to the application of fire by authorities to manage fire risk
- In other cases, a lack of fire due to challenges in burns in proximity to human habitation

Increased human activity within the nominated areas increases the risk of arson or accidental fires and may lead to further increases in fire frequency that could impact the EC. Key risk areas are those that are easily accessible to the public and in close proximity to urban development. Bushfire management by authorities is also likely in areas close to new urban development. For the TEC this includes areas throughout GPEC and WSA, with small parts of GMAC.

The Plan incorporates a range of measures to manage the bushfire risk to biodiversity. In summary, these include:

- A commitment (Commitment 18) to manage fire in strategic locations across the Strategic Assessment Area. This includes a number of actions with the most relevant to the outcome for the EC being:
    - Consultation with fire management authorities and traditional owners about how best to manage fire and maintain biodiversity values
    - Preparation of a fire management strategy for the Strategic Conservation Areas that will (amongst other things) provide guidance on fire management to maintain and promote biodiversity values
    - A process to work with delivery partners to implement the fire management strategy
    - Integration of the fire management actions for conservation land identified in the fire management strategy in stewardship agreements and reserve management plans
- The introduction of planning controls that will:
    - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering bushfire management for biodiversity in these areas
    - Require precinct plans to have asset protection zones (APZs) wholly within the urban-capable land. This will ensure the highest intensity bushfire risk mitigation activities occur away from the EC. While these APZs are designed to provide a buffer zone between a bushfire hazard and buildings or other infrastructure that need to be protected, they will also act as a protective buffer for the bushland areas from the sorts of activities within the urban capable land and transport corridors that might increase fire frequency or changes to natural fire regimes

The package of measures in the Plan is expected to adequately manage the risk to the EC from altered fire regimes as a result of development. This is because:

- Avoided lands where areas of the EC occur will be zoned appropriately to enable an adequate framework for management
- APZs for fire management are required to be located within urban capable lands which will reduce the risk of fire mitigation activities impacting the EC
- Fire management authorities will be engaged to ensure they understand the requirements of the EC and incorporate them in their fire management practices. This will include specific fire management approaches for conservation areas

WEED INVASION

The majority of remnants of the NSW BC Act listed TEC are impacted by weeds. Weed incursion occurs as a result of physical disturbance to the TEC, rubbish dumping, polluted agricultural and/or urban runoff, road/utility construction activities and grazing of livestock (OEH, 2004).

A large number of weeds are recognised as threats to the NSW BC Act listed TEC, including several grasses, vines and small shrubs and trees, including Lantana (*Lantana camara*), Privets (*Ligustrum sp.*) and African Olive (*Olea europea* subsp. *Cuspidate*), (OEH, 2004).

These weeds are already present within the Strategic Assessment Area and pose a threat to the EC. However, urban and transport development within the Strategic Assessment Area has the potential to increase the spread of these weeds by providing more opportunities for weed dispersal or changing conditions to favour weeds.

The EC is most susceptible to the threat of weeds from development under the Plan where new urban development or transport corridors occur adjacent to the EC and/or fragments patches of the EC into smaller patches and introduces edge effects. Key risk areas include:

- Transport corridors within GPEC and WSA, which will result in direct impacts to the potential EC and will increase fragmentation in some locations
- Urban development within GPEC and WSA, which will increase exposure of the EC along riparian corridors to edge effects associated with urban land uses

The Plan incorporates a range of measures to manage the risk posed by weed invasion to biodiversity. In summary, these include:

- A commitment (Commitment 16) to manage priority weeds in strategic locations in the Cumberland subregion to reduce threats to land secured within the Strategic Conservation Areas. This includes a number of actions, of which the following are the most relevant to the outcome for the EC:
  - Preparation of a Weed Control Implementation Strategy, and entering into written agreements with delivery partners to implement the weed control program
  - Integration of weed control actions for conservation land into biodiversity stewardship agreements and reserve management plans
  - Provision of grants to relevant stakeholders to reduce weeds in the following locations: on public land adjoining or near conservation land, and on Aboriginal-owned land adjoining or near to conservation land
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing weeds, consistent with the weed implementation strategy outlined in Commitment 16
- The introduction of planning controls that will:
  - Require proponents to undertake the following when applying for/undertaking development:
    - Submit a weed eradication and management plan with development applications for subdivisions, outlining weed control measures during and after construction
    - Subdivision design and earthworks to minimise environmental weed spread, and require the inclusion of measures to eradicate weeds in accordance with relevant council weed policies
    - Manage and eradicate Weeds of National Significance and weeds on the National Environmental Alert List under the National Weeds Strategy. The proponent is to refer to NSW Weed Wise for current weed identification and management approaches
  - Establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for considering management of weeds for biodiversity protection in these areas

Importantly for the EC, weeds will be actively managed within the 575 ha to be added to conservation as part of the offset program.

The package of measures in the Plan is expected to adequately manage the risk posed to the EC from weed invasion. This is because:

- Avoided lands where areas of the EC occur will be zoned appropriately to enable an adequate framework for management
- The Plan provides for a landscape scale approach to managing weeds through the development and implementation of a weed management strategy. This includes the land to be protected under the conservation program for the EC
- There will be a range of planning controls to minimise the potential spread of weeds during and after construction

INAPPROPRIATE HABITAT DISTURBANCE

Inappropriate habitat disturbance is identified in the Draft Conservation Advice as a threat to the EC. This relates to a wide range of different mechanisms for disturbance including:

- Dumping of rubbish and garden waste which can directly impact areas of the EC as well as facilitate increases in weeds (see above) and pollutants
- Inappropriate recreational activities such as ad hoc track building and trail bike use which can directly impact areas of the EC and facilitate processes such as erosion
- Inadvertent disturbance during construction which has the potential to directly impact the EC outside approved development areas

Each of these mechanisms have the potential to alter the structure and floristic composition of the EC.

Inappropriate habitat disturbance within the Strategic Assessment Area may increase due to development within the nominated areas. Occurrences of the EC considered most at risk are those within GPEC and WSA, and to a lesser extent in GMAC.

The Plan incorporates a range of measures to mitigate the risks associated with inappropriate habitat disturbance for the EC. In summary, these include:

- The introduction of planning controls that will establish environmental zoning (E2) on avoided lands. This zoning will set out objectives that a consent authority must consider when considering development applications, as well as the land uses that are permissible and prohibited. It will provide a framework for minimising a number of mechanisms for potential disturbance
- Development controls to minimise any potential inadvertent disturbance during construction. This includes measures such as temporary fencing to protect areas with high biodiversity value, and ensuring that parking, and equipment and laydown areas will be located away from land with biodiversity values
- Active management of land secured for conservation through the Plan which will address any issues associated with inappropriate habitat disturbance in those locations
- A commitment (Commitment 28) to implement a compliance program to ensure compliance with the Plan and conditions of approval. This will include funding for at least three council-based compliance officers to ensure compliance with the conservation program. These officers will work closely with council rangers to monitor illegal dumping and vegetation clearing
- A commitment (Commitment 21) that will provide opportunities for the residents of Western Sydney to learn about and actively participate in biodiversity conservation. This process will ideally help the local community understand and appreciate the biodiversity values that occur nearby, and potentially reduce the level of disturbance to natural areas

The package of measures in the Plan is expected to adequately manage the risk to the EC from inappropriate habitat disturbance as a result of development. This is because:

- Avoided lands where areas of the EC occur will be zoned appropriately to enable an adequate framework for management
- Development controls will be put in place to address potential impacts associated with construction
- Conservation lands will be actively managed which will address disturbance in those areas
- There will be funded compliance with a focus on minimising habitat disturbance

- A program of education for the community will be run to help them understand the biodiversity values they live near

CHANGES TO HYDROLOGY

Altered hydrological regimes, including narrowing of riparian corridors, installation of flood mitigation and/or drainage infrastructure, and changes in water quality, have all been identified as threats to the NSW equivalent TEC (OEH, 2019i).

The TEC is most susceptible to the following threats:

- Increase of polluted runoff from development under the Plan where new urban development or transport corridors occur adjacent to the potential TEC. Key risk areas for this threat are located in are located in GPEC and WSA
- Potential installation of flood mitigation and/or drainage infrastructure in localities adjacent to where the EC will be cleared for development of transport corridors. Key risk areas for this threat include areas in proximity to the Outer Sydney Orbital in GPEC and WSA

The Plan incorporates a range of measures to mitigate the risks associated with changes to hydrology for the EC. In particular, these include commitments which relate to mitigating indirect and prescribed impacts from urban development (Commitment 5) and transport (Commitment 6). As part of these commitments, potential impacts in relation to hydrology are proposed to be managed through:

- Development controls in the nominated areas in relation to:
  - Water cycle management. For example:
    - Water management measures must comply with council’s requirements for detention, drainage and water sensitive urban design principles
    - Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways
  - Water quality. For example, stormwater systems must be constructed and maintained to achieve EES water quality targets
  - Soil erosion and sedimentation. For example:
    - Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development
    - Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom 2004) and submitted with each subdivision development application
- The implementation of mitigation measures to transport projects based on the outcomes of environmental assessment of detailed designs in accordance with published, best practice guidelines, including but not limited to, the RMS Biodiversity Guidelines. These include a range of provisions to mitigate and minimise changes to hydrology

The package of measures in the Plan is expected to adequately manage the risk to the EC from changes to hydrology because:

- Development controls in urban areas will be put in place to ensure development is designed, constructed and operated in a way that avoids and minimises any potential impacts to the EC
- Transport projects will apply best practice approaches to avoiding and minimising any potential impacts to the EC

DISEASES, PATHOGENS AND DIEBACK

TECs are potentially susceptible to a range of diseases, pathogens and dieback which can substantially affect their long term viability. Recognised threats include dieback caused by the root-rot fungus *Phytophthora cinnamomi*.

Development under the Plan may increase the risk of the spread of infection/disease. This is primarily related to:

- Soil transportation on contaminated footwear, vehicles and machinery, and in residential garden establishment
- Increased site visitation rates
- Earthworks and activities conducted during construction
- Increased surface water runoff

The Plan incorporates a range of measures to manage the risks associated with diseases, pathogens and dieback. In summary, these include:

- A commitment (Commitment 19) to support new or existing programs to control key diseases affecting threatened species and ecological communities in the Cumberland subregion. This will include:
  - Consulting with researchers, government agencies and other delivery partners to identify programs that contribute to the management of disease and dieback in the Cumberland subregion
  - Entering into written agreements with delivery partners to implement priority disease control programs
- Development controls to require the preparation of Construction Environmental Management Plans (CEMP) that must set out the measures methods to protect the environment during construction, including best practice site hygiene protocols to minimise spread of *Phytophthora* and Myrtle Rust

The package of measures in the Plan is expected to adequately manage the risk to the EC from diseases, pathogens and dieback because:

- It supports a landscape scale approach to the issue across the Cumberland subregion
- It will ensure appropriate controls during construction

INVASIVE FAUNA

TECs can be threatened by introduced animals and aggressive native species. These species include:

- Domestic species such as cats and dogs which are related to urban development
- Pest species such as foxes, rats, house mice and rabbits which are primarily related to agricultural development
- Aggressive bird species which compete for resources including the Noisy Miner

Collectively, these animals can lead to declines in biodiversity through:

- Predation
- Damage to vegetation and soils
- Competition for resources

Existing land use within the nominated areas and surrounding region (which includes residential and rural residential areas, and farming) means that these issues are already present in the Strategic Assessment Area and are unlikely to pose a novel threat to the EC.

However, the extent of proposed new urban development under the Plan means that the threats associated with cats and dogs are likely to be exacerbated. It is likely that there will be an increase in the number of domestic cats and dogs in the local area, which, in turn, may lead to an increase in feral cat and wild dog numbers.

In relation to aggressive bird species, the two main drivers for increasing the threat within the EC are:

- Fragmentation of habitat which creates greater edge effects and facilitates access by aggressive bird species. As outlined above, the EC is already highly fragmented and subject to edge effects
- Habitat disturbance through inappropriate land management which can change the structure of the EC and facilitate access by aggressive bird species. As outlined above in relation to inappropriate habitat disturbance, the Plan includes a package of measures which are expected to adequately manage the risk to the EC from inappropriate habitat disturbance as a result of development

In relation to the residual risks associated with invasive fauna, the Plan incorporates a range of measures to manage the risks. In summary, these include:

- A commitment (Commitment 17) to manage priority pest animals in strategic locations in the Cumberland subregion to reduce threats to land protected in the Strategic Conservation Areas. This includes a number of actions with the most relevant to the outcome for the EC being:
  - The establishment of a pest animal working group to guide the implementation of pest animal control activities under the Plan
  - Preparation of a Pest Animal Control Implementation Strategy

  - A process to enter into written agreements with delivery partners to implement the pest animal control program
  - Integration of pest control actions for conservation lands into biodiversity stewardship agreements and reserve management plans
- Development controls that will:
  - Ensure that domestic animals are appropriately contained at urban/bushland interfaces
  - Require property boundaries to have appropriate fencing to contain domestic animals within the landholders' property
  - Require appropriate management and control of pest animals relevant to development sites
- A commitment (Commitment 23) to provide extension services to community groups, councils, Local Aboriginal Land Councils, and landholders to support biodiversity conservation on public and private land. This includes partnering with Local Land Services, councils, Local Aboriginal Land Councils and other delivery partners to provide community workshops on managing pests, consistent with the pest animal implementation strategy outlined in Commitment 16

POTENTIAL ADDITIONAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE AND TUNNELS

This section considers the potential additional impacts to the ecological community from essential infrastructure and tunnels. Please refer to the following chapters for details about these development types and the predicted outcomes for matters protected by the EPBC Act:

- *Chapter 36 – Summary of transport program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with tunnels*
- *Chapter 37 – Summary of urban program impacts which includes an analysis of the potential impacts on EPBC Act protected matters associated with essential infrastructure outside the urban capable lands (but still within the nominated areas)*

In addition to predicted impacts within the urban capable lands and transport corridors, there is the potential for impacts to the EC to occur due to:

- The development of essential infrastructure within nominated areas but outside the urban capable lands
- Tunnels associated with transport projects

31.13.7 POTENTIAL IMPACTS FROM ESSENTIAL INFRASTRUCTURE

The EC occurs on avoided land within GMAC (14.4 ha), WSA (101 ha) and GPEC (54.9 ha). It is possible that some of these areas will be impacted by essential infrastructure. However, the nature of the EC and its association with riparian corridors reduces its likelihood of being substantially impacted as these areas occur away from the typical locations for essential infrastructure.

As outlined in Chapter 37, any proposed essential infrastructure developments in these areas will be subject to the processes of the NSW BAM and require approval under the BC Act. These processes will include:

- On-ground surveys to determine the biodiversity values within the potential development area. In the case the EC gets listed under the EPBC Act, these surveys would identify if the listed TEC was present
- Measures to avoid impacts to the listed TEC through development design
- Measures to mitigate any potential indirect impacts
- Measures to offset any residual impacts in accordance with the requirements of the BAM

It is not expected that substantial impacts to the EC will occur as a results of essential infrastructure, and that any impacts that did occur would be adequately mitigated and offset. See Section 37.6 in Chapter 37 for more details.

31.13.8 POTENTIAL IMPACTS FROM TUNNELS

The EC occurs within the tunnel footprints for the Metro Rail Future Extension (11.1 ha) and the Outer Sydney Orbital (25.7 ha). The Plan includes commitments to:

- Avoid any direct impacts to the areas where the EC occurs

- Mitigate any potential indirect impacts (e.g. changes to hydrology, ground settling or subsidence) from the transport corridors as part of a future environmental impact assessment process

These commitments are expected to adequately address threats to the EC from the construction and operation of the tunnels. See Section 36.6 in Chapter 36 for more details.

LIKELY EFFECTS OF IMPLEMENTATION OF THE PLAN ON THE LONG-TERM VIABILITY OF THE EC

This section considers the likely effects of implementation of the Plan on the long-term viability of the EC. The analysis has regard for the guidance in the Draft Conservation Advice, and draws on the analysis of avoidance, direct impacts and offsets, and indirect impacts and mitigation presented above.

Where applicable, this section also identifies any potentially relevant Threat Abatement Plans. The general consistency of the Plan with Threat Abatement Plans is discussed in detail in Section 15.9 of Chapter 15.

31.13.9 IMPLICATIONS FOR LONG-TERM VIABILITY

The Draft Conservation Advice (TSSC, 2019c) identifies the following key issues that are likely to have the greatest influence on the long-term viability of the potential TEC:

- Habitat loss and fragmentation
- Indirect impacts including:
  - Inappropriate fire regimes
  - Weed invasion
  - Inappropriate habitat disturbance
  - Changes to hydrology
  - Diseases, pathogens and dieback
  - Invasive fauna

HABITAT LOSS AND FRAGMENTATION

While implementation of the Plan will result in the loss of 210.2 ha of the EC, this is not expected to substantially influence the long-term viability of the potentially listed TEC because:

- The mapping of the EC is based on PCT 835 which provides an over-estimate of both impacts and conservation actions for what might be the listed TEC
- Although the Plan authorises the clearing of 210.2 ha (approximately 3 per cent of the remaining EC), most of this is in thinned and scattered condition. 28.6 ha occurs in intact condition
- The majority of impacts are to small patches, or to the edges of patches
- Transport projects will apply future efforts to avoid impacts to the EC. These processes are set out in Chapter 36
- The Plan commits to protecting and managing 575 ha of PCT 835 as a surrogate for the future listed TEC. These areas will occur in strategic locations as part of the Plan's conservation program

Securing high conservation value EC in the SCAs directly supports a key high priority action in the Draft Conservation Advice to protect and conserve remaining areas of the ecological community.

INDIRECT IMPACTS

The potential indirect impacts associated with inappropriate fire regimes, weed invasion, inappropriate habitat disturbance, changes to hydrology, diseases, pathogens and dieback, and invasive fauna will be managed and mitigated through a number of commitments and actions in the Plan.

Indirect impacts are not expected to influence the long-term viability of the EC.

CONCLUSION

The nature of the impacts to the EC (mostly to smaller patches in lower condition) combined with the commitments to protect 575 ha of PCT 835 and manage indirect impacts will ensure that the implementation of the Plan does not adversely influence the long-term viability of the EC.

31.13.10 CONSISTENCY WITH RECOVERY PLAN

There is no recovery plan for the EC.

31.13.11 KEY THREATENING PROCESSES AND CONSISTENCY WITH THREAT ABATEMENT PLANS

Relevant Key Threatening Processes (KTPs) and any of their associated Threat Abatement Plans (TAPs) have been identified in Table 31-25 where they relate to:

- The potential direct impacts of the Plan, or
- The relevant indirect impacts

The Plan is not inconsistent with any of the relevant TAPs. Please refer to Section 15.9 of Chapter 15 for a detailed discussion of each TAP and the relationship of the Plan.

Table 31-25: Key Threatening Processes and relevant Threat Abatement Plans for Coastal Floodplain Eucalypt Forest of Eastern Australia

KEY THREATENING PROCESS	RELEVANT THREAT ABATEMENT PLAN
Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)	There is no relevant TAP
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DoEE, 2018d)
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DoEE, 2016b)
Land clearance	There is no relevant TAP
Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants	There is no relevant TAP
Novel biota and their impact on biodiversity	There is no relevant TAP
Predation by feral cats	Threat abatement plan for predation by feral cats (DoE, 2015g)
Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species	There is no relevant TAP

DATA TABLES

This section sets out the data tables for occurrence, avoidance and direct impacts. Cross references to the tables are provided throughout the text above.

Table 31-26: Occurrence of Coastal Floodplain Eucalypt Forest of Eastern Australia in the Strategic Assessment Area

	SAA TOTAL	WITHIN PROTECTED LANDS
TOTAL EC MAPPING (ha)	6,944.1	726.2
Intact	2,582.8	454.6
Thinned	1,443.1	169.6
Scattered Trees	2,918.2	102.0

Table 31-27: Avoidance of impacts to Coastal Floodplain Eucalypt Forest of Eastern Australia within the nominated areas

	WILTON	GMAC	WSA	GPEC	TOTAL IN NOMINATED AREAS
TOTAL EC IN NOMINATED AREA (ha)	**0.0**	**183.8**	**159.9**	**826.1**	**1,169.8**
Intact	0.0	55.7	13.4	321.4	390.5
EC WITHIN EXCLUDED LANDS (ha)	0.0	164.1	24.9	645.5	834.5
EC WITHOUT EXCLUDED LANDS (ha)	**0.0**	**19.7**	**135.0**	**180.6**	**335.3**
AVOIDANCE FOR BIODIVERSITY PURPOSE (ha)	0.0	4.7	32.9	23.1	60.7
Intact	0.0	3.6	4.2	7.3	15.2
AVOIDANCE FOR BIODIVERSITY PURPOSE (% EC WITHOUT EXCLUDED LANDS)	**N/A**	**24.0**	**24.4**	**12.8**	**18.1**
AVOIDANCE FOR OTHER REASONS (ha)	0.0	9.6	68.1	31.8	109.5
Intact	0.0	6.2	7.8	4.4	18.4
AVOIDANCE FOR OTHER REASONS (% EC WITHOUT EXCLUDED LANDS)	**N/A**	**48.8**	**50.4**	**17.6**	**32.6**
TOTAL AVOIDANCE (ha)	0.0	14.4	101.0	54.9	170.2
Intact	0.0	9.9	12.0	11.7	33.6
TOTAL AVOIDANCE (% EC WITHOUT EXCLUDED LANDS)	**N/A**	**72.8**	**74.8**	**30.4**	**50.7**

Table 31-28: Direct impacts to Coastal Floodplain Eucalypt Forest of Eastern Australia within the nominated areas and Transport Corridors

	WILTON	GMAC	WSA	GPEC	TRANSPORT OUTSIDE THE NOMINATED AREAS	TOTAL IMPACTS
DIRECT IMPACTS TO EC (ha)	**0.0**	**5.4**	**34.1**	**125.7**	**45.1**	**210.2**
Intact	0.0	0.2	0.4	11.6	16.4	**28.6**
Thinned	0.0	5.0	18.6	111.5	6.1	**141.3**
Scattered Trees	0.0	0.1	15.1	2.6	22.6	**40.4**

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CUMBERLAND PLAIN ASSESSMENT REPORT

PART 6A: ATTACHMENT

ATTACHMENT A - KOALA TERMINOLOGY

ATTACHMENT B - DETAILED BACKGROUND TO KOALAS IN THE STRATEGIC ASSESSMENT AREA

ATTACHMENT C - KOALA HABITAT MAPPING AND CONNECTIVITY ANALYSIS

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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A. Koala terminology

There are many terms used for mapping Koala habitat and understanding Koala ecology. For clarification, Table A-1 lists the terms used in this report.

Table A-1: Koala terminology used in this report

Term	Meaning
Blue Mountains Koala population	This refers to Koalas within the vicinity of the Blue Mountains, which is the closest Koala population to the WSA and GPEC.
Census population size	The total number of Koalas in a population
Connectivity	The degree of continuity and linkage among areas of vegetation. Greater connectivity increases potential gene flow across a landscape
Effective population size	The size of an idealised population (a population which varies in genotype frequencies only due to in the population census size), that would result in the degree of inbreeding and alteration in variance of frequencies observed in the population of interest. This can indicate the number of breeding individuals and degree of genetic diversity of the species
Food tree	Species of tree whose leaves are consumed by Koalas. Koala food trees can generally be considered to be those of the following genus: *Eucalyptus*, *Angophora, Corymbia, Lophostemon* and *Melaleuca*
Genetic diversity	The degree of variation of genes and genetic information of species in a specific area. This includes the genetic differences among individuals in a population
Habitat critical to the survival	Koala habitat that is considered to be important for the species' long-term survival and recovery. The *EPBC Act referral guidelines for the vulnerable Koala* (DoE, 2014) outlines the methodology by which this habitat is identified
Habitat tree	Species of trees which are utilised by Koalas, either as a food source, as a source of refuge or shelter, or to facilitate movement of Koalas through the landscape
Important habitat	Referred to in the Threatened Biodiversity Data Collection and comprises the species polygons for the BAM process. For this project important habitat is comprised of primary and secondary corridors
Inbreeding depression	The decrease in survival and reproduction in naturally outbreeding species caused by inbreeding (mating with genetically similar individuals). Inbreeding may negatively affect fecundity, gamete production and parental capabilities
Koala habitat	Habitat which is suitable for use by Koalas for the purposes of one or more of the following activities: feeding, resting, breeding and/or dispersal between different areas
Koala habitat is comprised of:	
• **High quality habitat**	Defined as the best habitat with the capacity to support higher densities of Koalas
• **Moderate quality habitat**	Defined as lower quality habitat with the capacity to support lower numbers of Koalas
• **Low quality habitat**	Defined as the lowest quality habitat areas, potentially used for movement through the landscape between higher quality areas
Koala metapopulation	A group of Koala populations or sub-populations connected by dispersal
Koala population	A group of Koalas which interbreed and are demographically, genetically, and/or spatially separated from other groups of Koalas

Term	Meaning
Movement corridors	Areas of habitat (often but not always linear) which facilitate the movement and dispersal of Koalas between habitat patches which would otherwise be disconnected
Movement corridors are comprised of:	
• **Primary corridors**	Defined as connected areas of principal habitat (and associated supporting habitat) that provide for ecological function of a population
• **Secondary corridors**	Defined as corridor areas that become narrow to less than 50 metres wide, or that are not connected at both ends
• **Tertiary corridors**	Smaller corridor areas that are not connected at the landscape level
Principal habitat	Comprises contiguous areas of high-quality habitat of sufficient size to support the home ranges of male Koalas
Shelter tree	Species of tree (typically with a dense canopy) which is not used as a Koala feed tree, which Koalas are known to utilise for shelter (particularly during hot periods)
Southern Sydney Koala population	This refers to Koalas within the vicinity of Wilton and GMAC, and includes Koalas from the Campbelltown/Wollondilly/Southern Highlands localities
Supporting habitat	The remaining areas of suitable habitat and vegetation structure that are outside principal habitat. Comprises scattered trees peripheral to and outside of identified Koala movement corridors
Viable population	A self-supporting population with sufficient numbers and genetic variety among healthy individuals and breeding pairs that are well enough distributed to ensure a high probability of survival despite the foreseeable effects of demographic, environmental and genetic events, and of natural catastrophes

B. Detailed background to Koalas in the Strategic Assessment Area

This attachment provides detailed information about Koala populations and ecology in the Strategic Assessment Area. It provides:

- A general background to the species
- An overview of the process of identifying Koala populations in the Cumberland subregion (and vicinity)
- Detailed information about the Koalas and Koala habitat which occurs within and near to Wilton and GMAC
- Relevant information about the Koalas and Koala habitat which occurs near the GPEC and WSA

SPECIES BACKGROUND

Koalas are arboreal marsupials that are distributed within coastal and inland regions of eastern Australia, from South Australia to northern Queensland.

MORPHOLOGY

Although Koalas are recognised as a single species, they have significant differences in morphology and behaviour across the extent of their range (Houlden, Costello et al., 1999). For instance, southern (Victorian) Koalas are on average 80 per cent larger (mean male body weight of 11.8kg) than northern (Queensland) Koalas (mean male body weight of 6.8kg) (Black, Price et al., 2014). There are also obvious variations in body form (including skull shape and fur colour) between northern Koalas and southern Koalas (Black, Price et al., 2014). These differences are the result of adaptions of Koalas to their local environment, which changes significantly between the northernmost and southernmost extent of the species' range.

FEEDING

Koalas are specialist folivores, meaning that they eat leaves and are highly selective in their choice of diet. They are known to eat the leaves of over 100 *Eucalyptus* species and over 30 non-*Eucalyptus* species (including genera such as *Angophora* and *Corymbia*) (OEH, 2018a).

However, local Koala populations typically tend to select their diet from only a small number of trees in their local area, with the preferred tree species varying between populations (McAlpine, Rhodes et al., 2008). McAlpine et al. (2008) proposes that Koalas may select their preferred trees through preferences for certain leaf nutrients (rather than tree species *per se*), and that leaf nutrients may vary between trees of the same species growing in different locations and under different conditions. This may explain why a certain tree species are used by Koalas in some locations but not in others.

Overall, Koalas typically preference trees growing on fertile soils, as fertile soils result in higher leaf nutrient content in trees.

SOCIAL INTERACTIONS

Koalas are territorial animals which exist in complex social networks. Ellis, Melzer & Bercovitch (2009) proposes that Koala habitat use is akin to a checkerboard model, where the ranges of Koalas overlap, yet where individual trees are rarely shared by different Koalas.

Males are more prone to dispersion, whereas female Koalas tend to remain close to natal sites (Houlden, Costello et al., 1999). Male ranges typically tend to be significantly larger than female ranges. The average size of a Koala's home range varies significantly between populations and between different areas and habitats. For example, some home ranges have been recorded to be 10-15 ha, whereas others have been recorded to be as large as 500 ha (NSW Chief Scientist & Engineer, 2016).

Reported densities of Koala populations also significantly vary between different habitats, ranging between 0.006/ha in the South East Forests of NSW to >8/ha in north-eastern Victoria (Close, Ward et al., 2017).

The differences in morphology, habitat preferences and behaviours between populations across the species' range means that research results of individual Koala populations may not be applicable to other populations. This means that local research is often required to determine the specific habitat requirements and conservation needs of any particular local population (McAlpine, Rhodes et al., 2008).

POPULATION NUMBERS AND TRENDS

Koalas had already undergone a series of population bottlenecks prior to European arrival (likely as a result of glacial/interglacial cycles). They therefore already had low genetic diversity prior to the impacts of European activities on the population (Black, Price et al., 2014). The number and density of Koalas in Australia prior to European settlement is unknown, although it is likely that Aboriginal hunting and dingo predation pressures combined to keep Koala populations low (Close, Ward et al., 2017; Tsangaras, Avila-Arcos et al., 2012).

Given uncertainty regarding the number of Koalas originally present in Australia prior to European arrival, determining long-term population trends of the species across its range is difficult. This challenge is further complicated by the cryptic nature of the species (particularly within low-density populations; see for example (Close, Ward et al., 2017)), which makes accurate survey and estimation of current population numbers difficult.

Nonetheless, Adams-Hoskings et al. (2016) estimated the numbers and trends of Koala populations across Australia (as of 2012), shown in Table B-1. The spatial distribution of Koala population trends across Australia is indicated in Figure B-1, sourced from McAlpine et al. (2015). It is noted that both studies acknowledge the presence of varying degrees (and sometimes significant levels) of uncertainty with regards to the accuracy of knowledge of the distribution and trends of Koala populations.

Table B-1: State and national Koala population sizes and trends for 2012, aggregated from bioregional estimates. Adapted from Adams-Hoskings, McBride et al. (2016)

	Queensland	New South Wales	Victoria	South Australia	National Total
Mean Population	79,000	36,000	183,000	33,000	331,000
Population Range	~33,000 - 153,000	~14,000 - 73,000	~77,000 - 327,000	~19,000 - 51,000	~144,000 - 605,000
Mean Population Change (per cent)*	-53	-26	-14	-3	-24

* Mean population change is based on the largest population change in any three-generation period, that is the past three Koala generations (from 15-21 years ago) to the future three Koala generation (15-21 years into the future).

A recent report (Lane, Wallis et al., 2020) set out to quantify the effects of the 2019-20 fires on Koalas in the context of broader population trends in NSW. That report concluded that over the past three Koala generations, numbers in NSW may have declined by a minimum of 28.52 per cent up to a possible 65.95 per cent. The report suggests declines are more likely to have occurred towards the upper estimate, and that the ongoing threats of climate change and high frequency fires will severely threaten the species in NSW over the coming years.

THREATS

Koala populations have been declining as a result of a diverse number of threats, including (McAlpine, Lunney et al., 2015; OEH, 2017):

- Habitat loss
- Habitat modification and fragmentation
- Predation from domestic and feral dogs
- Vehicle strike
- Fire (particularly increased fire intensity which burns the crown of trees)
- Disease (particularly *Chlamydia*)
- Heat stress through drought and heatwaves
- Climate change (which increases drought and heatwaves, but also alters habitat quality)

The presence and prevalence of each threat varies spatially and temporally across the range of the species, and Koala populations are often simultaneously under pressure from multiple threats (Rhodes, Ng et al., 2011). Conservation actions to protect Koala populations should therefore seek to address a suite of threats present for each population, as conservation actions which only target a single threat where multiple threats are present are unlikely to be adequate to safeguard a Koala population (Rhodes, Ng et al., 2011).

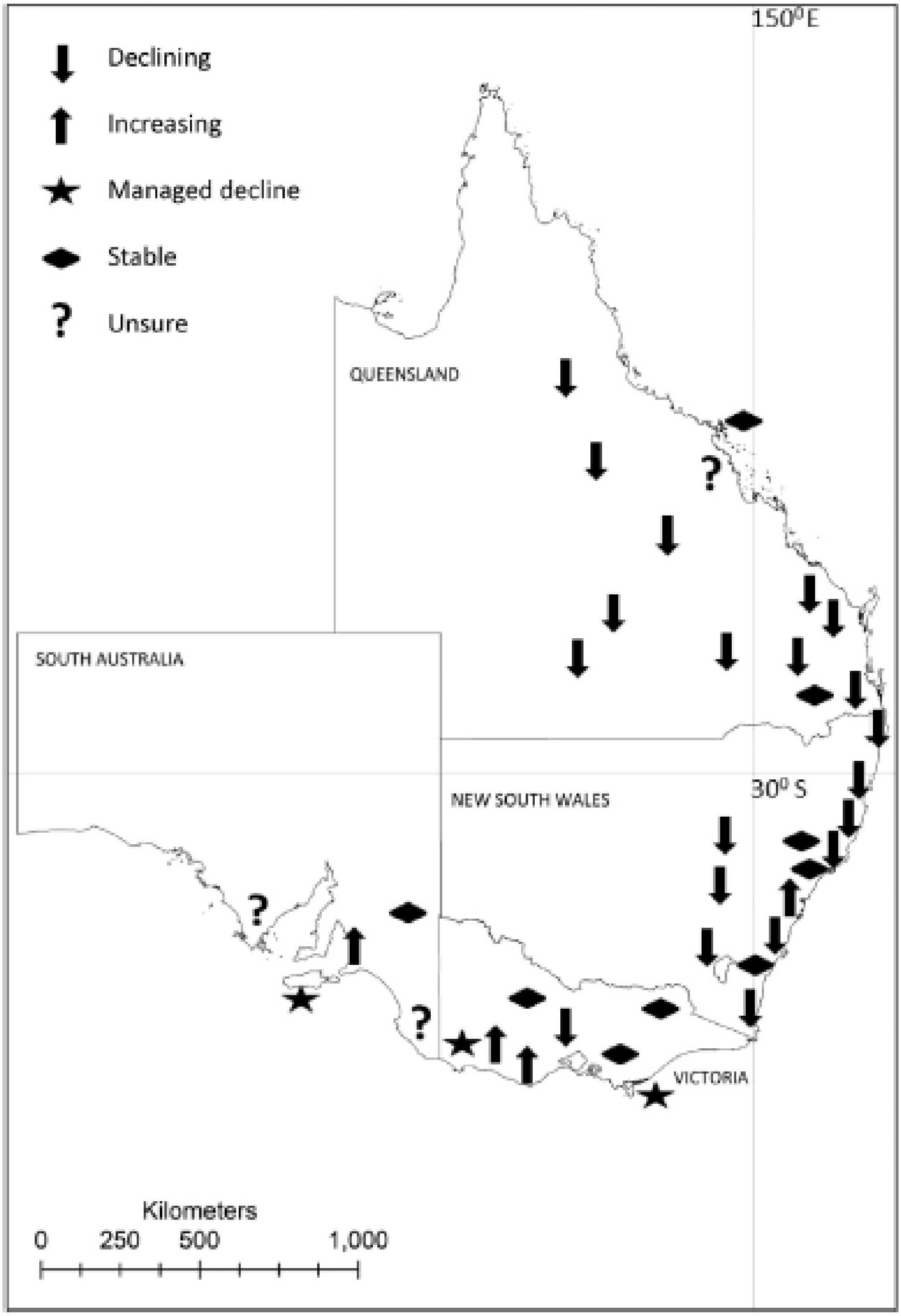

Figure B-1: Koala regional population trend synthesis map, based on the Australian Centre for Ecological and Synthesis expert workshop information (McAlpine, Lunney et al., 2015)(McAlpine et al., 2015)(McAlpine, Lunney et al., 2015) (taken from McAlpine et al., 2015)

IDENTIFYING KOALA POPULATIONS

Literature indicates that different Koala populations may have different habitat requirements and different threats, and therefore appropriate management of Koalas must be targeted to the specific needs of each population (McAlpine, Rhodes et al., 2008). To effectively conserve Koalas within and near the proposed nominated areas, identification and delineation of the characteristics and distributions of local Koala populations is essential.

Koalas are known to exist in the region surrounding Sydney, in wooded areas to the west and south of the main urban areas. Delineation of Koala populations within these regions was undertaken through examination of five different data sources, including:

- Genetic analyses
- Koala record distribution and landscape analysis
- Koala record tracking
- Koala *Chlamydia* distribution
- Koala population trends

The results of each data source were then compiled and analysed to determine the likely distribution and connectivity of Koala populations. The following provides an overview of the assessment process and findings.

GENETIC ANALYSES

Lee et al. (2010) undertook genetic analysis of Koala populations to the west and south of Sydney, and determined that there were three genetically-separate Koala populations:

- South Sydney - which encompassed an area from Heathcote to the Campbelltown region, and had low genetic diversity which indicated a recent population bottleneck event
- Southern Tablelands - which was abruptly genetically distinct from the Heathcote/Campbelltown population, indicating the presence of barrier/s to gene flow between the populations despite physical proximity. The nature of genetic differentiation between the two populations was such that it was likely that any barriers to gene flow between these populations were a recent, not historic, landscape feature. Note that Lee et al. (2010) does not provide detailed information on the sampling point locations used to identify the Southern Tablelands population, and therefore it is unknown whether this population incorporates Koalas from the Southern Highlands or not
- Blue Mountains - which was genetically distinct from both the South Sydney and Southern Tablelands population, and had comparatively higher genetic diversity

Kjeldsen et al. (2019) undertook further genetic analyses on a wide range of Koala populations, including the Blue Mountains, Campbelltown and Southern Highlands Koala populations. Results of this study indicated that:

- Genetic admixture is occurring between the Campbelltown and Southern Highlands Koala populations. Genetic admixture occurs when previously isolated populations begin interbreeding
- The Blue Mountains Koala population is one of the most genetically-diverse Koala populations in Australia

KOALA RECORD DISTRIBUTION AND LANDSCAPE ANALYSIS

The NSW BioNet database was accessed on 17 October 2018, to view the distribution of Koala records across Sydney and the wider region. The data was also cleaned or subject to expert review to ensure all data points were valid. The results are shown in Map 37. Note that a high density of sightings does not necessarily indicate a high density of Koalas yet may instead be indicative of areas where high human presence and activity leads to increased chances of wildlife sightings.

Map 37 indicates a largely continuous presence of Koalas, from north of Campbelltown through to the Southern Highlands. The continuity of Koala records suggests that Koalas are present throughout this region, and therefore there is a high likelihood that Koalas within the Campbelltown locality would be connected to Koalas within the Southern Highlands and beyond. It is further noted that there is an absence of any significant landscape features (e.g. large waterbodies, urban areas, major roads with wildlife fencing) between the Campbelltown locality and the Southern Highlands which would have the capacity to entirely block Koala movements between the two areas.

There are known Koala records in the Blue Mountains, particularly in the locality of Kurrajong. There are very few records of Koalas in the region between the Blue Mountains and the Campbelltown/Southern Highlands region, suggesting that there may not be large populations of Koalas within these areas. Therefore, it is likely that the Blue Mountains Koalas and the Koalas within the Campbelltown/Southern Highlands localities comprise separate populations.

KOALA TRACKING RESEARCH

Recent research has been conducted through the Saving Our Species program administered by OEH. As part of this research, Koalas have been tracked from Appin through to bushland south of Picton Road (Saving Our Species, 2019). These tracking records indicate that Koalas are able to successfully cross Appin Road and Picton Road, and therefore that the Campbelltown Koalas (to the north of Appin Road) and the Southern Highlands Koalas (to the south of Picton Road) currently have some degree of contact with each other through migration (Saving Our Species, 2019).

KOALA CHLAMYDIA DISTRIBUTION

Chlamydia is a genus of bacteria from the family *Chlamydiaceae*. Infection of Koalas with *Chlamydia* can lead to the development of a range of illnesses such as conjunctivitis, genital tract infection and urinary tract infection (Jackson, White et al., 1999). The range of illnesses caused by infection with *Chlamydia* is collectively referred to as Chlamydiosis. It is noted that a Koala which is infected with *Chlamydia* does not always present clinical symptoms of disease.

There are multiple species of *Chlamydia*, of which two are known to infect Koala populations within Australia (Jackson, White et al., 1999). The first of these is *C. pseumoniae*, whilst the second is *C. pecorum* (Jackson, White et al., 1999). Of these two species, *C. pecorum* is more pathogenic, as (Jackson, White et al., 1999):

- Infection with *C. pecorum* is more likely to result in clinical expression of disease
- When clinical expression occurs, *C. pecorum* is more likely to result in severe disease symptoms than *C. pseumoniae*

The Koalas within the Campbelltown locality are recognised as being important for conservation purposes as the Koalas are free of *Chlamydia* (Western Sydney University, 2017). It is likely that (to date) the population has been protected from contracting *Chlamydia* due to isolation from neighbouring populations (Western Sydney University, 2017).

Recent research has been undertaken through the Saving Our Species program to test for the presence of *Chlamydia* and Chlamydiosis within Koalas in the Campbelltown, Wollondilly and Southern Highlands localities using genetic analysis (Saving Our Species, 2019). Results of this research are as follows (Saving Our Species, 2019):

- Koalas within the Southern Highlands are infected with *C. pecorum*, and display clinical symptoms of the disease Chlamydiosis
- Koalas within the Wollondilly locality are infected with *C. pecorum*, yet do not display clinical symptoms of the disease
- Koalas within the Campbelltown locality (within the area bounded by Appin Road to the south and to the west) are not infected with *Chlamydia*

KOALA POPULATION TRENDS

There is a long history of Koala occupation within the Campbelltown locality (Western Sydney University, 2017). The Koala population is known to be recovering from a near extinction event, which may have been caused by hunting pressures associated with the fur trade, a severe outbreak of disease in the 1920s, or some combination of the two (Lee, Zenger et al., 2010). For a number of years, Koalas were extremely rare in the locality, with very few records occurring prior to the 1980's (Biolink, 2016).

Research undertaken by Biolink (2016) and Biolink (2018b) within the Campbelltown City Council Local Government Area has indicated that the Koala population is currently recovering, a trend which is evidenced through increases in the area of habitat utilised by Koalas on an ongoing basis.

There is also evidence that Koalas within the Southern Highlands underwent a near extinction event in the early 1920's, with reliable sightings of Koalas only reoccurring from the 1970's onwards. The population is since thought to have continued its recovery trend, based on historic reports and contemporary reports of increases in sightings, contemporary increases in roadkill occurrences, and from the results of spotlighting surveys conducted in the region (Saving Our Species, 2019; Tilley & Uebel, 1990).

RESULTS AND DELINEATION OF KOALA POPULATIONS WITHIN THE SYDNEY REGION

Genetic analyses have consistently identified the Blue Mountains Koalas as being genetically distinct from the Koala populations within the Southern Tablelands/Southern Highlands/Campbelltown localities (Kjeldsen, Raadsma et al., 2019; Lee, Zenger et al., 2010). Therefore, it is considered that the Blue Mountains Koalas belong to a different ecological population to the Koalas within Southern Tablelands/Southern Highlands/Campbelltown localities. Whilst there may be some degree of dispersal of Koalas between these two areas, the rate of dispersal is likely to be low. The Blue Mountains Koala population is recognised to be an important population for conservation due to its unusually high genetic diversity (Kjeldsen, Raadsma et al., 2019).

Delineation of populations within the Southern Tablelands/Southern Highlands/Campbelltown localities is more complicated. Genetic analysis indicates the following sequence of events has occurred for Koalas within these regions:

- The Koala populations would have originally been well connected (prior to European arrival) (Lee, Zenger et al., 2010)
- There had been a recent (post-European) introduction of some form of barrier which prevented gene flow between the Koalas in the Southern Tablelands and the Koalas in the Campbelltown locality, resulting in genetic differences between these two populations (Lee, Zenger et al., 2010)
- Even more recently, the Koalas within the Southern Highlands and the Campbelltown locality have begun to show signs of genetic mixing again, indicating that these populations are once again connected (Kjeldsen, Raadsma et al., 2019)

The landscape between the Campbelltown and Southern Highlands Koalas consists of largely continuous bushland intersected by several roads with moderate to high traffic densities (Picton Road and Appin Road). It is known that Koalas are able to successfully cross both of these roads. Therefore, there is an apparent absence of any significant landscape barrier which would effectively separate Campbelltown and Southern Highlands Koalas.

It is known that Koalas within the Campbelltown and Southern Highlands localities have previously undergone significant population decline, yet it is understood that both populations are currently in recovery. It is therefore hypothesised that the two Koala populations became separated as a result of contractions in Koala habitat occupancy, and that recent re-connection of the two Koala populations has occurred as a result of the recovery of both populations.

The historical and current distribution of *Chlamydia* supports this hypothesis. The Campbelltown Koala population has long been recognised as being *Chlamydia*-free, a feature which is likely to be the result of the isolation of the Campbelltown Koalas from neighbouring Koala populations (Western Sydney University, 2017). However, recent research has found the presence of *Chlamydia* as far north as Appin, indicating that the infection may be spreading further north into areas which had previously been *Chlamydia*-free (Saving Our Species, 2019).

The results of this analysis have therefore identified two Koala populations for the purposes of assessment within the vicinity of the proposed nominated areas. These populations are identified as:

- Southern Sydney Koala population – this refers to Koalas within the vicinity of Wilton and GMAC, and includes Koalas from the Campbelltown/Wollondilly/Southern Highlands localities
- Blue Mountains Koala population – this refers to Koalas within the vicinity of the Blue Mountains, which is the closest Koala population to the WSA and GPEC

The following sections provide an overview of the characteristics of each population.

SOUTHERN SYDNEY KOALA POPULATION

DELINEATION OF STUDY AREA

As discussed above, the ecological boundaries of Koala populations in the vicinity of Wilton and GMAC are unclear. It is possible that all Koalas within this vicinity are increasingly becoming connected into one large population, which extends north and south beyond the potential areas of impact associated with the proposed development.

Therefore, the study area for this population has been confined to areas of Koala habitat within proximity to the nominated areas, which have potential to be either directly or indirectly impacted by the proposed development.

HABITAT PREFERENCES AND USAGE

The Southern Sydney Koala population exhibits a well-documented preference for vegetation growing on Wianamatta shale soils over Hawkesbury sandstone soils, as a result of the higher nutrient content of shales (OEH, 2018b; Phillips & Callaghan, 2000; Ward, 2002). Ward (2002) found that Koalas were in better condition and bred more successfully on Wianamatta shale soils, while OEH (OEH, 2018b) found a higher density of preferred tree species, and a higher density of observed Koalas, on Wianamatta shale soils. However, Koalas are still known to utilise Hawkesbury sandstone habitats, and can successfully breed in these habitats (Ward, 2002). It is noted that there are few Koala records from Narrabeen shales in the region (Ward, 2002), but this is a very infrequent substrate in the region and mostly found deep in the inaccessible and flooded gorges.

A number of studies have aimed to identify preferred habitat tree species utilised by the Southern Sydney Koala population, the results of which are shown in Table B-2. Koalas have also exhibited preference for trees with greater diameter at breast height (DBH) (Phillips & Callaghan, 2000; Ward, 2002).

Table B-2: Tree species preferred by the Southern Sydney Koala population

Source	Preferred Tree Species
(OEH, 2018b)	*Eucalyptus punctata, E. globoidea, E. pilularis, E. longifolia, E. tereticornis, E. paniculata, Acacia decurrens*
(Ward, 2002)	*Eucalyptus punctata, E. globoidea, E. pilularis, E. agglomerata, E. capitellata, E. eugenioides, E. piperita, Syncarpia glomulifera**
(Sluiter, Close et al., 2002)	*Eucalyptus punctata, E. agglomerata, Corymbia gummifera*
(Phillips & Callaghan, 2000)	*Eucalyptus punctata**, E. agglomerata***

* Shelter tree.

** Preferences only exhibited when tree growing on shale soil.

Of all of the identified preferred habitat trees, grey gum (*Eucalyptus punctata*) is the only species which is consistent across each study. Further, *E. punctata* was identified as a preferred habitat tree for every tracked Koala within the study conducted by (OEH, 2018b), whereas other species were not consistently identified as a preference by all Koalas. Analysis of Koala faecal pellets also indicated that *E. punctata* accounted for a major proportion of Koala diet for three Koalas in the Campbelltown locality, with *E. punctata* accounting for between 66-92 per cent of leaf cuticle fragments in faecal matter (Sluiter, Close et al., 2002).

However, Koala habitat usage patterns are not solely determined by tree species and soil type, but also by a wide range of factors including Koala social interactions and age, in addition to temporal (e.g. seasonal) influences on tree nutritional values (Ellis, Melzer et al., 2009; Ramsay, 1999). For example, Ramsay (1999) found that juvenile Koalas at Nowendoc exhibited different tree preferences to their mothers and that there were seasonal effects upon tree nutrient and anti-nutrient contents, whilst Ellis et al. (2009) found that Koalas rarely re-use the same tree twice or share trees used by other Koalas and that social interactions play a significant role in influencing Koala habitat usage. Therefore, the observed variations in preferred tree species utilised by Koalas may be the result of differences in the wider range of factors which influence tree selection.

HABITAT DISTRIBUTION AND CONNECTIVITY

A range of assessments have been undertaken to assess the key characteristics, quality, distribution and connectivity of Koala habitat within the Plan Area. These assessments include:

- **Species-distribution model:** This provides information on habitat availability and distribution across the Cumberland subregion
- **Corridor habitat happing:** This provides information on habitat availability, distribution, characteristics and connectivity within and near to the four
- **GAPCLoSR:** This is a GIS-based analysis which provides information on habitat connectivity
- **Habitat critical to the survival of the species:** This provides information on the availability and distribution of habitat critical to the survival of the Koala, in accordance with the EPBC referral guidelines

Details of the methods for each assessment is provided in Attachment C.

KOALA HOME RANGE AND DENSITY ESTIMATES

A number of studies have sought to identify the densities and home range sizes of Koalas within the Southern Sydney population (see Table B-3).

Table B-3: Densities and ranges of Koalas within the Southern Sydney Koala population

Source	Koala Density (Koalas/ha)	Female Range (ha)	Male Range (ha)
(OEH, 2018b)	0.078 (within high quality habitat)	Average: 38 n = 3	Average: 114 n=8
	0.017 (within non high-quality habitat)		
	0.052 (overall average across full study area)		
(Ward, 2002)	0.035 ± 0.087 (using a transect method)	MCP* Range^: 28 - 129 MCP Midpoint: 79 90% Harmonic Mean** Range: 12 - 62 90% Harmonic Mean Midpoint: 37 60% Harmonic Mean Range: 5 - 25 60% Harmonic Mean Midpoint: 15 n = 6. It is noted that only 3 female adult Koalas had sufficient fixes to reach the asymptote in home range size.	MCP Range^: 38 - 387 MCP Midpoint: 213 90% Harmonic Mean Range: 12 - 165 90% Harmonic Mean Midpoint: 88.5 60% Harmonic Mean Range: 6 - 72 60% Harmonic Mean Midpoint: 39 n = 5. It is noted that no male adult Koalas had sufficient fixes to reach the asymptote in home range size.
	0.049 (using a home range method)		

^ Range data refers to adult ranges only (females ≥ 3 years old, males ≥ 4 years old) and has been rounded to the nearest hectare.

* Minimum Convex Polygon refers to the maximum area in which the Koala is observed and includes areas which are rarely used by the Koala.

** Harmonic Mean calculates the probability of the Koala being present within a given area. Therefore, the 90 per cent Harmonic Mean provides the range of the Koala within which the animal is present 90 per cent of the time, whilst the 60 per cent Harmonic Mean provides the range of the Koala within which the animal is present 60 per cent of the time.

KOALA POPULATION SIZE ESTIMATES

The assessment area examined within this report is similar in size and distribution to the study area examined in OEH (2018b).

In their assessment, OEH (2018b) calculated the potential population size of Koalas within the assessment area via the following method:

Koala Population Size = Koala Density (Koalas/ha) x Area of Available Habitat (ha)

Given an average recorded density of 0.052 Koalas/ha and a mapped habitat area of 8,293 ha within their assessment area, OEH (2018b) calculated that there was a potential Koala population size of up to 433 Koalas. This is a useful approximation for use in this assessment.

It is noted that calculating the potential size of the Koala population through extrapolation from observed Koala densities and mapped areas of Koala habitat relies upon the following assumptions:

- The reported density of Koalas in each habitat type is accurate (the accuracy of measurements for this parameter have potential to be influenced by field survey techniques, survey timing, survey longevity and sample size)
- All areas of available Koala habitat are occupied by Koalas
- The observed densities of Koalas within each habitat type are in equilibrium (i.e. the population is neither increasing nor decreasing in density)

The size of the Koala population estimated by OEH (2018b) is therefore subject to some degree of uncertainty.

KOALA POPULATION TRENDS

As discussed above, the Koala populations within the Campbelltown and Southern Highlands localities are thought to be expanding (Biolink, 2016, 2018b; Saving Our Species, 2019; Tilley & Uebel, 1990).

Within the Campbelltown locality specifically, is noted that part of the Koala habitat expansion has occurred through Koalas inhabiting areas further to the west, towards and across Appin Road (Biolink, 2018b). Recent survey work conducted by Biolink (2017) confirmed the presence of Koalas along the Nepean River, and found that the Campbelltown Koalas are in contact with the Nepean Koalas. It may be that the increasing westward trend in habitat occupancy of the Campbelltown Koalas may either indicate, or be the result of, strengthened connections with the Nepean Koalas.

POPULATION GENETIC DIVERSITY AND RESILIENCE

Low genetic diversity of a population has the potential to decrease the resilience of the population, through increasing risks associated with factors such as:

- Decreased biological fitness of individual Koalas as a result of inbreeding (known as inbreeding depression)
- Increased vulnerability to environmental change
- Increased vulnerability to threats such as disease

Genetic diversity is measured here as the effective population size (Ne), which is a calculated metric reflecting the population's genetic characteristics. Note that effective population size is distinct from the census population size (Nc), which refers to the total number of Koalas within the population. Available literature in population genetics suggests that an effective population size of between 50 and 100 is typically recommended as an estimate of required genetic diversity to ensure population viability, although it is recognised that such estimates are generalised metrics which may not be applicable for all species (Frankham, Bradshaw et al., 2014).

It is noted that Koalas are thought to have had low genetic diversity prior to European arrival (Tsangaras, Avila-Arcos et al., 2012), indicating that low genetic diversity may be a normal feature of healthy Koala populations. It is further recognised that some of the most successful Koala populations within Australia (which have such large population sizes that they are subject to managed population reduction measures) have very low genetic diversity as a result of strong historic population bottleneck events (McAlpine, Lunney et al., 2015). Therefore, it may be that Koalas have some degree of resilience to low rates of genetic diversity.

Lee et al. (2010) found that the Southern Sydney Koala population had an effective population size of Ne = 16-21, which indicates that the population had a very low genetic diversity and has been subject to a recent population bottleneck event. More recent analysis conducted by Kjeldsen et al. (2019) indicates that genetic mixing has recently begun to occur between Koalas in the Campbelltown and Southern Highlands localities, which would be contributing to increasing the genetic diversity within each of these populations.

Overall, it is noted that Koalas within the Campbelltown and Southern Highlands localities are currently experiencing population expansion (Biolink, 2018b; Saving Our Species, 2019), despite low genetic diversity.

Therefore, whilst it is recognised that the Koalas of Southern Sydney have low genetic diversity, it is considered that this feature of the population is unlikely to pose a significant threat to the population's ongoing recovery, and that other threats (such as habitat loss, disease, vehicle strikes and dog predation) are likely to pose more significant challenges to the population.

EXISTING KEY THREATS TO SOUTHERN SYDNEY KOALA POPULATION

Currently, the key threats to the Southern Sydney Koala population (based on documented threats to the population within the Campbelltown locality) include (Phillips & Biolink, 2016):

- Vehicle strike
- Wildfire
- Dog predation
- Habitat loss

The rates and distribution of Koala roadkill events have been analysed through an examination of available roadkill records within BioNet (as at October 2018). The distribution of roadkill records in the vicinity of Wilton and GMAC are shown in Map 41. It is noted that the true number of roadkill Koalas is likely to be greater than the number of records, as not all roadkill occurrences would necessarily be recorded. Therefore, the true number and rate of Koala roadkill occurrences is unknown. However, the records nonetheless provide insight into trends in the rate and distribution of roadkill events in the locality.

Vehicle strikes of Koalas are becoming more common within the Campbelltown and Wollondilly LGAs. The increasing rates of vehicle strike are correlated with a rapid increase in traffic density within the locality, particularly on Picton Road and Appin Road (OEH, 2018b). The increasing trend in traffic density, and corresponding increase in Koala mortality rates, is likely to continue with further development without the implementation of appropriate mitigation measures (OEH, 2018b).

Further, a number of roadkill hotspots have been identified, where a hotspot is defined as a location with greater than four roadkill Koalas within a 2 km stretch of road (OEH, 2018b). Roadkill hotspots tend to occur where a major road intersects a primary Koala corridor, often near the headwaters of a watercourse. Roadkill hotspots are known to occur at the following locations (OEH, 2018b):

- Picton Road between Cordeaux Dam and Wilton
- Macarthur Drive
- Eastern end of Wilton Road
- Appin Road between Appin and Campbelltown
- Hume Highway at the Bargo exit

The rates of Koala mortalities from the remaining key threats to the population (wildfires, dog predation and habitat loss) are currently unknown. Estimating the severity of these threats is difficult, such threats are typically not highly visible (e.g. dog attack from roaming dogs in bushland) and operate over long timescales (e.g. habitat loss) or in a stochastic manner (e.g. bushfires). It is therefore difficult to identify the prevalence and severity of each threat to the viability of the population as a whole, and subsequently it is difficult to determine how investment in conservation funding to address each threat should be prioritised.

Nonetheless, it is noted that Rhodes et al. (2011) found that, where multiple threats are present in a Koala population, addressing only a single threat is unlikely to achieve the desired result of protecting a Koala population from decline. Therefore, Rhodes et al. (2011) recommend implementation of a range of strategies to target and reduce multiple threats, as focusing on a single, key threat is unlikely to be effective.

BLUE MOUNTAINS KOALA POPULATION

This section provides an overview of the Blue Mountains Koala population, which is the closest Koala population to GPEC and WSA, and the source population for dispersing Koalas which may enter the nominated areas.

HABITAT AVAILABLE WITHIN GPEC AND WSA

An assessment of Koala habitat availability and quality within GPEC and WSA has been conducted through analysis of the following landscape features:

- Habitat mapping
- Consideration of threatening processes
- Consideration of distribution of Koala records

Each of these matters is considered in detail below.

HABITAT MAPPING WITHIN GPEC AND WSA

Three methods of mapping have been conducted to determine the availability and importance of Koala habitat within the GPEC and WSA.

The first method, known as a Species Distribution Model (SDM), did not find any areas of potential Koala habitat within either the GPEC or WSA. The results of the SDM mapping are presented in Map 37.

The second method, known as corridor mapping, found only scattered areas of supporting Koala habitat within the nominated areas. The results of the corridor mapping are presented in Map 38 and Map 39.

The third method, known as habitat critical to the survival mapping, did not map any habitat critical in the nominated areas.

Overall, none of the mapping methods identified the presence of important habitat within either nominated area. Further detail regarding the methodology for preparing the above mapping methods is presented in Attachment C.

CONSIDERATION OF THREATENING PROCESSES

GPEC already contains large areas of existing urban development. Urban environments pose significant threats to Koalas, through factors including high road and traffic densities, high densities of predators such as domestic dogs, landscape hazards such as swimming pools and barriers to movement such as fences.

Whilst Koalas may occasionally occur within areas of vegetation within GPEC, it is considered unlikely that a breeding and persisting population of Koalas would be able to permanently reside in habitat within GPEC, as it is considered likely that the mortality rates of Koalas due to the high threat pressures would be greater than the breeding rate. Therefore, it is probable that habitat currently available within GPEC constitutes 'sink habitat'.

WSA does not currently have such a high density of urban development, and therefore is less likely to have threat densities which are as significant as those in GPEC. However, it is noted that the scarcity of native vegetation within the nominated area would require Koalas to cross large areas of open habitat whilst traversing between vegetation, which would increase the vulnerability of Koalas to threats such as predation by dogs.

Overall, it is considered that significant threat pressures would be present within both nominated areas.

CONSIDERATION OF KOALA RECORD DISTRIBUTION

The BioNet record database has been examined to determine the likelihood that Koalas are present within GPEC and WSA. It is noted that there are high human population densities in both areas, particularly within GPEC, and therefore an absence of records would be likely to accurately reflect an absence of Koalas (as opposed to an absence of surveys).

There are no records of Koalas within WSA Area, and only one Koala record within GPEC which is dated from 1990 in Blackett. A small number of Koala records also occur in semi-rural localities to the north of GPEC, as follows:

- One record is dated from 1984 in the Londonderry locality
- One record is dated from 2006 and located in the Metro offset site near Colebee
- Two records are dated from 2018 and located to the west of Shanes Park

Further Koala records are located to the west of the two , within and in proximity to areas of remnant vegetation associated with the eastern boundary of the Blue Mountains.

Whilst a small number of Koala records occur within and in the vicinity of the GPEC and WSA, the scarcity of these records, and the length of time between sightings, suggests that Koalas are extremely rare within the locality, and that it is very unlikely that there is a persistent population in the locality. Instead, it is more likely that Koala sightings within these localities are of dispersing individuals travelling between areas of more suitable habitat.

*S*ummary

Koala habitat mapping, consideration of threatening processes and Koala BioNet records all suggest that:

- It is very unlikely that suitable Koala habitat is present within either GPEC or WSA
- It is likely that any Koalas which are present within the two are dispersing between areas of more suitable habitat

It is therefore considered that any Koalas within the GPEC or WSA would likely constitute individuals which have dispersed from the Blue Mountains Koala population, as this is the closest habitat area which is known to support a self-sustaining and expanding population from which Koalas are known to disperse.

OVERVIEW OF THE BLUE MOUNTAINS KOALA POPULATION

Compared to the Southern Sydney Koala population, comparatively little is known about the Blue Mountains Koala population. The majority of research in this area has been conducted through the 'Blue Mountains Koala Project', which is run by the non-profit conservation organisation Science for Wildlife (Leigh, pers. comm. 2019).

Research to date has largely focused on Koalas at two sites, around the Kurrajong/Richmond/Wollemi National Park region, and the Kanangra-Boyd/Hartley region, which has contributed to establishing a baseline understanding of the Koala populations in these areas (Leigh, pers. comm.) Preliminary surveys and opportunistic studies have recently been initiated by the 'Blue Mountains Koala Project' in areas between Yarramundi in the north and the Southern Highlands in the south, an area which currently has almost no available data on the presence or characteristics of Koala populations (Leigh, pers. comm. 2019). More intensive research was scheduled to start in late 2018 and data to date includes recent sightings of at least two Koalas in Mulgoa/Silverdale and several in the Lower Blue Mountains as far east as Glenbrook (Leigh, pers. comm. 2019).

Research to date has established the following characteristics of Koalas in the Blue Mountains:

- The Blue Mountains Koala population is important for conservation purposes as it has the highest recorded levels of genetic diversity of any Koala population in Australia (Kjeldsen, Raadsma et al., 2019)
- The Blue Mountains are likely to be an important refuge for Koalas under climate change, and research is still underway to assess how many Koalas occupy the protected area versus the urban fringe or use only developed land. There is potential for anthropogenic threats in developed areas to impact the viability of the Koala population/s in the protected area network.
- Increased sightings of Koalas in semi-rural and urban areas near the Blue Mountains indicate that the Koala population of the Blue Mountains (from the north of Kurrajong through to the Southern Highlands) is currently expanding, with greater number of dispersing Koalas being observed over time (Leigh, pers. comm. 2019). This is also linked with the fact that the Cumberland subregion supports richer soils and vegetation types that are likely to attract Koalas moving from the protected area.
- Koalas are able to disperse long distances. For example, one young male Koala was tracked from Mulgoa (near Penrith), down to the locality near Picton (a distance of over 30 km) (Leigh, pers. comm. 2019)
- The Koalas within the Kurrajong/Richmond/Wollemi locality may have a *Chlamydia* infection rate of up to 30 per cent. Despite this, the population is currently expanding (Leigh, pers. comm.)

As discussed previously, the 2019-20 bushfires affected significant areas of the Blue Mountains. The long-term implications for the Koala population are not currently known, but it can be presumed that the fires had a significant negative impact.

C. Koala habitat mapping and connectivity analysis

INTRODUCTION

Three forms of Koala habitat mapping were undertaken for this project. They include:

- A species distribution model (SDM) for the species across the Cumberland subregion
- Corridor habitat mapping
- Mapping of habitat critical to the survival of the species

In addition, a connectivity analysis was undertaken for part of the Southern Sydney population.

This attachment provides an overview of the methodology of each form of mapping and analysis.

SPECIES DISTRIBUTION MODEL FOR THE CUMBERLAND SUBREGION

RMIT University was engaged to prepare SDMs for a total of nineteen EPBC listed species found within the Cumberland subregion (see Supporting Document G). As part of this assessment, an SDM was prepared for Koalas.

The overall purpose of preparing the SDMs was to (Gordon & Koshkina, 2018):

- Provide context for detailed environmental impact analysis being undertaken within the nominated areas, such as through providing information about the relative importance of different areas of habitat within each nominated area compared to the rest of the subregion
- Assist in evaluating commitments by providing indicative information about the amount of habitat available for biodiversity offsetting
- Enable indicative impact assessment of transport corridors

The SDM for Koalas was prepared through the following process (Gordon & Koshkina, 2018):

1. Species records for Koalas within the Cumberland subregion were sourced from BioNet and examined. The following records were removed:
    - Erroneous/inaccurate records
    - Records which were *not* associated with native vegetation were also removed, as records outside of native vegetation were taken to represent dispersing male Koalas outside of regular habitat areas following the breeding season, or of records of areas that previously supported vegetation that is no longer there
2. A range of environmental parameters associated with Koala records were tested for their capacity to predict Koala occurrence across the subregion. The parameters which were selected for use in the SDM were those which:
    - Performed well in predicting Koala occurrence
    - Did not increase the risk of introducing bias into the model
3. The selected environmental parameters, in addition to Koala records, were used as inputs to generate three different SDMs. Each SDM adopted a different modelling methodology which accounted for different types of bias which were likely to be present within the input data
4. The outputs of each SDM were correlated, and a final SDM map was produced with the following categories:
    - 'Unlikely to occur' – Locations where none of the SDM models showed the species occurring
    - 'Potential to occur' – Locations where at least one of the SDM models showed the species occurring. These areas are the most appropriate for assessing potential impacts on the target species
    - 'Likely to occur' – Locations where all three of the SDM models showed the species occurring. These areas are the most appropriate for targeting conservation actions such as offsetting

The results of the SDM mapping are indicated in Map 37. Results show the presence of higher quality ('likely to occur') Koala habitat in the south of the Cumberland Plain, with small areas of lower quality habitat ('potential to occur') occurring elsewhere in the subregion (predominantly to the north-west and west). Overall, results indicate that there is likely to be very little Koala habitat available within the Cumberland subregion.

Despite there being few Koala records within the Cumberland subregion, it is recognised that there is an abundance of Koala records in close proximity to the boundaries of the Cumberland subregion. For instance, Gordon & Koshkina (2018) recognise that there are over 2,700 records of Koalas within a 10 km buffer distance of the subregion boundary.

It is important to recognise that the SDM mapping only shows areas where Koalas are likely to be present based on environmental predictors. This mapping does not take into account other key considerations, such as connectivity, habitat quality, minimum habitat patch sizes for population viability or presence of threats. Therefore, the SDM is best interpreted as an indicative map which shows the extent and distribution of potential habitat available within the subregion; it does not necessarily indicate which areas of habitat are the most important locations to conserve a species (Gordon & Koshkina, 2018).

CORRIDOR HABITAT MAPPING

The corridor habitat mapping built on the work of OEH in mapping habitat around Wilton and GMAC (OEH, 2018b). Mapping was undertaken for:

- Wilton Growth Area (Wilton) and Greater Macarthur Growth Area (GMAC)
- Greater Penrith to Eastern Creek Investigation Area (GPEC) and Western Sydney Aerotropolis (WSA)

MAPPING METHOD FOR WILTON AND GMAC

The mapping method for Wilton and GMAC is driven by the "long-established relationship between the presence of Koalas and vegetation that grow on higher fertility soils such as shale or shale-transition soils" (OEH, 2018b).

There are five steps in the mapping method:

1. Map Koala habitat
2. Identify principal and supporting habitat
3. Identify movement corridors
4. Categorise corridors into primary, secondary and tertiary
5. Define important habitat

Spatial scope of the mapping

The spatial scope of the mapping for Wilton and GMAC was:

- The two nominated areas
- Connected habitat between them
- Habitat to the east to the edge of the Strategic Assessment Area
- West to Bargo

Step 1: Map Koala habitat

Using Plant Community Types (PCTs) (see Table C-1), Koala habitat was mapped into three categories (Table 1):

- High quality habitat (HQH) = all shale and shale-enriched vegetation types with a dominant eucalypt canopy
- Moderate quality habitat (MQH) = Eucalypt-dominated riparian sandstone communities, rainforest communities on shale with some eucalypts present, and regenerating *Acacia* scrubs on shale. **NB:** based on the vegetation within Wilton and GMAC and the surrounding land in the Plan Area there are no PCTs that meet this definition of moderate quality
- Low quality habitat (LQH) = Low-fertility sandstone vegetation communities including heaths, heathy woodlands, swamps, and rocky woodlands

Table C-1: PCTs and Koala habitat in Wilton and GMAC

PCT	HQH	MQH	LQH
724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Y		

PCT	HQH	MQH	LQH
725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Y		
830 - Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Y		
835 - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Y		
849 - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Y		
850 - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Y		
1081 - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion.	Y		
1181 - Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Y		
1395 - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.	Y		
1292 - Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion			Y
883 - Hard- leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion			Y
1800 - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley			Y

STEP 2: IDENTIFY PRINCIPAL AND SUPPORTING KOALA HABITAT

Principal habitat is defined as HQH patches greater than 100 ha that contain Koala records.

The remainder of habitat is defined as "supporting".

STEP 3: IDENTIFY MOVEMENT CORRIDORS

Movement corridors include:

- All principal habitat except for those patches of principal habitat that are separated by more than 1 km
- Smaller patches of HQH within 100 m of patches of principal habitat in corridors
- Patches of MQH or LQH that connect patches of principal habitat within corridors or are entirely within principal habitat in corridors
- Scattered trees where they are completely or largely contained within corridors

Movement corridors exclude:

- Patches of principal habitat that are separated by more than 1 km
- Patches of MQH or LQH peripheral to corridors
- Scattered trees peripheral to corridors

Step 4: Categorise corridors into primary, secondary and tertiary

Primary corridors are identified as:

- Movement corridors that include patches of principal habitat which are contiguous (gaps between trees <100 m) and together contain greater than 380 ha

Secondary corridors are identified as:

- Movement corridors that include patches of principal habitat separated by more than 100 m from scattered trees or other principal habitat
- Are narrow or have pinch points of less than 50 m wide
- Together contain between 100 ha and 380 ha of principal habitat
- Otherwise, if containing greater than 380 ha of habitat or are not narrow, secondary corridors are those that do not connect to primary corridors on both ends

Tertiary corridors are identified as:

- Patches of principal habitat not linked to primary corridors
- Together contain between 30 ha and 100 ha of principal habitat
- Do not connect to other corridors on both ends
- Otherwise, if containing greater than 100 ha of habitat, tertiary corridors are those that lead away from other corridors

Step 5: Define important habitat

Important habitat comprises the species polygons for Koala. It is made up of primary and secondary corridors.

MAPPING METHOD FOR GPEC AND WSA

The Koala habitat mapping method for GPEC and WSA is based on the same concepts used for Wilton and GMAC. However, the same quantitative thresholds used for Wilton and GMAC are not transferrable to other areas. For this reason, habitat quality, and area thresholds for Koala habitat and corridors are not defined, nor any buffer areas.

This method of mapping is only indicative in identifying areas that could potentially be utilised by Koalas.

There are four steps:

1. Map Koala habitat
2. Identify principal and supporting habitat
3. Identify potential movement corridors
4. Categorise potential corridors into primary, secondary and tertiary
5. Define important habitat

Spatial scope of the mapping

The spatial scope of the mapping for this method included the GPEC and WSA boundaries.

Step 1: Map Koala habitat

Koala habitat is identified as PCTs (excluding derived grasslands and urban native condition classes) that contain preferred Koala feed trees (see Table C-2) (DECC 2008; Environment Protection Authority 2016).

Table C-2: PCTs - Potential Koala habitat GPEC, WSA and buffer area

PCT No.	PCT Name	Type of feed tree (DECC 2008)
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Primary

PCT No.	PCT Name	Type of feed tree (DECC 2008)
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Primary
830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Primary
835	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Primary
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Primary
850	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Primary
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion	Primary
941	Mountain Blue Gum - Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion	Supplementary
1067	Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	Primary
1081	Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion	Secondary
1083	Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion	Supplementary
1181	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion	Secondary
1281	Turpentine - Grey Ironbark open forest on shale in the lower Blue Mountains, Sydney Basin Bioregion	Secondary
1319	White Stringybark - Grey Gum grassy forest on shale caps of the Woronora Plateau, Sydney Basin Bioregion	Secondary
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Secondary
1787	Red Bloodwood - Scribbly Gum - Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus	Secondary
1789	Smooth-barked Apple - Blackbutt - Red Bloodwood open forest in enriched sandstone gullies of the western Woronora plateau	Secondary
1790	Red Bloodwood - Grey Gum - Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	Secondary
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Primary
1841	Smooth-barked Apple - Turpentine - Blackbutt tall open forest on enriched sandstone slopes and gullies of the Sydney region	Primary

STEP 2: IDENTIFY PRINCIPAL AND SUPPORTING KOALA HABITAT

Principal habitat is defined as potential habitat (above) that contains Koala records.

The remainder of habitat is defined as “supporting”. PCTs representative of supporting habitat are not listed in this document.

STEP 3: IDENTIFY POTENTIAL MOVEMENT CORRIDORS

Potential movement corridors include all identified Koala habitat, except for those patches that are separated by more than 1 km.

STEP 4: CATEGORISE CORRIDORS INTO PRIMARY, SECONDARY AND TERTIARY

Primary corridors are identified as:

- Patches of principal habitat which are contiguous (gaps between trees <100 m).

Secondary corridors are identified as:

- Patches of principal habitat separated by more than 100 m from other habitat.
- Are narrow or have pinch points of less than 50 m wide.
- Patches of principal habitat that do not connect to primary corridors on both ends.

Tertiary corridors are identified as:

- Patches of principal habitat not linked to primary corridors.
- Do not connect to other corridors on both ends.

STEP 5: DEFINE IMPORTANT HABITAT

Important habitat comprises the species polygons for Koala. It is made up of primary and secondary corridors.

HABITAT CONNECTIVITY MAPPING – GAPCLOSR

Mapping of habitat connectivity was undertaken using a GIS-based spatial analytical framework known as the Generalised Approach to Planning Connectivity at Local and Regional Scales (GAPCLoSR) (Biolink, 2018a). The text below provides a high level summary of that work, and the full report should be read to understand the project.

GAPCLoSR enables examination of issues associated with landscape connectivity and fragmentation. However, it is noted that the model only considers the length and arrangement of dispersal pathways; it does not consider other important factors which impact corridor usage (such as corridor width). The model is therefore useful as a support tool which enables more detailed analysis.

GAPCLoSR takes into account two key factors:

- The ecological needs and movement characteristics of the target species (e.g. the key characteristics of preferred habitat, the distribution and extent of preferred habitat, the greatest distance of open ground which can be crossed by the target species and the total distance which can be moved across the landscape by the species)
- The extent to which the existing landscape enables, influences and/or impedes movement of the target species

The program was used to investigate three different scenarios:

- **Baseline (*status quo*):** This constituted an analysis of the distribution of current habitat patches and connectivity through the Plan Area
- **Scenario 1:** This constituted analysis in which clearing occurred within the urban capable footprint, and where Appin Road was upgraded to a multi-lane dual carriageway with wildlife fencing on the eastern side of the road
- **Scenario 2:** This constituted analysis in which clearing occurred within the urban capable footprint, and where Appin Road was upgraded to a multi-lane dual carriageway with wildlife fencing on the eastern side of the road, with a wildlife crossing in place at the Ousedale-Mallaty corridor

METHODOLOGY

The basic model process involves inputting of key landscape features, determining the capacity for Koala movement across each landscape feature, and then analysing the spatial distribution of the overall landscape to determine the degree of connectivity and fragmentation across the Plan Area.

MAPPING LANDSCAPE FEATURES

Key landscape features within the model included:

- Transport infrastructure (e.g. roads and railway lines)
- Hydrology (drainage lines, canals, etc)
- Vegetation cover (including Preferred Koala Habitat)
- Mining and quarrying
- Agricultural areas (grazing and horticulture)
- Urban, commercial and industrial areas

Preferred Koala Habitat (PKH) was determined through the following process:

1. Vegetation mapping data was sourced from OEH and from publicly available NSW Government databases
2. Vegetation maps were analysed, and the following areas were removed from analysis as being non-suitable for Koala habitat:
    - Cleared areas
    - Highly-disturbed areas
    - Areas of scattered trees
    - Areas where satellite imagery did not match the vegetation type
3. Remaining vegetation layers are all considered to be Preferred Koala Habitat (PKH)
4. Areas of PKH were then classified into different sub-categories based on the availability of Preferred Koala Food Trees[1] (PKFTs). The following classes were made:
    - Primary Koala Habitat – where primary PKFTs comprise the dominant or co-dominant overstory species
    - Secondary Koala Habitat (Class A) – where primary PKFTs are a sub-dominant component of the overstory species
    - Secondary Koala Habitat (Class B) – primary PKFTs are absent, but the vegetation type is dominated by one or more 'secondary' PKFT
    - Secondary Koala Habitat (Class C) – primary PKFTs are absent, but one or more 'secondary' PKFTs are present as a sub-dominant component of the overstory species
    - Other – does not contain PKFT
5. Each vegetation class was then assigned a different movement cost as follows:
    - Where PKH (of any class) is within a 'habitat patch' (i.e. area of habitat >10ha, an area defined by the authors), there are no movement costs
    - When PKH is present as a corridor, Primary Koala Habitat has no movement cost, and Secondary Class Habitat has an increasing scale of movement cost (with the least movement cost for Class A, and the highest movement cost for Class C)

ALLOCATING RESISTANCE VALUES TO LANDSCAPE FEATURES

Each landscape feature was then assigned a Percentage Resistance Value (PRV). This value refers to the effort or cost it takes for a Koala to cross a particular land-use type or class.

The resistance of the Plan Area to Koala movement was then calculated as follows:

1. A rasterised surface was produced from land use layers of the Plan Area
2. Each pixel was then assigned a dispersal cost for Koalas to cross at each point. Dispersal costs were calculated through considering each of the land use layers present for each pixel

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[1] These include the following: *E. moluccana, E. longifolia, E. punctata, E. viminalis, E. tereticornis*

3. In instances where multiple land use layers intersected at a particular point, it was important to define which data layer took precedence over the other. The following outlines the precedence in terms of their cost value:
   a) Connectivity structures spanning roads, train lines and aqueducts
   b) Train lines and aqueducts
   c) Roads
   d) Hydrology
   e) Vegetation cover (including PKH and non-PKH)
   f) Urban / commercial / industrial / agricultural land uses
4. A Gap Crossing Layer of 220 m was applied as a buffer around all vegetation, which was taken to be the maximum distance that a Koala would travel across an open area (based on Euclidian distance of all Koala records within the region from the nearest patch of mapped vegetation).

MAPPING HABITAT CONNECTIVITY

The locations and importance of connectivity corridors through the Plan Area were then modelled as follows:

a) The PRV of each pixel was examined
b) The cumulative PRV cost of any potential pathway between habitat patches was calculated
c) If the cumulative PRV cost of any potential pathway between habitat patches exceeded a threshold value, then a pathway would not be formed

It is noted that this method for identifying connectivity corridors does not rely on the Euclidian distance between habitat patches, but instead considers how hostile the landscape is to movement.

HABITAT CRITICAL TO THE SURVIVAL OF THE SPECIES MAPPING

In order to address the requirements of the EPBC Act referral guidelines for the vulnerable Koala (CoA 2014) a map was prepared to identify habitat critical to the survival of the Koala. This mapping was prepared by adapting the method proposed in Koala Habitat Assessment Tool (KHAT) (Table 4, CoA 2014) for use with the data available within the nominated areas and broader Strategic Assessment Area.

The KHAT scores five attributes related to the quality and extent of Koala habitat, with each attribute scored out of 2. A total score of 10 is possible, and habitat a score of five or greater is habitat critical to the survival of the Koala. The five attributes considered in the KHAT are:

- Koala occurrence
- Vegetation composition
- Habitat connectivity
- Key existing threats
- Recovery value

A number of data sets were compiled for use in the mapping of habitat critical to the survival of the Koala within the Strategic Assessment Area. A method was then prepared based on the KHAT for use in the Strategic Assessment Area.

As a first step the habitat units to be assessed were defined by combining a compilation vegetation data set (Biosis 2019) with the mapping of Koala corridors for this project. These units were then interrogated against a number of different data sets (Step 2 – Step 6) to identify habitat critical to the survival of the Koala. Data sets used to define habitat critical to the survival of the Koala include Koala sighting records (OEH, 2018), Koala corridor mapping, an assessment of connectivity and key existing threats (road kill records (OEH, 2018) and adjacency to urban areas).

The method applied is described in Table C-3.

Table C-3: Method used to map habitat critical to the survival of the Koala within the Strategic Assessment Area

Step	KHAT attribute	Approach	Score allocated	Data used
Step 1	N/A	Habitat units were defined by combining a compilation vegetation data set (Biosis 2019) with the mapping of Koala corridors. Koala corridors were assigned to individual habitat units by Plant Community Type (PCT) and broad vegetation condition (intact, scattered etc). All internal linework between habitat units was dissolved where PCT, condition and corridor rank were identical. In the case of a Koala corridor not being allocated a PCT or condition state due to the land not being identified as native vegetation: Polygons smaller than 0.5 ha were removed from the habitat units layer Polygons >0.5 ha were allocated a PCT of 9999 and a condition of Unknown The habitat units were used as the based layer for the assessment.	N/A	Biosis 2019 - Compilation vegetation data set (100 km buffer from Cumberland subregion). Layer includes Biosis nominated area vegetation mapping, and where this isn't available a compilation of the best available data sets, including: Remnant Vegetation of the western Cumberland subregion, 2013 Update. VIS_ID 4207 The Native Vegetation of the Sydney Metropolitan Area - Version 3.1 (OEH, 2016) VIS_ID 4489 South East Local Land Services Biometric vegetation map, 2014. VIS_ID 4211 Southeast NSW Native Vegetation Classification and Mapping - SCIVI. VIS_ID 2230 Koala corridor mapping
Step 2	Koala occurrence	Koala occurrence was scored based on Koala records recorded within, and adjacent to, the Strategic Assessment Area over a five year period (2014 – 2018). Distance buffers were applied to allocate appropriate scores.	2 - Within 1 km of a record 1 - Within 1-2 km from a record 0 - Beyond 2 km from a record	Koala BioNet species records (OEH, 2018)
Step 3	Vegetation composition	Each habitat unit was allocated a vegetation composition score. The Koala corridors mapped for the Strategic Assessment Area were used as a surrogate for this score.	2 - Primary and secondary corridors 1 - Tertiary corridors 0 - Supporting habitat	Koala corridor mapping

Step	KHAT attribute	Approach	Score allocated	Data used
Step 4	Habitat connectivity	A score for habitat connectivity was calculated for each habitat unit. This was done by, first, calculating the patch size of each habitat unit. Habitat units were considered to be part of the same patch where adjacent or within 100 m of another patch. Patches were then separated where intersected by a major road or rail line as these features are likely to create barriers to the movement of corridors. The roads identified for this analysis include those classified as Arterial, Motorway or Primary Road.	2 - >500 ha of contiguous habitat 1 - 300-500 ha of contiguous habitat 0 - <300ha of contiguous habitat	NSW Spatial Data Services (Six Clip and Ship) (2019) – Railway and Road Segment (where road = Arterial, Motorway or Primary Road)
Step 5	Key existing threats	Key existing threats were assessed, with the lower score taken for each habitat unit. Threat from road kill was determined by calculating the distance from each road kill record to each habitat unit. The threat from existing urban development was determined by calculating the distance from existing urban areas to each habitat unit.	The lowest of: Threat from road kill (road kill records from 2014 - 2018). 2 - >2 km from road kill record 1 - 1-2 km from road kill record 0 - 0-1 km from road kill record Threat from urban land use (adjacency to urban land): 2 - >2 km from existing urban area 1 - 1-2 km from existing urban area 0 - 0-1 km from existing urban area	Koala BioNet species records (observation type = roadkill) (OEH, 2018) NSW Spatial Data Services (SiX Clip and Ship) (2019) – General cultural area (where area = Builtup)
Step 6	Recovery value	Each habitat unit was allocated a score based on whether the habitat is likely to be important for achieving the interim recovery objectives for the species. The Koala corridors mapped for the Strategic Assessment Area were used as a surrogate for this score.	2 - Primary and secondary corridors 1 - Tertiary corridors 0 - Supporting habitat	Koala corridor mapping

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CUMBERLAND PLAIN ASSESSMENT REPORT

PART 6B: STRATEGIC ASSESSMENT REPORT

CHAPTER 32 – MIGRATORY SPECIES IMPACT ASSESSMENT

CHAPTER 33 – RAMSAR IMPACT ASSESSMENT

CHAPTER 34 – WORLD AND NATIONAL HERITAGE IMPACT ASSESSMENT

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CHAPTER 38 – CUMULATIVE IMPACT ASSESSMENT

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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32 Migratory species impact assessment

This Chapter assesses the potential impacts to migratory species from the Plan.

The Strategic Assessment Area supports a number of migratory bird species that are protected under the EPBC Act. There are two key policy statements that apply to these species:

- The *Draft Referral guideline for 14 migratory birds listed under the EPBC Act* (DoE, 2015). Potential impacts to species relating to this guideline are assessed in Section 32.1. Assessment of migratory birds in this section is also supported by guidance material from the *Significant Impact Guidelines 1.1* (DoE, 2013b)
- The *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DoEE, 2017). Potential impacts to species relating to this guideline are assessed in Section 32.2

There are no other listed migratory species that are relevant to the assessment.

32.1 MIGRATORY BIRDS

Nine species listed in the migratory bird referral guidelines (DoE, 2015) have been observed within the Strategic Assessment Area. These species have large areas of important habitat in Australia, of which less than 1 per cent will be impacted by the Plan.

Potential direct and indirect impacts to the nine species as a result of the Plan are considered to be negligible.

Only one of the species (White-throated Needletail) has been observed in ecologically significant numbers in the Cumberland subregion. This species is almost exclusively aerial and found over a wide range of habitats including extensively modified and urban areas. Development under the Plan is considered unlikely to disrupt this species' use of the Strategic Assessment Area.

This section sets out:

- The regulatory context for assessing impacts to migratory birds
- The approach to the impact assessment
- Baseline information about migratory birds in the Strategic Assessment Area
- Analysis of the potential impacts
- An overview of relevant conservation measures
- Evaluation of the outcome for migratory birds

32.1.1 REGULATORY CONTEXT

This section assesses impacts to the species discussed in the *Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DoE, 2015). The section also outlines approval considerations under the EPBC Act.

REFERRAL GUIDELINES

The guidelines relate to site-by-site assessments under the EPBC Act (Parts 7-9) and set out three pathways for significant impacts to migratory birds:

- Impacts to habitat: Substantial modification of important habitat, or
- Impacts to individuals: Serious disruption of an ecologically significant proportion of a population
- Establishment of invasive species that is harmful to the migratory species in an area of important habitat for the migratory species

Only one pathway needs to be met to be considered a significant impact.

The migratory bird referral guidelines provide definitions of "important habitat" for each species, in addition to thresholds to define a "substantial modification" and an "ecologically significant proportion" of each species' habitat or population.

Substantial modification of important habitat is defined using a threshold of 1 per cent of the species' total habitat in Australia. A threshold of 0.1 per cent of the species' total population in Australia is used to require proponents to collect further information on the species' presence, including surveys.

Similarly, an ecologically significant proportion of a population is defined as 1 per cent of the species' total population, with a 0.1 per cent threshold triggering a requirement for additional information and surveys. This threshold is based on the number of individuals from a given species that use the relevant area over a year.

With regards to the introduction of invasive species in important habitat for migratory birds, the migratory bird referral guidelines are unclear about the scale of impact associated with introduced species which is required to trigger a significant impact. To resolve this, assessment of impacts from invasive species draws on guidance provided in the Significant Impact Guidelines 1.1.

EPBC ACT APPROVAL CONSIDERATIONS

Section 146L of the EPBC Act sets out the approval considerations in relation to migratory species. In summary, the outcomes of the Plan must not be inconsistent with any of the international agreements relating to migratory species. Of relevance to migratory birds are:

- The Bonn Convention (or the Convention on the Conservation of Migratory Species)
- The bilateral agreements for the conservation of migratory birds between the Government of Australia and the Government of Japan (JAMBA), the Government of China (CAMBA), and the Government of the Republic of Korea (ROKAMBA)

The *Wildlife Conservation Plan For Migratory Shorebirds* (DoEE, 2015) provides a useful summary of Australia's commitments under these agreements. The key obligations (of relevance to this assessment) which cut across the various agreements in different forms are for Australia to:

- Conserve and where possible restore habitats
- Mitigate and manage threats to migratory birds

It is also noted in the Wildlife Conservation Plan that the EPBC Act is the key piece of legislation which gives effect to Australia's international obligations. Following the process and meeting the requirements of the EPBC Act implicitly means that those obligations will be met.

32.1.2 APPROACH TO IMPACT ASSESSMENT

The following sections outline the assessment methodology used to assess impacts to habitat and individuals, and impacts associated with the establishment of harmful invasive species in migratory species habitat.

IMPACTS TO HABITAT AND INDIVIDUALS

The assessment drew on the concepts of substantial modification of habitat and ecologically significant proportions of a population set out in the migratory bird referral guidelines. It was based on available desktop information and used the 1 per cent threshold for impacts to habitat and impacts to individuals rather than the 0.1 per cent threshold. This is an appropriate threshold given the geographic scale and strategic nature of the assessment; noting the 0.1 per cent thresholds for additional surveys are based on site-by-site assessments.

The assessment considered two questions for each impact pathway (see Table 32-1).

Table 32-1: Steps for identifying significant impacts

Steps	Impacts to habitat	Impacts to individuals
Step one	Do the urban capable land and transport corridors contain over 1 per cent of important habitat for the species, as identified in the migratory bird referral guidelines?	Do the urban capable land and transport corridors support over 1 per cent of the population of the species in Australia, as identified in the migratory bird referral guidelines?

Steps	Impacts to habitat	Impacts to individuals
Step two	If so, will the classes of action modify, destroy, or isolate the relevant habitat?	If so, will the classes of action disrupt the lifecycle of the relevant population?

The steps for each impact pathway are discussed further below.

Impacts to habitat

Table 2 of the migratory bird referral guidelines provides definitions of important habitat, which occur as written descriptions of habitat features utilised by each migratory bird. The consulting team has identified all PCTs that correspond with the descriptions of important habitat set out in the migratory bird referral guidelines, which has been used to assess the distribution of important habitat within the Strategic Assessment Area. Given the general nature of habitat descriptions provided in the migratory bird referral guidelines and the large number of PCTs which contain potentially suitable habitat features, this mapping approach is considered to be precautionary.

Step 1 compared the impacts to the PCTs associated with important habitat within the urban capable land and transport corridors against the thresholds set out in the migratory bird referral guidelines (DoE, 2015).

The impact analysis showed that potential impacts would not exceed the 1 per cent thresholds set out in guidelines for any of the species, so it was not necessary to apply Step 2.

Impacts to individuals

Step 1 drew on observation records from Birdlife Australia, the Atlas of Living Australia, and BioNet Atlas. These records reflect observations as well as organised surveys. The analysis used a conservative estimate of individuals based on the total recorded sightings of each species per year across the Cumberland subregion.

Some of the species are more prevalent in Australia during the summer. To ensure that all the birds that are recorded in a summer season are counted together, the analysis combined records between the 1st of July and the 30th of June the following year. For example, the Atlas of Living Australia contains 210 Fork-tailed Swift records in the Cumberland subregion between July 1st, 1982 and June 30th, 1983. Most of these are over the 1982-83 summer and are recorded in this analysis as occurring in 1982-83.

The impact analysis showed that only one species (White-throated Needletail) is present in the Strategic Assessment Area in ecologically significant numbers. For this species, Step 2 was applied to consider the extent and type of impacts to foraging and roosting habitat to determine whether the Plan is likely to disturb an ecologically significant proportion of the population.

IMPACTS FROM INTRODUCTION OR ESTABLISHMENT OF INVASIVE SPECIES IN IMPORTANT HABITAT

The migratory bird guidelines state that "*An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will... result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species*."

The migratory bird referral guidelines do not provide sufficient guidance with regards to what scale of impact is required to trigger assessment as a significant impact with regards to invasive species. Therefore, the assessment of impacts from invasive species draws on guidance from the Significant Impact Guidelines 1.1.

The *Significant impact guidelines 1.1* (DoE, 2013b) define important habitat as habitat which meets one of the following criteria:

- Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining

The impacts from introduction or establishment of invasive species in important habitat has therefore been assessed with regards to the habitat definition provided in the Significant Impact Guidelines 1.1.

APPROACH TO EPBC ACT APPROVAL CONSIDERATIONS

Regulatory requirements were considered at the end of the assessment by drawing together the results of the impact analysis, examination of the benefits of the conservation measures in the Plan and reviewing any specific requirements for migratory species.

32.1.3 MIGRATORY BIRDS IN THE STRATEGIC ASSESSMENT AREA

Nine species covered by the migratory bird referral guidelines have been observed within the Strategic Assessment Area. The species and their habitat and population thresholds are listed in Table 32-2.

Table 32-2: Migratory birds and impact thresholds in the Strategic Assessment Area

Common name	Scientific name	1% threshold for impacts to habitat	1% threshold for impacts to individuals (individuals)
Oriental Cuckoo, Himalayan Cuckoo	*Cuculus saturatus*	250,000 ha	10,000
Fork-tailed Swift	*Apus pacificus*	*	1,000
Rufous Fantail Southern	*Rhipidura rufifrons rufifrons*	2,600 ha	1,100
Satin Flycatcher	*Myiagra cyanoleuca*	4,400 ha	1,700
Black-faced Monarch	*Monarcha melanopsis*	865 ha	465
White-throated Needletail+	*Hirundapus caudacutus*	*	100
Spectacled Monarch Southern	*Symposiachrus trivirgatus*	1,300 ha	410
Osprey	*Pandion haliaetus*	840 km of coastline	240
Yellow Wagtail	*Motacilla flava*	*	10,000

* No thresholds are available for these species due to a lack of knowledge or rarity

+ The White-throated Needletail is also listed as a vulnerable species and is assessed both in this chapter as a migratory species, and in Chapter 30 as a threatened species

32.1.4 IMPACT ANALYSIS

This section considers the impacts to each species in Table 32-2 using the approach described above.

IMPACTS TO HABITAT

The total area of impacts to native vegetation within the urban capable land and transport corridors is 1,777.8 ha. This is well below the threshold for Oriental Cuckoo (250,000 ha) and Satin Flycatcher (4,400 ha). There is no coastline in the Strategic Assessment Area, but 135 km of potential Osprey habitat exists along the Nepean and Hawkesbury Rivers within the Strategic Assessment Area. This is also well below the threshold for substantial modification of important habitat for Osprey (840 km of coastline).

The Fork-tailed Swift, White-throated Needletail and Yellow Wagtail do not have thresholds for substantial modification of important habitat. The guidelines note that roosting habitat for White-throated Needletail is poorly understood and may be a constraint on the species. This will be considered below.

This leaves three species to consider:

- Rufous Fantail Southern
- Black Faced Monarch
- Spectacled Monarch Southern

The guidelines describe important habitat for each of these species. Table 32-3 gives these descriptions, along with the corresponding PCTs that could be impacted by the Plan, and the extent of potential impacts to those PCTs.

Table 32-3 shows that the potential impacts to the three species are well below the thresholds for substantial modification of important habitat.

The Plan will not substantially modify, destroy or isolate an area of important habitat for any of the migratory birds listed in the guidelines.

Table 32-3: Important habitat and potential impacts for three migratory bird species

Species (threshold in ha)	Important habitat	Corresponding PCTs within the urban capable land and transport corridors	Extent of potential impacts (ha)*
Rufous Fantail Southern (2,600)	Moist, dense habitats, including mangroves, rainforest, riparian forests and thickets, and wet eucalypt forests with a dense understorey. When on passage a wider range of habitats are used including dry eucalypt forests and woodlands and Brigalow shrublands.	724, 725, 781, 830, 835, 849, 850, 889, 1181, 1395, 1800	1,777.8
Black Faced Monarch (865)	Wet forest specialist, found mainly in rainforest and wet sclerophyll forest, especially in sheltered gullies and slopes with a dense understorey of ferns and/or shrubs.	830, 835, 1800	184.4
Spectacled Monarch Southern (1,300)	Dense vegetation, mainly in rainforest but also in moist forest or wet sclerophyll and occasionally in other dense vegetation such as mangroves, drier forest and woodlands.	724, 725, 781, 830, 835, 883, 1800	275.5

* Impact calculations exclude impacts to derived native grasslands, as all three species require forests, woodlands, or dense vegetation

IMPACTS TO INDIVIDUALS

Ecologically significant proportions of populations

Atlas of Living Australia, Birdlife Australia and BioNet Atlas records for each species were aggregated over 12-month periods starting from July 1st each year since 1979-80. Prior to 1979-80, sightings were recorded sporadically and in small numbers that are not helpful for this analysis.

For each 12-month period, the total number of sightings was defined as the largest number of records for that period from either the Atlas of Living Australia, Birdlife Australia, or BioNet Atlas data sets.

Table 32-4 sets out the total number of records for each species for the ten 12-month periods with the highest numbers of records since 1980. It also provides the year in which those sightings were made.

Table 32-4: Years with the largest number of records of migratory birds in the Cumberland subregion since 1980

	Ranked year of highest number of records (number of individuals (year))									
Species	**First**	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**	**Seventh**	**Eighth**	**Ninth**	**Tenth**
Fork-tailed Swift	250 (1985-86)	210 (1982-83)	158 (2016-17)	52 (2017-18)	15 (2006-07)	12 (2003-04)	8 (2012-13)	8 (2012-13)	7 (2013-14)	7 (1981-82)
Oriental Cuckoo	1 (2015-16)	1 (2013-14)	1 (2009-10)	Species only recorded in three years						
White-throated Needletail	2576 (2016-17)	2208 (2012-13)	1472 (2017-18)	884 (2015-16)	739 (2014-15)	676 (2011-12)	644 (2013-14)	593 (2010-11)	356 (2009-10)	233 (1986-87)

	Ranked year of highest number of records (number of individuals (year))									
Species	**First**	**Second**	**Third**	**Fourth**	**Fifth**	**Sixth**	**Seventh**	**Eighth**	**Ninth**	**Tenth**
Black-faced Monarch	53 (2016-17)	20 (2013-14)	17 (2014-15)	14 (2017-18)	12 (2011-12)	11 (2015-16)	11 (2012-13)	5 (2005-06)	4 (2010-11)	4 (2003-04)
Yellow Wagtail	2 (2016-17)	2 (2012-13)	Species only recorded in two years							
Satin Flycatcher	26 (2014-15)	10 (2012-13)	9 (2013-14)	8 (2011-12)	6 (2016-17)	5 (2017-18)	4 (2003-04)	3 (2004-05)	3 (1997-98)	2 (1983-84)
Osprey	16 (2013-14)	12 (2012-13)	9 (2010-11)	5 (2017-18)	5 (2014-15)	3 (2016-17)	3 (2015-16)	2 (2003-04)	1 (2004-05)	1 (1989-90)
Rufous Fantail Southern	137 (2016-17)	84 (2017-18)	48 (2016-15)	48 (2013-14)	44 (2014-15)	39 (2012-13)	39 (2011-12)	14 (2010-11)	13 (2009-10)	8 (2000-01)
Spectacled Monarch Southern	1 (1986-87)	Species only recorded in one year								

All of the species in Table 32-4 are well below the thresholds for ecologically significant populations except for the White-throated Needletail. The threshold for this species is 100 birds, and it has been recorded in flocks of up to 300 individuals, with over 2,000 records per year in two years. Based on this data, it has been assumed that an ecologically significant proportion of its population uses the Strategic Assessment Area.

For the other species, the records are sufficiently low across the entire Cumberland subregion that it is unlikely that the urban capable land or transport corridors support an ecologically significant proportion of their populations.

<u>Potential Impacts to the White-throated Needletail</u>

The White-throated Needletail is a large swift. It has two subspecies, of which only one (*Hirundapus caudacutus caudacutus)* occurs in Australia. This subspecies breeds in central and eastern Siberia, northern Mongolia, Northern China and the Korean Peninsula, Sakhalin and Japan, and migrates to Australia for the non-breeding season (DoEE, 2018d).

There is limited information of the ecology of this species. In Australia, it is often found in large flocks of hundreds or thousands of birds. It is widespread in eastern and south-eastern Australia. The species is an insect feeder and is almost exclusively aerial in Australia. It occurs over a wide range of habitats, ranging from heavily treed forests to open habitats such as farmland, heathland or mud flats (DoEE, 2018d).

It is not threatened in NSW and is listed as vulnerable under the EPBC Act. There is limited data on total population and population trends in Australia, but there is some evidence that the population and area of occupancy is in decline (DoEE, 2018d).

Impacts to foraging habitat

The species has been observed foraging over a wide range of habitats. The Atlas of Living Australia, Birdlife Australia and BioNet Atlas contain numerous records in or above heavily modified and urban environments. The species is aerial while foraging and is often observed in areas of updraughts (e.g. above cliffs, ridges, and dunes, in the smoke of bushfires, in whirlwinds, or along the edges of low pressure systems) (TSSC, 2019).

The species appears to prefer certain geographic and meteorological conditions, rather than relying on particular kinds of vegetation. It is unlikely that modification of habitat from the Plan will substantially alter the species' use of the Strategic Assessment Area or the urban capable land and transport corridors. There are no anticipated impacts to foraging habitat from the Plan.

Impacts to roosting habitat

There are limited records of the White-throated Needletail roosting and it was previously thought that the species was exclusively aerial in Australia. Records now suggest that the species roosts in tall trees and may prefer roosting sites on ridgelines. There is some evidence that the species uses traditional roosting sites although there are no records of these sites in the Cumberland subregion.

The species is wide-ranging and not known to roost within the Strategic Assessment Area. The Plan will conserve large areas of high-quality woodland, which will ensure the species has continued access to potential roosting sites within the Cumberland subregion. There is a low risk of impacts to roosting habitat from the Plan.

Summary of impacts to the White-throated Needletail

The Plan is unlikely to disrupt foraging within the Cumberland subregion. It is possible that roosting sites may be present within the urban capable land and transport corridors, but there are no records of this and the risk of loss of roosting habitat is low. The Plan will ensure the conservation of high-quality woodland which will provide continued access to potential roosting habitat within the Strategic Assessment Area. The Plan will not seriously disrupt the lifecycle of the proportion of the White-throated Needletail population that frequents the Cumberland subregion.

IMPACTS FROM INTRODUCTION OR ESTABLISHMENT OF INVASIVE SPECIES IN IMPORTANT HABITAT

The migratory bird referral guidelines identify introduced species that present key threats to some of the migratory bird species. A migratory species can be significantly impacted under the guidelines if one of the relevant introduced species becomes established in an area of important habitat as a result of an action. Four of the species known to occur within the Cumberland subregion have key threats listed in the guidelines (see Table 32-5).

Table 32-5: Invasive species harmful to migratory species in the Strategic Assessment Area

Species	Invasive species harmful to the migratory species
Osprey	Any introduced species that causes a large reduction in fish stocks
Black-faced Monarch	Black Rat (*Rattus rattus*) Vines that invade riparian habitats
Spectacled Monarch	Black Rat (*Rattus rattus*) Vines that invade riparian habitats
Rufous Fantail	Black Rat (*Rattus rattus*) Vines that invade riparian habitats

Impacts associated with introduced species are only significant if they occur within important habitat for the relevant migratory species. As noted above, with regards to the assessment of impacts relating to invasive species, the important habitat has been defined in this section based on the definition provided in the Significant Impact Guidelines 1.1.

There is no important habitat for any of the four migratory species in Table 32-5 within the Cumberland subregion, because:

- None of the habitat in the Strategic Assessment Area is of critical importance to Osprey, Black-faced Monarch, Spectacled Monarch, or Rufous Fantail at particular life stages
- The Cumberland subregion is not at the limit of any of these species' range
- None of these species are present in ecologically significant proportions (as shown in Table 32-4)
- There is no evidence that the populations of Osprey, Black-faced Monarch, Spectacled Monarch, or Rufous Fantail are in decline within the Strategic Assessment Area. Table 32-4 shows:
  - An increase in observations of Osprey and Black-faced Monarch within the Strategic Assessment Area since 2010
  - Only one record of Spectacled Monarch in the Cumberland subregion (from 1986-87) which is inadequate to establish a population trend
  - Numerous observations (over 200 birds in two 12-month periods) of Rufous Fantail in 1982-83 and 1985-86, but these seem anomalous and the species has been observed in increasing numbers in the last 10 years

The Plan includes a range of commitments and actions to minimise and avoid indirect impacts, including from introduced species (see Chapter 15 for details). The populations of Osprey, Black-faced Monarch, Spectacled Monarch and Rufous Fantail using the Strategic Assessment Area are small, and the region is of limited importance for these species. The management measures for indirect impacts are considered sufficient to minimise the risk of these impacts to migratory birds within the Strategic Assessment Area.

32.1.5 CONSERVATION MEASURES THAT WILL BENEFIT MIGRATORY BIRDS

The Plan includes a range of conservation measures that will benefit the migratory birds discussed in this section. The Plan will set aside for conservation a minimum of 5,475 ha of native vegetation with a focus on large, well connected, high quality patches. This will protect foraging and passage habitat for these species within the Cumberland subregion.

32.1.6 EVALUATION OF THE OUTCOME FOR MIGRATORY BIRDS

As outlined in Section 32.1.1, the outcomes of the Plan must not be inconsistent with any of the international agreements relating to migratory species. The key obligations (of relevance to this assessment) which cut across the various agreements in different forms are for Australia to:

- Conserve and where possible restore habitats
- Mitigate and manage threats to migratory birds

The Plan is not inconsistent with these obligations:

- The potential impacts to the nine species listed in the guidelines are below the thresholds for substantial modification of important habitat for all species
- Only the White-throated Needletail is present in the Strategic Assessment Area in ecologically significant numbers. The species is known to forage above a wide range of habitats and is unlikely to be disrupted or displaced by development. There are no known roosting sites within the Cumberland subregion, and the commitments and actions in the Plan will protect potential roosting sites and other vegetation to benefit the species

32.2 MIGRATORY SHOREBIRDS

Thirty-seven species of migratory shorebirds regularly visit Australia during their non-breeding season (from the Austral spring to autumn). The majority of those breed in the northern hemisphere and use the East Asian-Australasian Flyway which stretches from Siberia and Alaska, through east and south-east Asia, to Australia and New Zealand. They depend upon a range of sites along the flyway for breeding, staging, feeding and roosting. In Australia, coastal and freshwater wetlands provide important habitat (DoEE, 2015).

Twenty-one of these species have been recorded within the Cumberland subregion. Two of those have been recorded at a site level in important numbers. They are the Sharp-tailed Sandpiper and Latham's Snipe.

Potential impacts to migratory shorebirds as a result of the Plan are considered to be negligible. No important habitat will be lost, and the risk of indirect impacts such as degradation of habitat and disturbance of birds is considered to be low.

This section sets out:

- The regulatory context for assessing impacts to migratory shorebirds
- The approach to the impact assessment
- Baseline information about migratory shorebirds in the Strategic Assessment Area
- Analysis of the potential impacts
- An overall conclusion

32.2.1 REGULATORY CONTEXT

GUIDELINES

The *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (DoEE, 2017) provide guidance about how the EPBC Act applies to that group of species. They are designed to be read in conjunction with the *Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (DoE, 2013b).

Impact pathways

The guidelines set out four pathways by which impacts can be significant to migratory shorebirds:

- Loss of important habitat
- Degradation of important habitat leading to a substantial reduction in migratory shorebird numbers
- Increased disturbance within important habitat leading to a substantial reduction in migratory shorebird numbers
- Direct mortality of birds leading to a substantial reduction in migratory shorebird numbers

Definition of important habitat

Important habitat for migratory shorebirds is a key concept outlined in the guidelines. It relates to three of the impact pathways.

Important habitats are sites that meet one or more of the following criteria:

- Habitat that is already identified as internationally important
- Habitat that regularly supports 0.1 per cent of the flyway population of a single species of migratory shorebird. Estimates of the flyway populations for each of the species is provided in the *Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species* (Hansen, Fuller et al., 2016)
- Habitat that regularly supports 2,000 migratory shorebirds, or
- Habitat that regularly supports 15 migratory shorebird species (DoEE, 2017)

There are different criteria for identifying important habitat for Latham's snipe (*Gallinago harwickii*). This is because this species does not typically aggregate in large flocks and uses different habitat to the other species discussed in the migratory shorebird guidelines. Important habitat for Latham's snipe is:

- Any area that has been previously identified as internationally important for the species, or

- Any area that supports at least 18 individuals of the species (DoEE, 2017)

Avoiding and/or mitigating impacts

The guidelines also outline a set of general measures to avoid and/or mitigate impacts to shorebirds. Measures include:

- Making every effort to avoid habitat loss
- Ensuring habitat is not degraded through the introduction of exotic species; changes to hydrology or water quality (including toxic inflows); fragmentation of habitat or exposure to litter or pollutants; and exposure of acid sulphate soils
- Mitigating against the impacts of disturbance
- Considerations around direct mortality to shorebirds
- Consideration of climate change

WILDLIFE CONSERVATION PLAN FOR MIGRATORY SHOREBIRDS

The Wildlife Conservation Plan for Migratory Shorebirds (DoEE, 2015) provides a framework to guide the conservation of migratory shorebirds in Australia. It:

- Summarises Australia's commitments to migratory shorebirds under international conventions and agreements
- Outlines national actions to support shorebird conservation

The Wildlife Conservation Plan is consistent with the EPBC Act referral guidelines. Particularly in relation to the definition of important habitat and the discussion of threats.

EPBC ACT APPROVAL CONSIDERATIONS

Migratory species

Section 146L of the EPBC Act sets out the approval considerations in relation to migratory species. In summary, the outcomes of the Plan must not be inconsistent with any of the international agreements relating to migratory species. Of relevance to migratory shorebirds are:

- The Bonn Convention (or the Convention on the Conservation of Migratory Species)
- The bilateral agreements for the conservation of migratory birds between the Government of Australia and the Government of Japan (JAMBA), the Government of China (CAMBA), and the Government of the Republic of Korea (ROKAMBA)

The Wildlife Conservation Plan (DoEE, 2015) provides a useful summary of Australia's commitments under these agreements. The key obligations (of relevance to this assessment) which cut across the various agreements in different forms are for Australia to:

- Conserve and where possible restore habitats
- Mitigate and manage threats to shorebirds

It is also noted in the Wildlife Conservation Plan that the EPBC Act is the key piece of legislation which gives effect to Australia's international obligations. Following the process and meeting the requirements of the EPBC Act implicitly means that those obligations will be met.

Threatened species

A number of the migratory shorebirds are also listed as threatened. These species are addressed both in this chapter as a migratory species, and in Chapter 30 as threatened species.

32.2.2 APPROACH TO IMPACT ASSESSMENT

This assessment primarily draws on the concepts presented in the migratory shorebird guidelines and is based on:

- Development of baseline information, which includes:
    - Compilation of available records for shorebird species

  - Habitat mapping (including the identification of important habitat) across the Cumberland subregion
- Analysis of potential direct and indirect impacts with a focus on:
  - The four potential impact pathways set out in the Guidelines
  - The general measures to avoid and/or mitigate impacts to shorebirds set out in the Guidelines
- Consideration of regulatory requirements for migratory and (where relevant) threatened species

BASELINE INFORMATION

Compilation of records

Records were compiled from the Birdlife Australia Database and the OEH BioNet Database. This is considered to be the most complete data for shorebirds in the Cumberland subregion.

Approach to habitat mapping within the Cumberland subregion

Habitat mapping was undertaken broadly in accordance with the approach outlined in the EPBC guidelines. However, the method applied was more precautionary than required under the EPBC guidelines to ensure that no important habitat sites were missed (see 'limitations in the baseline data' below).

The process involved the following steps:

Step 1: Analysis of records across the Cumberland subregion

Records were compiled and examined across the whole of the Cumberland subregion. The initial step considered the subregion as a single habitat unit to determine which species exceeded the thresholds for important habitat across the whole area (i.e. which species occur in numbers greater than the threshold when records are summed across the whole subregion).

Step 2: Identification of important migratory shorebird habitat sites

The spatial distribution of records was then assessed to identify the individual wetland and waterbody (or wetland mosaic) where the thresholds were exceeded at a site level. Each wetland that was identified as important for migratory shorebirds had its boundary marked and a 250-metre buffer applied. This buffer distance is consistent with the guidelines which suggest buffer distances ranging from 165 to 255 m to mitigate against disturbance (DoEE, 2017).

For ephemeral wetlands the threshold was considered across every year where records were held.

For permanent wetlands, the guidelines suggest considering the last five years. The approach taken for this assessment was to look at records for the last 20 years for sites that were thought to be permanent. This acknowledges the uncertainty in determining if habitat sites are permanent or ephemeral across the Strategic Assessment Area.

Step 3: Identification of potential migratory shorebird habitat

The remaining potential migratory shorebird habitat in the subregion was determined based on the presence of suitable wetlands throughout the landscape that exceed 1.5 ha in area. This 1.5 ha threshold was used as a proxy for the minimum disturbance distance for shorebirds of 150 m.

Wetland mapping layers were interrogated from the Directory of Important Wetlands (DoEE, 2018c) and the LPI topographical data Hydro Area layer (LPI, 2016) to identify areas of potential habitat.

Limitations in the baseline data

The data used in the habitat mapping is the best available across the Cumberland subregion. It incorporates:

- Historical records from both BioNet and Birdlife Australia
- Wetland and waterbody mapping from DAWE and LPI

However, there has not been a systematic survey for migratory shorebirds across the subregion and it is likely that shorebirds visit a number of sites where there are no records.

To address uncertainty in the data a precautionary approach was taken. This involved:

- Considering the whole of the Cumberland subregion to determine what species occurred in numbers greater than the important habitat thresholds when their records were summed for all sites
- Mapping potential habitat using wetland and waterway mapping

APPROACH TO ANALYSING IMPACTS

Direct and indirect impacts were assessed by considering the four impact pathways identified in the guidelines.

The potential loss of important habitat was calculated by:

- Intersecting the urban capable land and transport corridors with the habitat mapping
- Considering potential changes to hydrology, water quality or vegetation structural changes near important habitat sites

Potential degradation and disturbance within important habitat, and potential direct mortality of migratory shorebirds were assessed through:

1. Identifying the activities under the Plan that may lead to these impacts
2. Considering how those activities are proposed to be managed under the Plan (noting that Chapter 15 provides a detailed description and analysis of how indirect impacts will be managed)
3. Analysing the residual risk to important habitat and shorebirds

APPROACH TO EPBC ACT APPROVAL CONSIDERATIONS

Regulatory requirements were considered at the end of the assessment by drawing together the results of the impact analysis, examination of the benefits of the conservation measures in the Plan and reviewing any specific requirements for migratory and (where relevant) threatened species.

32.2.3 MIGRATORY SHOREBIRDS IN THE STRATEGIC ASSESSMENT AREA

Migratory shorebirds are found at a number of sites within and adjacent to the Strategic Assessment Area during their seasonal occurrence in the southern hemisphere. Site usage varies based on the extent and quality of habitat.

This section provides:

- An overview on the migratory shorebirds recorded in the Cumberland subregion
- An overview of habitat in the subregion
- Site profiles for important habitat

MIGRATORY SHOREBIRDS RECORDED IN THE CUMBERLAND SUBREGION

A total of 21 species have been recorded across the Cumberland subregion (see Table 32-7). Of these:

- Four have been recorded in numbers that exceed the thresholds for important habitat when the subregion is considered as a single habitat unit. They are Sharp-tailed Sandpiper, Latham's Snipe, Black-tailed Godwit and Bar-tailed Godwit
- Two have exceeded thresholds for important habitat at the individual site level. They are Sharp-tailed Sandpiper and Latham's Snipe
- Five are also listed as threatened species under the EPBC Act. They are Bar-tailed Godwit (vulnerable), Curlew Sandpiper (critically endangered), Eastern Curlew (critically endangered), and Red Knot (endangered)

OVERVIEW OF SHOREBIRD HABITAT

A total of 11 important sites occur for migratory shorebirds across the subregion (see Map 49). None of these sites will be directly impacted by development under the Plan.

Table 32-6: Summary of migratory shorebird habitat sites

Habitat type	Number of sites	Total area of habitat (ha)
Important habitat within the Strategic Assessment Area	5	182.3
Important habitat within the broader Cumberland subregion	6	54.5

The important habitat sites can be broadly placed into five groups based on their location:

- Sites in the Strategic Assessment Area:
    - Sites 7, 9, 17 and 21 all occur near to the Hawkesbury River in the north of the Strategic Assessment Area
    - Site 19 occurs in the Mt Annan Botanic Gardens to the west of GMAC
- Sites outside the Strategic Assessment Area in the broader Cumberland subregion:
    - Sites 1 and 11 occur in the Marsden Park North Precinct of the existing North West Growth Area
    - Sites 3, 13 and 15 all occur within the vicinity of Sydney Olympic Park
    - Site 5 occurs outside in the suburb of Panania

It is important to note that important migratory shorebird habitat has been mapped for use in BAM assessments. No important migratory shorebird habitat has been identified within the Strategic Assessment Area.

A number of sites are subject to existing management (e.g. as a nature reserve). The section below provides a profile for each site.

Table 32-7: List of migratory shorebird species occurring within the Cumberland subregion (species in excess of important habitat thresholds = blue, threatened species = bold)

Common name	Scientific name	EPBC Act listing status	0.1% flyway population threshold (Hansen, Fuller et al., 2016)	Species exceeds 0.1% across the whole Strategic Assessment Area?	Number of individual sites exceeding the 0.1% flyway population threshold	Sites where key^ species have been recorded
Bar-tailed Godwit	***Limosa lapponica***	**Migratory Vulnerable#**	**325**	**Yes**	**0**	**9, 13, 15**
Black-tailed Godwit	*Limosa limosa*	Migratory	160	Yes	0	7, 9, 13, 21
Common Greenshank	*Tringa nebularia*	Migratory	110	No	0	1, 3, 7, 9, 13, 21
Common Sandpiper	*Actitis hypoleucos*	Migratory	190	No	0	9, 13, 17
Curlew Sandpiper	***Calidris ferruginea***	**Migratory Critically Endangered**	**90**	**No**	**0**	**1, 3, 7, 9, 13, 21**
Double-banded Plover	*Charadrius bicinctus*	Migratory	19	No	0	1, 3, 7, 11, 21
Eastern Curlew	***Numenius madagascariensis***	**Migratory Critically Endangered**	**35**	**No**	**0**	**13**
Greater Sand-plover	***Charadrius leschenaultii***	**Migratory Vulnerable**	**200**	**No**	**0**	**3**
Grey Plover	*Pluvialis squatarola*	Migratory	80	No	0	3, 21
Latham's Snipe	*Gallinago hardwickii*	Migratory	18*	Yes	3	1, 3, 7, 9, 11, 13, 15, 17, 19, 21
Little Curlew	*Numenius minutus*	Migratory	110	No	0	7, 9, 21
Long-toed Stint	*Calidris subminuta*	Migratory	230	No	0	7, 9, 21
Marsh Sandpiper	*Tringa stagnatilis*	Migratory	130	No	0	3, 7, 9, 13, 21
Pacific Golden Plover	*Pluvialis fulva*	Migratory	120	No	0	3, 7, 9, 13, 15, 21
Pectoral Sandpiper	*Calidris melanotos*	Migratory	1,220	No	0	1, 3, 7, 9, 21

Common name	Scientific name	EPBC Act listing status	0.1% flyway population threshold (Hansen, Fuller et al., 2016)	Species exceeds 0.1% across the whole Strategic Assessment Area?	Number of individual sites exceeding the 0.1% flyway population threshold	Sites where key^ species have been recorded
Red Knot	***Calidris canutus***	**Migratory** **Endangered**	**110**	**No**	**0**	**13**
Red-necked Stint	*Calidris ruficollis*	Migratory	475	No	0	1, 3, 7, 9, 13
Ruddy Turnstone	*Arenaria interpres*	Migratory	30	No	0	1, 3
Ruff	*Philomachus pugnax*	Migratory	25	No	0	3, 7, 9, 21
Sharp-tailed Sandpiper	*Calidris 32-15cuminate*	Migratory	85	Yes	8	1, 3, 7, 9, 11, 13, 15, 21
Wood Sandpiper	*Tringa glareola*	Migratory	130	No	0	1, 3, 9, 21

^ For species occurring in excess of important habitat thresholds and/or threatened species

Two subspecies of *L. lapponica* regularly occur in Australia. In the non-breeding season, *L. l. bauera* (listed as migratory and vulnerable) occurs along the north and east coasts of Australia (TSSC, 2016b). *L. l. menzbieri* (listed as migratory and critically endangered) on the other hand occurs predominately in Western Australia (TSSC, 2016c) and is not considered likely to occur in the Cumberland subregion.

* For Latham's Snipe important habitat is defined based on the presence of 18 birds rather than the 0.1 per cent threshold which is 30 individuals

SITE PROFILES FOR IMPORTANT HABITAT

Profiles for each of the eleven important habitat sites within the Cumberland subregion are provided below.

Site 1

SITE DETAILS	
Site ID number:	1
Site name:	Old Riverstone Meatworks ponds
Location:	Outside the Strategic Assessment Area within the broader Cumberland subregion
Approximate distance to nearest development area:	5.6 km
Important habitat for:	Sharp-tailed Sandpiper (187 birds recorded in 2005)
Total species recorded:	9
Area of important habitat:	8.1 ha
Area with buffer:	57.1 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Site 1 is comprised of a group of former wastewater ponds associated with the old Riverstone Meatworks in the Marsden Park North Precinct of the existing North West Growth Area. The site is currently surrounded by farm land to the West, North and East; and low density development to the South. The Precinct is in the process of being rezoned and options are being explored for re-creating shorebird habitat in the vicinity before removing the old ponds (NSW NPWS, 2000).	

Site 3

SITE DETAILS	
Site ID number:	3
Site name:	Mason Park Wetlands
Location:	Outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion
Approximate distance to nearest development area:	21 km
Important habitat for:	Sharp-tailed Sandpiper (120 birds recorded in 2004; 150 in 2005; 112 in 2007; and 100 in 2009)
Total species recorded:	8
Area of important habitat:	7.8 ha
Area with buffer:	60.2 ha
DESCRIPTION & LANDSCAPE CONTEXT	
The Mason Park Wetlands occur near to Sydney Olympic Park. The wetlands are bounded by Saleyards and Powells Creeks, and used to form part of the once extensive estuarine environment of the Parramatta River. They contain remnant salt marsh communities and are recognised for their habitat value for migratory shorebirds (NSW NPWS, 2003).	

Site 5

SITE DETAILS	
Site ID number:	5
Site name:	N/A
Location:	Outside the Strategic Assessment Area within the broader Cumberland subregion
Approximate distance to nearest development area:	8.5 km
Important habitat for:	Latham's Snipe (50 birds recorded in 1983)
Total species recorded:	1
Area of important habitat:	3.7 ha
Area with buffer:	45.1 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Site 5 is an unnamed ephemeral water body. It occurs approximately 500 m from the Georges River and is not connected to any other waterways.	

Site 7

SITE DETAILS	
Site ID number:	7
Site name:	Bushell's Lagoon
Location:	In the north of the Strategic Assessment Area, to the north of the Hawkesbury River
Approximate distance to nearest development area:	14 km
Important habitat for:	Sharp-tailed Sandpiper (100 birds recorded in 2002)
Total species recorded:	12
Area of important habitat:	118.1
Area with buffer:	317.2
DESCRIPTION & LANDSCAPE CONTEXT	
Bushell's Lagoon is a natural, ephemeral water body that occurs on the floodplain of the Hawkesbury River. It is connected to a number of first order streams. The wetland is surrounded by farm land.	

Site 9

SITE DETAILS	
Site ID number:	9
Site name:	Pitt Town Lagoon
Location:	In the north of the Strategic Assessment Area, to the east of the Hawkesbury River
Approximate distance to nearest development area:	15 km
Important habitat for:	Sharp-tailed Sandpiper (183 birds recorded in 2005; 1,000 in 2006; 261 in 2009; 100 in 2013)
Total species recorded:	15

Area of important habitat:	39.6 ha
Area with buffer:	130.5 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Pitt Town lagoon is part of the Pitt Town Nature Reserve and is managed by NSW National Parks. The site is mostly surrounded by farmland and flows into the Hawkesbury River to the north. The site is recognised for its habitat value for migratory shorebirds (NSW NPWS, 2000).	

Site 11

SITE DETAILS	
Site ID number:	11
Site name:	N/A
Location:	Outside the Strategic Assessment Area within the broader Cumberland subregion
Approximate distance to nearest development area:	5.5 km
Important habitat for:	Sharp-tailed Sandpiper (187 birds in 2012)
Total species recorded:	4
Area of important habitat:	0.9 ha
Area with buffer:	30.0 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Site 11 is a grassy area in a developed area of the Riverstone Precinct of the existing North West Growth Area. The site appears unlikely to provide suitable long term habitat for migratory shorebirds, but was identified as important based on the number and accuracy of available records.	

Site 13

SITE DETAILS	
Site ID number:	13
Site name:	Wanngal Wetland
Location:	Outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion
Approximate distance to nearest development area:	22 km
Important habitat for:	Sharp-tailed Sandpiper
Total species recorded:	12
Area of important habitat:	32.1 ha
Area with buffer:	117.7 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Wanngal Wetland is part of the Newington Nature Reserve within Sydney Olympic Park. It is part of a highly modified estuarine wetland system. The site contains a range of important ecological values and contains significant areas of remnant saltmarsh and mangroves in excellent condition. It is recognised for its habitat value for migratory shorebirds (NSW NPWS, 2003).	

Site 15

SITE DETAILS	
Site ID number:	15
Site name:	N/A
Location:	Outside the Strategic Assessment Area on the eastern edge of the Cumberland subregion
Approximate distance to nearest development area:	21.5 km
Important habitat for:	Sharp-tailed Sandpiper (202 birds recorded in 2012)
Total species recorded:	4
Area of important habitat:	2.0 ha
Area with buffer:	38.0 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Site 15 is located within the Sydney Olympic Park precinct. It occurs adjacent to Brickpit Park and is an ephemeral waterbody that is not connected to other waterways.	

Site 17

SITE DETAILS	
Site ID number:	17
Site name:	Yarramundi Lagoon
Location:	In the north of the Strategic Assessment Area, to the east of the confluence of the Grose and Nepean Rivers
Approximate distance to nearest development area:	4 km
Important habitat for:	Latham's Snipe (counts for the species not available, however, multiple records occur for 2002, 2003 and 2004 – taking a precautionary approach the site has been identified as important)
Total species recorded:	1
Area of important habitat:	10.3 ha
Area with buffer:	102.4 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Yarramundi Lagoon is a linear shaped wetland that occurs in the active floodplain of the Hawkesbury – Nepean River (LandArc, 2007). The site is surrounded by farmland and is connected to the Hawkesbury River to the north through a chain of first order streams and small wetlands.	

Site 19

SITE DETAILS	
Site ID number:	19
Site name:	N/A
Location:	In the south of the Strategic Assessment Area, to the west of GMAC

Approximate distance to nearest development area:	1.4 km
Important habitat for:	Latham's Snipe (species has multiple records across a number of years – taking a precautionary approach the site has been identified as important)
Total species recorded:	2
Area of important habitat:	0.2 ha
Area with buffer:	26.1 ha
DESCRIPTION & LANDSCAPE CONTEXT	
Site 19 is a small wetland that occurs in the Mt Annan Botanic Gardens. It is part of a chain of managed ponds that drains north towards Annan Creek.	

Site 21

SITE DETAILS	
Site ID number:	21
Site name:	McGraths Hill Wetland
Location:	In the north of the Strategic Assessment Area, to the south of the Hawkesbury River
Approximate distance to nearest development area:	11 km
Important habitat for:	Sharp-tailed Sandpiper (276 birds recorded in 1982)
Total species recorded:	13
Area of important habitat:	14.1 ha
Area with buffer:	77.4 ha
DESCRIPTION & LANDSCAPE CONTEXT	
McGraths Hill Wetland is part of an effluent reuse and wetland project (associated with a sewerage treatment plant). The site occurs on a floodplain and drains into Wianamatta (South Creek) and ultimately into the Hawkesbury River.	

32.2.4 IMPACT ANALYSIS

This section considers the potential impacts to migratory shorebirds against the four impact pathways identified in the EPBC referral guidelines (DoEE, 2017). It also provides a brief consideration of climate change and an evaluation of the outcomes for shorebirds as listed migratory species.

LOSS OF IMPORTANT HABITAT

As outlined in the guidelines (DoEE, 2017), loss of important habitat can occur through either:

- Direct loss: e.g. through clearing, inundation, infilling or draining
- Indirect loss: e.g. through changes to hydrology, water quality or vegetation structural changes near roosting areas

Direct loss

There will be no direct loss of important habitat (or habitat buffers) due to development under the Plan. No important habitat areas occur closer than 1.4 km from the urban capable land and transport corridors and the majority of important sites are significantly further away.

Indirect loss

Changes to hydrology and water quality

Urban development and transport have the potential to lead to changes to hydrology and water quality. This is related to a range of factors but includes:

- Potential disruption to natural water flows
- The increase of hard surfaces leading to increased runoff
- Potential introduction of a range of contaminants that may affect water quality (e.g. nutrients, chemicals)

Migratory shorebird habitat that would be at risk of these effects are sites that are:

- In close proximity to development areas
- Hydrologically well connected (e.g. downstream) to development areas

None of the important habitat sites meet these criteria. Table 32-8 provides an analysis of the risk to each site due to potential changes in hydrology and water quality. Sites are grouped according to their general location in the Cumberland subregion. The risk of impacts is low in all cases.

Table 32-8: Risk of hydrology or water quality changes to important migratory shorebird habitat sites

Sites	Risk of impacts due to changes in hydrology and water quality
Sites within the Strategic Assessment Area:	
Sites 7, 9, 17 and 21	These sites occur in the north of the Strategic Assessment Area on (or close to) the floodplain of the Hawkesbury River. The broad area is downstream of much of the western third of the Cumberland subregion which includes all or part of the four nominated areas and transport corridors. The sites are relatively distant from the nearest development (4 km to 14 km). They would not be immediately influenced by any potential changes to hydrology or water quality. They are also subject to a range of existing influences such as: • Water extraction • Nutrient and chemical inputs from adjacent farmland • Sewerage treatment While broadly downstream of development, they are not considered to be well connected because: • They occur upstream of the Hawkesbury River on the floodplain • They are relatively distant from the development Risks to these sites is considered to be low.
Site 19	This site occurs in the Mt Annan Botanic Gardens to the west of GMAC. It is part of a managed series of ponds. The area is not hydrologically connected to the development in GMAC where the water flows to the east. Risks to this site are considered to be low.
Sites outside the Strategic Assessment Area in the broader Cumberland subregion:	
Sites 1 and 11	These sites occur within or near to existing development in the Marsden Park North Precinct of the existing North West Growth Area (outside the Strategic Assessment Area). Site 1 is comprised of wastewater ponds at the old Riverstone Meatworks. The Precinct is in the process of being rezoned and options are being explored for re-creating shorebird habitat in the vicinity before removing the old ponds (DPE, 2018). Site 11 appears unlikely to provide suitable long term habitat for migratory shorebirds (it is a grassy area surrounded by development), but was identified as important based on the number and accuracy of available records. Risks to these sites are considered to be low.

Sites	Risk of impacts due to changes in hydrology and water quality
Sites 3, 13 and 15	These sites all occur within or close to Sydney Olympic Park on the eastern edge of the Cumberland subregion. The area is approximately 20 km from the nearest development and not connected hydrologically. Risks to these sites are considered to be low.
Site 5	Site 5 occurs outside the Strategic Assessment Area in the suburb of Panania. It is an unnamed ephemeral water body that occurs approximately 500 m from the Georges River. The site is not connected to any other waterways and risks are considered to be low.

Whilst the risk of impacts due to changes in hydrology and water quality are low, the Plan includes commitments and actions to ensure that development will be planned and managed to control and manage environmental risks from indirect impacts. This includes actions relating to:

- Water Sensitive Urban Design
- Sediment and erosion controls for construction and operational phases of development
- Protection of waterways, groundwater, and riparian corridors

These commitments and actions further reduce the risk of potential impacts to important migratory shorebird habitat sites.

Changes to vegetation structure

Changes to vegetation structure can arise from factors such as increased vegetation cover or encroachment of buildings (DoEE, 2017). This may be possible at sites that are in close proximity to development.

Given the distance of important habitat to development, the risks of changes to vegetation structure is considered to be low.

DEGRADATION OF IMPORTANT HABITAT LEADING TO A SUBSTANTIAL REDUCTION IN MIGRATORY SHOREBIRD NUMBERS

The guidelines (DoEE, 2017) set out examples of the types of activities that can lead to degradation of important habitat. They include:

- Activities occurring in coastal or estuarine environments. For example:
  - Substantial loss of marine or estuarine vegetation
  - Invasion of intertidal mudflats by weeds
  - Exposure of acid sulphate soils
- Water pollution and changes to the water regime

Activities in coastal or estuarine environments

No development under the Plan will occur in coastal or estuarine environments.

Of the eleven important habitat sites, none are coastal and three occur within or close to estuarine areas. The three that occur within or close to estuarine areas are the three sites in proximity to Sydney Olympic Park. All of the sites are subject to existing management and will not be influenced by development under the Plan.

Risks from activities in coastal or estuarine environments are nil.

Water pollution and changes to the water regime

Potential water pollution and changes to the water regime are similar issues to those discussed above in relation to hydrology and water quality.

The risks to all sites are considered to be low because:

- They are generally distant to development

- No sites are hydrologically well connected
- There are commitments and actions in the Plan to manage and control environmental risks from indirect impacts

INCREASED DISTURBANCE WITHIN IMPORTANT HABITAT LEADING TO A SUBSTANTIAL REDUCTION IN MIGRATORY SHOREBIRD NUMBERS

As outlined in the guidelines (DoEE, 2017), increased disturbance to migratory shorebirds is a key threat within Australia. It may occur through:

- Construction activities (e.g. demolition)
- Residential and recreational activities such as four-wheel-driving, jet- and water-skiing, power boating, fishing, walking, wind-surfing, kite-surfing, walking dogs, noise and night-lighting

Migratory shorebird habitat that would be at risk of these effects are sites that are:

- In close proximity to development areas
- Publicly accessible for recreation (particularly where this is not managed to protect shorebirds)
- Adjacent to recreation areas (e.g. waterways used for boating etc)

Table 32-9 provides an analysis of the risk to each site due to potential increases in disturbance. Sites are grouped according to their general location in the Cumberland subregion. The risk of impacts is low in all cases.

Table 32-9: Risk of increased disturbance within important habitat leading to impacts to migratory shorebirds

Sites	Risk of impacts due to increased disturbance
Sites within the Strategic Assessment Area:	
Sites 7, 9, 17 and 21	These sites occur in the north of the Strategic Assessment Area on (or close to) the floodplain of the Hawkesbury River. ***Proximity to development*** The sites are relatively distant from the nearest development (4 km to 14 km). They would not be immediately influenced by disturbance from activities under the Plan. ***Accessibility*** It is considered unlikely that development under the Plan will lead to a significant increase in access and use of the sites: • Sites 7 and 17 are surrounded by farmland and while likely subject to a current level of disturbance, their distance from the nominated areas and landscape context make it unlikely that development under the Plan will lead to increased disturbance • Site 9 is part of the Pitt Town Nature Reserve and is managed by NSW National Parks. Access is managed and increased disturbance is considered unlikely • Site 21 is part of an effluent reuse facility. Increased disturbance is considered unlikely ***Proximity to recreation areas*** None of the sites occur within proximity to high intensity recreational areas. They are either: • Surrounded by farm land (Sites 7 and 17) • Part of a nature reserve where access and use is managed (Site 9) • Part of an effluent reuse facility (Site 21) ***Overall risks*** The overall risks to these sites from increased disturbance are considered to be low.
Site 19	This site occurs in the Mt Annan Botanic Gardens to the west of GMAC. It is part of a managed series of ponds. ***Proximity to development*** This site is the closest to a development area under the Plan (approximately 1.4 km from GMAC). However, it is sufficiently distant to ensure that it would not be immediately influenced by disturbance from activities under the Plan.

Sites	Risk of impacts due to increased disturbance
	Accessibility The area is currently accessible as part of the Botanic Gardens. It is possible that visitation will increase as the population of Western Sydney increases. However, dog walking, which is one of the key causes of disturbance, is prohibited in the gardens. It is considered unlikely that disturbance to shorebirds will significantly increase. ***Proximity to recreation areas*** The site does not occur within proximity to high intensity recreational areas. ***Overall risks*** The overall risks to these sites from increased disturbance are considered to be low.
Sites outside the Strategic Assessment Area in the broader Cumberland subregion:	
Sites 1 and 11	These sites occur within or near to existing development in the Marsden Park North Precinct of the existing North West Growth Area (outside the Strategic Assessment Area). Site 1 is comprised of wastewater ponds at the old Riverstone Meatworks. The Precinct is in the process of being rezoned and options are being explored for re-creating shorebird habitat in the vicinity before removing the old ponds (DPE, 2018). Site 11 appears unlikely to provide suitable long term habitat for migratory shorebirds (it is a grassy area surrounded by development), but was identified as important based on the number and accuracy of available records. Risks to these sites are considered to be low.
Sites 3, 13 and 15	These sites all occur within or close to Sydney Olympic Park on the eastern edge of the Cumberland subregion. ***Proximity to development*** The sites are approximately 20 km from the nearest development and would not be immediately influenced by disturbance from activities under the Plan. ***Accessibility*** The sites are currently accessible as part of the Sydney Olympic Park. However, access is managed and the area is already subject to significant visitation. It is considered unlikely that disturbance to shorebirds will significantly increase. ***Proximity to recreation areas*** The sites do not occur within proximity to high intensity recreational areas. ***Overall risks*** The overall risks to these sites from increased disturbance are considered to be low.
Site 5	Site 5 is an unnamed ephemeral water body that occurs outside the Strategic Assessment Area in the suburb of Panania. ***Proximity to development*** The site is approximately 8.5 km from the nearest development and would not be immediately influenced by disturbance from activities under the Plan. ***Accessibility*** The site is currently accessible. However, it is bordered by a range of disturbed areas and recreational opportunities appear to be limited. Given that it occurs in an existing suburb, it is considered unlikely that disturbance to shorebirds will significantly increase due to development under the Plan. ***Proximity to recreation areas*** The site does not occur within proximity to high intensity recreational areas. ***Overall risks*** The overall risks to this site from increased disturbance are considered to be low.

DIRECT MORTALITY OF BIRDS LEADING TO A SUBSTANTIAL REDUCTION IN MIGRATORY SHOREBIRD NUMBERS

As outlined in the guidelines (DoEE, 2017), direct mortality of birds may results from activities relating to:

- Bird strike due to:
    - Development of wind farms in migration or movement pathways
    - Aeroplanes or fixed structures such as towers with support cables
- Inappropriate waste management and chemical or oils spills

Bird strike

Development under the Plan does not relate to windfarms, aeroplanes or large fixed structures with support cables. Risks of significant bird strike due to the development are considered to be low.

Inappropriate waste management and chemical or oils spills

Potential impacts due to inappropriate waste management and chemical or oils spills are similar issues to those discussed above in relation to hydrology and water quality.

The risks to all sites are considered to be low because:

- They are generally distant to development
- No sites are hydrologically well connected
- There are commitments and actions in the Plan to manage and control environmental risks from indirect impacts. This includes an action relating to pollution avoidance and reduction, including spill management and response plans

Risks associated with these causes of direct mortality are considered to be low.

CONSIDERATION OF CLIMATE CHANGE

The guidelines (DoEE, 2017) suggest that "areas landward of important shorebird habitat areas should be maintained in an undeveloped state to allow the natural coastal processes of erosion and accretion to respond to possible rising sea levels".

None of the important habitat sites in the Cumberland subregion occur in coastal areas and consideration of climate change in this context is not considered relevant.

Chapter 41 of the report describes how the Plan more broadly has considered the extent to which it facilitates adaptation to climate change for MNES, including consideration of any particularly vulnerable matters.

EVALUATION OF THE OUTCOME FOR MIGRATORY SHOREBIRDS

As outlined in Section 32.2.1, the outcomes of the Plan must not be inconsistent with any of the international agreements relating to migratory species. The key obligations (of relevance to this assessment) which cut across the various agreements in different forms are for Australia to:

- Conserve and where possible restore habitats
- Mitigate and manage threats to shorebirds

The Plan is not inconsistent with these obligations. There will be:

- No direct impacts to important habitat
- Low to negligible risks of indirect impacts to important habitat
- Commitments and actions in the Plan to manage and control threats to shorebirds from development

32.2.5 CONCLUSION

Potential impacts to migratory shorebirds as a result of the Plan are considered to be negligible. No important habitat will be lost, and the risk of indirect impacts such as degradation of habitat and disturbance of birds is considered to be low.

The outcomes of the Plan for these species meets the regulatory requirements for listed migratory and (where relevant) threatened species under the EPBC Act.

33 Ramsar impact assessment

33.1 INTRODUCTION

While there are no Ramsar sites in the Strategic Assessment Area, the Towra Point Nature Reserve occurs downstream in the Botany Bay Catchment.

This Chapter sets out:

- Australia's international conservation obligations with regards to Towra Point Nature Reserve
- A general description of the Towra Point Nature Reserve
- The Ramsar listing criteria
- A summary of the ecological character of the site
- Analysis of the potential direct, indirect and facilitated impacts
- An overall conclusion

The analysis shows that an impact to the ecological character of the Towra Point Nature Reserve is not expected as a result of implementation of the Plan. There will be no direct impacts and potential indirect impacts will be adequately mitigated.

Attachment A sets out more detail about the ecological character of the site.

Potential cumulative impacts to Towra Point Nature Reserve are considered in Chapter 38.

33.2 INTERNATIONAL AGREEMENTS AND OBLIGATIONS TO PROTECT TOWRA POINT

Australia is party to a number of international agreements and treaties which require protection of significant wetlands and habitat for migratory birds. These include (DECCW & SMCMA, 2010):

- The Ramsar Convention on Wetlands
- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn)
- The Japan - Australia Migratory Bird Agreement (JAMBA)
- The China - Australia Migratory Bird Agreement (CAMBA)
- The Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)
- The East Asian - Australasian Flyway Partnership (EAAFP)

The Ramsar Convention aims to prevent the degradation and loss of important wetlands across the globe through requiring implementation of appropriate site management and conservation principles.

The Bonn Convention is an environmental treaty of the United Nations, and aims to conserve migratory species within their migratory ranges. The Bonn convention is the only global convention which specialises in the conservation of migratory species, their habitats and migration routes. As of 1 November 2019, there were 130 Parties to the Convention.

JAMBA, Bonn, CAMBA and ROKAMBA are bilateral agreements which provide for protection of migratory birds and their important habitats.

The EAAFP is an informal and voluntary initiative which aims to protect migratory waterbirds and their habitats. Members of EAAFP include countries, intergovernmental agencies, NGOs and the international business sector.

33.3 GENERAL DESCRIPTION OF TOWRA POINT NATURE RESERVE

The Towra Point Nature Reserve has an area of 603.7 ha, located on the southern shore of Botany Bay opposite Sydney Kingsford Smith International Airport. The site is approximately 16 km from the centre of Sydney, within the Sutherland Shire local government area (see Figure 33-1).

The Towra Point Nature Reserve is an estuarine wetland complex. It is the largest of its type in the Sydney region and supports vegetation types that are regionally significant, including around 40 per cent of the remaining mangrove communities and 60 per cent of the remaining saltmarsh communities in Sydney. It is also an important link for migratory shorebirds on the East Asian-Australasian Flyway, supporting 30 out of 80 species of birds listed under international bilateral agreements (JAMBA, CAMBA, ROKAMBA). The site is comprised of the following eight wetland types:

- 'Marine subtidal aquatic beds', including significant areas of seagrass meadows within and adjacent to the Towra Point Nature Reserve
- 'Sand, shingle or pebble shores', including the itinerant sand spits and islands around Towra Point that are continually changing as a result of sand movement. These areas provide important habitat for shorebirds. They include Towra Spit Island, formed in 1991 from the tip of Towra Point when it became separated by a channel. Since its formation, it has been recognised as the second most important nesting site in NSW for the little tern
- 'Estuarine waters'. Those that surround Towra Point include Botany Bay, Georges River, Cooks River, Woolooware Bay, Quibray Bay and Weeney Bay. Approximately 1,400 ha of these surrounding waters have been designated as the Towra Point Aquatic Reserve
- 'Intertidal mud, sand or salt flats', including 156 (low tide) ha of muddy sand flats that extend along the shoreline from mean low water spring to mean high water spring tides. These areas are high in organic matter and provide rich feeding grounds for many shorebirds
- 'Intertidal marshes', including around 134 ha of saltmarsh within and adjacent to Towra Point Nature Reserve, which occurs on the landward side of adjacent areas of mangrove. The saltmarsh at Towra Point is one of the largest stands in NSW
- 'Intertidal forested wetlands', supporting a significant 385 ha of mangrove within and adjacent to Towra Point Nature Reserve
- 'Coastal brackish lagoons' and 'Coastal freshwater lagoons'. There are three named lagoons at Towra Point including Towra Lagoon, Mirrormere and Weedy Pond, and at least three unnamed lagoons that have no ecological information. All lagoons meet the definition of Sydney Freshwater Wetlands – an endangered ecological community in NSW

The Towra Point Nature Reserve is in the Botany Bay catchment which covers 1,165 km^2 and supports a population of approximately 2 million people (OEH, 2012; SMCMA, 2011). The Georges and Cooks Rivers and their tributaries flow into Botany Bay.

The entire Ramsar site lies within the boundary of the Towra Point Nature Reserve which is managed by the NSW National Parks and Wildlife Service (OEH, 2012). The site is also adjacent to the Towra Point Aquatic Reserve (see Figure 33-2) which is an important nursery area for fish and invertebrates, provides important habitat for migratory seabirds and is rich in marine biodiversity.

Figure 33-1 shows the Ramsar site within the context of its upstream catchment. The data for the catchment was downloaded from the Australian Government Department of Agriculture, Water and Environment spatial data viewer (http://www.environment.gov.au/fed/catalog/main/home.page). The data layer was derived using:

- "Each of the Ramsar Wetland site's boundaries
- A 10 km buffer area to each site, clipped to 3km where the buffer area extends seawards from the coast
- A catchment for each site from an upstream trace process using the Australian Hydrological Geospatial Fabric (Geofabric) features and relationships
- A multi-ring buffer, intersect and erase process to divide the catchment into distance bands from the Ramsar site"

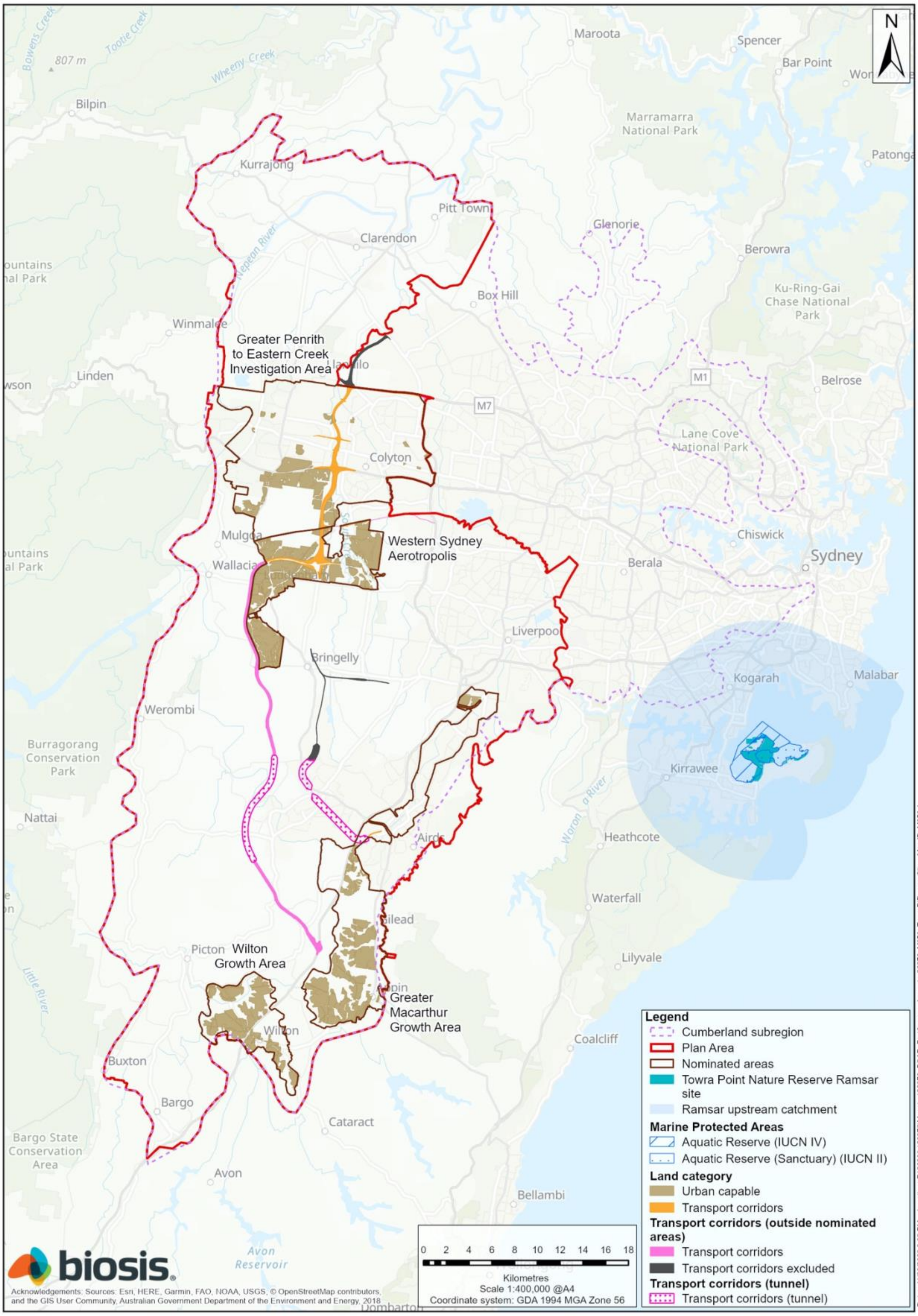

Figure 33-1: Map of Towra Point Nature Reserve Ramsar site in the Sydney Basin Bioregion

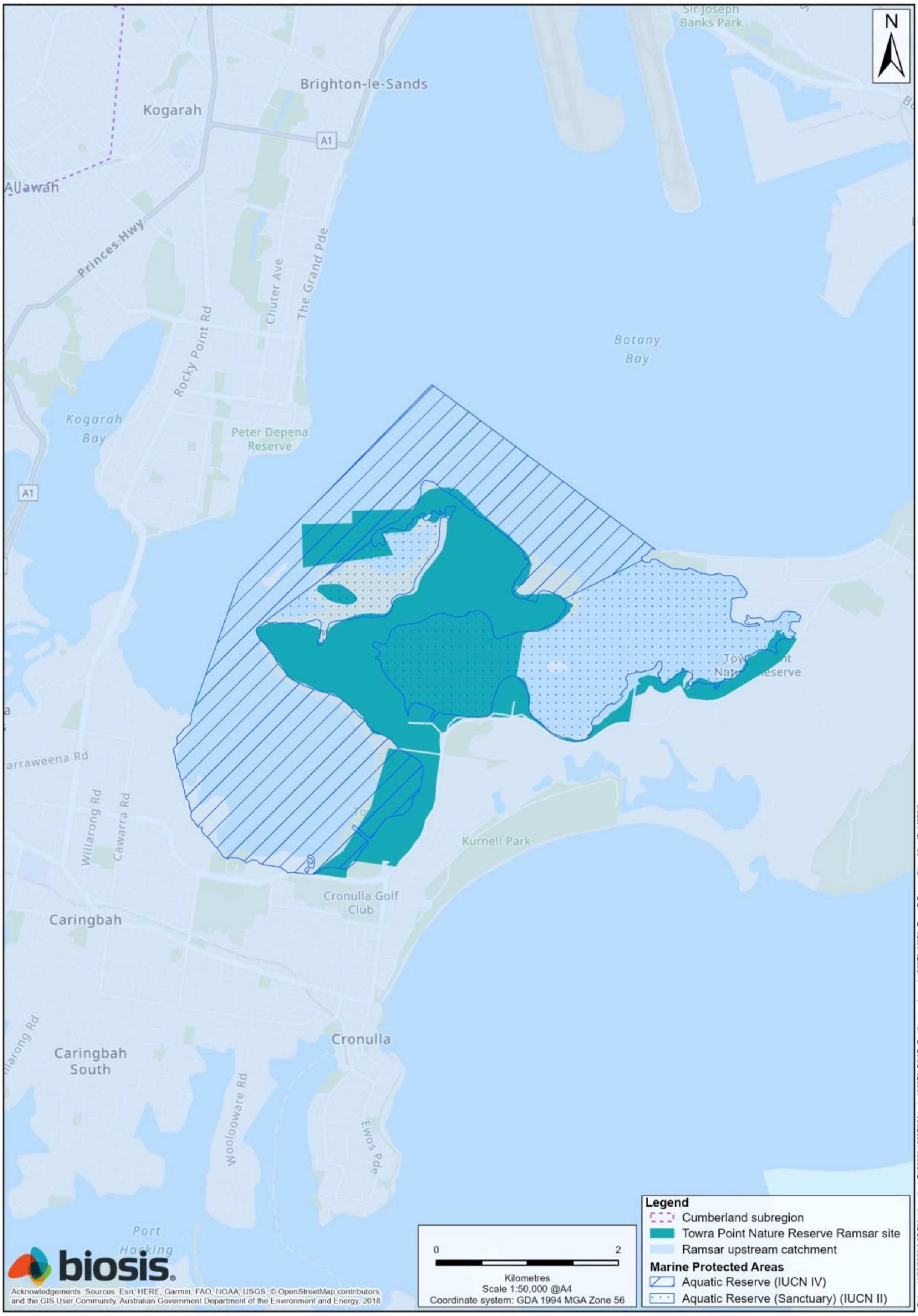

Figure 33-2: Site map of Towra Point Nature Reserve Ramsar site

33.4 RAMSAR LISTING CRITERIA

The Towra Point Nature Reserve was listed as a Wetland of International Importance under the Ramsar Convention in February 1984. For a wetland to be designated as a Ramsar site it must satisfy one or more of the Ramsar listing criterion. Towra Point Nature Reserve is considered to meet criteria 2, 3, 4 and 8 (see Table 33-1). Note that these criteria have changed since the original listing in 1984 due to administrative changes.

Table 33-1: Criteria for Ramsar listing

Criterion	Justification
2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities	It supports three EPBC Act listed threatened species • Grey-headed flying fox (*Pteropus poliocephalus*) • Magenta lilly pilly (*Syzygium paniculatum*) • Green and golden bell frog (*Litoria aurea)*
3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	In 1993 Botany Bay was recognised as one of the four most important migratory wading bird sites in NSW. Towra Spit Island was recognised as the second most important breeding area in NSW for the little tern *(Sterna albifrons)* (NSW NPWS, 2001) Towra Point is home to seagrass beds, mangrove and saltmarsh communities that provide critical habitat for juvenile fish and crustaceans (DECCW & SMCMA, 2010) The site also provides critical links for ecological connectivity and supports species that are uncommon elsewhere in the Sydney region (DECCW & SMCMA, 2010)
4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions	Towra Point provides habitat for species of juvenile fish and crustaceans at a vulnerable stage in their life cycle. Such as the common silver biddy *(Gerres ovatus)*, yellow fin bream *(Acanthopagrus australis)*, flat-tailed mullet *(Liza argentea)*, and luderick *(Girella tricuspidata)* Migratory shorebirds use Towra Point as a critical stopover on migratory routes from Korea, Japan, China, Russia, Siberia and Alaska during September to April (DECCW & SMCMA, 2010)
8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend	The site provides habitat and food sources for at least 25 species of fish of economic importance. The seagrass, mangroves, and saltmarshes provide important habitat for protection for juvenile and migratory fish as well as food sources (DECCW & SMCMA, 2010)

By designating Towra Point Nature Reserve as a Ramsar site, Australia is obligated to establish and implement a management framework that aims to conserve the wetland and ensure its wise use. ‘Wise use’ under the Convention is broadly defined as maintaining the ‘ecological character’ of the wetland.

Ecological character is defined under the Ramsar Convention as the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time (Ramsar Convention, 2005). It provides a baseline description of the wetland at the time of listing and often incorporates limits of acceptable change (LAC). LACs are the “range of variation in the components, processes and benefits or services that can occur without causing a change in the ecological character of the site” (DEWHA, 2008).

Ecological character is also the main element for the consideration of significant impacts under the EPBC Act. The significant impact guidelines (DoE, 2013b) state that:

> *An action is likely to have a significant impact on the ecological character of a declared Ramsar wetland if there is a real chance or possibility that it will result in:*
>
> - *areas of the wetland being destroyed or substantially modified*
> - *a substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland*
> - *the habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent upon the wetland being seriously affected*
> - *a substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health, or*
> - *an invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.*

This assessment uses these guidelines to discuss the potential impacts to the Towra Point Nature Reserve.

33.5 SUMMARY OF THE ECOLOGICAL CHARACTER OF THE SITE

The Ecological Character Description (ECD) for Towra Point was developed retrospectively in 2010 (DECCW & SMCMA, 2010). It identifies in detail the critical components, processes, services and benefits of the site, along with the limits of acceptable change.

Table 33-2 provides a high level summary of the ecological character of the site and Attachment A provides more detail.

Table 33-2: High level summary of the ecological character of Towra Point

Component of ecological character	Key points	Limits of acceptable change (LAC)
Components and processes		
Geomorphology	• Towra Point was formed as a result of dynamic wind, wave, and tidal processes over time. In particular from the dynamic movement of marine sand from Botany Bay and fluvial mud from the Georges River • Since its listing, a range of factors (anthropogenic and natural) have altered its geomorphology. Notably, sediment connecting Towra Spit Island to the mainland was dredged in 2004 and needs to continuously be managed to maintain the ecological value of the Island • The wetland is low lying and the flora and fauna reflect their tolerance to salt water • The sedimentation processes of erosion and accretion facilitate the movement and colonisation of vegetation. They also create mudflats that provide favourable habitat for migratory birds and mangroves	• The LAC for geomorphology is the same as those set for the little tern because the spit is an important breeding and roosting habitat for migratory birds (including the little tern) • The LAC is the 'successful annual breeding in one out of every two years' of the little tern
Hydrology	• The site is part of a dynamic system and relies on the hydrological processes of tides, wave action, and groundwater • Anthropogenic changes (before and after listing) have affected tidal movements and wave action • The site is situated on the Botany Bay Sand Aquifer that extends from Centennial Park in the north, to Botany Bay and Kurnell Peninsula in the south, and west to Rockdale • The area around the wetland provides an important point of recharge for the aquifer	• Limits of acceptable change for groundwater are determined by the relevant water quality guidelines (ANZECC & ARMCANZ, 2000; ANZG, 2018)
Physiochemical environment	• At Towra Point the physiochemical environment determines water quality, which is vital for sustaining the diverse range of flora and fauna • The key components of the physiochemical environment at Towra Point are: o Salinity o Nutrients o Heavy metals o Turbidity	• Water quality guidelines for marine water have been used to determine limits of acceptable change for the physiochemical environment (ANZECC & ARMCANZ, 2000; ANZG, 2018)

Component of ecological character	Key points	Limits of acceptable change (LAC)
Biota	• Towra Point supports a number of regionally significant flora that occur as distinct vegetation zones across the wetland. Critical components include: o Seagrass o Mangroves o Saltmarsh o Substantial areas of terrestrial vegetation • Towra Point is one of the last remaining wetlands of its type in the Sydney region and provides important habitat for a number of threatened and migratory species. Fauna species present at the site include: o Macro-invertebrates o Fish o Reptiles and amphibians (including the Green and Golden Bell Frog) o Mammals (including the Grey-headed Flying Fox) o Birds (189 species, important habitat for migratory shorebirds, important site for the Little Tern (*Sternula albifrons*))	• LACs have been developed (where possible) for vegetation and a range of specific species
Climate	• Climate exists as an ecosystem regulator and plays an important role in maintaining equilibrium • The flora and fauna at Towra Point have adapted to the temperate climate of the region. Climate change and anthropogenic changes around Botany Bay are altering the intensity of climatic parameters	• Parameters for climate cannot be managed at a local scale. It has therefore been identified that LACs cannot be set for climate for Towra Point Nature Reserve Ramsar site
Services and benefits		
Provisioning services	• Provisioning services include: o Fisheries production o Trophic relay (transfer of energy and nutrients to different parts of the estuary)	• N/A
Regulating services	• Regulating services of Towra Point Ramsar site include: o Maintenance of hydrological regimes o Shoreline stabilisation and storm protection o Biological control of pests and disease o Pollution control	• N/A

Component of ecological character	Key points	Limits of acceptable change (LAC)
Cultural services	• Cultural services of Towra Point Ramsar site include: o Recreation and tourism o Science and education o Aesthetic amenity o Aboriginal heritage o Non-Aboriginal heritage	• N/A
Supporting services	• Supporting services of Towra Point Ramsar site include: o Hydrological processes o Food webs o Physical habitat o Nutrient cycling o Primary production o Sediment trapping and stabilisation o Biodiversity o Special ecological, physical or geomorphic features o Threatened wetland species, habitats and ecosystems o Priority wetland species o Ecological connectivity	• N/A

33.6 ANALYSIS OF POTENTIAL IMPACTS

33.6.1 DIRECT IMPACTS

Towra Point Nature Reserve is located outside the Strategic Assessment Area. The Ramsar site is approximately 23 km from the nearest nominated area (see Figure 33-1) and the Plan will not result in any direct impacts on the site.

33.6.2 INDIRECT OR FACILITATED IMPACTS

The Plan has the potential to cause the following indirect and facilitated impacts on Towra Point Nature Reserve:

- Reduction in surface water quality and changes to surface water flows due to run-off from urban and industrial, infrastructure, and transport development in the upstream catchment
- Potential changes to the ecological character of the reserve from increased recreational use from increased populations in Western Sydney facilitated by the urban development

CHANGES TO SURFACE WATER FLOWS AND REDUCTION IN WATER QUALITY

Nature, extent and duration of indirect impacts

Towra Point Nature Reserve is located in the Botany Bay catchment, which comprises four major sub-catchments:

- Direct to Botany Bay (this incorporates the minor sub-catchment of South Botany Bay, which would most directly influence Towra Point Nature Reserve)
- Cooks River
- Georges River
- Woronora River

A small part of the Strategic Assessment Area is located within the Georges River sub-catchment. Water quality within Towra Point Nature Reserve may be affected by the development through:

- Urban development within a part of GMAC that overlaps with the Georges River sub-catchment (170 ha)
- Transport corridors that occur within the Georges River sub-catchment (9 ha)

Towra Point Nature Reserve is also connected to the Botany Sand Aquifer, which extends from Centennial Park to Botany Bay and Kurnell Peninsula. The development occurs outside this area and is unlikely to impact on this aquifer.

Potential impacts to surface water quality may occur due to construction activities and an increased extent of urban land. Construction activities have the potential to impact water quality entering the Georges River and its tributaries for the duration of construction through the following pathways:

- Soil disturbance as part of construction activities may lead to an increase in erosion and runoff which would mean more sediments and nutrients entering the system
- Introduction of contaminants as a result of spillage or improper use and disposal of hazardous substances

Urban development may affect water quality entering the Georges River as a result of:

- Disruption to natural flows and processes
- Increase of hard surfaces leading to an increased volume of water entering downstream waterways
- Introduction of contaminants into surface water, such as nutrients, sediment and other pollutants

The components, processes, services and benefits of the ecological character of the Towra Point Nature Reserve that may be affected by these indirect impacts are identified in Table 33-4 and Table 33-5.

The exact location and timing of construction activities within GMAC are not known at this time, which means the nature and extent and duration of possible changes to water quality entering the Georges River cannot be quantified. However, there are a number of factors which substantially reduce the level of risk to the ecological character of Towra Point Nature Reserve from construction and a change in land use. These include:

- Distance of the development to Towra Point: GMAC is approximately 23 km from Towra Point. This distance provides a buffer to potential impacts relating to an increase in water flows and will reduce any sediment load and level of nutrients and contaminants reaching Towra Point
- Well flushed nature of the wetland: Towra Point is part of a tide-dominated estuarine system. Tidal movement means that suspended solids can only reside in the bay for a short time, leading to a well flushed water body and relatively high water quality
- Vegetated buffers on all riparian corridors: the development has avoided riparian corridors (see Chapter 14). This riparian vegetation will minimise direct runoff into waterways and act as a sink for nutrients and sediments

Commitments to address indirect impacts

Mitigation of urban and industrial development

As part of implementing the commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5), a Development Control Plan (DCP) will be prepared for each nominated area by either the Department (in the case of Department led precincts) or by the relevant councils in collaboration with the Department.

A DCP provides detailed guidelines and environmental standards for new development, which need to be considered when preparing a development application seeking development approval.

DCPs for each nominated area will be prepared in accordance with:

- Standard format for DCPs and a set of model provisions prepared by the Department to apply across NSW
- Any processes and guidelines for preparing DCPs specific to each council
- Current best practice standards, guidelines or targets (e.g. water quality standards for urban runoff)

Two broad types of development controls will be implemented under each DCP:

- General environmental controls that will benefit the environment generally, including biodiversity values
- Specific controls that apply to specific species and TECs in specific locations or broader nominated areas. These controls have been identified through this Assessment Report and are needed to address residual risks to species or TECs that remain after implementation of the general environmental controls

Several general environmental controls are relevant to managing indirect impacts from the urban and industrial development on Towra Point Nature Reserve. These development controls are examples of controls typically included by councils in DCPs and likely to be implemented in the nominated areas (see Chapter 15, Section 15.6.1).

A detailed description of the process to implement these development controls in the nominated areas, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.1.

It is considered that these general environmental controls and the process to implement them described in Chapter 15 are adequate to mitigate impacts to Towra Point Nature Reserve from urban and industrial development and no additional measures are considered necessary for the protection of the site.

Table 33-3: General environmental controls relevant to managing indirect impacts on Towra Point

Control type	Summary of example control in draft Wilton DCP
Water cycle management	• Water management measures must comply with council's requirements for detention, drainage and water sensitive urban design principles • Water management measures must be designed to prevent damage by stormwater to the natural environment and minimise urban water run-off and sediment and pollutants to waterways

Control type	Summary of example control in draft Wilton DCP
Water quality	• Stormwater systems must be constructed and maintained to achieve EES water quality targets
Soil erosion and sedimentation	• Development must incorporate measures to minimise soil erosion and sedimentation during construction and following completion of development • Soil and Water Management Plans must be prepared in accordance with Managing Urban Stormwater (Landcom, 2004) and submitted with each subdivision development application
Disturbance to saline soils	• Salinity Management Plans must be prepared in accordance with the Western Sydney Salinity Code of Practice 2004 (WSROC, 2004) and submitted with each subdivision development application
Contaminated soils	• All subdivision development applications must be accompanied by a Stage 1 Preliminary Site Investigation. Where this identifies potential site contamination, a Stage 2 detailed site investigation must be prepared • A Remediation Action Plan (RAP) must be prepared for areas identified as contaminated land in the Stage 2 Site Investigation

Mitigation of infrastructure and transport corridors

A different process will be implemented under the Plan to mitigate the indirect impacts of infrastructure and the transport corridors. For both types of development, the Plan includes commitments to mitigate indirect and prescribed impacts (Commitment 5.3 for infrastructure, and Commitment 6 for transport). These commitments will be delivered for both types of development through a process of environmental assessment and approval that will be applied to detailed design of each infrastructure and transport project at the time the project is brought forward for development.

For infrastructure development, the assessment process will be undertaken under Part 4 or Part 5 of the EP&A Act (or equivalent at the time). State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed under the EPA Act.

For transport development, the assessment process will be undertaken under the State Significant Infrastructure approval process (or equivalent at the time) under the EP&A Act.

These future environmental assessment and approval processes will assess and identify mitigation measures to manage the non-biodiversity related potential environmental impacts of the projects. This process will, for example, assess the potential for a project to result in changes to surface water flows and water quality impacts, based on the detailed design of the project, and identify mitigation measures to address these risks.

These processes therefore provide the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Towra Point Nature Reserve from the infrastructure and transport development and no additional measures are considered necessary for the protection of the site.

A detailed description of the assessment and approval process for transport corridors and infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, Section 15.6.2 and 15.6.3.

Conclusion

It is considered unlikely that there will be a reduction in surface water quality to a point that there are notable or consequential impacts to the ecological character of the Towra Point Nature Reserve. There are several factors that substantially reduce the potential for water quality impacts from the development on Towra Point and the commitments and processes under the Plan to manage indirect impacts is considered to adequately mitigate any residual risks.

POTENTIAL CHANGES TO ECOLOGICAL CHARACTER FROM INCREASED RECREATIONAL USE

Nature, extent and duration of indirect impacts

The development under the Plan will lead to increased numbers of people in Western Sydney that may result in increased visitation to Towra Point Nature Reserve, which could lead to a degradation of site values.

The components, processes, services and benefits of the ecological character of the Towra Point Nature Reserve that may be affected by increased recreational use are summarised in Table 33-6.

Existing management of visitor access

Access to Towra Point is restricted by permits. In addition to being listed as a Ramsar site, Towra Point is also a nature reserve. Nature Reserves differ from National Parks as they only allow restricted access. Permits are granted for scientific and educational purposes and are fully supervised.

There are two areas that do not require permits to access. These are Quibray Bay viewing platform and Towra Point day use area. The day use area is restricted to the shoreline of Towra Point beach and is only accessible by boat (OEH, 2012).

Activities associated with visitation to Towra Point beach day use area include:

- Recreational fishing
- Use of Towra Point beach recreational area

These activities have the potential to impact fish stocks as a result of recreational fishing, in addition to beach nesting birds. While Towra Spit Island and other habitats for threatened beach nesting birds do not permit public access, beach nesting birds such as the Little Tern are susceptible to disturbance as a result of human activity in the wider area, including swimmers, boats, fishers and divers (DECC, 2008).

There is a Plan of Management for Towra Point Nature Reserve that sets out a range of management strategies to be implemented by the NSW National Parks and Wildlife Service (NSW NPWS, 2001). The Plan includes a range of measures to manage visitor use and enforce of prohibitions and restrictions on access, including (DECC, 2008):

- Restricting access to areas of threatened species habitat, including Towra Spit Island, which is a significant nesting site for the Little Tern
- Use of signage, brochures, media releases and regular on-site patrols to educate the public regarding the importance of Towra Spit Island
- Implementing temporary beach closures and fencing off large areas around nesting colonies where required
- Provision of day-use access to nearby Towra Beach and shorebird viewing platforms to enable safe public engagement with the wetland while protecting wetland values
- Multiple management measures to raise public awareness of the importance of shorebird conservation

These existing measures to manage potential impacts associated with human visitation to Towra Point Nature Reserve are expected to be adequate to manage potential increases in visitor numbers resulting from the urban development.

Conclusion

The potential risk to the ecological character of Towra Point Nature Reserve as a result of an increased number of visitors is considered minimal. Due to existing high population densities in proximity to Towra Point Nature Reserve, the reserve implements a wide range of ongoing and comprehensive management measures to manage the potential impacts associated with human visitation, and these are expected to adequately address this risk.

33.7 ADDRESSING OBLIGATIONS UNDER THE RAMSAR CONVENTION

Section 4.7 of the ToRs requires the Assessment Report to consider the extent to which the impacts of the Plan are consistent with Australia's international obligations, including the Ramsar Convention. The Ramsar Convention's broad aims are to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. This requires international cooperation, policy making, capacity building and technology transfer.

The Plan includes a combination of avoidance and mitigation measures relevant to managing indirect impacts on Towra Point Nature Reserve. As described in section 33.6.2 and considered further in Chapter 15, the Plan includes a commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5) as well as from the transport development (Commitment 6).

The Plan also includes a monitoring, evaluation and reporting program (MER) (see Sub-Plan A) that provides for public reporting on progress in achieving the commitment and actions, and regular and consistent monitoring and evaluation to inform adaptive management responses. Commitment 27 includes an action to publish yearly updates over the life of the Plan.

The Ramsar Convention has been considered in the development of the Plan, which requires avoidance, mitigation and management measures for Ramsar wetlands. The Plan requires information related to the development to be publicly available to ensure equitable sharing of information and improved knowledge relating to the site.

Impacts to Towra Point Nature Reserve are unlikely and loss of wetlands is not foreseeable. The Plan is not considered to be inconsistent with the Ramsar Convention.

Table 33-4: Components, processes, and services of the ecological character of Towra Point that may be impacted by potential indirect impacts from construction

	Components & processes																						Services & benefits			
Potential indirect impacts	**Geology & morphology**	**Topography & microtopography**	**Sedimentation**	**Tides**	**Wave action**	**Groundwater**	**Salinity**	**Nutrients**	**Heavy metals**	**Turbidity**	**Seagrass**	**Mangroves**	**Saltmarsh**	**Terrestrial vegetation**	**Macro-invertebrates**	**Fish**	**Reptiles & amphibians**	**Mammals**	**Birds**	**Temperature**	**Rainfall**	**Storms**	**Provisioning services**	**Regulating services**	**Cultural services**	**Supporting services**
Soil disturbance	X	X	X	X	X	X	X	✓	✓	✓	✓	X	X	X	X	✓	X	X	✓	X	X	X	✓	✓	✓	✓
Introduction of contaminants	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	✓	✓	X	X	✓	X	X	X	✓	✓	✓	✓

Key:

No risk of potential impacts:	X
Some risk of potential impacts:	✓

Table 33-5: Components, processes, and services of the ecological character of Towra Point that may be impacted by potential indirect impacts from increase in extent of urban and industrial areas

	Components & processes																						Services & benefits			
Potential indirect impacts	**Geology & morphology**	**Topography & microtopography**	**Sedimentation**	**Tides**	**Wave action**	**Groundwater**	**Salinity**	**Nutrients**	**Heavy metals**	**Turbidity**	**Seagrass**	**Mangroves**	**Saltmarsh**	**Terrestrial vegetation**	**Macro-invertebrates**	**Fish**	**Reptiles & amphibians**	**Mammals**	**Birds**	**Temperature**	**Rainfall**	**Storms**	**Provisioning services**	**Regulating services**	**Cultural services**	**Supporting services**
Loss of vegetation	X	X	X	X	X	X	X	✓	✓	✓	✓	X	X	X	X	✓	X	X	✓	X	X	X	✓	✓	✓	✓
Impervious surfaces	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	X	✓	✓	X	X	✓	X	X	X	✓	✓	✓	✓
Sewerage & waste contamination	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	✓	✓	X	X	✓	X	X	X	✓	✓	✓	✓
Point source spills & accidents	X	X	X	X	X	X	X	✓	✓	✓	✓	✓	X	X	✓	✓	X	X	✓	X	X	X	✓	✓	✓	✓

Key:

No risk of potential impacts:	X
Some risk of potential impacts:	✓

Table 33-6: Components, processes, and services of the ecological character of Towra Point that may be impacted by potential facilitated impacts from increase in visitation

	Components & processes																						Services & benefits			
Potential indirect impacts	**Geology & morphology**	**Topography & microtopography**	**Sedimentation**	**Tides**	**Wave action**	**Groundwater**	**Salinity**	**Nutrients**	**Heavy metals**	**Turbidity**	**Seagrass**	**Mangroves**	**Saltmarsh**	**Terrestrial vegetation**	**Macro-invertebrates**	**Fish**	**Reptiles & amphibians**	**Mammals**	**Birds**	**Temperature**	**Rainfall**	**Storms**	**Provisioning services**	**Regulating services**	**Cultural services**	**Supporting services**
Recreational fishing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	X	X	X	X	X	X	✓	X	X	X
Recreational use of beach	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	✓	X	X	X	X	X	X	X

Key:

No risk of potential impacts:	X
Some risk of potential impacts:	✓

34 World and National Heritage impact assessment

Fires within Greater Blue Mountains World Heritage Area

NSW experienced extensive bushfires throughout the spring and summer of 2019-20. As of 3rd February 2020, the fires had burnt 5.37 million hectares of land (approximately 7 per cent of NSW). This includes 37 per cent of the national park estate, including 81 per cent of the Greater Blue Mountains World Heritage Area (DPIE, 2020).

An assessment of the potential impacts of the Plan on the Greater Blue Mountains World Heritage Area in relation to fire is provided in section 34.2.5.

World Heritage and National Heritage sites are Matters of National Environmental Significance (MNES) and are protected under the Commonwealth EPBC Act.

This Chapter assesses the potential impacts to World Heritage and National Heritage sites from urban, transport and agricultural development under the Plan. It sets out:

- The regulatory context for World and/or National Heritage properties
- A discussion of each of the properties listed in Table 34-1, including:
    - An assessment of potential direct, indirect and facilitated impacts
    - An assessment of the consistency of the Plan with the regulatory requirements for each property

There are three World and/or National Heritage listed sites in or near the Strategic Assessment Area that could potentially be impacted by development under the Plan. Table 34-1 lists these sites and their World Heritage and National Heritage listing status.

The Greater Blue Mountains World Heritage Area is located close to the nominated areas and has been considered in detail. The other heritage sites are further from the urban capable land and transport corridors and are unlikely to impacted, and have been considered in less detail.

In summary, the direct and indirect impacts to these sites from the Plan are negligible. There is the possibility of facilitated impacts from increased visitor numbers, but visitor impacts are already managed at each site and the existing management arrangements for these sites are considered sufficient to manage this risk.

Table 34-1: World and National Heritage sites in or near the Strategic Assessment Area

Site	World Heritage status	National Heritage status
Greater Blue Mountains World Heritage Area	Listed	Listed
Parramatta Female Factory and Institutions Precinct	-	Listed
Old Government House and Government Domain	Part of Australian Convict Sites listing (one of 11 sites across Australia)	Listed

34.1 REGULATORY CONTEXT

The EPBC Act sets out a range of protections for World Heritage and National Heritage properties. This assessment draws on four components of this regulatory framework:

- The concept of Outstanding Universal Value
- The EPBC Act Significant Impact Guidelines 1.1 (DoE, 2013b)
- EPBC Act Section 146G: Approvals relating to declared World Heritage properties
- EPBC Act Section 146H: Approvals relating to National Heritage places

Each of these components is discussed in detail below.

34.1.1 OUTSTANDING UNIVERSAL VALUE

The concept of Outstanding Universal Value (OUV) is defined in the *Operational Guidelines for the Implementation of the World Heritage Convention* (the Guidelines, UNESCO, 2017) as "cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity".

For a World Heritage Property to be considered to have OUV, it must:

- Meet one or more of the ten World Heritage criteria listed in the Guidelines (UNESCO, 2017)
- Meet the conditions of integrity and/or authenticity (noting that authenticity is not relevant to the Greater Blue Mountains Area as a natural area)
- Have an adequate protection and management system

The OUV of a World Heritage Property is articulated in a Statement of Outstanding Universal Value which is typically prepared at the time of inscription. Besides describing the attributes of the property that contribute to its OUV, the Statement of OUV provides the basis for the future protection and management of the property.

34.1.2 SIGNIFICANT IMPACT GUIDELINES 1.1

This assessment draws on key concepts outlined in the EPBC Act Significant Impact Guidelines 1.1 (DoE, 2013b) in relation to World and National Heritage. These guidelines describe three pathways for significant impacts to World Heritage properties or National Heritage places.

Actions are likely to have significant impacts if there is a real chance or possibility that they will lead to:

- A loss of one or more World or National Heritage values
- Degradation or damage to one or more World or National Heritage values
- Notable alteration, obscuring, or diminishment of one or more World or National Heritage values

These concepts have been used to discuss the potential likelihood and severity of impacts to OUV. The World or National Heritage values for each site will be identified in the relevant section.

34.1.3 APPROVALS RELATING TO DECLARED WORLD HERITAGE PROPERTIES

Section 146G of the EPBC Act sets out the approval considerations in relation to World Heritage properties. It requires the outcomes of the Plan to not be inconsistent with any of:

- Australia's obligations under the World Heritage Convention
- The Australian World Heritage management principles
- A management plan for a World Heritage property that falls under the Sections 316 or 321 of the EPBC Act

The strategic assessment process is consistent with the requirements for public consultation and environmental impact assessment in the Australian World Heritage management principles.

The Australian World Heritage management principles set out requirements for public consultation in the management of and assessment of the possibility of significant impacts to World Heritage properties. These requirements are consistent with the strategic assessment process.

The World Heritage Convention sets out a broad range of obligations to recognise and protect World Heritage properties and cooperate internationally for the ongoing preservation. As outlined below, the potential impacts to World Heritage properties from the Plan are acceptable, and the Plan is not inconsistent with these obligations.

A key test for approval for World Heritage properties is that the outcomes of the Plan are not inconsistent with the property's management plan. The relevant management plans under Sections 316 or 321 of the EPBC Act are discussed in the EPBC Act Approval Considerations section for each property.

34.1.4 APPROVALS RELATING TO NATIONAL HERITAGE PLACES

Section 146H of the EPBC Act sets out the approval considerations in relation to National Heritage places. It requires the outcomes of the Plan to not be inconsistent with any of:

- The National Heritage management principles
- An agreement to which the Commonwealth is a party in relation to a National Heritage place
- A management plan for a National Heritage place that falls under Sections 324S or 324X of the EPBC Act

The National Heritage management principles relate to the identification, protection, management and use of National Heritage places. The principles are broadly consistent with the strategic assessment process.

A key requirement for approval under the EPBC Act is whether the outcomes of the Plan are inconsistent with any relevant management plans or agreements for each National Heritage place. The relevant plans are discussed in the EPBC Act Approval Considerations section for each property.

34.2 GREATER BLUE MOUNTAINS WORLD HERITAGE AREA

The Greater Blue Mountains World Heritage Area (GBMWHA) is listed as both a World Heritage site and a National Heritage place. It occurs adjacent to the Cumberland subregion (see Figure 34-1).

This section assesses the likely impacts of the proposed development under the Plan on the GBMWHA. It sets out:

- A brief description of the area
- The relevant EPBC Act approval considerations
- The values of the World Heritage area
- The relationship between the Plan and the GBMWHA
- The potential direct, indirect and facilitated impacts to the values of the GBMWHA associated with the Plan
- Consistency with the Strategic Plan for the World Heritage area
- An evaluation of the adequacy of the outcome

This assessment shows that the only relevant potential impacts to the OUV of the GBMWHA from the Plan are from facilitated impacts. Specifically, the Plan will support population growth near the World Heritage area which may increase the extent and intensity of impacts from visitor use.

The GBMWHA is made up of eight conservation reserves, each of which is protected and managed for conservation. The management plans for these reserves sufficiently address impacts associated with visitor use. Provided these conservation reserves continue to monitor and adaptively manage impacts from visitors over time, the risk of impacts to the OUV of the GBMWHA from the development under the Plan is considered minimal.

34.2.1 DESCRIPTION OF THE GREATER BLUE MOUNTAINS WORLD HERITAGE AREA

The GBMWHA covers 1.03 million ha to the west of the Strategic Assessment Area. It extends between 60 and 180 km inland from central Sydney, between Bowral in the south, and Newcastle and Mudgee to the north (DECC, 2009b).

It contains a deeply incised sandstone plateau with a wide range of forest ecosystems, mallee scrubs, swamps, deep valleys, cliffs, canyons and rivers. It protects large areas of wilderness and provides habitats for an internationally significant diversity of flora, fauna and ecological communities. It provides connectivity between coastal ecosystems to the east and the western slopes and is an important north-south corridor (DECC, 2009b).

The park is adjacent to Sydney and urban areas in the Hunter and Central Coast regions. It provides important opportunities for education, recreation, research and access to wilderness (DECC, 2009b).

34.2.2 EPBC ACT APPROVAL CONSIDERATIONS

The Greater Blue Mountains World Heritage Area Strategic Plan (the Strategic Plan) was published in 2009 for the management of the World Heritage property as described by Section 321 of the EPBC Act. The Strategic Plan also acts as a management plan for a National Heritage place under Section 324X of the EPBC Act.

A key consideration for approval of the Plan is that it is not inconsistent with the Strategic Plan. This section sets out the broad objectives of the Strategic Plan and the conditions the Plan must meet to be approvable under the EPBC Act.

OBJECTIVES OF THE STRATEGIC PLAN

The Strategic Plan sets out a range of values that are expressed in the GBMWHA. Some of these are recognised as being Outstanding Universal Values, while others support OUV within the GBMWHA or could potentially be listed in the future. The Outstanding Universal Values and these supporting values are discussed below. To manage these values, the Strategic Plan lists ten key management issues, each of which has one or more objectives and a range of desired outcomes and management responses. The key management issues and their objectives are provided in Table 34-2.

Table 34-2: Key management issues and objectives for the GBMWHA

Key management issue	Objective
Integrity	• To maintain, and wherever possible, improve the current and future integrity of the GBMWHA
Major impacts	• To reduce the potential for major impacts to adversely affect the integrity of the GBMWHA. Major impacts include mining adjacent to or underlying the GBMWHA, highway construction through the GBMWHA, or other development within or adjacent to the GBMWHA
Biodiversity	• To conserve the GBMWHA's biodiversity and ensure the ecological viability and capacity for ongoing evolution of its World Heritage and other natural values is maintained
Geodiversity	• To protect the GBMWHA's geodiversity
Water catchment protection	• To maintain and improve the water quality and water catchment values of the GBMWHA
Cultural heritage	• To identify, formally recognise and protect the cultural heritage values of the GBMWHA • To manage the GBMWHA jointly with local Indigenous people
Landscape, natural beauty and aesthetic values	• To protect the landscape, natural beauty and aesthetic values of the GBMWHA
Recreation and visitor use	• To provide for an appropriate range of recreation and visitor use, consistent with the protection of World Heritage and related values
Social and economic issues	• Consistent with the protection of World Heritage and other values, optimise the potential and existing social and economic benefits derived from visitation to the GBMWHA
Education, community participation and consultation	• To encourage community stewardship of the GBMWHA through education, consultation and the provision of opportunities for community participation in its protection

There are a large number of desired outcomes, many of which are not relevant to implementation of the Plan. Desired outcomes that may be affected by the Plan are discussed individually as appropriate.

TEST FOR APPROVAL

For approval under the EPBC Act, the Plan must not be inconsistent with the Strategic Plan. To achieve this, it must not:

- Prevent the achievement of any of the objectives
- Prevent any of the desired outcomes

These conditions are considered after a discussion of the potential impacts of the Plan.

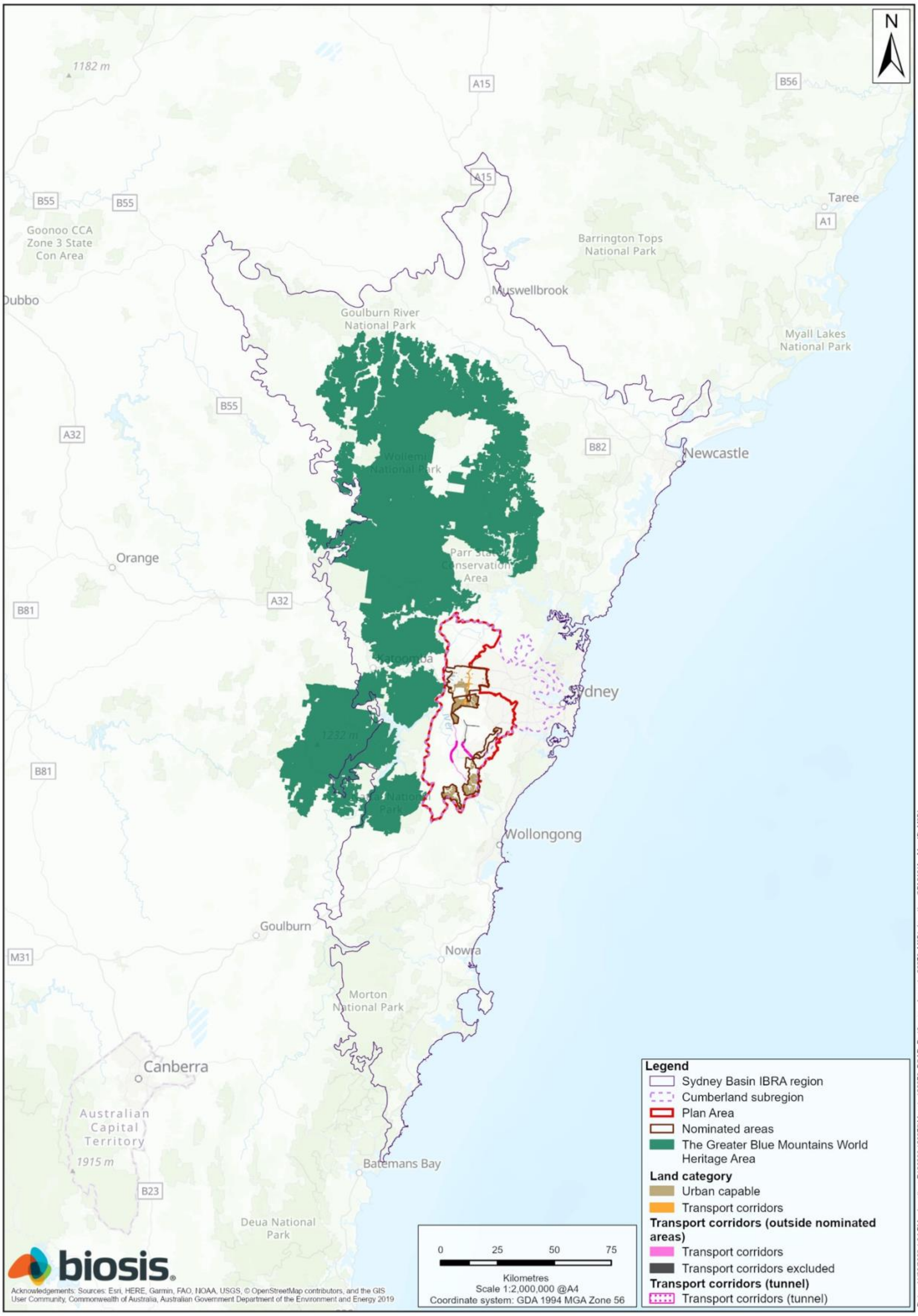

Figure 34-1: The Greater Blue Mountains World Heritage Area

34.2.3 THE VALUES OF THE GREATER BLUE MOUNTAINS WORLD HERITAGE AREA

The GBMWHA is World and National Heritage listed because it contains globally significant examples of eucalyptus evolution and diversification and an outstanding diversity of ecosystems, habitats and ecological communities.

World Heritage Listing

As a World Heritage Area, the GBMWHA is recognised under the *World Heritage Convention* as having OUV. A Statement of OUV was not prepared for the GBMWHA at the time of inscription. However a retrospective Statement of OUV was adopted by the World Heritage Commission in 2013 (UNESCO, 2018c) and is summarised below.

Criteria and attributes

The GBMWHA meets two criteria for OUV:

- **Criterion (ix):** it is an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals
- **Criterion (x):** it contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation (UNESCO, 2017)

While the precise wording of the listing criteria are periodically updated by UNESCO, the natural heritage criteria that have been met in the GBMWHA reflect ecological and biological processes; and biological diversity including threatened species. The criteria listed in this report are those in the 2017 Operational Guidelines.

The attributes that meet these criteria are discussed in Table 34-3.

Table 34-3: Outstanding Universal Values of the Greater Blue Mountains World Heritage Area

World Heritage listing criteria	Examples of World and National Heritage attributes
Criterion (ix): it is an outstanding example representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals	The GBMWHA has: • Outstanding and representative examples in a relatively small area of the evolution and adaptation of the genus Eucalyptus and eucalypt-dominated vegetation on the Australian continent • Wide and balanced representation of eucalypt habitats including wet and dry sclerophyll forests and mallee heathlands with localised swamps, wetlands and grassland • Significant examples of eucalypt evolution and diversification • Examples of dynamic processes that cover the full range of interactions between eucalypts, understorey, fauna, environment and fire • Primitive species of outstanding significance to the evolution of the earth's plant life (e.g. the Wollemi pine *Wollemia nobilis* and the Blue Mountains pine *Pherosphaera fitzgeraldii*) (UNESCO, 2018a)
Criterion (x): it contains the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation	The GBMWHA contains: • An outstanding diversity of habitats, plant communities, species and ecosystems (152 plant families, 484 genera and approximately 1,500 species) • A significant proportion of the Australian continent's biodiversity, especially its scleromorphic flora • Exceptionally high levels of species diversity in the Myrtaceae, Fabaceae, and Proteaceae plant families, including 13 per cent of the world's eucalyptus species • Primitive and relictual species with Gondwanan affinities • Many plants of conservation significance (114 endemic species and 177 threatened species)

World Heritage listing criteria	Examples of World and National Heritage attributes
	• More than 400 vertebrate taxa (of which 40 are threatened) including around one third of Australia's bird species (265 species) • An estimated 120 butterfly and 4,000 moth species and rich cave invertebrate fauna (UNESCO, 2018b)

Integrity

All World Heritage properties are required to meet the conditions of integrity. This is defined by the Guidelines (UNESCO, 2017) as "a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes". An assessment of the integrity of a property is required to determine the extent to which the property:

- Includes all elements necessary to express its OUV
- Is of adequate size to ensure the complete representation of the features and processes which convey the property's significance
- Suffers from adverse effects of development and/or neglect

The Statement of OUV for the GBMWHA (UNESCO, 2018b) sets out the features of the property that meet these conditions.

- The GBMWHA is of a sufficient size (over 1 million ha) and connectivity to protect its biota and ecosystem processes despite anomalies in its boundary that reduce the protective effect of its size
- Much of the property neighbours State Forests and State Conservation Areas which provide protection to the World Heritage area
- Designated wilderness areas (covering 65 per cent of the property) and closed and protected catchments provide additional protections
- Most of the natural bushland within the property is of high wilderness quality and remains close to pristine
- Plant communities and habitats within the property form a largely undisturbed matrix with little disruption from structures, earthworks, or other human intervention
- The complexity of the property's geological structure, geomorphology and water systems are critical to the evolution of its outstanding biodiversity and require the same level of protection
- The property has a strong and ongoing connection with Aboriginal people from six language groups. Continuation of this custodial relationship is fundamental to the protection of the property's integrity

Protection

All World Heritage properties are required to be adequately protected and managed to ensure that their OUV (including the conditions of integrity at the time of inscription) are sustained or enhanced over time (UNESCO, 2017).

The Guidelines outline the broad level requirements for effective protection and management. This includes:

- Appropriate legislative, regulatory and contractual measures for protection
- Boundaries for effective protection
- Buffer zones
- Appropriate management systems

Finally, the Guidelines provide for the sustainable use of World Heritage Areas where that use does not adversely impact on the OUV of the property.

The GBMWHA is completely contained within the following conservation reserves:

- Blue Mountains National Park
- Gardens of Stone National Park
- Jenolan Caves Karst Conservation Reserve
- Kanangra-Boyd National Park
- Nattai National Park

- Thirlmere Lakes National Park
- Wollemi National Park
- Yengo National Park

Large areas in the southern part the GBMWHA are within the catchment for Sydney's water. These areas are protected under *Sydney Water Catchment Management Act 1998* that restricts access and acceptable use. This affords an additional level of protection.

All of these reserves are managed by the NSW National Parks and Wildlife Service (UNESCO, 2018b) and are subject to a range of State Government legislation.

In addition to the Strategic Plan, plans of management have been gazetted for the seven national parks listed above and a draft plan of management has been published for the Jenolan Caves Karst Conservation Reserve (UNESCO, 2018b). The plan of management for each conservation reserve is listed in Table 34-4.

Table 34-4: Plans of management for the GBMWHA

Conservation reserve	Plan of management title	Publisher	Year of publication
Blue Mountains National Park	Blue Mountains National Park Plan of Management	DECC	2001
Gardens of Stone National Park	Gardens of Stone National Park Plan of Management	DECC	2009
Kanangra-Boyd National Park	Kanangra-Boyd National Park Plan of Management	NSW NPWS	2001
Nattai National Park	Nattai Reserves Plan of Management	NSW NPWS	2001
Thirlmere Lakes National Park	Thirlmere Lakes National Park Plan of Management	NSW NPWS	1997
Wollemi National Park	Wollemi National Park Plan of Management	NSW NPWS	2001
Yengo National Park	Yengo National Park Finchley Aboriginal Area Plan of Management	DECC	2009
Jenolan Caves Karst Conservation Reserve	Jenolan Karst Conservation Reserve Draft Plan of Management	OEH	2013

NATIONAL HERITAGE LISTING

The GBMWHA meets four criteria for National Heritage listing. It was judged to meet these criteria on the basis of its World Heritage listing. The criteria are:

- **Criterion A Events, Processes** by virtue of meeting World Heritage criteria (ix) and (x)
- **Criterion B Rarity** by virtue of meeting World Heritage criterion (x)
- **Criterion C Research** by virtue of meeting World Heritage criteria (ix) and (x)
- **Criterion D Principal characteristics of a class of places** by virtue of meeting World Heritage criterion (ix) (DoEE, 2018a)

The GBMWHA's National Heritage listing is based on its World Heritage status. An assessment of the significance of impacts to the GBMWHA's OUV is considered sufficient to determine the acceptability of impacts to its National Heritage values.

SUPPORTING ATTRIBUTES

The Strategic Plan sets out a number of values that are not recognised as having OUV, but support, complement, or interact with the GBMWHA's World Heritage values. Some of these may be nominated for World Heritage listing in the future. The supporting values described in the Strategic Plan are set out in Table 34-5. Some of these attributes have already been discussed in the Statement of OUV. Only the attributes that have not already been identified in the World Heritage listing will be considered further below.

Table 34-5: Supporting values of the GBMWHA

Value	Description
Geodiversity and biodiversity	These attributes are discussed in the Statement of OUV
Water catchment	The GBMWHA protects a large number of pristine catchment areas, which make a substantial contribution to water storage for human use as well as water quality and natural flows for the Hawkesbury-Nepean and Goulburn-Hunter river systems
Indigenous values	This attribute is discussed in the Statement of OUV
Historic values	The GBMWHA includes numerous places of historic significance to European settlement of Australia
Recreation and tourism	The GBMWHA provides settings for recreation and tourism that are outstanding and increasingly rare by world standards, adjacent to a major city
Wilderness	This attribute is discussed in the Statement of OUV
Social and economic	The GBMWHA has considerable social and economic value as a tourism destination
Research and education	The variety of ecological communities and landscapes and associated cultural sites makes the GBMWHA ideal for research and educational visits
Scenic and aesthetic	The GBMWHA contains some of the most dramatic scenery in Australia with views of uninterrupted forest wilderness, contrasting forested slopes and cleared valleys, sandstone canyons and pagoda rock formations. The Jenolan Karst Conservation Reserve contains extensive aesthetic caves
Bequest, inspiration, spirituality and existence	The GBMWHA has value as a unique and important landscape that can be experienced by future generations and contributes to Aboriginal cultural continuity

34.2.4 HOW DEVELOPMENT UNDER THE PLAN RELATES TO THE GBMWHA

The proposed urban capable land and transport corridors do not occur within or overlap with the GBMWHA.

The western boundary of the Strategic Assessment Area is adjacent to the World Heritage area immediately west of GPEC. The Strategic Assessment Area and the World Heritage area overlap slightly close to the southern end of the Strategic Assessment Area.

GPEC is the nearest nominated area, occurring approximately 1 km from the edge of the World Heritage area, as shown in Figure 34-2. The distance from the GBMWHA to key locations within the urban capable land and transport corridors is given in Table 34-6.

Table 34-6: Distance between GBMWHA and key locations in the urban capable land and transport corridors

Location	Distance
Urban capable land in Greater Penrith to Eastern Creek Investigation Area (GPEC)	1 km
Urban capable land in Western Sydney Aerotropolis (WSA)	5.3 km
Urban capable land in Wilton Growth Area (Wilton)	6.5 km
Urban capable land in Greater Macarthur Growth Area (GMAC)	15.8 km

The proposed development will support an increasing population in Western Sydney. The Metropolis of Three Cities plan projects that the population of the Western Parkland City will increase from 740,000 in 2016 to over 1.5 million in 2056 (GSC, 2018). Population growth of this size in close proximity to the GBMWHA is anticipated to increase visitor numbers and in turn increase the pressure on the World Heritage Area from visitors.

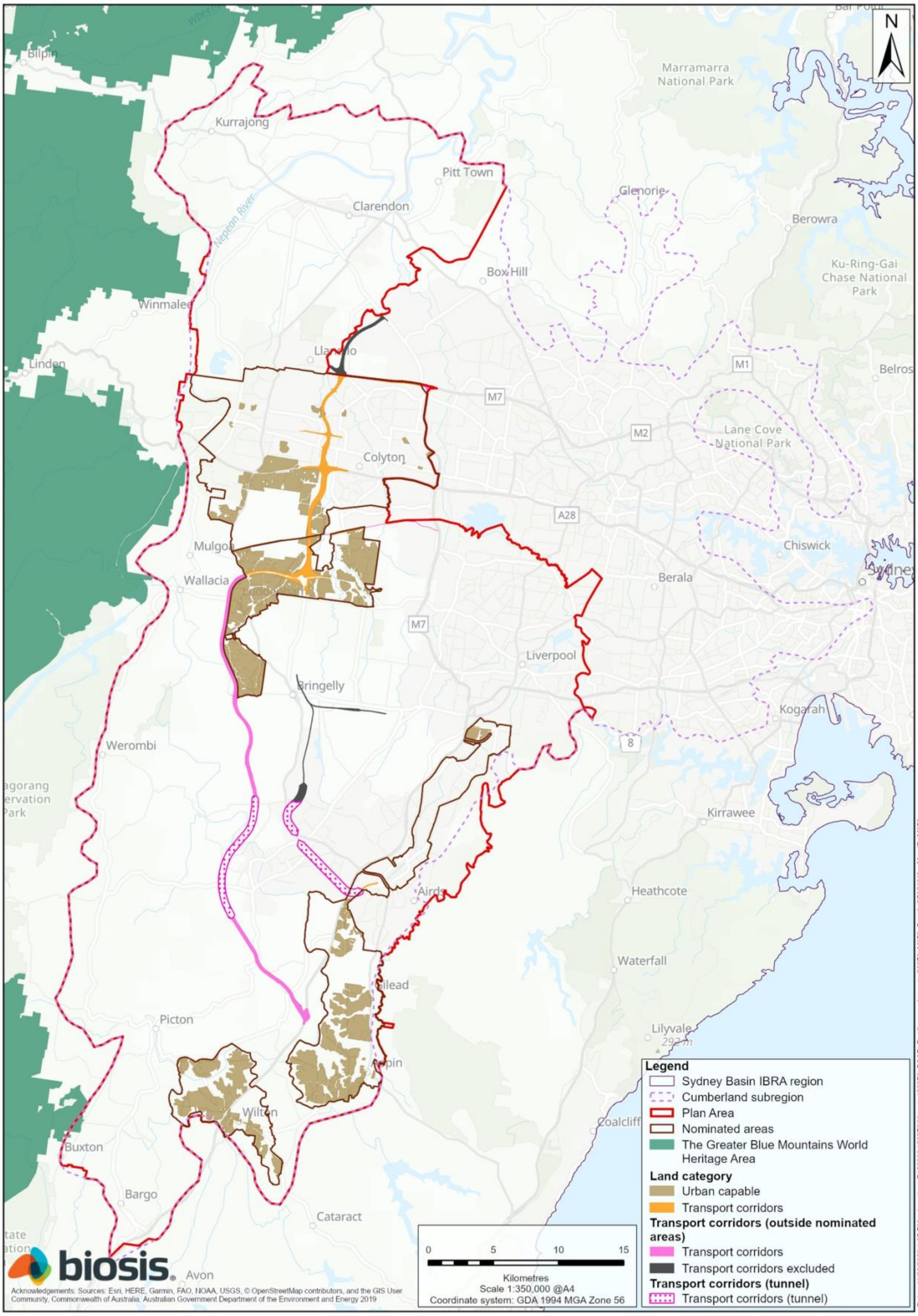

Figure 34-2: GBMWHA and the Plan Area

34.2.5 POTENTIAL IMPACTS TO OUTSTANDING UNIVERSAL VALUE

It is not reasonably foreseeable that any of the impacts described in this section will affect the level of conservation protection for the GBMWHA. As a result, this section will focus on the possibility of impacts to the OUV and integrity of the GBMWHA, as well as its supporting values.

Potential direct impacts

The Plan does not include any actions or development within the GBMWHA. As a result, there will be no direct impacts to OUV or the GBMWHA's supporting values from the Plan.

Potential indirect impacts

Potential indirect impacts to the GBMWHA are discussed below in relation to:

- Habitat connectivity
- Edge effects
- Visual impacts
- Other impacts

Habitat connectivity

Of the attributes that support criterion (x), several wide-ranging fauna species (e.g. bats, such as the Grey-headed Flying-fox, and birds) are likely to move between the World Heritage Area and the Cumberland subregion. This is particularly the case in the context of the recent bushfires, which affected over 81 per cent of the Greater Blue Mountains World Heritage Area (DPIE, 2020) and may have increased the importance of habitat outside the area for these species.

Habitat within the nominated areas may provide connectivity for these wide ranging species to foraging resources or smaller areas of habitat within or surrounding the subregion, including protected areas to the north-east and south-east of the subregion, or the Holsworthy Military Reserve to the south-east.

The direct impacts of urban and other development may reduce habitat connectivity within the nominated areas for wide-ranging fauna species associated with GBMWHA, which may affect ecosystem processes that may cause impacts to the OUV and integrity of the GBMWHA, as well as its supporting values.

Habitat connectivity refers to the degree of connectedness of areas of habitat. Habitat connectivity can include:

- Corridors of vegetation linking other areas of habitat
- Isolated patches of habitat that provide 'stepping stones' between other areas of habitat
- Habitat features (such as large trees with hollows) scattered within areas of non-habitat (e.g. urban land) that provide habtiat connectivity between intact areas of habitat

Habitat connectivity was mapped within the nominated areas as part of this Assessment Report by:

- Identifying BIO Map regional corridors and core areas (DECCW, 2010), which have been identified by EES and represent the areas where the protection and management of native vegetation is likely to maximise benefits to biodiversity within the subregion. These areas are likely to represent the most important areas of habitat connectivity in the nominated areas for the majority of species[1]
- Identifying local corridors using the native vegetation mapping to identify connected patches of native vegetation. This was done visually in GIS, with only contiguous patches identified as being connected

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- [1] Note that EES has only identified BIO Map corridors within the boundaries of the Cumberland subregion. To undertake the mapping for the small parts of the nominated areas outside the subregion the Priority Conservation Lands layer (DECCW, 2010) (EES used this layer as basis for BIO Map) or the native vegetation map prepared for this Assessment Report (see Chapter 11) was used to extend the BIO Map corridor mapping

- Identify any remaining native vegetation not within a regional corridor or local corridor as:
  - Connected patches – within 100 m of another patch of woody vegetation
  - Isolated patches – greater than 100 m from another patch of woody vegetation

Key areas of habitat connectivity in the nominated areas are shown in Map 19.The impacts of urban and other development on this habitat connectivity are described in Table 34-7.

Urban and other development is not considered likely to impact habitat connectivity within the nominated areas to the extent that this would cause impacts to the OUV and integrity of the GBMWHA, as well as its supporting values through impacts to wide-ranging fauna species. The vast majority of BIO Map regional corridors/core areas and smaller habitat corridors have been avoided and will not be impacted. Where impacts occur to these areas, this is generally to the edges of habitat and connectivity is generally maintained. Many smaller connected and isolated patches of habitat will be directly impacted, which is likely to reduce habitat connectivity within the nominated areas for more mobile species, such as microbats and birds. These impacts are not considered substantial in the context of maintaining habitat connectivity within the broader landscape and between the nominated areas and GBMWHA.

Furthermore, the conservation program under the Plan (see Part 2) will result in:

- Protecting a minimum of 5,473 hectares of native vegetation and habitat in the subregion (Commitment 8)
- Securing priority habitat corridors in the subregion (Commitment 12)
- Undertaking ecological restoration in priority sites (Commitment 13)
- Managing landscape threats in strategic locations to improve habitat values, including weeds (Commitment 16) and pests (Commitment 17) and fire (Commitment 17)

Importantly, the strategic conservation areas (SCAs) where these commitments will be delivered represent the areas in the Cumberland subregion that are considered most likely to be viable in the long-term and to maximise ecological function and connectivity across the landscape. In determining the location of the SCAs, priority was given to including the largest, best condition and best-connected areas of native vegetation remaining in the subregion (see Part 2).

The Plan also includes several mitigation measures that will minimise impacts to habitat connectivity within the nominated areas for wide-ranging fauna species. These are described in Chapter 15, and include:

- Retain large trees (including dead trees) (≥50cm DBH) during precinct planning where possible
- Retain areas of high density proteaceae shrubs where possible, particularly along riparian corridors
- Establish minimum setbacks for urban development around flying fox camps
- Design road crossings of waterways to minimise impacts to vegetated riparian corridors and species movements

These commitments and mitigation measures are considered to adequately address any residual risks of impacts to habitat connectivity that may cause impacts to the OUV and integrity of the GBMWHA, as well as its supporting values.

Table 34-7: Potential impacts on habitat connectivity from urban and other development in the nominated areas

Nominated area	Nature	Extent	Duration
Wilton	**Direct impacts:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impact occurs in the southern part of the nominated area where the development will remove part of a corridor/core area that connects native vegetation either side of the nominated area in this location. The impact reduces the width of the corridor/core area by about half. Connectivity is maintained to the south and east of the impacted area. In all other areas, direct impacts occur only to the edges of corridors/core areas in a few locations and connectivity along these areas is maintained There are very minor direct impacts to the local corridor on the eastern side of the nominated area between the Hume Motorway and Wilton Road The majority of impacts to connected vegetation occur to smaller scattered patches in the middle of the nominated area and to the edge of larger areas of connected vegetation where it occurs adjacent to BIO Map regional corridors/core areas around the nominated area	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 78.9 ha (7.6 per cent) • Local corridor – 6 ha (2.9 per cent) • Connected vegetation – 140 ha (25.7 per cent) • Isolated vegetation – 1 ha (47 per cent)	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands	Temporary or long-term
GMAC	**Direct impact:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. Direct impacts occur only to the edges of corridors/core areas in a few locations. There are no locations were direct impacts completely sever or significantly narrow a core area/corridor and connectivity is maintained for these areas of habitat connectivity across all parts of the nominated area The vast majority of the local corridor in the middle of the southern part of the nominated area has been avoided and is not directly impacted. Impacts occur only to the edges of the corridor and connectivity is maintained in this location across the nominated area The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected vegetation in the southern part of the nominated area. In these cases, the size of the patches will be reduced, but the impacts will not generally sever connectivity between this connected vegetation and other areas of native vegetation, such as BIO Map corridors/core areas	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 45 ha (2 per cent) • Local corridor – 19 ha (12 per cent) • Connected vegetation – 217 ha (21 per cent) • Isolated vegetation – 2 ha (16 per cent)	Long-term

Nominated area	Nature	Extent	Duration
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands	Temporary or long-term
WSA	**Direct impact:** The vast majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impact occurs in the south-eastern part of the nominated area where the development will remove the majority of a corridor/core area that connects Wianamatta (South Creek) and Kemps Creek in the Kemps Creek area. While this area is identified as a regional corridor, connectively has already been completely severed in this location by existing industrial land use. In all other areas, direct impacts occur only to the edges of corridors/core areas in a few locations and connectivity along these areas is maintained The majority of local corridors have been avoided and will not be directly impacted. Direct impacts occur: • At Cosgrove Creek in the middle part of the nominated area where the OSO severs the riparian corridor in two locations • At Badgerys Creek in the middle part of the nominated area where the OSO severs the riparian corridor in one location The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected vegetation in the north-eastern, middle and southern parts of the nominated area. In some cases, the impacts will sever or reduce connectivity between this connected vegetation and other areas of connected vegetation within and outside the nominated area	**Direct impacts:** The following approximate amounts of each category of habitat connectivity will be directly impacted by the development: • BIO Map corridors – 22.3 ha (7.0 per cent) • Local corridor – 34.2 ha (27.5 per cent) • Connected vegetation – 279.1 ha (52.5 per cent) • Isolated vegetation – 10.8 ha (67.1 per cent)	Long-term
	Indirect impacts: The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance	**Indirect impacts:** Areas of habitat connectivity adjacent to urban capable lands	Temporary or long-term

<table>
<tr><th>Nominated area</th><th>Nature</th><th>Extent</th><th>Duration</th></tr>
<tr><td rowspan="2">GPEC</td><td>Direct impact:
The majority of BIO Map regional corridors/core areas have been avoided and will not be directly impacted. The main direct impacts occur:
• Within Wianamatta Regional Park where the OSO severs the eastern part of the regional park that is connected to Ropes Creek with the western part of the park
• Along Wianamatta (South Creek) where the OSO directly impacts the Wianamatta (South Creek) riparian corridor and severs the narrow connection along the corridor that links Wianamatta Regional Park and Orchid Hills
In all other areas direct impacts have been avoided, except in the western part of the nominated area near Glenmore Park where there is a small direct impact to the edge of a corridor/core area
No local corridors occur within the nominated area
The majority of impacts to connected vegetation occur to smaller scattered patches, where patches will be completely cleared. Impacts also occur to the edges of several larger areas of connected vegetation in some parts of the nominated area. In these cases, the size of the patches will be reduced, but the impacts will not generally sever connectivity between this connected vegetation and other areas of native vegetation, such as BIO Map corridors/core areas</td><td>Direct impacts:
The following categorises of habitat connectivity will be directly impacted by the development:
• BIO Map corridors – 178.9 ha (7.0 per cent)
• Local corridor – 0 ha (0 per cent)
• Connected vegetation – 190 ha (17 per cent)
• Isolated vegetation – 0.5 ha (6.3 per cent)</td><td>Long-term</td></tr>
<tr><td>Indirect impacts:
The development may cause a range of indirect impacts to areas of habitat connectivity. Key risks are weed invasion, pest animals, changes to hydrology, increased risk of fire, and human disturbance</td><td>Indirect impacts:
Areas of habitat connectivity adjacent to urban capable lands</td><td>Temporary or long-term</td></tr>
</table>

Edge effects

Potential indirect impacts from the Plan relating to edge effects, such as the introduction of weeds and feral animals, changes to water quality, inappropriate fire regimes or disturbance from light or noise are also considered unlikely to affect the OUV or the supporting values of the GBMWHA for the following reasons:

- The urban capable land and transport corridors are at least 1 km from the GBMWHA. Where development occurs close to the World Heritage area (e.g. on the western edge of the footprints in GPEC), it takes place in existing urban or highly modified environments. These areas have already been disturbed, and further disturbance is unlikely to lead to substantial edge effects
- Most of the development proposed by the Plan is over 5 km from the edge of the GBMWHA. This distance is sufficient to protect the World Heritage area from edge effects
- The urban capable land and transport corridors are downstream of or outside the catchment for the GBMWHA. The Plan is therefore unlikely to influence aquifer drawdown, ground water quality or surface water quality relating to the GBMWHA
- A range of mitigation and management measures will be undertaken as part of implementation of the Plan to address potential construction impacts and edge effects. These measures are identified in Part 2 of this report and further minimise the risks associated with potential indirect impacts

Visual impacts

Scenic and aesthetic attributes are identified in the Strategic Plan as a supporting value for the World Heritage Area. Of particular relevance are views of uninterrupted forest wilderness, contrasting forested slopes and cleared valleys, sandstone canyons and pagoda rock formations. However, these views are not typically related to the Cumberland subregion.

Development within parts of the nominated areas will be visible from some areas in the GBMWHA. However, impacts to scenic and aesthetic values are likely to be limited in scope and scale because:

- The Cumberland subregion does not represent the key scenic values identified in the Strategic Plan
- Development that does occur near to the GBMWHA will generally occur within existing urban or highly modified environments, or where it occurs in greenfield areas, will be distant from the World Heritage area and is likely to have limited visual impact
- The urban capable land and transport corridors are only visible from the eastern fringes of the World Heritage area and are not visible from the most popular and sensitive tourism and recreation sites (e.g. the Jamison Valley south of Echo Point or Wentworth Falls lookouts, the Grose Valley east of Evans or Govetts Leap lookouts, Kanangra Walls, or other wilderness areas)

Visual impacts will be negligible and do not present a risk to the scenic and aesthetic values of the GBMWHA.

Other impacts

It is not anticipated that the Plan will indirectly impact on the social, economic, cultural, historical, Indigenous, or other values of the GBMWHA.

POTENTIAL FACILITATED IMPACTS

Facilitated impacts are the main source of risk to the GBMWHA from the Plan and the focus of the remaining Chapter.

The population of Sydney is already growing, and the overarching Strategic Plan and the plans of management for each individual reserve within the GBMWHA recognise the pressure from increasing visitors as a major management challenge. The Plan will facilitate further population growth, potentially intensifying these impacts.

The potential impacts from increased visitors to the GBMWHA are:

- Disturbance from people, vehicles and horses
- Increased frequency of fires
- Removal of bushrock and fallen timber
- Introduced plants

- Development or increased maintenance of visitor or management facilities or infrastructure

The plans of management set out a range of policies and actions, and monitoring processes for managing the impacts listed above. The impacts and the relevant management and monitoring policies are discussed below.

Increased disturbance from people, vehicles and horses

Additional visitors to the GBMWHA may increase disturbance to flora, fauna, ecological communities, geological features, and cultural or historical sites. This is listed as a key management challenge in the GBMWHA Strategic Plan (DECC, 2009b). The impacts of disturbance vary according to the type, intensity and frequency of visitor use and the sensitivity of the ecosystems and landscape features found throughout the World Heritage area. Unmarked tracks in wilderness areas may see around a thousand visits, remote wilderness areas may not be visited at all, and popular lookouts or tracks may see over a million visits each year. Visitors may be on foot, in vehicles, with horses (in limited parts of the GBMWHA), using watercraft, or using ropes to rock climb or access canyons.

Potential impacts are varied and include soil loss and compaction, loss of vegetative cover, erosion, lack of regeneration, creation of fireplaces, damage to trees, removal of firewood, installation of rock climbing and canyoning anchors, individual mortality of flora and fauna, incorrect disposal of waste, and damage to cultural or historic sites (DECC, 2001).

Potential impacts to Outstanding Universal Value and supporting values

The OUV of the GBMWHA reflects its outstanding examples of eucalyptus diversification and evolution and its diversity of habitats, ecological communities, and species. Without appropriate management, increased disturbance from people, vehicles and horses could notably diminish or alter these values through:

- Impacts across large areas, or to many high-quality sites that support examples of eucalyptus diversification and evolution
- Intense impacts in important, sensitive areas especially habitats for species and ecological communities with a limited extent in the World Heritage area
- Any impacts to highly sensitive areas, including habitat for the Wollemi pine

Impacts that notably diminish the integrity of the GBMWHA are unlikely, but could result from:

- Widespread impacts in otherwise pristine environments
- Impacts to culturally sensitive areas

Impacts to supporting values including geodiversity and biodiversity, water catchments, Indigenous and historical values, recreation and tourism, wilderness, and scenic and aesthetic values could be notably degraded by:

- Intense impacts in sensitive areas, especially geological formations, historic and cultural sites, or key visitor locations
- Widespread impacts across high-quality areas such as water catchments, visitor sites, or areas of scenic and aesthetic value
- Impacts in highly sensitive areas, especially wilderness areas

Impacts to the protection arrangements for the GBMWHA are not reasonably foreseeable.

Impacts that notably diminish OUV or its supporting values from disturbance by people, vehicles and horses are only likely if they occur across many sites or in highly sensitive areas.

Existing management and monitoring policies

Disturbance by people, vehicles and horses is already managed in the conservation reserves that make up the GBMWHA. The sections in the plans of management for each conservation reserve that discuss management or monitoring of these impacts are listed in Table 34-8.

Table 34-8: Management and monitoring of impacts from people, vehicles and horses

Conservation Reserve	Management of Impacts	Monitoring
Blue Mountains National Park	• s3.2 lists management of recreation and tourism to ensure minimal impacts as a specific objective of the plan. • s1.1 established a policy to manage erosion from visitor use and management activities. • s4.3 lists policies and actions to manage impacts from visitor use (including people, vehicles and horses).	• s3.3 emphasises monitoring and improved management of public and commercial recreation opportunities with potential adverse impacts. • s4.3 lists a range of monitoring actions for different types of use within the park.
Gardens of Stone National Park	• s4.3 lists policies and actions to manage impacts from visitor use (including people, vehicles and horses). • s4.1.1 commits NPWS to develop maintenance priorities to minimise erosion from roads, trails and tracks.	• s4.3.1 commits to monitor visitor impacts at popular sites around the park.
Kanangra-Boyd National Park	• s3.2 describes management of recreation and tourism within the park to minimise impacts is a specific objective for the plan of management. • s1.1 commits to manage erosion from visitor use and management activities. • s4.3 lists policies and actions to manage impacts from visitor use (including people, vehicles and horses).	• s3.3 commits to monitoring of recreation and commercial tourism with potential adverse impacts. • s4.3 lists a range of monitoring actions for different types of use within the park.
Nattai National Park	• s3 lists appropriate recreational use as an objective of the plan of management. • s4.3 sets out a limited set of appropriate uses for the park and policies and actions to manage impacts from these uses.	• s4.3 lists monitoring priorities including water quality and four-wheel drive access and impacts.
Thirlmere Lakes National Park	• s3.2 lists appropriate recreational use as an objective of the plan of management. • s4.3 sets out a limited set of appropriate uses for the park and policies and actions to manage impacts from these uses.	• The plan of management does not list actions or policies for monitoring of impacts from visitor use.
Wollemi National Park	• s4.1.1 commits to minimise erosion from management activities. • s4.3 list policies and actions to manage impacts from visitor use (including people, vehicles and horses).	• s4.3 commits to monitor a range of impacts from visitor use within the park.
Yengo National Park	• s3.0 lists maintenance of dispersed, low-impact recreation activities as a management objective. • s4.3 gives management policies and actions for use of the park	• s4.3 lists monitoring actions for the park.
Jenolan Caves Karst Conservation Reserve	• s3.5 sets out policies and actions for managing impacts from visitor use within the reserve.	• Table 5 in s3.5 sets out a range of monitoring processes for impacts associated with visitor use.

The plans of management set out an extensive set of policies and actions to manage impacts from visitors across the GBMWHA. They include actions to limit the areas that are subject to impacts from visitors, manage impacts in areas of frequent visitation, limit visitor numbers in wilderness and key recreation areas, and protect sensitive environments. The plans address impacts to OUV and supporting values.

These policies and actions are considered sufficient to mitigate the existing risk from visitor use and have been developed to manage increasing visitor pressure. Monitoring programs are generally sufficient to inform adaptive management and enable policies and actions to be changed to manage increasing impacts as required. The one exception is Thirlmere Lakes National Park, which does not have a monitoring program for impacts associated with visitor use.

Increased frequency of fires

NSW experienced extensive bushfires throughout the spring and summer of 2019-20. As of 3rd February 2020, the fires had burnt 5.37 million hectares of land (approximately 7 per cent of NSW). This includes 81 per cent of the Greater Blue Mountains World Heritage Area (DPIE, 2020). Of the fire affected national parks in NSW, 23 per cent were subject to full canopy damage, 36 per cent had partial canopy damage, and for 27 per cent the canopy was unburnt. Note that areas where the canopy was unburnt may have been affected by fire through the understorey (DPIE, 2020).

The full impact of the fires will not be understood for some time. However, the extent and intensity of the fires will have notably altered or diminished many of the attributes that contribute to OUV within the GBMWHA.

High frequency fire is identified as a key threatening process for all of the national parks in the GBMWHA.

Currently arson is the most common ignition source for bushfires in the Blue Mountains National Park and escaped campfires and burnoffs are also a significant source of fires (35 per cent and 9 per cent respectively) (Hammill & Tasker, 2010). The population increase in Western Sydney associated with the Plan could facilitate an increase in the number of deliberate or accidental fires in the GBMWHA and could increase overall fire frequency in the World Heritage area.

Fire regimes in the GBMWHA are also predicted to be affected by climate change. The recent NSW bushfires may have been exacerbated by climate change. Climate change modelling suggests that dangerous fire conditions will occur more often and over a longer season by 2050 (Hammill & Tasker, 2010). This has the potential to amplify the impacts of deliberate or accidental fires in the GBMWHA.

Potential impacts to Outstanding Universal Value and supporting values

Inappropriate fire regimes could notably diminish or alter all of the attributes that contribute to OUV within the GBMWHA. The risk to OUV from fires facilitated by the Plan depends on the location of the fires and their contribution to the broader fire regime. OUV is at risk from:

- Widespread fires in wet sclerophyll forest, especially where those fires burn the canopy
- Frequent (less than five to seven years apart), intense fires, especially where these fires are widespread or in ecosystems with a limited extent within the GBMWHA
- Any intense fires in highly sensitive areas (e.g. Wollemi pine habitat) or rainforest areas
- Intense or widespread fires in refugia areas (including rainforests, wetlands, swamps, and wet sclerophyll forests)

Impacts that notably diminish the integrity of the GBMWHA could result from:

- Frequent fires that degrade the condition of natural bushland in previously undisturbed areas or disrupt the structure and composition of plant communities
- Frequent, intense fires in drought conditions that degrade wetland and swamp environments that regulate water flow
- Fires that damage or degrade culturally sensitive areas

All of the supporting values of the GBMWHA are at risk from potential fires facilitated by the Plan, especially from:

- Fires that threaten visitor infrastructure, businesses or homes in or near the GBMWHA
- Fires that damage cultural or historical sites
- Widespread fires in water catchments, areas of scenic or aesthetic value

- Changes to OUV that follow from increased fire frequency and affect the research, bequest, and existence values of the GBMWHA

Impacts to the protection arrangements for the GBMWHA are not reasonably foreseeable.

Impacts that notably diminish OUV from potential fires facilitated by the Plan are only likely if they burn in sensitive areas or are intense fires that occur too frequently.

Existing management strategies

Fire frequency and intensity and the risk of accidental or deliberate fires are managed within the conservation reserves that make up the GBMWHA. Fuel loads are managed within the GBMWHA and, where appropriate and possible, fires are contained or extinguished to protect human life and property and biodiversity.

Under the Enhanced Bushfire Management Program, NSW NPWS plans to treat over 135,000 hectares per year in 800 or more hazard reduction activities across NSW, including within GBMWHA. Over 1,000 burns were carried out by NPWS in the last 5 years. Achieving this target is dependent on suitable weather conditions for burning safely and effectively.

Climate change is predicted to increase fire seasons and reduce these opportunities and NSW NPWS is continuing to adapt its fire management strategies to a changing climate (Hammill & Tasker, 2010).

The sections in the plans of management for each conservation reserve that discuss management of impacts from fire or monitoring of fire management practices are listed in Table 34-9.

Table 34-9: Management and monitoring of impacts from increased frequency of accidental fires

Conservation Reserve	Management of Impacts	Monitoring
Blue Mountains National Park	• s4.1.5 sets out the fire management policies and actions • The plan of management stands alongside the Blue Mountains National Park Reserve Fire Management Plan	• s4.1.5 and §4.3.10 prioritise research into fire behaviour and effects within the World Heritage area
Gardens of Stone National Park	• s4.1.5 sets out a range of fire management policies and actions to protect threatened species and fire sensitive areas • A fire management plan will be developed for the park	• s4.1.5 encourages research into fire ecology
Kanangra-Boyd National Park	• s4.1.4 sets out a range of fire management policies and actions to protect threatened species and fire sensitive areas • The plan of management stands alongside the Kanangra-Boyd National Park Fire Management Plan	• s4.1.4 encourages research into fire behaviour and ecology
Nattai National Park	• s4.1.4 sets out fire management policies and actions for the park	• s4.1.4 encourages research into fire behaviour and ecology
Thirlmere Lakes National Park	• s4.1.4 sets out fire management policies and actions for the park	• s4.1.4 commits to develop criteria for measure fire regime thresholds and review fire regimes annually
Wollemi National Park	• s4.1.5 sets out fire management policies and actions for the park	• s4.1.5 encourages research into fire behaviour and ecology

Conservation Reserve	Management of Impacts	Monitoring
Yengo National Park	• s4.1.5: NPWS will develop a fire management strategy for the Park including annual hazard reduction burns, assessment of neighbouring farm dams for fire management purposes, and maintenance of management trails	• s4.1.3: NPWS will undertake biodiversity surveys to improve fire management
Jenolan Caves Karst Conservation Reserve	• s3.5 includes policies and actions to manage the risk from accidental fires • s4.2 sets out a range of policies and actions to manage fire in the conservation reserve	• s4.2 includes commitments to monitor fire regimes and their impact on threatened flora

The discussion above shows that fires that could notably diminish OUV fall into two main categories:

- Individual fire events in sensitive areas
- Changes to fire regimes across the GBMWHA

It is possible that population growth associated with the Plan could facilitate an individual fire event that impacts OUV or its supporting values. However, the risk of deliberate or accidental fires in the GBMWHA in sensitive areas is already managed under the existing protection arrangements for the GBMWHA.

Impacts from potential changes to fire regimes across the GBMWHA are more difficult to assess.

Considered in isolation, it is possible that the risk of additional fires facilitated by the Plan could contribute to a broader change in fire regimes across the GBMWHA. This is unlikely and management of fire loads, management of visitor use, total fire bans, and policing of arson are already used to mitigate this risk. Existing monitoring and adaptive management programs are sufficient to manage any increase in this risk facilitated by the Plan.

Climate change is projected to increases the frequency of dangerous fire conditions and has the potential to amplify the impacts of deliberate or accidental fires in the GBMWHA. However, there are many ignition events from existing sources to start fires, and the Plan is unlikely to substantially increase these. It is considered that the existing protection arrangements for the GBMWHA are sufficient to manage the risk of increased fire frequency from the Plan.

Increased spread of introduced plants

A number of introduced plant species are already present in the GBMWHA. Introduced plants are listed as a key management challenge or important threatening process in some of the plans of management for the conservation reserves that make up the GBMWHA. Increased visitor use of the World Heritage area has the potential to introduce weed species or spread existing infestations to new areas.

Potential Impacts to Outstanding Universal Value and supporting values

The OUV attributes that support the GBMWHA's outstanding examples of eucalyptus diversification and evolution and diversity of habitats, ecological communities, and species could be notably diminished or altered by:

- Introduction and establishment of weeds in habitats for species and ecological communities that have a limited extent within the GBMWHA
- Infestation of sensitive habitats by introduced plants
- Introduction and establishment of weeds in large areas across the GBMWHA
- Introduction of weeds to highly sensitive areas (e.g. Wollemi pine habitat)

Impacts that notably diminish the integrity of the GBMWHA could result from:

- Spread of or establishment of new weed infestations in undisturbed areas
- Introduction of weeds to culturally sensitive areas

The impacts of introduced plants to the supporting values of the GBMWHA are likely to be limited. Notable impacts could result from:

- Infestation of wilderness areas or popular recreation areas by introduced plants
- Infestation of sensitive historic or cultural sites by weeds

Impacts to the protection arrangements for the GBMWHA are not reasonably foreseeable.

Introduced plants are only likely to notably alter or diminish the OUV or supporting values of the GBMWHA following the widespread introduction and establishment of weeds or new weed infestations in sensitive areas. Natural processes can also transfer weeds, which can amplify the impacts of human activity. In particular, weeds are often spread along watercourses. Introduction of weeds in new catchments or riparian corridors presents a greater risk to OUV.

Existing management strategies

All of the conservations reserves except for Thirlmere Lakes National Park note the presence of substantial weed infestations from a range of introduced plant species. These are typically in disturbed areas, areas of grazing land that have been incorporated into the conservation reserves, or along watercourses.

All the conservation reserves have plans to manage existing infestations or new outbreaks. The sections in each plan that deal with management and monitoring of introduced plants are given in Table 34-10.

Table 34-10: Management and monitoring of impacts from increased movement of disease and introduced plants

Conservation Reserve	Management of Impacts	Monitoring
Blue Mountains National Park	• s4.1.4 lists management policies and actions for introduced plants.	• s4.1.4 commits to develop an introduced species management database. • s4.3.10 gives priority to research into introduced species.
Gardens of Stone National Park	• s4.1.3 commits to manage introduced plants, with priority given to species that have a high capacity for dispersal.	• s4.1.3 commits to systematically survey introduced plants and monitor weed control programs.
Kanangra-Boyd National Park	• s4.1.3 lists management policies and actions for introduced plants.	• s4.1.3 commits to monitoring of introduced plant management activities.
Nattai National Park	• s4.1.2 commits to manage impacts from introduced plants. • s4.1.5 commits to implement control programs for introduced plants in wilderness areas.	• s4.3.3 prioritises research into management of introduced plants.
Thirlmere Lakes National Park	• s4.1.2 states that current levels of infestation in the park are low and sets out a range of priorities for control of introduced plants in the event of future outbreaks.	• s4.1.2 commits to develop a Pest Species Management Plan for the park.
Wollemi National Park	• s4.1.4 commits to manage impacts from introduced plants.	• s4.1.4 commits to monitor control programs for introduced plants.
Yengo National Park	• s4.1.4 commits NPWS to develop a program for control of weeds, consider strategic burning for Blackberry and other weeds, and survey and control infestations in the Macdonald River and Webbs Creek catchment.	• s4.1.3 commits NPWS to undertake biodiversity surveys to improve management of introduced plants. • s4.1.4 commits NPWS to undertake weed surveys and monitor weed control activities every 2 years.
Jenolan Caves Karst Conservation Reserve	• s4.1 sets out a range of actions and policies to manage introduced plants within the conservation reserve.	• s4.1 commits to monitor introduced plant control activity.

All of the plans of management for the conservation reserves within the GBMWHA include policies and actions to manage introduced plants. They all contain commitments to monitor weeds or encourage research into weeds. As visitor pressure on the conservation reserves increases, these monitoring commitments will be sufficient to ensure that management actions and policies can be altered as required.

Removal of bushrock and fallen timber

Bushrock is an important habitat feature for a range of flora and fauna in the GBMWHA. Its removal is identified as one of three key threatening processes in the Blue Mountains National Park Plan of Management (DECC, 2001). Bushrock removal impacts on habitat for a range of species within the World Heritage area and can increase erosion.

The plan of management for the Gardens of Stone National Park also lists illegal collection of fallen timber for firewood as a major threat to vegetation communities (DECC, 2009a). This potential impact is similar in its management and impacts to removal of bushrock and will be included in the discussion below.

Potential impacts to Outstanding Universal Value and supporting values

Collection of bushrock is unlikely to impact any attributes of OUV that relate to eucalyptus diversification and evolution in the GBMWHA. However, without appropriate management, bushrock removal could notably diminish or alter the attributes associated with outstanding diversity of species and ecological communities, especially through:

- Widespread bushrock removal or removal of bushrock or fallen timber from sensitive areas that impacts flora or fauna with a limited extent in the GBMWHA
- Bushrock removal in habitat for threatened species that are dependent on this habitat feature (e.g. the Broad-headed snake (DoE, 2014b))

Impacts that notably diminish the integrity of the GBMWHA are unlikely, but could result from:

- Extensive bushrock removal in undisturbed areas
- Intensive bushrock removal in sensitive areas that impacts the property's geological structure, geomorphology and water systems
- Bushrock removal in culturally sensitive areas

Impacts to supporting values from removal of bushrock are likely to be limited. Impacts could follow from:

- Disturbance of geological features in areas that contribute to the geodiversity of the GBMWHA
- Widespread removal of bushrock that leads to erosion in water catchments

Impacts to the protection arrangements for the GBMWHA are not reasonably foreseeable.

Impacts that notably diminish OUV from bushrock removal and firewood collection are only likely if they occur across many sites or in highly sensitive areas.

Existing management strategies

Bushrock removal is prohibited from all of the conservation reserves that make up the GBMWHA. Education and law enforcement has reduced the incidence of illegal bushrock removal, but the practise is still a problem in some easily accessible areas that are remote from management supervision (DECC, 2001). Illegal bushrock removal is managed under all of the plans of management for the conservation reserves that make up the World Heritage area. The relevant sections for management and monitoring of impacts are set out in Table 34-11.

Table 34-11: Management and monitoring of impacts from removal of bushrock

Conservation Reserve	Management of Impacts	Monitoring
Blue Mountains National Park	• s4.1.4: Commits to manage bushrock removal	• No specific commitment is made to monitor bushrock removal, but s4.3 commits to monitor a range of impacts at visitor facilities which could include bushrock removal.
Gardens of Stone National Park	• s4.1.2: Education programs in the local community will discourage collection of firewood and bushrock. Signage will be altered to note penalties associated with collection of firewood and bushrock.	• No commitment is made to monitor bushrock removal.
Kanangra-Boyd National Park	• Bushrock removal is not listed as management concern in the plan of management.	• The plan of management does not include monitoring of bushrock removal.
Nattai National Park	• Bushrock removal is associated with unauthorised vehicle access. §4.3.2 sets out a range of policies and actions to limit and manage unauthorised access.	• s4.3.2 commits to supervise and monitor four-wheel drive access.
Thirlmere Lakes National Park	• Bushrock removal is not listed as management concern in the plan of management.	• The plan of management does not include monitoring of bushrock removal.
Wollemi National Park	• s4.1.3 notes that bushrock is “managed reasonably well” within the park. No policies or actions are given for bushrock removal.	• The plan of management does not include monitoring of bushrock removal.
Yengo National Park	• s4.1.3: Notes bushrock removal as a significant threat to reptiles and amphibians in the park. Policies commit to maintain plant and animal diversity and distribution. • s4.1.1: Commits to manage unauthorised use of management trails – a key means of illegal bushrock removal.	• No specific commitments are made to monitor bushrock removal. However, commitments are made to monitor trail use (§4.3.3) and species distributions (§4.1.3) which will capture the main means of bushrock removal and its impacts.
Jenolan Caves Karst Conservation Reserve	• Bushrock removal is not listed as management concern in the plan of management.	• The plan of management does not include monitoring of bushrock removal.

Bushrock removal is recognised as a threatening process for a number of fauna species within the GBMWHA. It is managed in four of the eight conservation reserves within the GBMWHA. There is no commitment to monitor bushrock removal or the key activities that are associated with it (e.g. unauthorised vehicle access) at:

- Gardens of Stone National Park (although the plan of management includes bushrock removal management actions)
- Kanangra-Boyd National Park
- Thirlmere Lakes National Park
- Wollemi National Park
- Jenolan Caves Karst Conservation Reserve

Without appropriate monitoring for this threatening process across the World Heritage area, potential increases in bushrock removal associated with population growth in Western Sydney could impact on the OUV or the supporting values of the GBMWHA. Bushrock removal may not be a serious risk to these reserves, either because of the ecology and landscape of the reserve or the current patterns in visitor use. If visitor use of these reserves changes, it may be necessary to monitor bushrock removal to support best practice management of this threatening process.

Development and maintenance of new visitor facilities or increased maintenance of existing facilities

An increase in visitors to the World Heritage area will increase the demand for and maintenance requirements of a range of facilities and infrastructure, including:

- Information and interpretation centres or signage
- Camping and day use facilities
- Walking tracks
- Roads and parking areas
- Service trails
- Toilets and waste disposal facilities

Facilities and infrastructure are essential for appropriate and sustainable use of the GBMWHA and are often used to manage or mitigate other impacts from visitor use. However, the construction and maintenance of these structures or earthworks can lead to a range of impacts, including:

- Clearing
- Individual mortality
- Altered surface water hydrology and erosion
- Reduced water quality
- Fragmentation and edge effects

Development and maintenance activity in conservation reserves is often required to mitigate or manage impacts from visitor use. NSW NPWS do not have complete control over where development and maintenance activities are required, and these works may be necessary in sensitive areas within the GBMWHA.

Potential impacts to Outstanding Universal Value

Without appropriate management, the cumulative impacts from development and maintenance of visitor facilities could notably alter or diminish the OUV of the GBMWHA. Attributes of OUV that relate to the outstanding examples of eucalyptus diversification and evolution and the diversity of habitats, species and ecological communities could be notably impacted by:

- Impacts across many high-quality or important sites that support examples of eucalyptus diversification and evolution
- Intense impacts over large areas, or in important, sensitive areas especially habitats for species and ecological communities with a limited extent in the World Heritage area
- Any impacts to highly sensitive areas, including habitat for the Wollemi pine

Impacts that notably diminish the integrity of the GBMWHA are unlikely, but could result from:

- Widespread impacts in otherwise pristine environments
- Impacts to culturally sensitive areas

Development of additional visitor infrastructure is likely to have beneficial effects on many supporting values of the GBMWHA. Impacts could result from:

- Impacts in wilderness areas or water catchments
- Widespread impacts in areas of scenic or aesthetic value

Impacts to the protection arrangements for the GBMWHA are not reasonably foreseeable.

Impacts that notably diminish OUV from development and maintenance of visitor facilities are only likely if they occur across many important sites or in highly sensitive areas.

Existing management strategies

The plans of management for the conservation reserves that make up the GBMWHA include a range of measures to limit the impacts from the provision of visitor facilities. These range from limiting the development of new infrastructure to locating infrastructure in appropriate areas and managing impacts from maintenance work. Importantly, the plans of management include possible closures of areas that are subject to intense impacts from visitor use, which allows recovery of these areas without the need for substantial infrastructure. The plans of management also set out mitigation measures and controls to ensure that where new infrastructure is required it minimises impacts on the supporting values of the GBMWHA.

Table 34-12 gives the relevant sections within each plan of management for management and monitoring of impacts from visitor infrastructure.

Table 34-12: Management and monitoring of impacts from development or maintenance of visitor facilities

Conservation Reserve	Management of Impacts	Monitoring
Blue Mountains National Park	• s4.3 sets out a range of management actions and policies for new and existing visitor infrastructure.	• s4.3.10 sets out monitoring programs for impacts from management facilities and activities.
Gardens of Stone National Park	• s4.3.10 sets out a range of management actions and policies for new and existing visitor infrastructure.	• s4.3 commits to monitor a range of impacts associated with visitor infrastructure around the park.
Kanangra-Boyd National Park	• s4.3.12 sets out a range of management actions and policies for new and existing visitor infrastructure.	• s4.3 commits to monitor a range of impacts associated with visitor infrastructure around the park.
Nattai National Park	• s4.3.4 sets out management action and policies for new and existing visitor infrastructure.	• s4.3 commits to monitor a range of impacts associated with visitor infrastructure around the park.
Thirlmere Lakes National Park	• s4.3 sets out management action and policies for new and existing visitor infrastructure.	• The plan of management does not list actions or policies for monitoring of impacts from new or existing infrastructure.
Wollemi National Park	• s4.3.10 sets out a range of management actions and policies for new and existing visitor infrastructure.	• s4.3 commits to monitor a range of impacts associated with visitor infrastructure around the park.
Yengo National Park	• s4.3.8 sets out policies and actions to minimise impacts from management operations.	• s4.3.8 describes a range of long-term adaptive actions that including monitoring of impacts from management operations.
Jenolan Caves Karst Conservation Reserve	• s5.1 sets out policies and actions to minimise impacts from management operations.	• Table 5 in s3.5 sets out a range of monitoring processes for impacts associated with management activities.

All of the conservation reserves within the GBMWHA have actions and policies to manage impacts from new visitor facilities and maintenance of existing facilities. These actions and policies typically include commitments to review infrastructure needs and decommission or upgrade facilities as required. Appropriate monitoring or adaptive management commitments are made at all the conservation reserves except for Thirlmere Lakes National Park. While it is likely that the management arrangements at Thirlmere Lakes National Park are adequate, impacts from visitor use and increased maintenance or new development of visitor facilities and infrastructure should be monitored as appropriate to ensure that management measures can be adjusted to minimise impacts as visitor pressures increase.

34.2.6 CONSISTENCY WITH THE STRATEGIC PLAN

Neither the Plan nor its likely impacts will prevent the achievement of any of the objectives for management of the GBMWHA set out in the Strategic Plan. The likely effects of the Plan on each of the key management issues are discussed in Table 34-13.

Table 34-13: Impacts of the Plan on the management objectives for the GBMWHA

Key management issue and objectives	Likely impacts of the Plan
Integrity • To maintain, and wherever possible, improve the current and future integrity of the GBMWHA.	Current management and monitoring measures are considered sufficient to ensure that the Plan does not undermine or prevent future improvement of the integrity of the GBMWHA.
Major impacts • To reduce the potential for major impacts to adversely affect the integrity of the GBMWHA. Major impacts include mining adjacent to or underlying the GBMWHA, highway construction through the GBMWHA, or other development within or adjacent to the GBMWHA.	The Plan will not have major impacts on the GBMWHA and will not reduce the opportunities to manage or minimise major impacts from other projects.
Biodiversity • To conserve the GBMWHA's biodiversity and ensure the ecological viability and capacity for ongoing evolution of its World Heritage and other natural values is maintained.	Current management and monitoring measures are sufficient to ensure that the Plan does not appreciably impact the biodiversity or ecological viability of the GBMWHA.
Geodiversity • To protect the GBMWHA's geodiversity.	Current management and monitoring measures are sufficient to ensure that the Plan does not appreciably impact the geodiversity of the GBMWHA.
Water catchment protection • To maintain and improve the water quality and water catchment values of the GBMWHA.	Current management and monitoring measures are sufficient to ensure that the Plan does not appreciably impact water quality of the catchment values of the GBMWHA.
Cultural heritage • To identify, formally recognise and protect the cultural heritage values of the GBMWHA. • To manage the GBMWHA jointly with local Indigenous people.	Current management and monitoring measures are sufficient to ensure that the Plan does not appreciably impact cultural heritage values within the GBMWHA. The Plan will not affect joint management of the GBMWHA with local Indigenous people.
Landscape, natural beauty and aesthetic values • To protect the landscape, natural beauty and aesthetic values of the GBMWHA.	The Plan is anticipated to have minor visual impacts along part of the eastern fringe of the GBMWHA. These impacts will not appreciably affect the landscape, natural beauty or aesthetic values of the GBMWHA, which are located elsewhere in the World Heritage area.
Recreation and visitor use • To provide for an appropriate range of recreation and visitor use, consistent with the protection of World Heritage and related values.	The Plan is likely to increase visitor pressures on the GBMWHA. Current management and monitoring measures are sufficient to manage these impacts and ensure an appropriate range of recreation and visitor use opportunities.
Social and economic issues • Consistent with the protection of World Heritage and other values, optimise the potential and existing social and economic benefits derived from visitation to the GBMWHA.	The Plan is likely to enhance the social and economic benefits. Where impacts are possible (e.g. from increasing fire frequency), the current management and monitoring measures are sufficient to manage the risk to social and economic benefits.

Key management issue and objectives	Likely impacts of the Plan
Education, community participation and consultation • To encourage community stewardship of the GBMWHA through education, consultation and the provision of opportunities for community participation in its protection.	The Plan is not anticipated to affect this objective.

The desired outcomes have also been reviewed and found to be not inconsistent with the Plan. There are too many desired outcomes to warrant a detailed discussion here, but they are generally consistent with the objectives for each management issue and thus not affected by the Plan.

34.2.7 CONCLUSION

The potential facilitated impacts of the Plan on the GBMWHA are intensifications of existing threats that are already managed across the conservation reserves that make up the World Heritage area. The management plans for each of the reserves set out a range of management actions and monitoring programs that will support adaptive management of these threats over the life of the Plan. The protection arrangements for each of the conservation reserves and the GBMWHA as a whole are considered adequate to manage the potential facilitated impacts associated with the Plan.

The Plan will not prevent the achievement of any of the objectives or desired outcomes for the management of the GBMWHA set out in the Strategic Plan. It is not inconsistent with the Strategic Plan.

34.3 PARRAMATTA FEMALE FACTORY AND INSTITUTIONS PRECINCT

The Parramatta Female Factory and Institutions Precinct (the Precinct) is a National Heritage site whose values relate to the history of convict women and institutional care of women and children in Australia. It is located in North Parramatta, 13 km from the nearest urban capable land or transport corridor, and is unlikely to be impacted by the Plan.

34.3.1 DESCRIPTION OF THE PRECINCT

The Precinct is located between Fleet Street and the Parramatta river in North Parramatta (PFFPA, 2018). Its location is shown in Figure 34-3. The site covers 7.3 ha and contains a range of buildings from the early 19th to late 20th centuries. Some buildings are still occupied, while others are vacant and dilapidated. The site has served a range of purposes typically related to institutionalisation of women and children, including:

- The Parramatta Female Factory (1821-1847)
- The Parramatta Lunatic Asylum (under various names, 1847-1983)
- The Roman Catholic Orphanage (1844-1886)
- The Parramatta Girls Industrial School (1886-1974)
- The Norma Parker Centre (1974-2008) (DoEE, 2018b)

After several name changes, the site of the Parramatta Lunatic Asylum was renamed the Cumberland Hospital in 1983. The Cumberland Hospital and the NSW Institute of Psychiatry continue to operate at the site.

34.3.2 EPBC ACT APPROVAL CONSIDERATIONS

The Parramatta North Historic Sites Consolidated Conservation Management Plan (TKD Architects, 2017) meets the conditions of Section 146H of the EPBC Act for a plan of management for this National Heritage place. It sets out a range of principles for management of heritage values at the site. These principles prioritise:

- The need to understand, retain, protect and communicate heritage values at the site
- Application of best-practise heritage management guidelines including ensuring that works at the site are carried out by appropriately skilled and experienced people
- Community engagement in the management and care of the site

To meet the requirements of the EPBC Act, the Plan must not make it impossible to follow these principles or meet their aims.

34.3.3 HERITAGE VALUES

The Precinct meets three criteria for National Heritage listing:

- Criterion A Events, Processes
- Criterion B Rarity
- Criterion C Research

The Precinct provides insight into the experiences of women and children, particularly convict women, in institutions over 150 years of Australian history. It reflects government attitudes to vulnerable women and children and the role of institutions in the welfare system over 150 years. It is a physical locus of the stories of women and children who were institutionalised and whose experiences have often been dismissed or disbelieved (DoEE, 2018b).

There are limited examples of sites associated with convict women in Australia. Nine of 12 female factories have been completely demolished. The presence of original buildings and walls in the Precinct and its connection to the history of convict women and institutionalised women and children make the site outstandingly valuable to the nation (DoEE, 2018b).

Further archaeological study within and around the Precinct has the potential to reveal more about the lives of convict women and the history of institutional care (DoEE, 2018b).

The heritage values for the Precinct are expressed in the remaining physical fabric of the precinct including the buildings, grounds and walls of the Female Factory, Roman Catholic Orphanage, Parramatta Girls Industrial School, The Norma Parker Centre and the Cumberland Hospital (DoEE, 2018b).

34.3.4 POTENTIAL IMPACTS FROM THE PLAN

The Precinct is over 13 km from the urban capable land or transport corridors in an existing urban area. Its heritage values are expressed in structures and areas that are unlikely to be susceptible to indirect or facilitated impacts. It is unlikely that there will be any impacts to the National Heritage values of the Precinct as a result of implementation of the Plan. The Plan will not prevent the application of any of the principles from the management plan for this National Heritage place, nor will it prevent the management plan from achieving its aims.

34.3.5 CONCLUSION

There are unlikely to be any notable impacts to the National Heritage values of the Parramatta Female Factory and Institutions Precinct as a result of the Plan. The Plan is not inconsistent with the plan of management for National Heritage values at this site.

34.4 OLD GOVERNMENT HOUSE AND THE GOVERNMENT DOMAIN

Old Government House and the Government Domain is World and National Heritage place in North Parramatta. Its buildings and open spaces played a role in the early government and agriculture of colonial Australia and have been recognised as having heritage value (DoEE, 2018b). The site is over 12 km from the nearest urban capable land or transport corridor and unlikely to be impacted by the Plan.

34.4.1 DESCRIPTION OF THE HERITAGE PLACE

The Government Domain covers an area of 85 ha and contains buildings, memorials, relics, historic plantings, and archaeological sites. It is mostly made up of open, grassy areas and includes patches of native vegetation. These open spaces were the site of early colonial agriculture including some of the first successful crops in Australia (DoEE, 2018b). Its location is shown in Figure 34-3.

Situated at the southern end of the Government Domain, Old Government House is the site of the first governor's residence in Parramatta. The first governor's cottage was constructed in 1790 and the house and its surrounding buildings were variously extended, renovated and replaced over the next 65 years. The house ceased to be used as an official residence, fell into disrepair, and was leased out in 1856. It was extensively restored and renovated in 1909 when the building was repurposed as a school. It was acquired by the National Trust in 1967, which has undertaken a range of restoration works to return the house to the configuration that was used by Governor Macquarie. The house and surrounding grounds is now used as a museum (DoEE, 2018b).

34.4.2 EPBC ACT APPROVAL CONSIDERATIONS

The key management document for this World Heritage property is the Old Government House and Domain, Parramatta Park Management Plan (PPT, 2009). This document serves as a management plan under Section 146G of the EPBC Act.

The management plan sets out a range of policies for management of World Heritage and National Heritage values at the site. Summarised, these policies have the following objectives:

- Manage the landscape, buildings, and other structures at the site to conserve their historical values, ensuring maintenance, new works and repairs maintain or restore the historical character of the site
- Ensure the Government Domain grounds are primarily used for recreation, sport and entertainment, and that use of Old Government House enhances and facilitates understanding of its history and significance
- Restore, protect and maintain natural systems within the site
- Maintain historical views and the infrastructure at and around the site to preserve the character of the site
- Promote and enable research at the site

To meet the requirements of the EPBC Act, the Plan must not prevent the achievement of any of these objectives.

34.4.3 HERITAGE VALUES

Old Government House and the Government Domain meets four criteria for National Heritage listing:

- Criterion A Events, Processes
- Criterion C Research
- Criterion D Principal characteristics of a class of places
- Criterion H Significant people (DoEE, 2018b)

It is also one of 11 convict sites across Australia that are jointly listed as a World Heritage place, under two criteria:

- Criterion (iv): recognising the importance of these buildings to the system of deportation and forced labour that contributed to the British Empire's colonial project
- Criterion (vi): recognising that these sites are an outstanding example of the transportation of convicts to colonial lands and reflect the history of attitudes to penal, political and colonial systems in contemporary and modern Europe. (UNESCO, 2018a)

The site is a tangible link with the earliest days of colonial history in Australia which has been recognised as having outstanding heritage value for all Australians. Old Government House is the oldest surviving public building in mainland Australia and contains:

- Brick floors from the 1790 cottage of Governor Phillip
- Rooms dated to 1799, constructed by order of Governor Hunter
- Rooms dated to 1818, constructed by order of Governor Macquarie (DoEE, 2018b)

The house, surrounding buildings, relics and open areas are examples of convict workplaces and important sites in the foundation of British settlement in Australia. These areas have the potential to yield further insight through archaeological research (DoEE, 2018b).

The Government Domain contains historic agricultural areas (an area called "the Crescent"), a dairy, a bathhouse, a Boer War Memorial, carriageways and gatehouses, and the remains of Governor Brisbane's astronomical observatory. These elements reflect Australia's development from a penal colony dependant on Great Britain to a self-governing nation. Old Government House provides evidence of the development of early administration in the colony (DoEE, 2018b).

Old Government House and the Government Domain provide a connection to the life and work of Australia's early colonial governors. The house and surrounding buildings provide insight into Governors Phillip, Hunter, King, Macquarie, and Brisbane, who all lived and worked at the site (DoEE, 2018b).

34.4.4 POTENTIAL IMPACTS FROM THE PLAN

Old Government House and the Government Domain is over 12 km from the urban capable land or transport corridors in an existing urban area. Its heritage values are expressed in structures and areas that are unlikely to be susceptible to indirect or facilitated impacts.

The *Conservation Agreement for the protection and conservation of the World Heritage Values and National Heritage Values of the Australian Convict Sites, Old Government House and Domain, Parramatta New South Wales* notes possibility of impacts to the landscape values of the sites from development in nearby urban areas (DoE, 2013a), but the urban capable land and transport corridors are well outside the range of possible visual impacts.

It is unlikely that there will be any impacts to the National Heritage values of Old Government House and the Government Domain as a result of the Plan. The Plan will not prevent the achievement of any of the objectives from the management plan for this property.

34.4.5 CONCLUSION

There are unlikely to be notable impacts to the World or National Heritage values of Old Government House and the Government Domain as a result of the Plan. The outcomes of the Plan are not inconsistent with the management plan for the property.

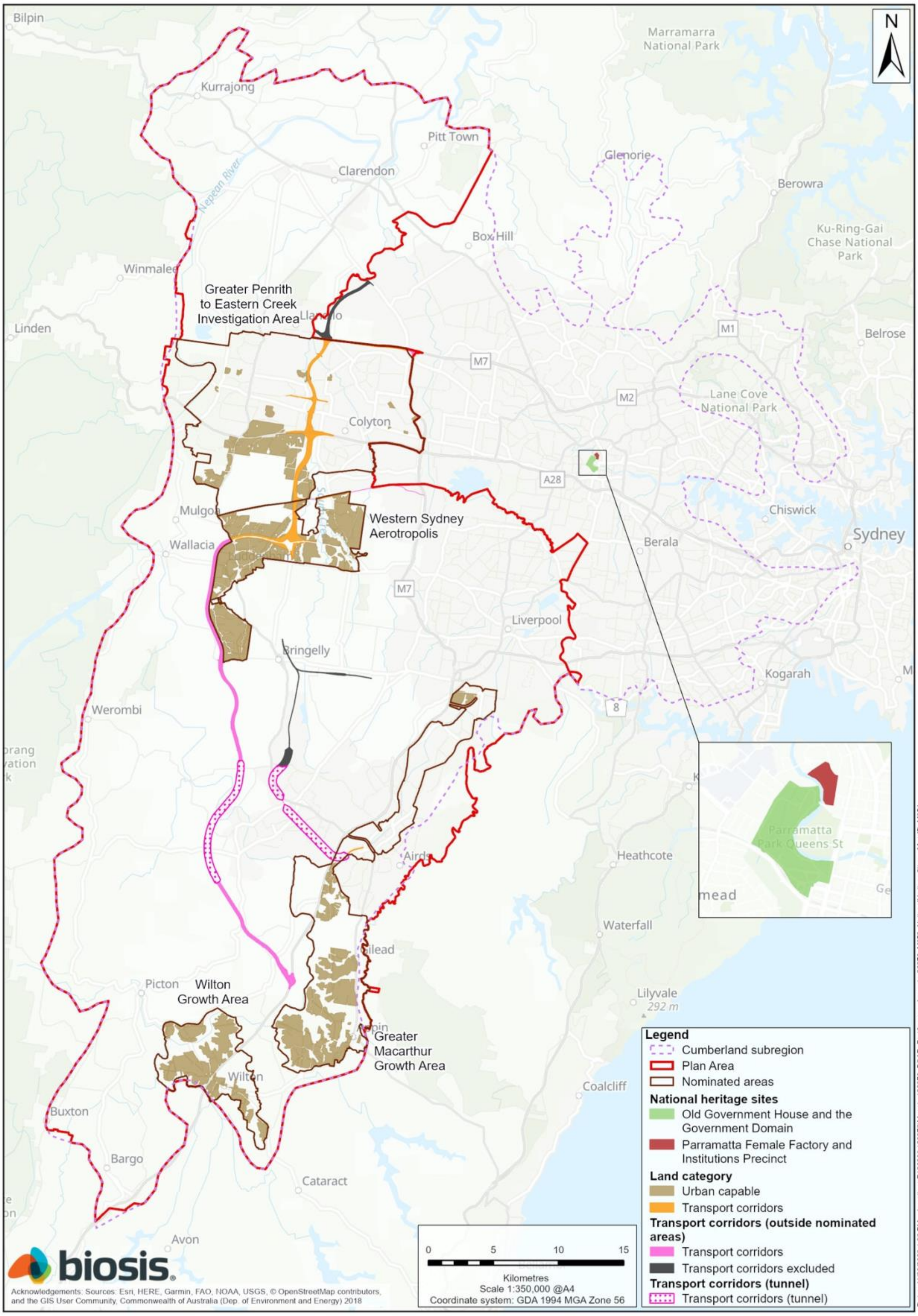

Figure 34-3: The location of Parramatta Female Factory and Institutions Precinct, Old Government House and the Government Domain

35 Commonwealth land impact assessment

35.1 INTRODUCTION

Commonwealth land is a matter protected under Section 26 of the EPBC Act. There are 12 known Commonwealth land sites within the Strategic Assessment Area (see Map 54.1), excluding Shanes Park.

This Chapter provides an assessment of potential impacts to the environment on this land from the urban and industrial, infrastructure, agribusiness and transport development under the Plan.

The impact assessment has been based on desktop information and framed around the Commonwealth's *Significant Impact Guidelines 1.2 – Actions on, or impacting upon, Commonwealth land and Actions by Commonwealth Agencies* (DSEWPC, 2013). The assessment provides an understanding of the range of environmental values on each site.

Three of the 12 Commonwealth land sites occur within the nominated areas:

- Site 3 in GPEC
- Site 4 in GMAC
- Site 5 in GPEC

None of these sites will be directly impacted by urban, industrial, infrastructure or agribusiness development.[2]

Potentially only one site (Site 10) will be directly impacted by development – by the transport corridors outside the nominated areas. However, three other sites – Site 4 (Western Sydney University), Site 6 (Camden Airport) and Site 7 (a small site at Grassmere) – may also be directly impacted by the tunnels associated with the transport corridors. The tunnels extend under these sites and some disturbance to the land surface within these sites may be necessary for construction activities and permanent infrastructure.

While all Commonwealth sites are potentially at risk from indirect and facilitated impacts, the likelihood of many of these impacts varies significantly between sites, and this largely depends on each sites proximity to the urban capable land and transport corridors in the context of that impact. For example, construction of the development is very unlikely to cause any indirect impacts to Commonwealth sites that are distant (many km) from construction areas.

35.1.1 SHANES PARK

Shanes Park is currently Commonwealth land that occurs along the northern boundary of GPEC (north of Willmot). The M7/Ropes Crossing Link Road will directly impact approximately 4.7 hectares of native vegetation in Shanes Park, comprising Commonwealth-listed Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest.

The NSW Government is currently in the process of finalising a Deed of Transfer with the Australian Government which will transfer the land to the NSW Minister for Environment. It is anticipated that this transfer will occur in the coming months. The impacts on TECs and species within Shanes Park are addressed in Chapters 29, 30 and 31.

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[2] For three of these sites, GIS analysis suggests there are very small direct impacts, as follows:

- Site 4 – 0.3 ha along the southern boundary of the site
- Site 5 – 0.001 ha along the northern and eastern boundary of the site
- Site 8 – 0.1 ha along the northern and western boundaries of the site

Inspection of aerial photos and cadastre boundaries shows that there are slight errors with the GIS spatial data of the boundaries of the urban capable land and transport corridors in these areas and direct impacts will not occur to these sites.

35.2 ASSESSMENT APPROACH

35.2.1 COMMONWEALTH ASSESSMENT CRITERIA

There are 12 Commonwealth land sites in the Strategic Assessment Area, excluding Shanes Park.

Under the EPBC Act, an assessment of impacts to Commonwealth land needs to consider the whole of the environment, which is much broader than MNES. Environment in this context is defined under Section 528 to include:

- Ecosystems and their constituent parts, including people and communities; and
- Natural and physical resources; and
- The qualities and characteristics of locations, places and areas; and
- Heritage values of places; and
- The social, economic and cultural aspects of a thing mentioned in paragraph (a), (b), (c) or (d).

Direct, indirect and facilitated impacts have been assessed for the 12 Commonwealth land sites in the Strategic Assessment Area using the Commonwealth's *Significant Impact Guidelines 1.2* (DSEWPC, 2013). The sites have been described and assessed against the list of matters required to be considered in the guidelines, including:

- Landscapes and soils
- Water resources
- Biodiversity values – vegetation and plant and animal species
- Conservation and special use areas
- Heritage values
- Services and infrastructure/people and communities

35.2.2 DATA SOURCES

The assessment in this Chapter is based on the desktop information outlined in Table 35-1. Profiles for each of the 12 Commonwealth land sites have been generated from this information (see sections 35.3 to 35.3.12).

The limitations in the data for Commonwealth land are similar to the limitations for the Assessment Report generally (see Chapter 13). Key limitations include:

- Ground truthing was not generally undertaken as part of the impact assessment for Commonwealth land
- Impacts on species are based on potential habitat mapping (the Knowledge-Based Method (KBM) and Species Distribution Model (SDM) methods), which are likely to over-predict the extent of actual habitat

Table 35-1: Data sources for the Commonwealth land assessment

Data type	Data source
General	• Unclipped spatial data of Commonwealth land in Strategic Assessment Area provided by the Commonwealth of Australia • Existing reports and statutory documents such as the Biodiversity Offset Delivery Plan for Western Sydney, Liverpool Biodiversity Management Plan, Holsworthy MUR Project, Western Sydney Airport EIS, Local Environmental Plans • Information generated as part of the broader strategic assessment for MNES, including species habitat mapping across the Cumberland subregion, Strategic Assessment Area boundary, and the urban capable land and transport corridors
Soils	• Area of soil landscapes from eSPADE v2.0 (OEH, 2018a).
Waterways and topography	• Mapped watercourses and waterbodies in NSW from the *Water Management (General) Regulation 2018* hydroline spatial data 1.0

Data type	Data source
Vegetation	• Vegetation mapping for this project: o Vegetation mapping for this project within the nominated areas (Biosis 2018) o EPBC TEC mapping for this project across the Cumberland subregion (Biosis 2019) • Existing vegetation mapping: o Remnant Vegetation of the Western Cumberland Subregion 2013 Update VIS_ID 4207 (OEH 2013) o The Native Vegetation of the Sydney Metropolitan Area VIS_ID 4489 (OEH 2016)
Fauna and flora	• Threatened flora and fauna records from Atlas of NSW Wildlife (BioNet) • Important populations spatial data provided by Biosis and created from BioNet records • Commonwealth SPRAT database • NSW Threatened Species Profiles • OEH Threatened Biodiversity Data Collection • Recovery plans and conservation advices
Heritage	• World, Commonwealth and National heritage list and Register for the National Estate information from the Australian Heritage Database • NSW Heritage information from the Office of Environment and Heritage website • World, Commonwealth, and National heritage list spatial data from the Department of Environment and Energy database • Register for the National Estate (non-statutory) spatial data from the Department of Environment and Energy database • State Heritage Register (curtilages & centroids) from the NSW SEED database
Landscape context	• Area of priority conservation lands (PCLs) from the NSW SEED database • Area of core and corridors from the Biodiversity Investment Opportunities Map (BIO Map)

35.3 ASSESSMENT OF IMPACTS TO EACH SITE

35.3.1 SITE 1 (RAAF TRANSMITTING STATION)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	RAAF Transmitting Station
Site ID number	1
Area	63.3 ha
Address	419-499 Londonderry Road, Londonderry NSW
Folio	1/598180, 1/91240
General description	Site 1 is located at 419-499 Londonderry Road, Londonderry. Based on available information, the site has limited ecological value. A main building with four smaller outhouses is located in the south-west corner of the site. It is located within the Strategic Assessment Area approximately 50 km north-west of the Sydney CBD
Site map	The location of Site 1 is shown in Map 54.2

DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS

Site 1 is located approximately 9 km from the nearest development under the Plan

LANDSCAPES AND LANDFORMS

The site occurs in a gently undulating low rise landscape on Tertiary terraces of Hawkesbury-Nepean River system

SOIL AND SUBSTRATES

The soil landscape is made up of Berkshire Park soil. Berkshire Park soil consists of heavy clays and clayey sands that are made up of less than a third of soil aggregates (OEH, 2018a)

WATER

The site has a first order watercourse that flows from north-south through the north-east corner of the site. It is a tributary of Rickabys Creek (DoI, 2019; DTA, DCA et al., 2019)

The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018)

VEGETATION

The site is largely unvegetated other than a narrow strip of vegetation that forms part of a riparian corridor, connecting with larger areas of vegetation to the north and east of the site

Approximately 1 ha (or 1.7 per cent of the site) has been mapped as native vegetation

Plant Community Types (PCTs)/NSW listed threatened ecological communities (TECs)

PCT number	PCT name	NSW TEC name	BC Act status	Area (ha)
724	Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered	0.3
725	Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	Endangered	0.0
883	Hard-leaved Scribbly Gum – Parramatta Red Gum healthy woodland of the Cumberland Plain, Sydney Basin Bioregion	Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion Castlereagh Swamp Woodland Community	Vulnerable Endangered	0.4
1067	Parramatta Red Gum on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	Castlereagh Swamp Woodland Community	Endangered	0.4

Commonwealth listed threatened ecological communities (TECs)

Commonwealth TEC name	EPBC Act status	Area (ha)
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	Endangered	0.1
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered	<0.1
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	0.2

Threatened flora species			
Name	**EPBC Act or BC Act status**	**Area of potential habitat (ha)**	**Number of BioNet records**
Dillwynia tenuifolia	Vulnerable (BC Act)	0.0	1
Persoonia nutans (Nodding Geebung)	Endangered (BC Act & EPBC Act)	63.3	1
Acacia bynoeana (Bynoe's Wattle)	Vulnerable (BC Act) Endangered (EPBC Act)	56.1	0
Micromyrtus minutiflora	Endangered (BC Act) Vulnerable (EPBC Act	63.3	0
Persoonia hirsuta (Hairy Geebung)	Endangered (BC Act & EPBC Act)	0.6	0
Pimelea spicata (Spiked Rice-flower)	Endangered (BC Act & EPBC Act)	1.4	0
Pomaderris brunnea (Brown Pomaderris)	Endangered (BC Act) Vulnerable (EPBC Act)	0.4	0
Pultenaea parviflora	Endangered (BC Act) Vulnerable (EPBC Act)	21.8	0
BIO Map Priority Investment Areas			
No BIO Map core or corridor areas have been identified on this site			
ANIMAL SPECIES			
There is one threatened species record known from the site – Cumberland Plain Land Snail			
Threatened fauna species			
Name	**EPBC Act or BC Act status**	**Area of potential habitat (ha)**	**Number of BioNet records**
Litoria aurea (Green and Golden Bell Frog)	Endangered (BC Act) Vulnerable (EPBC Act)	7.9	0
Pommerhelix duralensis (Dural Land Snail)	Endangered (BC Act & EPBC Act)	49.3	0
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	0.1	0
Petauroides volans (Greater Glider)	Vulnerable (EPBC Act)	0.8	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	1.1	0
Dasyurus maculatus maculatus (Spot-tailed Quoll)	Vulnerable (BC Act) Endangered (EPBC Act)	0.8	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	1.1	0
Meridolum corneovirens (Cumberland Plain Land Snail)	Endangered (BC Act)	0.0	1
CONSERVATION AND SPECIAL USE AREAS			
There are no conservation or special use areas present on this site The closest conservation or special use areas are: • Western Sydney University EucFACE experiment site (approximately 1.4km north) • Agnes Banks Nature Reserve (approximately 3km west) • Castlereagh Nature Reserve (approximately 3km south)			

HERITAGE PLACES AND ITEMS
It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having heritage values
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The site is a former RAAF transmitting station and appears to be no longer in use Medium density urban housing borders the southern edge of the site, while low density rural lots border the north, east and part of the western edge of the site No mining or petroleum tenements exist on this site (NNTT, 2020) No Native Title Claims exist over this site (NNTT, 2020)

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 1 due to the Plan.

Indirect and facilitated impacts

Site 1 occurs approximately 9 km from the nearest development under the Plan – urban and industrial development and transport development within GPEC. The site is also located upstream of the nearest development and within a separate sub-catchment. The location of the site relative to the development means:

- The site is very unlikely to be impacted by impacts typically associated with construction of the development in GPEC, such as air quality, noise, construction traffic, or the spread of weeds or disease
- The site will not be impacted by soil erosion of sedimentation, changes to surface and groundwater quantity and flows, or water quality impacts associated with the construction and operation of the development

Furthermore, the site no longer appears to be in use. If this is the case, the development would not disrupt any services or infrastructure or affect the health or safety of any person associated with the site.

The potential indirect or facilitated impacts associated with the development in GPEC and the key values of the environment of Site 1 that are potentially impacted are shown in Table 35-2.

Table 35-2: Potential indirect impacts on Site 1 associated with the development

Potential indirect impact	Extent within site 1	Duration	Values of site potentially impacted
Construction			
Clearing of habitat during construction of the development that links the site to other areas of habitat, leading to impacts on biodiversity values	Whole of site	Long term	Biodiversity values

Biodiversity values

There is a small amount of potential habitat for native species at Site 1, primarily associated with the riparian corridor on the site. This riparian corridor is connected to vegetation within the surrounding area and also to the Hawkesbury River.

The connectivity of this riparian corridor to the surrounding area will not be directly impacted by development under the Plan, and therefore the habitat values of the site are unlikely to be impacted indirectly by the Plan.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address the potential indirect impacts on the environment of Site 1 from the development under the Plan.

35.3.2 SITE 2 (RICHMOND AIR BASE)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	RAAF Richmond Air Base and surrounding area
Site ID number	2
Area	379.1 ha
Address	115 Dight St, Richmond NSW 5 Wood St, Richmond NSW 24-162 Percival St, Clarendon NSW
Folio	197/824047, 2/90072, 196/824045, 1/616709, 5-67244683, 11-13/563483, 1-3/572977
General description	Site 2 is made up of several lots of land located adjacent to each other at the addresses given above. Approximately 1.2 per cent of the site is covered by vegetation. The southern part of the site is comprised of a landing strip with aeroplane hangars and other smaller buildings located towards the north east of the site. The part of the site located on Percival street appears to mostly comprise exotic grassland with a few buildings located in the north west corner The site is used as a Royal Australian Airforce (RAAF) base. It is located approximately 47 km north-west of the Sydney CBD, within the Strategic Assessment Area
Site map	The location of Site 2 is shown in Map 54.3
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
Site 2 is located over 12 km from the nearest development under the Plan	
LANDSCAPES AND LANDFORMS	
The site is mostly flat and occurs on the terraces and floodplain of the Nepean River	
SOIL AND SUBSTRATES	
The soil landscape of Site 2 is made up of: • 86 ha of Freemans Reach soil – Freemans Reach soil consists of deep brown sands and loams on the active floodplain of the Nepean River • 293 ha of Richmond soil – Richmond soils consist of orange to red clay loams, clays, and sands that are poorly structured (OEH, 2018a) • < 1 ha of Upper Castlereagh soil – Upper Castlereagh soil consists of apedal sandy clay loam or fine sandy clay loam overlying light medium clay	
WATER	
The site is bordered by bordered on the eastern side by Rickabys Creek, a minor perennial creek. Two canal lanes occur in the east of the site and drain into Rickabys Creek The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018)	
VEGETATION	
There is 5 ha of native vegetation on the site and the vegetation is relatively isolated from other areas of vegetation	

<table>
<tr><th colspan="5">Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)</th></tr>
<tr><th>PCT number</th><th>PCT name</th><th>NSW TEC name</th><th>BC Act status</th><th>Area (ha)</th></tr>
<tr><td rowspan="2">781</td><td rowspan="2">Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion</td><td>Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions</td><td>Endangered</td><td rowspan="2">1.8</td></tr>
<tr><td>Sydney Freshwater Wetlands in the Sydney Basin Bioregion</td><td>Endangered</td></tr>
<tr><td>835</td><td>Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion</td><td>River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions</td><td>Endangered</td><td>3.3</td></tr>
<tr><th colspan="5">Commonwealth listed threatened ecological communities (TECs)</th></tr>
<tr><th colspan="3">TEC name</th><th>EPBC Act status</th><th>Area (ha)</th></tr>
<tr><td colspan="3">Coastal floodplain eucalypt forest of eastern Australia</td><td>Currently being assessed for listing under EPBC Act</td><td>3.3</td></tr>
<tr><th colspan="5">Threatened flora species</th></tr>
<tr><th colspan="2">Name</th><th>EPBC Act or BC Act status</th><th>Area of habitat (ha)</th><th>Number of BioNet records</th></tr>
<tr><td colspan="2">Acacia bynoeana (Bynoe's Wattle)</td><td>Vulnerable (BC Act)
Endangered (EPBC Act)</td><td>54.3</td><td>0</td></tr>
<tr><td colspan="2">Micromyrtus minutiflora</td><td>Endangered (BC Act)
Vulnerable (EPBC Act</td><td>0.3</td><td>0</td></tr>
<tr><td colspan="2">Pimelea spicata (Spiked Rice-flower)</td><td>Endangered (BC Act & EPBC Act)</td><td>0.7</td><td>0</td></tr>
<tr><td colspan="2">Pomaderris brunnea (Brown Pomaderris)</td><td>Endangered (BC Act)
Vulnerable (EPBC Act)</td><td>2.5</td><td>0</td></tr>
<tr><td colspan="2">Pultenaea parviflora</td><td>Endangered (BC Act)
Vulnerable (EPBC Act)</td><td>1.9</td><td>0</td></tr>
<tr><th colspan="5">BIO Map Priority Investment Areas</th></tr>
<tr><td colspan="5">A small area (0.5 per cent) of Richmond air base has been identified as a BIO Map corridor</td></tr>
<tr><th>Type</th><th colspan="4">Area (ha)</th></tr>
<tr><th>Core areas</th><td colspan="4">0</td></tr>
<tr><th>State and Regional Biodiversity Corridors</th><td colspan="4">2</td></tr>
<tr><th colspan="5">ANIMAL SPECIES</th></tr>
<tr><td colspan="5">Records of two threatened fauna species occur on the site
It is likely that some common, urban-adapted native fauna species inhabit or move through the site, based on the presence of PCTs and condition/quality of the vegetation described above</td></tr>
</table>

Threatened fauna species			
Name	**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Litoria aurea (Green and Golden Bell Frog)	Endangered (BC Act) Vulnerable (EPBC Act)	2.2	0
Pommerhelix duralensis (Dural Land Snail)	Endangered (BC Act & EPBC Act)	163.5	0
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	2.1	0
Botaurus poiciloptilus (Australasian Bittern)	Endangered (BC Act & EPBC Act)	1.5	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	3.3	0
Rostratula australis (Australian Painted Snipe)	Endangered (BC Act & EPBC Act)	1.8	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	3.3	0
Ephippiorhynchus asiaticus (Black-necked Stork)	Endangered (BC Act)	0.0	1
Glossopsitta pusilla (Little Lorikeet)	Vulnerable (BC Act)	0.0	1

CONSERVATION AND SPECIAL USE AREAS

There are no conservation or special use areas present on this site

The closest conservation or special use areas are:

- Windsor Downs Nature Reserve (approximately 3.5 km south)
- Pitt Town Nature Reserve (approximately 4.5 km north east)

HERITAGE PLACES AND ITEMS

A large part of the site is listed as a historic place on the Commonwealth Heritage List (place ID 105653) and is also registered as a historic place on the Register of the National Estate (non-statutory) (place ID 102845) as *RAAF Base Richmond*. The site meets six of the nine Commonwealth Heritage List listing criteria:

- Criterion A (Process): the site is associated with a number of events and cultural phases that have been significant in the development of the Royal Australian Air force (DoEE, 2018a)
- Criterion B (Rarity): the site demonstrates the design and construction of Australia's first purpose built military air force base under British influences in the 1930s (DoEE, 2018a)
- Criterion D (Characteristic value): the site includes features that demonstrates the principal characteristics (design, layout, architectural style) of the first purpose built military air force base under British influences in the 1930s (DoEE, 2018a)
- Criterion E (Aesthetic characteristics): parts of the site are valued in the wider community for its cultural, aesthetic and social associations (DoEE, 2018a)
- Criterion F (Technical achievement): the site illustrates the achievements of the Commonwealth architectural staff in the 1930s (DoEE, 2018a)
- Criterion G (Social value): parts of the site are valued in the wider community for its cultural, aesthetic and social associations (DoEE, 2018a)

It is not known whether the site has any other historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having other heritage values

SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The site is an RAAF air base. It operates the majority of the RAAFs fixed wing aircraft. It includes a single 2,134 m runway. The base includes the headquarters building of the 36th and 37th Squadron. The base also serves as the headquarters for the Air Lift Group, and houses the following wing units: No. 84 Wing (air-to-air refuelling), No. 86, No. 37 (transport), No.44 (air traffic control), No. 1 (combat communication), No. 22 (air force reserve), No. 87 (photography), No. 285 (flight simulator) and No. 3 (combat support hospital). No mining or petroleum tenements exist on this site (NNTT, 2020) No Native Title Claims exist over this site (NNTT, 2020)

Impact assessment

Direct impacts

There will be no direct impacts to Site 2 due to the Plan.

Indirect and facilitated impacts

Site 2 occurs over 12 km from the nearest development under the Plan – urban and industrial development and transport development within GPEC. The site is also located upstream of the nearest development and within a separate sub-catchment. The location of the site relative to the development means:

- The site is very unlikely to be impacted by impacts typically associated with construction of the development in GPEC, such as air quality, noise, construction traffic, or the spread of weeds or disease
- The site will not be impacted by soil erosion of sedimentation, changes to surface and groundwater quantity and flows, or water quality impacts associated with the construction and operation of the development

The potential indirect or facilitated impacts associated with the development under the Plan and the key values of the environment of Site 2 that are potentially impacted are shown in Table 35-3.

Table 35-3: Potential indirect impacts on Site 2 associated with the development

Potential indirect impact	Extent within site 1	Duration	Values of site potentially impacted
Construction			
Clearing of habitat during construction of the development that links the site to other areas of habitat, leading to impacts on biodiversity values	Whole of site	Long term	Biodiversity values
Operation			
Disruption to land uses, services or infrastructure	Whole of site	Long term	People and communities

Biodiversity values

Although Site 2 is mostly cleared, there are small areas of vegetation present which provide some habitat values for several species, including two species of threatened birds. It is likely that some common, urban-adapted native fauna species inhabit or move through the site, based on the presence of PCTs and condition/quality of the vegetation.

Approximately 2 ha of vegetation on the site is part of a BioMap corridor (OEH, 2015) and is therefore considered to be important for landscape connectivity in the region. The main connectivity from the site to other areas of habitat comprises the riparian corridor associated with the Hawkesbury River. The site is also marginally connected to Castlereagh Nature Reserve to the south along Rickabys Creek.

The development under the Plan will not disrupt these two main habitat connectivity links from the site to the surrounding area, and therefore the habitat values of the site are unlikely to be impacted indirectly by the Plan.

People and communities

Increased populations associated with urban development under the Plan has the potential to disrupt the services provided by the site as a RAAF base due to:

- The potential need to reduce noise impacts from aircraft in new residual areas
- Increased pressure on roads, transport and other infrastructure that service site 1

These potential indirect impacts are considered unlikely.

Many existing urban areas surround Site 2, including the University of Western Sydney Hawkesbury campus, and the site already has in place policies and procedures to minimise noise to surrounding urban areas (Department of Defence, 2020b). The majority of the flying training occurs in designated training areas to the north west of the base. These areas are situated predominantly over semi-rural, rural and farming areas of the Blue Mountains region minimising the time that aircraft spend over residential areas (Department of Defence, 2020b). Noise modelling shows the areas most affected by aircraft noise (Australian Noise Exposure Forecast levels > 20) are limited to areas in the vicinity of the site and distant from the nearest urban development in GPEC (Department of Defence, 2020a).

The Plan addresses the issue of increased pressure on roads, transport and other infrastructure that service Site 2 to some extent by supporting the delivery of major transport projects for Western Sydney. It is also expected that future transport and other infrastructure needs will be further provided for through future planning processes.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address the potential indirect impacts on the environment of Site 2 from the development under the Plan.

35.3.3 SITE 3 (PENRITH TRAINING DEPOT)

Profile

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Penrith Training Depot
Site ID number	3
Area	3.7 ha
Address	10 The Crescent, Penrith NSW
Folio	10/1159973
General description	This site is the Penrith Training Depot that houses a sub-unit of the 5th Combat Engineer Squadron. The site is located at 10 The Crescent, Penrith NSW. The site is mostly unvegetated and comprises five groups of buildings. A rail corridor borders the southern side of the site. The site is located in the Strategic Assessment Area in Penrith, approximately 50 km north-west of the Sydney CBD
Site map	The location of Site 3 is shown in Map 54.4
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
Site 3 is located approximately 0.8 km from nearest development under the Plan. Site 3 is surrounded by large areas of existing urban and/or commercial development and is not directly connected to any substantial vegetation corridors or habitat patches	
LANDSCAPES AND LANDFORMS	
The site occurs mainly in a flat landscape the Quaternary terraces of the Nepean and Georges River with a small area of the site transitioning to undulating rolling low hills	
SOIL AND SUBSTRATES	
The soil landscape of Site 3 is made up of: • < 1 ha Luddenham soil – Luddenham soils exist in varying forms depending on their location on a slope. Podzolic soils or earthy clays, yellow podzolic soils, and prairie soils are found on crests, upper slopes, and drainage lines respectively (OEH, 2018a) • 3 ha Richmond soil – Richmond soils consist of orange to red clay loams, clays, and sands that are poorly structured (OEH, 2018a)	
WATER	
The site is flat and contains no watercourses or waterbodies (DoI, 2019; DTA, DCA et al., 2019) The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018)	
VEGETATION	
The site is largely unvegetated and isolated from other areas of vegetation. Inspection of aerial photos shows scattered trees along the northern and eastern edges of the site. No Commonwealth-listed TECs are mapped as occurring on site.	

Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)

PCT number	PCT name	NSW TEC name	BC Act status	Area (ha)
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	0.3

Threatened flora species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Acacia pubescens (Downy Wattle)	Vulnerable (BC Act & EPBC Act)	0.3	0
Dillwynia tenuifolia	Vulnerable (BC Act)	0.1	0

BIO Map Priority Investment Areas

No BIO Map core or corridor areas have been identified on this site

ANIMAL SPECIES

There are several records of Grey-headed Flying Fox known from the site

Threatened fauna species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	0.3	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	0.3	0
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	0.0	14 (wires records)

CONSERVATION AND SPECIAL USE AREAS

There are no conservation or special use areas present on this site

The closest conservation or special use areas are:

- Wianamatta Regional Park/Metro offset site (approximately 2.5km north east)
- Mulgoa Nature Reserve (approximately 4.5km south west)
- Blue Mountains National Park (approximately 4.5km south west)

HERITAGE PLACES AND ITEMS

While not registered as a heritage site under the *Penrith Local Environment Plan 2010*, Site 3 has some heritage values in association with its use as a military depot facility from World War 2 up to the Vietnam War and was the main engineering depot of the Eastern Command from 1943. During much of this time, Thornton Hall, a residence located near the site which was constructed in the 1870's, was used as the Commanding Officer's quarters (OEH, 2020)

It is not known whether the site has any other historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having heritage values

SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES

The site is a multi-user depot that is surplus to Defence capability requirements and is being prepared for sale in the 2020-21 financial year (DoD, n.d.). The site contains 1 large building, 3 medium sized buildings and 10-11 small structures scattered across the site.

No mining or petroleum tenements exist on this site (NNTT, 2020).

No Native Title Claims exist over this site (NNTT, 2020).

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 3 due to the Plan.

Indirect and facilitated impacts

Site 3 is located within a high density existing urban/commercial district within Penrith, approximately 0.8 km from the nearest urban capable land. This urban capable land comprises small areas to the north and west of the site separated from the majority of the urban development in GPEC, which occurs approximately 3 km to the south. The site is also located upstream of the nearest urban development and within a separate sub-catchment.

The location of the site relative to the development and within a high density existing urban area means:

- The site is very unlikely to be impacted by impacts associated with construction of the development in GPEC, such as air quality, noise, construction traffic, or the spread of weeds or disease
- The site will not be impacted by soil erosion of sedimentation, changes to surface and groundwater quantity and flows, or water quality impacts associated with the construction and operation of the development
- The heritage values of the site will not be impacted by alterations to the setting of the place inconsistent with its values, such as through changes to the surrounding landscape causing visual or amenity impacts

The site is largely unvegetated (contained scattered trees only) and isolated from other areas of vegetation and has no or little biodiversity value. While records of Grey-headed Flying Fox occur on the site, these are wires records indicating injured individuals have been found in the area, and are unlikely to indicate regular use of the site.

The site does not appear to be currently in use and is being prepared for sale in the 2020-21 financial year (DoD, n.d.). The development is unlikely to disrupt existing land uses, services or infrastructure.

Furthermore, the site is not open to the public, and therefore increased populations associated with the urban development will not lead to disturbance to the heritage values of the site through increased visitor use.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address the potential indirect impacts on the environment of Site 3 from the development under the Plan.

35.3.4 SITE 4 (WESTERN SYDNEY UNIVERSITY – CAMPBELLTOWN CAMPUS)

Profile

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Western Sydney University - Campbelltown Campus
Site ID number	4
Area	92.5 ha
Address	Narellan Road and Gilchrist Drive, Campbelltown NSW
Folio	3098/12300
General description	The Campbelltown Campus of the University of Western Sydney is located at Narellan Road and Gilchrist Drive, Campbelltown NSW. It is used for tertiary education purposes. The campus contains 24.3 per cent native vegetation cover that is predominantly associated with drainage lines. Much of the remainder of the site has been developed or is cleared of vegetation. It is located approximately 45 km south-west of the Sydney CBD
Site map	The location of Site 4 is shown in Map 54.5
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
Site 4 occurs within the footprint of the eastern end of the Metro Rail Future Extension tunnel The closest urban development occurs approximately 250 m from the south-western boundary of the site. The landscape between this urban development area and the boundary of Site 4 consists of a railway line and cleared fields, with some thin vegetation corridors predominantly located to the east. Bow Bowing Creek, and its associated riparian corridor, links the proposed urban capable land with the Site 4 boundary to the east	
LANDSCAPES AND LANDFORMS	
The site occurs in a landscape with gently undulating rises to rolling low hills, which have been predominately cleared or modified for development. The surrounding areas comprise residential land uses, with newer residential developments in the immediate vicinity and established areas of Campbelltown to the north (over Narellan Road), and east and south (over Menangle Road). The Hume Motorway lies to the west, and rural land to the south west	
SOIL AND SUBSTRATES	
The soil landscape at Site 4 is made up of: • 80 ha of Blacktown soil – Blacktown soils are a hard setting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 13 ha of Luddenham soil – Luddenham soils exist in varying forms depending on their location on a slope. Podzolic soils or earthy clays, yellow podzolic soils, and prairie soils are found on crests, upper slopes, and drainage lines respectively (OEH, 2018a)	
WATER	
The site occurs within the Georges River catchment. The University campus topography is undulating. There are two main drainage lines in the middle of the site that are largely vegetated. These flow into a series of constructed/modified waterbodies that subsequently flow into Bow Bowing Creek (DoI, 2019; DTA, DCA et al., 2019)	
VEGETATION	
Approximately 24.3 per cent (22.5 ha) of the site is covered by native vegetation, which is predominantly associated with the drainage lines. The remainder of the site is developed or comprises of open fields/grassland No Commonwealth-listed TECs are mapped as occurring on site. Coastal Floodplain Eucalypt Forest of Eastern Australia (currently being assessed for listing) occurs in several patches across the site (note that the mapping of this TEC was based on PCT 835 and is likely to overestimate the extent of the TEC) The site contains potential habitat for several Commonwealth-listed species, but no species records for the site occur The vegetated areas are isolated from any substantial areas of vegetation by development, the nearest being approximately 6 km to the east beyond Campbelltown's suburbs connected to Dharawal and Heathcote National Parks.	

Vegetation on site is partially connected to the vegetated corridor along the motorway and other vegetated drainage lines in the areas, which together may provide a level of stepping-stone connectivity for fauna

Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)

PCT number	PCT name	NSW TEC name	BC Act status	Area (ha)
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	17.5
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	5.0

Threatened ecological communities (TECs)

TEC name	EPBC Act status	Area (ha)
Coastal floodplain eucalypt forest of eastern Australia	Currently being assessed for listing under EPBC Act	17.5

Threatened flora species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Pomaderris brunnea (Brown Pomaderris)	Endangered (BC Act) Vulnerable (EPBC Act)	15.0	0
Acacia pubescens (Downy Wattle)	Vulnerable (BC Act & EPBC Act)	16.4	0
Marsdenia viridiflora subsp. *viridiflora*	Endangered Population (BC Act)	16.1	0
Pilularia novae-hollandiae (Austral Pillwort)	Endangered (BC Act)	1.1	0

BIO Map Priority Investment Areas

No BIO Map core or corridor areas have been identified on this site

ANIMAL SPECIES

There is one record of a NSW-listed species – the Cumberland Plain Land Snail – known from the site, and several records of this species and other threatened fauna, including Large-eared Pied Bat, immediately adjacent to the site

It is likely that some common, urban-adapted native fauna species inhabit or move through the site, based on the presence of PCTs and condition/quality of the vegetation described above

Threatened fauna species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	13.3	0
Botaurus poiciloptilus (Australasian Bittern)	Endangered (BC Act & EPBC Act)	13.2	0
Meridolum corneovirens (Cumberland Plain Land Snail)	Endangered (BC Act)	16.3	1

Cercartetus nanus (Eastern Pygmy-possum)	Vulnerable (BC Act)	8.7	0
Chalinolobus dwyeri (Large-eared Pied Bat)	Vulnerable (BC Act & EPBC Act)	16.3	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	17.5	0
Rostratula australis (Australian Painted Snipe)	Endangered (BC Act & EPBC Act)	0.3	0
Petaurus norfolcensis (Squirrel Glider)	Vulnerable (BC Act)	0.2	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	17.5	0
Haliaeetus leucogaster (White-bellied Sea-eagle)	Vulnerable (BC Act)	2.2	0

CONSERVATION AND SPECIAL USE AREAS
There are no conservation or special use areas present on this site The closest conservation or special use areas are: • Australian Botanic Gardens at Mt Annan (approximately 100m west) • Metro offset site in Claymore (approximately 2km north) • William Howe Regional Park (approximately 2.5km west)
HERITAGE PLACES AND ITEMS
It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having heritage values
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The site is a university campus with approximately 6,500 students. Facilities at the site include education facilities, student accommodation, food outlets, library, recreational facilities, religious centres and a range of other services The site is accessed by via Hume Motorway and Narellan Road, and Macarthur Train Station The following tenement exists on this site (NNTT, 2020): • Petroleum tenement (PPL4) No Native Title Claims exist over this site (NNTT, 2020)

IMPACT ASSESSMENT

Direct impacts

Site 4 occurs within the footprint of the eastern end of the Metro Rail Future Extension tunnel and may be directly impacted by construction of the tunnel. There will be no direct impacts to Site 4 due to other development under the Plan (although note the GIS boundary error discussed in section 35.1, which wrongly suggests there are very small direct impacts).

Metro Rail Future Extension tunnel

An assessment of the tunnel impacts on biodiversity values is provided in Chapter 36. This section provides a summary of the potential impacts of the tunnel in relation to the environment of Site 4.

It is not possible to determine at this stage the specific nature, extent and duration of the direct impacts of the Metro Rail Future Extension tunnel on Site 4. Development for the tunnels will generally occur within the tunnel footprints and direct impacts to the land surface will only occur within small areas of the footprint (see Part 2).

Disturbance to the land surface of Site 4 from the tunnel may occur due to:

- Construction activities

- Ancillary infrastructure, including ventilation systems
- Other infrastructure, such as entry and exit ramps and connection and tie in with existing roads and infrastructure
- Pedestrian and cyclist facilities
- Drainage work, pavement and finishing work

This may result in:

- Clearing of native vegetation and habitat
- Disturbance or destruction of buildings, roads and other infrastructure, and associated disruption of services
- Visual impacts from any permanent infrastructure, including ventilation shafts and the entrance to the tunnel, which is located within Site 4 (as indicated by the current extent of the tunnel footprint)

The most important biodiversity values within the tunnel footprint of Site 4 that may be directly impacted are:

- Small amounts of Coastal Floodplain Eucalypt Forest of Eastern Australia – the potential for notable impacts to this TEC is low. While several small patches of the TEC have the potential to be directly impacted, the amount of impact in the context of the amount remaining in the Strategic Assessment Area is not substantial
- Records and habitat of Cumberland Plain Land Snail – direct impacts to this species may be notable, as the species is listed as endangered in NSW, is restricted to the Cumberland subregion, and several records occur immediately adjacent to Site 4 at the south-eastern end of the site, suggesting a notable population may occur in the area (the notes attached to several of the records suggest the individuals recorded were not alive, however, there is potential for the population to occur at the site)

The Plan includes commitments that are expected to adequately address these potential direct impacts (see below).

Indirect and facilitated impacts

Site 4 has the potential to be indirectly impacted by construction and operation of:

- Metro Rail Future Extension tunnel, which occurs within the site
- Urban and industrial, and infrastructure development, which occurs approximately 250 m to the south of the site

The potential indirect and facilitated impacts associated with these developments and the key values of the environment of Site 4 that are potentially impacted are shown in Table 35-4.

Table 35-4: Potential indirect impacts on Site 4 associated with the development

<table>
<tr><th>Potential indirect impact</th><th>Extent within site 4</th><th>Duration</th><th>Values potentially impacted</th></tr>
<tr><td colspan="4">Construction</td></tr>
<tr><td>Soil erosion and disturbance from vegetation clearing and earthworks</td><td rowspan="5">Vicinity of the tunnel footprint
Southern end of the site closest to urban capable land</td><td rowspan="5">Generally short term</td><td rowspan="5">People and communities
Biodiversity values</td></tr>
<tr><td>Changes to water quality from soil erosion or disturbance of contaminated soils</td></tr>
<tr><td>Air quality, noise impacts, and visual or other impacts to amenity</td></tr>
<tr><td>Construction traffic causing disruption or reduced accessibility to the site</td></tr>
<tr><td>Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat</td></tr>
<tr><td>Disruption to land uses, services or infrastructure</td><td>Whole of site</td><td>Generally short term</td><td>People and communities</td></tr>
</table>

Operation			
Ground settlement and subsidence from tunnels due to the tunnel void or groundwater removal, leading to disturbance to the land surface	Vicinity of the tunnel footprint	Short to long term	People and communities Biodiversity values
Changes to surface water and groundwater quantities and flows due to groundwater drawdown caused by the tunnel void and additional runoff from urban areas	Vicinity of tunnel footprint Bow Bowing Creek	Long term	Water resources Biodiversity values
Disruption to land uses, services or infrastructure	Whole of site	Long term	People and communities

Biodiversity values

Construction of the tunnel may cause notable indirect impacts to biodiversity values in Site 4 from the spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat or vegetation. The tunnel also has the potential to cause ground settlement and subsidence due to the tunnel void or groundwater removal leading to disturbance to the land surface, as well as groundwater drawdown, both of which may impact biodiversity values.

The most important biodiversity values within the tunnel footprint of Site 4 that may be indirectly impacted are:

- Small amounts of Coastal Floodplain Eucalypt Forest of Eastern Australia – the indirect impacts to this TEC are unlikely to be notable (see explanation above for direct impacts)
- Records and habitat of Cumberland Plain Land Snail – the indirect impacts to this species may be notable (see explanation above for direct impacts)

The Plan includes commitments that are expected to adequately address these potential impacts on biodiversity values in Site 4 resulting from construction and operation of the tunnel (see below).

Water resources – Bow Bowing Creek

Construction of the tunnel may impact the water quality of Bow Bowing Creek from soil erosion, disturbance of contaminated soils, or spillage of chemicals and fuels used during construction. Furthermore, groundwater drawdown from the tunnel may affect flows to Bow Bowing Creek, as well as the water quality of the waterway due to any need for ongoing disposal of groundwater from the tunnel. Additional runoff from increased hard surfaces associated with the urban and industrial development has the potential to increase surface water flows in Bow Bowing Creek and impact the water quality of the waterway.

These potential impacts on Bow Bowing Creek are considered to be minor. The waterway is already located in an urban environment, and has been subject to previous development including impoundment, clearing of riparian vegetation and the creation of artificial channels along some sections. Furthermore, the Plan includes commitments that are expected to adequately address these potential impacts on water resources in Site 4 (see below).

People and communities

Construction of the tunnel has the potential to significantly disrupt the university facilities at Site 4 as a result of potential temporary closures to parts of the site to allow construction, or include construction sites, disruption to pedestrian or traffic access to or within the site, and air quality and noise impacts. The Plan includes commitments that are expected to adequately address these potential construction impacts (see below).

If construction of infrastructure within urban capable land in the vicinity of Site 4, there may be minor disruption to road or pedestrian traffic, or noise disturbance. However, the impact to students and others using the site is likely to be minor, as the site is already within an existing urban environment.

The increase in populations in the area facilitated by the urban development is likely to increase the demand for educational services and other infrastructure at the site. This is likely to be overall a positive benefit to the university and is expected to be adequately managed through existing management and operational processes.

Population increases may also lead to increased pressure on roads, transport and other infrastructure that service the university. However, the Plan intends to provide for future transport needs by supporting the delivery of major transport projects for Western Sydney. It is also expected that future transport and infrastructure needs of the university will be provided for through existing local and regional planning processes.

The urban development may also positively impact Site 4 through increased provision of housing, which will increase demand for education services and the availability of housing options close to the university for students and staff.

Commitments and mitigation measures

The Plan includes commitments to mitigate direct and indirect impacts from construction and operation associated with transport corridors, urban and industrial development, and infrastructure development. These commitments and processes to deliver these comments are different for each type of development.

Metro Rail Future Extension tunnel - direct impacts

The Plan includes a commitment to avoid and minimise impacts from the transport corridors outside the nominated areas (Commitment 4). This includes the following at Western Sydney University (Commitment 4.1):

- Avoiding and minimising impacts where possible to:
  - Existing infrastructure
  - Populations and habitat of Cumberland Plain Land Snail
- Minimising disruption to existing services

This avoidance process will be undertaken during strategic planning and detailed design of the Metro Rail Future Extension tunnel project. The process will seek to avoid and minimise direct impacts of the tunnel to Site 4, including impacts to existing infrastructure and disruption to university services, as well as biodiversity values.

This commitment is considered to adequately address the risks associated with the potential direct impacts of the Metro Rail Future Extension tunnel on Site 4. Note that each transport project will be subject to an environmental assessment process under the EP&A Act. While this assessment will not apply to tunnel activities on Site 4 (as Commonwealth land is outside the jurisdiction of NSW planning laws), the minimisation of impacts to infrastructure and disruption to existing services will occur in accordance with standard construction management processes.

Metro Rail Future Extension tunnel - indirect impacts

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport development (Commitment 6). This includes the following measure relevant at Western Sydney University (Commitment 6.2):

- Implement mitigation measures to address impacts on Cumberland Plain Land Snail, including to manage the spread of weeds and disturbance to ground shelter habitat

This commitment will be delivered through an environmental assessment process that will apply to each transport project under the EP&A Act (currently the State Significant Infrastructure approval process) to assess and manage the direct and indirect impacts of the project. A description of the process is provided in Chapter 15, section 15.6.3.

This process will assess the environmental impacts of the construction and operation of the tunnel project based on detailed design, in accordance with the standard requirements and policies applying to major infrastructure assessments in NSW (see Chapter 15, section 15.6.3). The current process requires an assessment of risks to the environment and the identification of avoidance and mitigation measures to manage these risks. This will include the assessment and management of indirect impacts of the tunnel project that may affect Site 4, including construction activities, changes to surface and groundwater flows and water quality, including groundwater drawdown, noise and air quality impacts, impacts to traffic and accessibility, and disruption to services and infrastructure.

This assessment process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 4 from the transport development.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.3.

Urban and industrial development

The Plan includes a commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5). This commitment will be delivered through development controls specified in Development Control Plans (DCPs) and implemented through the standard development application process that occurs under the NSW planning system. A description of the process is provided in Chapter 15, section 15.6.1.

Relevant councils will prepare a DCP for each nominated area in collaboration with the Department and in accordance with standard processes for developing DCPs in NSW. The DCP will include development controls relevant to addressing the indirect and facilitated impacts of the urban and industrial development that may affect Site 4.

The general environmental controls likely to be included in DCPs are set out in Chapter 15, section 15.6.1, and include:

- Preparation of Construction Environmental Management Plans to manage on-site construction impacts
- Controls for managing impacts to:
    - Hydrology and water quality
    - Noise and air quality
    - Construction traffic

These development controls and the process for implementing them are expected to adequately address the potential indirect and facilitated impacts of the urban and industrial development that will occur adjacent to Site 4.

A detailed description of the development controls and implementation process, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

Infrastructure development

The Plan includes a commitment to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3). This commitment will be delivered through an environmental assessment and approval process that will be applied to detailed design of each infrastructure project at the time the project is brought forward for development. This will be undertaken under Part 4 or Part 5 of the EP&A Act (or equivalent at the time). State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed under the EPA Act.

This assessment process will assess and identify mitigation measures to manage the non-biodiversity related potential environmental impacts of the project. This will include the assessment and management of indirect impacts of any infrastructure projects that may affect Site 4, including construction activities, noise and air quality impacts, impacts to traffic and accessibility, and disruption to services and infrastructure.

This process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 4 from the infrastructure development.

A detailed description of the assessment and approval process for infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.2.

35.3.5 SITE 5 (DEFENCE ESTABLISHMENT ORCHARD HILLS)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Defence Establishment Orchard Hills
Site ID number	5
Area	1,970.7 ha
Address	2042B The Northern Rd, Mulgoa NSW 2042-2550 The Northern Road, Orchard Hills NSW 2304A The Northern Road, Orchard Hills NSW 18C The Haven, Orchard Hills NSW 66A Wentworth Road, Orchard Hills NSW 1-17 Stockdale Road, Orchard Hills NSW 114-122 Patons Lane, Orchard Hills NSW
Folio	4/238092, 1-3/238092, 6/578629, 9/238092, 2/589479, 1-2/586093, 1/629326, 11/598345, 1-17/242968
General description	Defence Establishment Orchard Hills is an explosive ordnance depot. It is used for the storage of munitions, weapon ranges, firing ranges, firefighting training, and above and below ground fuel storage (DoD, 2017). It occurs within the Strategic Assessment Area, approximately 50 km west of the Sydney CBD. Approximately 42.0 per cent of the site is covered by native vegetation communities. The site contains areas of high biodiversity value, with parts of the site proposed as an offset site for the new Western Sydney Airport (DIRDC, 2018)
Site map	The location of Site 5 is shown in Map 54.6
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
Urban capable land and transport corridors are located immediately adjacent to Site 5, including: • Along most of the northern and eastern boundaries of the site • Small areas of either end of the southern border of the site (i.e. the south-western and south-eastern edges) • Approximately half of the western boundary of the site	
LANDSCAPES AND LANDFORMS	
This site occurs in a landscape with gently undulating rises to floodplains, valley flats and drainage depressions	
SOIL AND SUBSTRATES	
The soil landscape at Site 5 is made up of: • 1,706 ha of Blacktown soil – Blacktown soils are hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 265 ha of Wianamatta (South Creek) soil – Wianamatta (South Creek) soils are deep layered sediments that occur over bedrock or relict soils (minerals/structures that have not undergone metamorphic change while the surrounding rock has) (OEH, 2018a)	
WATER	
The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by the negative effects of historical land uses (e.g. clearing, urbanisation) (GES, 2018) Watercourses that flow through the site include first to fourth order streams. Blaxland Creek is a fourth order stream into which the majority of the site drains. It diagonally dissects the site, flowing in a south-west to north-east direction (DIRDC, 2018). Blaxland Creek and its tributaries are some of the least disturbed catchment areas remaining in the	

Cumberland subregion, and are regarded as one of the most pristine creek systems on Wianamatta Shale in Western Sydney. The creek system has a high diversity of species which are sensitive to disturbance, and provides habitat for species that have largely disappeared from more impacted watercourses in the region. Blaxland Creek at Orchard Hills provides a benchmark to measure disturbance of riparian corridors elsewhere on the Cumberland subregion, and is listed as part of the Commonwealth heritage value of the site (DoEE, 2018a)

A tributary of Cosgroves Creek also occurs in the south-east corner of the site (DoEE, 2018a; DoI, 2019)

VEGETATION

Native vegetation covers approximately 42 per cent (828.2 ha) of the site and mostly occurs in a large patch within the north-east and part of the south-east of the site that is broadly associated with Blaxland Creek and its tributaries

The site contains the largest and least disturbed remnant of Cumberland Plain Woodland and large and intact areas of Coastal Floodplain Eucalypt Forest of Eastern Australia (currently being assessed for listing under EPBC Act), and is regarded as an important area for the conservation of these two TECs in the subregion. The natural values of these vegetation communities are listed as part of the Commonwealth heritage value of the site (DoEE, 2018a)

The vegetation at Orchard Hills is located within a largely cleared, agricultural/rural residential landscape, which contains scattered, smaller patches of vegetation, paddock and garden trees, through which vegetated riparian corridors provide important connectivity pathways for native flora and fauna. The main vegetated areas which Orchard Hills is connected to includes vegetated areas to the west (linking the site to the Blue Mountains), and riparian corridors to the north-east linking the site to Wianamatta (South Creek). Dense urban development is located to the north and north-west of the site, which limits habitat connectivity in these directions

Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)

PCT number	PCT name	NSW TEC name	BC Act status	Area (ha)
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	129.3
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	651.5
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	17.9
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter Valley	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	29.4

Commonwealth listed threatened ecological communities (TECs)

TEC name	EPBC Act status	Area (ha)
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	426.5

Coastal floodplain eucalypt forest of eastern Australia	Currently being assessed for listing under EPBC Act	129.3

Threatened flora species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Dillwynia tenuifolia	Vulnerable (BC Act)	137.7	4
Grevillea juniperina subsp. *juniperina* (Juniper-leaved Grevillea)	Vulnerable (BC Act)	665.7	9
Marsdenia viridiflora subsp. *viridiflora*	Endangered Population (BC Act)	815.2	14
Pultenaea parviflora	Endangered (BC Act) Vulnerable (EPBC Act)	0.8	4
Acacia pubescens (Downy Wattle)	Vulnerable (BC Act & EPBC Act)	726.5	0
Pimelea spicata (Spiked Rice-flower)	Endangered (BC Act & EPBC Act)	1,135.9	0
Maundia triglochinoides	Vulnerable (BC Act)	28.7	0
Pilularia novae-hollandiae (Austral Pillwort)	Endangered (BC Act)	11.5	0
Pimelea curviflora var. *curviflora*	Vulnerable (BC Act & EPBC Act)	299.6	0
Pultenaea pedunculata (Matted Bush-pea)	Endangered (BC Act)	481.8	0

BIO Map Priority Investment Areas

The site has been identified on BIO Map as containing over 1,100 ha of core areas and 279 ha of corridors

Type	Area (ha)
Core areas	1,113.5
State and Regional Biodiversity Corridors	279.3

ANIMAL SPECIES

The site contains substantial areas of habitat for native fauna species. There are 68 bird species and 10 reptile species that have been recorded at the site as well as several native marsupial mammals, including Easter Grey Kangaroo (*Macropus giganteus*), Swamp Wallabies (*Wallabia bicolor*) and Common Wallaroos (*Macropus robustus*) (DIRDC, 2018)

Threatened fauna species

Name	EPBC Act or BC Act status	Area of habitat (ha)	Number of BioNet records
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	699.9	4
Botaurus poiciloptilus (Australasian Bittern)	Endangered (BC Act & EPBC Act)	85.5	0
Meridolum corneovirens (Cumberland Plain Land Snail)	Endangered (BC Act)	786.5	34
Cercartetus nanus (Eastern Pygmy-possum)	Vulnerable (BC Act)	363.4	0

Callocephalon fimbriatum (Gang-gang Cockatoo)	Vulnerable (BC Act)	93.7	0
Petauroides volans (Greater Glider)	Vulnerable (EPBC Act)	356.0	0
Hieraaetus morphnoides (Little Eagle)	Vulnerable (BC Act)	150.9	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	828.2	0
Myotis macropus (Southern Myotis)	Vulnerable (BC Act)	55.9	0
Dasyurus maculatus maculatus (Spot-tailed Quoll)	Vulnerable (BC Act) Endangered (EPBC Act)	760.0	0
Lophoictinia isura (Square-tailed Kite)	Vulnerable (BC Act)	179.1	0
Petaurus norfolcensis (Squirrel Glider)	Vulnerable (BC Act)	780.9	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	828.2	0
Haliaeetus leucogaster (White-bellied Sea-eagle)	Vulnerable (BC Act)	179.1	0
Artamus cyanopterus cyanopterus (Dusky Woodswallow)	Vulnerable (BC Act)	0.0	1
Burhinus grallarius (Bush Stone-curlew)	Endangered (BC Act)	0.0	2
Chthonicola sagittata (Speckled Warbler)	Vulnerable (BC Act)	0.0	10
Daphoenositta chrysoptera (Varied Sittella)	Vulnerable (BC Act)	0.0	4
Ephippiorhynchus asiaticus (Black-necked Stork)	Endangered (BC Act)	0.0	1
Micronomus norfolkensis (Eastern Coastal Free-tailed Bat)	Vulnerable (BC Act)	0.0	1
Miniopterus orianae oceanensis (Large Bent-winged Bat)	Vulnerable (BC Act)	0.0	2
Petroica boodang (Scarlet Robin)	Vulnerable (BC Act)	0.0	1
Stagonopleura guttata (Diamond Firetail)	Vulnerable (BC Act)	0.0	1

CONSERVATION AND SPECIAL USE AREAS

Large parts of the site are proposed to be secured as an offset for the impacts of Stage 1 of Western Sydney Airport (DIRDC, 2018). The offset will comprise restoration and management of at least 900 ha of native vegetation, including Cumberland Plain Woodland, at the site. Other conservation or special use areas near the site include Mulgoa Nature Reserve (approximately 1.5km west) and an offset site in Glenmore Park (approximately 1.5km west)

HERITAGE PLACES AND ITEMS

Approximately 1,370 ha (70 per cent) of the site is listed on the Commonwealth Heritage List and the Register of the National Estate (non-statutory) as *Orchard Hills Cumberland Plain* Woodland, including for its natural values.

The site meets four of the nine Commonwealth Heritage listing criteria:

- Criterion A: Orchard Hills has evidence of historic canal works from the 1890s. It contains the largest and least disturbed remaining remnant of Cumberland Plain Woodland as well as some of the least disturbed catchment areas. Blaxland Creek supports a higher level of macro-invertebrate diversity than elsewhere in Western Sydney (DoEE, 2018a)
- Criterion B: Orchard Hills contains threatened species and TECs, and tributaries of Blaxland Creek are considered to have regional conservation significance for invertebrate species (DEWHA, 2007; DoEE, 2018a).
- Criterion C: Tributaries of Blaxland Creek provide a benchmark to measure disturbance of riparian areas

elsewhere on the Cumberland Plain. The lack of fire at Orchard Hills for 50 years also provides valuable research into the regeneration of Cumberland Plain Woodland (DoEE, 2018a) • Criterion D: Orchard Hills demonstrates the principle characteristics of Cumberland Plain Woodland, Sydney River Flat Forest in the Penrith area, and examples of some of the most outstanding remaining Forest Red gum trees. It also contains numerous indigenous sites along the main steam (DoEE, 2018a) It is not known whether the site has any other historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having any other heritage values
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The site is an explosive ordnance depot managed for defence capability purposes, defence training activities and the use and safe storage of explosives. Site facilities include munitions storage, weapon ranges, firing ranges, fire-fighting training areas, and fuel storage and distribution from above ground and underground storage tanks. The site also contains a sewage treatment plant. Two historical landfills also exist, containing non-putrescible refuse, including building rubble and asbestos containing materials. The majority of the site provides a buffer zone for the safe use and storage of explosives to nearby residential and rural residential land uses (Department of Defence, 2017) No mining or petroleum tenements exist on this site (NNTT, 2020) No Native Title Claims exist over this site (NNTT, 2020)

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 5 due to development under the (although note the GIS boundary error discussed in section 35.1, which wrongly suggests there are very small direct impacts).

Indirect and facilitated impacts

Site 5 has the potential to be indirectly impacted by construction and operation of:

- OSO, which occurs adjacent to the eastern boundary of the site
- Urban and industrial, and infrastructure development, which occurs along the boundaries of all sides of the site, particularly the northern, eastern and western boundaries

The potential indirect and facilitated impacts associated with these developments and the key values of the environment of Site 5 that are potentially impacted are shown in Table 35-5.

Table 35-5: Potential indirect impacts on Site 5 associated with the development

Potential indirect impact	Extent within Site 5	Duration	Values potentially impacted
Construction			
Soil erosion and disturbance from vegetation clearing and earthworks	Boundaries of the site	Generally short term	People and communities Biodiversity values/heritage values (natural)
Changes to water quality from soil erosion or disturbance of contaminated soils			
Air quality, noise impacts, and visual or other impacts to amenity			
Construction traffic causing disruption or reduced accessibility to the site			
Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat			
Clearing of habitat during construction of the development that links the site to other areas of habitat, leading to impacts on biodiversity values	Whole of site	Long term	Biodiversity values/heritage values (natural)

Disruption to land uses, services or infrastructure	Whole of site	Generally short term	People and communities
Operation			
Changes to surface water flows due to additional runoff from urban areas	Vicinity of tunnel footprint Bow Bowing Creek	Long term	Water resources Biodiversity values/heritage values (natural)
Disruption to land uses, services or infrastructure	Whole of site	Long term	People and communities

Biodiversity values/heritage values (natural)

Construction of urban, industrial, and infrastructure development and the OSO adjacent to the boundaries of the site may cause indirect impacts to biodiversity values from the spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat or vegetation.

The site is of very high conservation value. The site is listed on the Commonwealth Heritage List, including for its natural values. It contains very large areas of good condition native vegetation, including TECs and known populations of several threatened flora and fauna species. The site has also been identified on BIO Map as containing large areas of core areas and corridors, and is located within the Cumberland Conservation Corridor, which is a community led, government-recognised proposal to help address the conservation of biodiversity values and especially connectivity of habitat in the Cumberland subregion (DIRDC, 2018).

The most important biodiversity values within Site 5 that may be indirectly impacted are:

- Cumberland Plain Woodland and Coastal Floodplain Eucalypt Forest of Eastern Australia – indirect impacts to these TECs may be notable, as the site contains very large and intact areas of these TECs
- Records and habitat of *Marsdenia viridiflora* subsp. *viridiflora*, *Pultenaea parviflora* and Cumberland Plain Land Snail, as well as several other threatened flora and fauna species

Two large areas in the northern and southern parts of the site are proposed to be secured as an offset for Stage 1 of Western Sydney Airport (DIRDC, 2018). The offset will comprise restoration and management of at least 900 ha of native vegetation and include large areas of Cumberland Plain Woodland, Coastal Floodplain Eucalypt Forest of Eastern Australia, and records and habitat for *Marsdenia viridiflora* subsp. *viridiflora* and several other threatened flora and fauna species. The offset site also includes large parts of the riparian corridor of Blaxland Creek (DIRDC, 2018).

It is expected that the establishment and management of the offset site would adequately mitigate any key risks to the most important biodiversity values on the site from indirect impacts of the development under the Plan. Under the offset proposal, the Department of Infrastructure, Transport, Regional Development and Communications (DITRDC) would provide funds for the intensive management of the offset site for biodiversity conservation and restoration for a period of up to 20 years. This would include the management of weeds and other landscape scale threats to the biodiversity values of the site. Management actions would be undertaken in accordance with an Offset Plan prepared under an agreement with the Department of Defence, who would be responsible for managing the site. Furthermore, the Plan includes commitments that are expected to adequately minimise the risk of potential impacts on biodiversity values in Site 5 resulting from construction and operation of the development (see below).

Clearing of habitat that links the site to other areas of habitat has the potential to lead to impacts on the biodiversity values of the site due to a reduction in habitat connectivity to and from the site.

The key areas of habitat connectivity associated with the site are:

- Riparian corridors and small patches of native vegetation and scattered paddock trees to the north and east of the site that link to a larger riparian corridor associated with Wianamatta (South Creek)
- Larger patches of native vegetation and scattered paddock trees to the south-west of the site that provide some connectivity to riparian corridors and large areas of habitat associated with the Blue Mountains

The development has the potential to result in a reduction in habitat connectivity from the loss of small patches of native vegetation and scattered paddock trees to the north and east of the site. Habitat connectivity in this area, particularly associated with the riparian corridor along Wianamatta (South Creek), will also be potentially impacted by the OSO, which may lead to a reduction in connectivity to the site. The Plan includes a commitment to avoid and minimise impacts of the transport corridors in riparian corridors (Commitment 3) (see below), and this is expected to adequately address this risk.

The larger patches of native vegetation and scattered paddock trees to the south-west of the site will not be impacted by the development. Furthermore, riparian corridors that connect to the site have been avoided as part of the design of the urban capable land (see Chapter 14) and will not be impacted by the development.

Water resources

Construction and operation of the urban, industrial, and infrastructure development adjacent to the southern and western boundaries of the site has the potential to cause changes to surface water flows and impact the water quality of Blaxland Creek and its tributaries that occur within the site due to:

- Soil erosion, disturbance of contaminated soils, or spillage of chemicals and fuels used during construction
- Increased urban run-off during operation as a result of increased hard surfaces from urban areas

Potential impacts to Blaxland Creek and its tributaries are notable as this system within the site contains some of the least disturbed catchment areas remaining in the Cumberland subregion, has a high diversity of species which are sensitive to disturbance, and provides habitat for species that have largely disappeared from other watercourses in the region. The creek system at the site provides a benchmark to measure disturbance of riparian corridors elsewhere in Cumberland subregion, and is listed as part of the Commonwealth heritage value of the site (DoEE, 2018a)

Urban, industrial, and infrastructure development to the east and north of the site and construction of the OSO to the east of the site are unlikely to impact Blaxland Creek and its tributaries within the site as these areas are generally inn separate sub-catchments and surface run-off generally occurs south west to north east across the site.

Processes to manage changes to surface water flows and water quality impacts will implemented under the Plan (see below). The Plan also includes a specific commitment to manage these impacts at Blaxland Creek. These measures are expected to adequately address the potential impacts on water resources in Site 5 (see below).

People and communities

Construction of the urban, industrial, infrastructure and transport development is considered unlikely to disrupt services at the site. The majority of the site includes buffer zones to mitigate risks associated with the use and storage of explosives on adjacent residual areas (Department of Defence, 2017). These buffers are likely to mitigate any potential disruption to services from many construction activities, such as through air or noise impacts.

The Plan includes commitments that are expected to adequately address other potential impacts associated with construction, such as disruption to site access associated with construction traffic (see below).

Increased populations associated with urban development under the Plan has the potential to disrupt the services provided by the site as a defence base due to:

- Risks associated with the use and storage of explosives
- Increased pressure on roads, transport and other infrastructure that service the site

These potential indirect impacts are considered unlikely.

Existing urban areas already occur in the vicinity of the site, including low density rural residual areas immediately adjacent to and surrounding the majority of the site, as well as higher density urban areas to the west and north east of the site. The site already has in place measures to mitigate the risks associated with the use and storage of explosive on adjacent residual areas, including buffer zones that comprise the majority of the site (Department of Defence, 2017), and it is therefore not expected that the development will disrupt the use of the site for this purpose.

The Plan addresses the issue of increased pressure on roads, transport and other infrastructure that service Site 5 to some extent by supporting the delivery of major transport projects for Western Sydney. It is also expected that future transport and other infrastructure needs will be adequately provided for through future planning processes.

Commitments and mitigation measures

The Plan includes commitments to mitigate indirect impacts from construction and operation associated with transport corridors, urban and industrial development, and infrastructure development. These commitments and processes to deliver these comments are different for each type of development.

Transport development

The Plan includes a commitment to mitigate indirect impacts from transport corridors (Commitment 6). This commitment will be delivered through an environmental assessment process that will apply to each transport project under the EP&A Act (currently the State Significant Infrastructure approval process) to assess and manage the direct and indirect impacts of the project. A description of the process is provided in Chapter 15, section 15.6.3.

This process will assess the environmental impacts of the construction and operation of the OSO based on detailed design, in accordance with the standard requirements and policies applying to major infrastructure assessments in NSW (see Chapter 15, section 15.6.3). The current process requires an assessment of risks to the environment and the identification of avoidance and mitigation measures to manage these risks. This will include the assessment and management of indirect impacts that may affect Site 5, including construction activities.

This assessment process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 5 from the OSO.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.3.

Urban and industrial development

The Plan includes a commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5). This commitment will be delivered through development controls specified in Development Control Plans (DCPs) and implemented through the standard development application process that occurs under the NSW planning system. A description of the process is provided in Chapter 15, section 15.6.1.

Relevant councils will prepare a DCP for each nominated area in collaboration with the Department and in accordance with standard processes for developing DCPs in NSW. The DCP will include development controls relevant to addressing the indirect and facilitated impacts of the urban and industrial development that may affect Site 5, particularly changes to surface water flows and water quality impacts on Blaxland Creek and its tributaries.

The general environmental controls likely to be included in DCPs are set out in Chapter 15, section 15.6.1, and include:

- Preparation of Construction Environmental Management Plans to manage on-site construction impacts
- Controls for managing impacts to:
  - Hydrology and water quality
  - Noise and air quality
  - Construction traffic

The Plan also include a specific measure as part of Commitment 5.1 to put in place development controls though the relevant DCP to ensure urban, industrial, and infrastructure development adjacent to the southern and western boundaries of the site mitigates impacts to surface water flows and the water quality of Blaxland Creek.

These development controls and the process for implementing them are expected to adequately address the majority of the potential indirect and facilitated impacts of the urban and industrial development that will occur adjacent to Site 5.

A detailed description of the development controls and implementation process, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

Infrastructure development

The Plan includes a commitment to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3). This commitment will be delivered through an environmental assessment and approval process that will be applied to detailed design of each infrastructure project at the time the project is brought forward for development. This will be undertaken under Part 4 or Part 5 of the EP&A Act (or equivalent at the time). State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed under the EPA Act.

This assessment process will assess and identify mitigation measures to manage the non-biodiversity related potential environmental impacts of the project. This will include the assessment and management of indirect impacts of any infrastructure projects that may affect Site 4, including construction activities, noise and air quality impacts, impacts to traffic and accessibility, and disruption to services and infrastructure.

This process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 4 from the infrastructure development.

A detailed description of the assessment and approval process for infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.2.

35.3.6 SITE 6 (CAMDEN AIRPORT)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Camden Airport
Site ID number	6
Area	186.7 ha
Address	766 Aerodrome Road, Cobbitty NSW
Folio	102/112144
General description	Camden airport is located at 766 Aerodrome Road Hanger, Camden, NSW. The site is a general aviation airport that facilitates the operation of small aircrafts in the commercial, private, sports and recreational aviation areas (CAL, 2015). Approximately 26.3 per cent of the site is covered by native vegetation. It occurs within the Strategic Assessment Area, approximately 50 km south-west of the Sydney CBD
Site map	The location of Site 6 is shown in Map 54.7
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
The site occurs within the footprint of the tunnel section of the OSO from Cobbitty to Cawdor. The nearest urban capable land occurs approximately 9 km to the west within GMAC	
LANDSCAPES AND LANDFORMS	
This site occurs in a flat landscape on Tertiary and Quaternary floodplains and terraces of the Nepean River	
SOIL AND SUBSTRATES	
The soil landscape at site 6 is made up of: • 8 ha of Blacktown soil – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 178 ha of Theresa Park soil – Theresa Park soils occur on Tertiary and Quaternary floodplains and terraces • < 1 ha of unknown soil	
WATER	
The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018) The site is flat and contains one minor, non-perennial drainage line in the north-eastern part of the site and is bordered on the east, south and western sides by the Nepean River	
VEGETATION	
Vegetation covers approximately 26.3 per cent (49.2 ha) of the Camden Airport site. These vegetated areas occur on the banks of the Nepean River that runs along the edge of the site	

Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)				
PCT number	**PCT name**	**NSW TEC name**	**BC Act status**	**Area (ha)**
0	Cleared	N/A	N/A	137.5

835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	49.1
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	<0.1
Commonwealth listed threatened ecological communities (TECs)				
TEC name			**EPBC Act status**	**Area (ha)**
Coastal floodplain eucalypt forest of eastern Australia			Currently being assessed for listing under EPBC Act	49.1
Threatened flora species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Eucalyptus benthamii (Camden White Gum)		Vulnerable (BC Act & EPBC Act)	49.2	129
Pomaderris brunnea (Brown Pomaderris)		Endangered (BC Act) Vulnerable (EPBC Act)	71.5	22
Acacia bynoeana (Bynoe's Wattle)		Vulnerable (BC Act) Endangered (EPBC Act)	1.4	0
Pultenaea parviflora		Endangered (BC Act) Vulnerable (EPBC Act)	0.4	0
Persicaria elatior (Tall Knotweed)		Vulnerable (BC Act & EPBC Act)	20.7	0
BIO Map Priority Investment Areas				
The site has been identified on BIO Map as containing 51 ha of corridors				
Type	**Area (ha)**			
Core areas	0.0			
State and Regional Biodiversity Corridors	50.6			
ANIMAL SPECIES				
Threatened fauna species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pteropus poliocephalus (Grey-headed Flying-fox)		Vulnerable (BC Act & EPBC Act)	48.8	0
Botaurus poiciloptilus (Australasian Bittern)		Endangered (BC Act & EPBC Act)	3.0	0
Petauroides volans (Greater Glider)		Vulnerable (EPBC Act)	33.4	0

Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	49.2	0
Rostratula australis (Australian Painted Snipe)	Endangered (BC Act & EPBC Act)	1.6	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	49.2	1
Meridolum corneovirens (Cumberland Plain Land Snail)	Endangered (BC Act)	0.0	1
*Micronomus norfolkensis (*Eastern Coastal Free-tailed Bat)	Vulnerable (BC Act)	0.0	2
Miniopterus orianae oceanensis (Large Bent-winged Bat)	Vulnerable (BC Act)	0.0	1
Petroica boodang (Scarlet Robin)	Vulnerable (BC Act)	0.0	1
*Scoteanax rueppellii (*Greater Broad-nosed Bat)	Vulnerable (BC Act)	0.0	2
CONSERVATION AND SPECIAL USE AREAS			
The 49 ha of native vegetation on the site is protected as a registered property agreement administered by the BCT			
HERITAGE PLACES AND ITEMS			
The Camden Airport Environment Strategy (Camden Airport Limited, 2015) identifies the heritage values present on the property With regards to indigenous heritage, an Aboriginal Archaeological Survey of the site in 2009 identified an artefact scatter which contained flaked stone artefacts along an access track leading to the Nepean River. This site was registered on the NSW Aboriginal Heritage Information Management System (AHIMS). The stone artefacts have since been relocated off the access track to another on-Airport location under an Aboriginal Heritage Impact Permit (AHIP). While the access track provides tangible evidence of previous Aboriginal occupation, it is noted that Aboriginal representatives have indicated the site does not have specific cultural significance which would require ongoing protection (Camden Airport Limited, 2015) With regards to non-indigenous heritage, the site was first developed in the 1930's, with the original airport hangar still in use today. The site was used during World War II by the Royal Australian Air Force (RAAF), with structures from that period still present on site today. No structures on site pre-date the 1930's (Camden Airport Limited, 2015) The site is listed for heritage purposes within the *Camden Local Environment Plan 2010*, and on the Register of the National Estate (RNE), which is a non-statutory list which closed in 2007 (Camden Airport Limited, 2015)			
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES			
The site is a general aviation airport, hosting small commercial, private and recreational aircraft operations Aviation facilities at the site include • Taxiways and aprons • Lighting • Air traffic control • Navaids • Refuelling Passenger facilities at the site include: • Parking • Ground transportation No mining or petroleum tenements exist on this site (NNTT, 2020) No Native Title Claims exist over this site (NNTT, 2020)			

IMPACT ASSESSMENT

Direct impacts

Site 6 occurs within the footprint of the OSO tunnel and may be directly impacted by construction of the tunnel. There will be no direct impacts to Site 6 due to other development under the Plan.

OSO tunnel

An assessment of the tunnel impacts on biodiversity values is provided in Chapter 36. This section provides a summary of the potential impacts of the tunnel in relation to the environment of Site 6.

It is not possible to determine at this stage the specific nature, extent and duration of the direct impacts of the OSO tunnel on Site 6. Development for the tunnels will generally occur within the tunnel footprints and direct impacts to the land surface will only occur within small areas of the footprint (see Part 2).

Disturbance to the land surface of Site 6 from the tunnel may occur due to:

- Construction activities
- Ancillary infrastructure, including ventilation systems
- Other infrastructure, such as entry and exit ramps and connection and tie in with existing roads and infrastructure
- Pedestrian and cyclist facilities
- Drainage work, pavement and finishing work

This may result in:

- Clearing of native vegetation and habitat
- Disturbance or destruction of buildings, roads and other infrastructure, and disruption of services
- Visual impacts from any permanent infrastructure, including ventilation shafts

It is unlikely that the development of the OSO tunnel would impact sites of heritage significance, as indigenous heritage items have previously been removed from their original position on the site for protection, and non-indigenous heritage items on site include site infrastructure such as airport hangars which are unlikely to be directly impacted.

The most important biodiversity values within the tunnel footprint of Site 6 that may be directly impacted are:

- Small amounts of Coastal Floodplain Eucalypt Forest of Eastern Australia – the potential for notable impacts to this TEC is low. While several small patches of the TEC have the potential to be directly impacted, the amount of impact in the context of the amount remaining in the Strategic Assessment Area is not substantial
- Records and habitat of *Eucalyptus benthamii* and *Pomaderris brunnea* – direct impacts to these species may be notable, as large important populations of each species occur in the tunnel footprint
- Riparian corridor of Nepean River – Site 6 occurs within parts of the riparian corridor of the Nepean River. The corridor contains native vegetation that provides habitat and records of *Eucalyptus benthamii* and *Pomaderris brunnea* as well as likely providing habitat for several common species. It also provides a narrow habitat corridor link across the landscape from Site 6, including to several other larger patches of habitat nearby

Almost all native vegetation and other biodiversity values within Site 6 occur around the western, southern and eastern edges of the site end within the area covered by the Registered Property Agreement.

The Plan includes commitments that are expected to adequately address these potential direct impacts (see below).

Potential Indirect impacts

Site 6 has the potential to be indirectly impacted by construction and operation of the OSO tunnel.

The nearest urban and industrial and infrastructure development is too distant (over 9 km) to be impacted by construction of the development. However, there may be indirect impacts on the site from increased populations in the area associated with urban development.

The potential indirect and facilitated impacts associated with this development and the key values of the environment of Site 6 that are potentially impacted are shown in Table 35-6.

Note that it is considered unlikely that heritage values of the site will be indirectly impacted. Indigenous heritage items have previously been removed from the site for protection purposes, whilst non-indigenous heritage items are of an industrial nature (and includes infrastructure such as airport hangars). It is therefore considered that addition of potential infrastructure associated with a tunnel (such as air vents) would not be inconsistent with the visual amenity and general characteristics of the site.

Table 35-6: Potential indirect impacts on Site 6 associated with the development

<table>
<tr><th>Potential indirect impact</th><th>Extent within Site 6</th><th>Duration</th><th>Values potentially impacted</th></tr>
<tr><td colspan="4">Construction</td></tr>
<tr><td>Soil erosion and disturbance from vegetation clearing and earthworks</td><td rowspan="5">Vicinity of the tunnel footprint</td><td rowspan="5">Generally short term</td><td rowspan="5">People and communities
Biodiversity values</td></tr>
<tr><td>Changes to water quality from soil erosion or disturbance of contaminated soils</td></tr>
<tr><td>Air quality, noise impacts, and visual or other impacts to amenity</td></tr>
<tr><td>Construction traffic causing disruption or reduced accessibility to the site</td></tr>
<tr><td>Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat</td></tr>
<tr><td>Disruption to land uses, services or infrastructure</td><td>Whole of site</td><td>Generally short term</td><td>People and communities</td></tr>
<tr><td colspan="4">Operation</td></tr>
<tr><td>Ground settlement and subsidence from tunnels due to the tunnel void or groundwater removal, leading to disturbance to the land surface</td><td>Vicinity of the tunnel footprint</td><td>Short to long term</td><td>People and communities
Biodiversity values</td></tr>
<tr><td>Changes to surface water and groundwater quantities and flows due to groundwater drawdown caused by the tunnel void</td><td>Vicinity of tunnel footprint
Riparian corridor within Nepean River</td><td>Long term</td><td>Water resources
Biodiversity values</td></tr>
<tr><td>Disruption to land uses, services or infrastructure</td><td>Whole of site</td><td>Long term</td><td>People and communities</td></tr>
</table>

Biodiversity values

Construction of the tunnel may cause notable indirect impacts to biodiversity values from the spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat or vegetation. The tunnel also has the potential to cause ground settlement and subsidence due to the tunnel void or groundwater removal leading to disturbance to the land surface, as well as groundwater drawdown, both of which may impact biodiversity values.

The most important biodiversity values within the tunnel footprint of site 6 that may be indirectly impacted are:

- Small amounts of Coastal Floodplain Eucalypt Forest of Eastern Australia – the potential for notable impacts to this TEC is low (as above for direct impacts)
- Records and habitat of *Eucalyptus benthamii* and *Pomaderris brunnea* – indirect impacts to these species may be notable (as above for direct impacts)

- Riparian corridor of Nepean River – The riparian corridor contains native vegetation that provides habitat and records of *Eucalyptus benthamii* and *Pomaderris brunnea* as well as likely providing habitat for several common species. It also provides a narrow habitat corridor link across the landscape from Site 6

The Plan includes commitments that are expected to adequately address these potential impacts on biodiversity values in site 4 resulting from construction and operation of the tunnel (see below).

People and communities

Construction of the tunnel has the potential to significantly disrupt the aviation and passenger facilities at Site 6 as a result of potential temporary closures to parts of the site to allow construction or provide for construction sites, disruption to pedestrian or traffic access to or within the site, and air quality and noise impacts. The Plan includes commitments that are expected to adequately address these potential construction impacts (see below).

The increase in populations in the area facilitated by the urban development is likely to increase the demand for aviation services and passenger facilities at the site. This is likely to be overall a positive benefit to the airport and is expected to be adequately managed through existing management and operational processes.

Population increases may also lead to increased pressure on roads, transport and other infrastructure that service the university. However, the Plan intends to provide for future transport needs by supporting the delivery of major transport projects for Western Sydney. It is also expected that future transport and infrastructure needs of the airport will be provided for through existing local and regional planning processes.

Commitments and mitigation measures

The Plan includes commitments to mitigate direct and indirect impacts from construction and operation of the tunnel.

Direct impacts

The Plan includes a commitment to avoid and minimise impacts from the transport corridors outside the nominated areas (Commitment 4). This includes the following at Camden Airport (Commitment 4.1):

- Avoiding and minimising impacts where possible to:
  - Existing infrastructure
  - Registered Property Agreement site
  - Populations and habitat of *Eucalyptus benthamii* and *Pomaderris brunnea*
- Minimising disruption to existing services

This avoidance process will be undertaken during strategic planning and detailed design of the OSO tunnel project. The process will seek to avoid and minimise direct impacts of the tunnel to Site 6, including impacts to existing infrastructure and disruption to aviation services, as well as biodiversity values.

This commitment is considered to adequately address the risks associated with the potential direct impacts of the OSO tunnel on Site 6. Note that each transport project will be subject to an environmental assessment process under the EP&A Act. While this assessment will not apply to tunnel activities on Site 6 (as Commonwealth land is outside the jurisdiction of NSW planning laws), the minimisation of impacts to infrastructure and disruption to existing services will occur in accordance with standard construction management processes.

Indirect impacts

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport development (Commitment 6). This includes the following measures relevant to Camden Airport (Commitment 6.2):

- Implement mitigation measures to address impacts on *Eucalyptus benthamii* and *Pomaderris brunnea*, including to manage hydrological disturbance, spread of weeds and disease, and soil erosion and sedimentation

This commitment will be delivered through an environmental assessment process that will apply to each transport project under the EP&A Act (currently the State Significant Infrastructure approval process) to assess and manage the direct and indirect impacts of the project. A description of the process is provided in Chapter 15, section 15.6.3.

This process will assess the environmental impacts of the construction and operation of the tunnel project based on detailed design, in accordance with the standard requirements and policies applying to major infrastructure assessments in NSW (see Chapter 15, section 15.6.3). The current process requires an assessment of risks to the environment and the identification of avoidance and mitigation measures to manage these risks. This will include the assessment and management of indirect impacts of the tunnel project that may affect Site 6, including construction activities, changes to surface and groundwater flows and water quality, including groundwater drawdown, noise and air quality impacts, impacts to traffic and accessibility, and disruption to services and infrastructure.

This assessment process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 6 from the transport development.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.3.

35.3.7 SITE 7

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	N/A
Site ID number	7
Area	4.7 ha
Address	12 Werombi Road, Grasmere NSW
Folio	5/221387
General description	The site located at 12 Werombi Road, Grasmere NSW. It is understood the site is a space weather monitoring site run by the Bureau of Meteorology. It occurs within the Strategic Assessment Area, approximately 53 km south-west of the Sydney CBD
Site map	The location of Site 7 is shown in Map 54.8
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
The site occurs within the footprint of the tunnel section of the OSO from Cobbitty to Cawdor. The nearest urban capable land occurs approximately 9 km to the west within GMAC	
LANDSCAPES AND LANDFORMS	
This site occurs in a landscape of gently undulating rises on Wianamatta Group shales	
SOIL AND SUBSTRATES	
The soil landscape at Site 7 is Blacktown soil. Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a)	
WATER	
The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018) A minor non-perennial watercourse intersects the north-west corner of the site. The Nepean River occurs approximately 600 m north east of the site	
VEGETATION	
Native vegetation covers the whole site. The vegetation that occurs on the site is Cumberland Plain Woodland, a Commonwealth and NSW-listed TEC. The TEC is in thinned condition. The vegetation is relatively isolated, and is bounded by Werombi Road to the south, and existing urban development to the west and east. There is some connectivity to the north of the site with the riparian corridor of the Nepean River	

Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)				
PCT number	**PCT name**	**NSW TEC name**	**BC Act status**	**Area (ha)**
0	Cleared	N/A	N/A	0.1
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	1.0

850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	3.5
Commonwealth listed threatened ecological communities (TECs)				
TEC name			**EPBC Act status**	**Area (ha)**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest			Critically Endangered	4.5
Threatened flora species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pimelea spicata (Spiked Rice-flower)		Endangered (BC Act & EPBC Act)	4.4	0
Pomaderris brunnea (Brown Pomaderris)		Endangered (BC Act) Vulnerable (EPBC Act)	1.9	0
BIO Map Priority Investment Areas				
No BIO Map core or corridor areas have been identified on this site				
ANIMAL SPECIES				
There are no threatened fauna records known from the site				
Threatened fauna species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pommerhelix duralensis (Dural Land Snail)		Endangered (BC Act & EPBC Act)	4.3	0
Pteropus poliocephalus (Grey-headed Flying-fox)		Vulnerable (BC Act & EPBC Act)	4.4	0
Anthochaera phrygia (Regent Honeyeater)		Critically Endangered (BC Act & EPBC Act)	4.5	0
Lathamus discolor (Swift Parrot)		Endangered (BC Act) Critically Endangered (EPBC Act)	4.5	0
CONSERVATION AND SPECIAL USE AREAS				
There are no conservation or special use areas on the site. A Registered Property Agreement protecting biodiversity values occurs at Camden Airport (approximately 700 m north of the site on the other side of the Nepean River)				
HERITAGE PLACES AND ITEMS				
It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having heritage values				
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES				
The site is understood to be currently used for space weather monitoring and includes one building The following tenements exist on this site (NNTT, 2020): • Mining tenement (AUTH281) • Petroleum tenement (PPL1) No Native Title Claims exist over this site (NNTT, 2020)				

IMPACT ASSESSMENT

Direct impacts

Site 7 occurs wholly within the footprint of the OSO tunnel and may be directly impacted by construction of the tunnel. There will be no direct impacts to Site 7 due to other development under the Plan.

OSO tunnel

An assessment of the tunnel impacts on biodiversity values is provided in Chapter 36. This section provides a summary of the potential impacts of the tunnel in relation to the environment of Site 7.

It is not possible to determine at this stage the specific nature, extent and duration of the direct impacts of the OSO tunnel on Site 7. Development for the tunnels will generally occur within the tunnel footprints and direct impacts to the land surface will only occur within small areas of the footprint (see Part 2).

Disturbance to the land surface of Site 7 from the tunnel may occur due to:

- Construction activities
- Ancillary infrastructure, including ventilation systems
- Other infrastructure, such as entry and exit ramps and connection and tie in with existing roads and infrastructure
- Pedestrian and cyclist facilities
- Drainage work, pavement and finishing work

This may result in:

- Clearing of native vegetation and habitat
- Disturbance or destruction of the building on site and disruption of the weather services it provides
- Visual impacts from any permanent infrastructure, including ventilation shafts

The most important biodiversity values within the tunnel footprint of Site 7 that may be directly impacted are small amounts of Cumberland Plain Woodland. The potential for notable impacts to this TEC is low. While a patch of the TEC has the potential to be directly impacted, the amount of impact in the context of the amount remaining in the Strategic Assessment Area is not substantial and the patch is in thinned condition and is relatively isolated.

The Plan includes commitments that are expected to adequately address these potential direct impacts (see below).

POTENTIAL INDIRECT IMPACTS

Site 7 has the potential to be indirectly impacted by construction and operation of the OSO tunnel.

The nearest urban and industrial and infrastructure development is too distant (over 9 km) to be impacted by construction of the development. However, there may be indirect impacts on the site from increased populations in the area associated with urban development.

The potential indirect and facilitated impacts associated with this development and the key values of the environment of Site 7 that are potentially impacted are shown in Table 35-7.

Table 35-7: Potential indirect impacts on Site 7 associated with the development

Potential indirect impact	Extent within Site 7	Duration	Values potentially impacted
Construction			
Soil erosion and disturbance from vegetation clearing and earthworks	Whole of site	Generally short term	People and communities Biodiversity values
Changes to water quality from soil erosion or disturbance of contaminated soils			
Air quality, noise impacts, and visual or other			

Potential indirect impact	Extent within Site 7	Duration	Values potentially impacted
impacts to amenity			
Construction traffic causing disruption or reduced accessibility to the site			
Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat			
Disruption to land uses, services or infrastructure	Whole of site	Generally short term	People and communities
Operation			
Ground settlement and subsidence from tunnels due to the tunnel void or groundwater removal, leading to disturbance to the land surface	Whole of site	Short to long term	People and communities Biodiversity values

Biodiversity values

Construction of the tunnel may cause indirect impacts to biodiversity values in Site 7 from the spread of weeds, disease, and inadvertent impacts on adjacent habitat or vegetation. The tunnel also has the potential to cause ground settlement and subsidence due to the tunnel void or groundwater removal leading to disturbance to the land surface, as well as groundwater drawdown, both of which may impact biodiversity values.

The most important biodiversity values within the tunnel footprint of Site 7 that may be indirectly impacted are small amounts of Cumberland Plain Woodland. The potential for notable impacts to this TEC is low (as above for direct impacts).

The Plan includes commitments that are expected to adequately address these potential impacts on biodiversity values in Site 7 resulting from construction and operation of the tunnel (see below).

People and communities

Construction of the tunnel has the potential to disrupt the services provided at Site 7 – space weather monitoring – as a result of potential temporary closures to parts of the site to allow construction or provide for construction sites, disruption to traffic access to or within the site, and air quality and noise impacts. The Plan includes commitments that are expected to adequately address these potential construction impacts (see below).

Commitments and mitigation measures

The Plan includes commitments to mitigate direct and indirect impacts from construction and operation of the tunnel.

Direct impacts

The Plan includes a commitment to avoid and minimise impacts from the transport corridors outside the nominated areas (Commitment 4). This includes the following at Site 7 (Commitment 4.1):

- Avoiding and minimising impacts where possible to existing infrastructure
- Minimising disruption to existing services

This avoidance process will be undertaken during strategic planning and detailed design of the OSO tunnel project. The process will seek to avoid and minimise direct impacts of the tunnel to Site 7, including impacts to existing infrastructure and disruption to weather services, as well as biodiversity values.

This commitment is considered to adequately address the risks associated with the potential direct impacts of the OSO tunnel on Site 7. Note that each transport project will be subject to an environmental assessment process under the EP&A Act. While this assessment will not apply to tunnel activities on Site 7 (as Commonwealth land is outside the jurisdiction of NSW planning laws), the minimisation of impacts to infrastructure and disruption to existing services will occur in accordance with standard construction management processes.

Indirect impacts

The Plan includes a commitment to mitigate indirect impacts from transport corridors (Commitment 6). This commitment will be delivered through an environmental assessment process that will apply to each transport project under the EP&A Act (currently the State Significant Infrastructure approval process) to assess and manage the direct and indirect impacts of the project. A description of the process is provided in Chapter 15, section 15.6.3.

This process will assess the environmental impacts of the construction and operation of the tunnel project based on detailed design, in accordance with the standard requirements and policies applying to major infrastructure assessments in NSW (see Chapter 15, section 15.6.3). The current process requires an assessment of risks to the environment and the identification of avoidance and mitigation measures to manage these risks. This will include the assessment and management of indirect impacts of the tunnel project that may affect Site 7, including construction activities.

This assessment process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 7 from the transport development.

A detailed description of the assessment and approval process for transport, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.3.

35.3.8 SITE 8 (WESTERN SYDNEY (NANCY-BIRD WALTON) INTERNATIONAL AIRPORT)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Western Sydney (Nancy-Bird Walton) International Airport
Site ID number	8
Area	1,745.5 ha
Address	Badgerys Creek Road, Badgerys Creek NSW
Folio	101/123631, 11/226448, 9/226448, 3/611519, 7/3050, 8/3050, 2/C/1451, 11/1239207, 98/1236319, 99/1236319, 102/123631, 103/123631, 9/1233751, 14/1233751, 13/1233751, 8/1233751, 5/1233751, 32/259698, 108/123631, 107/123631, 23/259698, 17/258581, 6/1233751, 1/1233751, 3/1233751, 4/1233751, 1/129674
General description	Site 8 comprises the new Western Sydney (Nancy-Bird Walton) International Airport at Badgerys Creek. Construction of the airport is currently underway. The site has historically been used for agricultural purposes, consisting of stock grazing, cropping, orchards, dairying, and market gardening (DIRD, 2016a). Prior to commencement of airport construction works, native vegetation covered 25.0 per cent of the site. The site is located approximately 42 km west of the Sydney CBD
Site map	The location of Site 8 is shown in Map 54.9
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
Site 8 shares its northern, western and south-western border with urban capable land in WSA	
LANDSCAPES AND LANDFORMS	
This site occurs in a landscape of gently undulating to rolling low hills and floodplains, valley flats and drainage depressions. As part of airport construction works, extensive landscaping will be undertaken on site to flatten the runway regions and provide suitable surfaces for airport infrastructure	
SOIL AND SUBSTRATES	
The soil landscape at Site 8 is made up of: • 1,478 ha Blacktown soil landscape – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 79 ha Luddenham soil – Luddenham soils exist in varying forms depending on their location on a slope. Podzolic soils or earthy clays, yellow podzolic soils, and prairie soils are found on crests, upper slopes, and drainage lines respectively (OEH, 2018a) • 189 ha Wianamatta (South Creek) soil – Wianamatta (South Creek) soils are deep layered sediments that occur over bedrock or relict soils (minerals/structures that have not undergone metamorphic change while the surrounding rock has) (OEH, 2018a)	
WATER	
Site 8 occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018). The site is located on the Bringelly Shale aquifer (DIRD, 2016d) There are several waterways within Site 8, including Badgerys Creek, Cosgroves Creek, Oaky Creek, and Duncans Creek. These will be significantly modified by the new airport (DIRD, 2016d)	
VEGETATION	
Most native vegetation that exists within the site will be removed for the new airport. While some areas of low vegetation (such as grass) will likely be retained within the airport layout (such as adjacent to the runways), such vegetation will be subject to ongoing management (such as mowing) and has little biodiversity value Environmental protection zones will be established along the riparian corridor of Badgerys Creek, and on the small site	

to the west of The Northern Road which is separated from the rest of Site 8. Existing vegetation within these areas will be protected from impacts associated with the airport development. Ecological communities within these areas include (DIRD, 2016b)

- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain
- Exotic grassland

BIO Map Priority Investment Areas

No BIO Map core or corridor areas have been identified on this site

ANIMAL SPECIES

Prior to the completion of the airport development, available fauna habitat on Site 8 included grassland, cropped areas, native woodland, riparian forest, and wetlands, and the site was known to support 173 fauna species known to occur at the site, including a number of threatened fauna species (DIRD, 2016b)

Following completion of the airport development, fauna habitat types at Site 8 will primarily include riparian forest and grassland and it is expected that fewer fauna species will have suitable habitat available on-site

CONSERVATION AND SPECIAL USE AREAS

Environmental protection zones will be established along the riparian corridor of Badgerys Creek, and on the small site to the west of The Northern Road which is separated from the rest of Site 8

HERITAGE PLACES AND ITEMS

Surveys were conducted for the Western Sydney Airport EIS that identified existing and new historic and indigenous heritage items (DIRD, 2016a, 2016c).

Identified indigenous heritage sites include numerous surface artefacts (including a grinding groove site), a modified tree, and subsurface artefacts. Higher artefact densities were found in close proximity to permanent water. The site was identified to be important as a place of cultural significance and continuing cultural connection by indigenous stakeholders consulted as part of the EIS process for Western Sydney Airport.

European heritage items reflect the historical development of the locality, including early efforts to develop agricultural economies and settled village communities. Examples of heritage items include early residential and commercial buildings, remains of early churches and associated graveyards, and infrastructure including historical wells.

As part of the airport development process, numerous strategies have been prepared and implemented to record, preserve and (where required) salvage heritage items on site to ensure that these items are protected from the impacts of the airport development

SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES

Site 8 is the future site for the new Western Sydney (Nancy-Bird Walton) International Airport, which is currently being constructed. The site will include

- Runways
- Taxiways and aprons
- Aviation rescue and fire-fighting services
- Air traffic control
- Airport terminals
- Utilities
- Road and rail access

The following tenement exists on this site (NNTT, 2020):

- Mining tenement (EL8429) – exploration lease
- Mining tenement (ML1771) – mining lease

No Native Title Claims exist over this site (NNTT, 2020)

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 8 due to the Plan (although note the GIS boundary error discussed in section 35.1, which wrongly suggests there are very small direct impacts).

Indirect and facilitated impacts

Site 8 has the potential to be indirectly impacted by construction and operation of the urban and industrial, and infrastructure development which occurs adjacent to the northern, western and southern boundaries of the site.

The potential indirect and facilitated impacts associated with these developments and the key values of the environment of Site 8 that are potentially impacted are shown in Table 35-8.

Table 35-8: Potential indirect impacts on Site 8 associated with the development

Potential indirect impact	Extent within Site 8	Duration	Values potentially impacted
Construction			
Soil erosion and disturbance from vegetation clearing and earthworks	Boundaries of the site	Generally short term	People and communities Biodiversity values
Changes to water quality from soil erosion or disturbance of contaminated soils			
Air quality, noise impacts, and visual or other impacts to amenity			
Construction traffic causing disruption or reduced accessibility to the site			
Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat			
Disruption to land uses, services or infrastructure	Whole of site	Generally short term	People and communities
Operation			
Changes to surface water flows due to additional runoff from urban areas	Waterways within the site	Long term	Water resources Biodiversity values
Disruption to land uses, services or infrastructure	Whole of site	Long term	People and communities

Biodiversity values

There is potential for indirect impacts from construction and operation of urban, industrial, and infrastructure development on the environmental protection zones to the west of The Northern Road, including spread of weeds and disease, fauna disturbance and inadvertent impacts on adjacent habitat, as well as potentially increased risk of human disturbance from public access. This area contains approximately 12 ha of mostly good condition Forest Red Gum - Rough-barked Apple grassy woodland, 4.9 ha of mostly poor condition Grey Box - Forest Red Gum grassy woodland, with the remainder of the site (approximately 3.5 ha) containing exotic grassland (DIRD, 2016b).

The OSO to the west of the site has the potential to reduce the connectivity of the environmental protection zones adjacent to The Northern Road. This area is currently connected to the riparian corridor of Duncan's Creek, which connects to patches of habitat and riparian corridors that link to the Nepean River to the west. The potential impacts of the OSO on the riparian corridor at Duncan's Creek may reduce the habitat values of the site for native species, and may decrease the viability of the vegetation communities on site.

The Plan includes commitments that are expected to adequately address these potential impacts on biodiversity values in Site 8 resulting from construction and operation of the development (see below).

Water resources

There is potential for runoff from urban industrial, and infrastructure development to impact surface water flows and water quality in Badgerys Creek, as this development is located adjacent to upstream tributaries of the creek. The Plan includes commitments that are expected to adequately address these potential impacts (see below).

The riparian corridor along Badgerys Creek is not considered to be at risk of other indirect impacts (such as noise or light) as a result of the Plan, as urban development is not planned to occur adjacent to the creek.

People and communities

Construction of the development has the potential to disrupt the airport services and facilities at Site 8 once the site is operating, as a result of potential temporary closures to parts of the site to allow construction or provide for construction sites, disruption to pedestrian or traffic access to the site, and air quality and noise impacts. The Plan includes commitments that are expected to adequately address these potential construction impacts (see below).

The urban, industrial, infrastructure, agribusiness and transport development within the vicinity of Site 8 will directly complement the use of the site as a major airport facility. The development will provide commercial and residential and agribusiness facilities in close proximity to the airport. This will allow for:

- The development of new commercial precincts in association with economic activity generated by the airport
- The provision of accessible and affordable housing close to the airport site to provide for employees of the airport and related commercial enterprises

The urban development and transport development under the Plan will therefore complement the operation of the airport at Site 8 and will subsequently produce a range of social and economic benefits.

Commitments and mitigation measures

The Plan includes commitments to mitigate indirect impacts from construction and operation associated with urban and industrial and infrastructure development. These commitments and processes to deliver these comments are different for each type of development.

Urban and industrial development

The Plan includes a commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5). This commitment will be delivered through development controls specified in Development Control Plans (DCPs) and implemented through the standard development application process that occurs under the NSW planning system. A description of the process is provided in Chapter 15, section 15.6.1.

Relevant councils will prepare a DCP for each nominated area in collaboration with the Department and in accordance with standard processes for developing DCPs in NSW. The DCP will include development controls relevant to addressing the indirect and facilitated impacts of the urban and industrial development that may affect Site 8.

The general environmental controls likely to be included in DCPs are set out in Chapter 15, section 15.6.1, and include:

- Preparation of Construction Environmental Management Plans to manage on-site construction impacts
- Controls for managing impacts to hydrology and water quality

These development controls and the process for implementing them are expected to adequately address the potential indirect and facilitated impacts of the urban and industrial development that will occur adjacent to Site 8.

A detailed description of the development controls and implementation process, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

Infrastructure development

The Plan includes a commitment to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3). This commitment will be delivered through an environmental assessment and approval process that will be applied to detailed design of each infrastructure project at the time the project is brought forward for development. This will be undertaken under Part 4 or Part 5 of the EP&A Act (or equivalent at the time). State

Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed under the EPA Act.

This assessment process will assess and identify mitigation measures to manage the non-biodiversity related potential environmental impacts of the project. This will include the assessment and management of indirect impacts of any infrastructure projects that may affect Site 8, including impacts to hydrology and water quality.

This process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 8 from the infrastructure development.

A detailed description of the assessment and approval process for infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.2.

35.3.9 SITE 9 (RAAF TELECOMMUNICATIONS UNIT)

Profile

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	RAAF Telecommunications Unit
Site ID number	9
Area	114.9 ha
Address	215 Badgerys Creek Road, Bringelly NSW
Folio	10/1235662
General description	The site is located 215 Badgerys Creek Road, Bringelly NSW. The site contains 16.2 per cent native vegetation cover. The site occurs in the Strategic Assessment Area, approximately 45 km south-west of the Sydney CBD
Site map	The location of Site 9 is shown in Map 54.10
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
The site is located approximately 2 km from nearest development under the Plan – urban and industrial, infrastructure and agribusiness development in WSA. The land surrounding the site consists of low density, rural residential and commercial areas	
LANDSCAPES AND LANDFORMS	
This site occurs in a landscape of gently undulating rise and floodplains, valley flats and drainage depressions	
SOIL AND SUBSTRATES	
The soil landscape at Site 9 is made up of: • 85 ha Blacktown soil – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 30 ha Wianamatta (South Creek) soil – Wianamatta (South Creek) soils are deep layered sediments that occur over bedrock or relict soils (minerals/structures that have not undergone metamorphic change while the surrounding rock has) (OEH, 2018a)	
WATER	
The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018) The site is relatively flat. Moore Gully waterway passes through the southern part of the site. Two naturally occurring ponds are connected to this waterway. Five other drainage lines flow into Thompsons Creek and originate from varying locations on the site (DoI, 2019; DTA, DCA et al., 2019)	
VEGETATION	
Approximately 16.2 per cent (18.6 ha) of the site is covered by native vegetation. The eastern edge of the site borders on a narrow riparian corridor that follows Thompsons Creek in a south-north direction The native vegetation on the site, with the exception of the riparian corridor, is isolated from other substantial areas of vegetation and is in thinned (low) condition	

Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)				
PCT number	**PCT name**	**NSW TEC name**	**BC Act status**	**Area (ha)**
0	Cleared	N/A	N/A	96.3

835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	4.1
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	5.6
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	8.9
Commonwealth listed threatened ecological communities (TECs)				
TEC name			**EPBC Act status**	**Area (ha)**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest			Critically Endangered	6.9
Coastal floodplain eucalypt forest of eastern Australia			Currently being assessed for listing under EPBC Act	4.1
Threatened flora species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Acacia bynoeana (Bynoe's Wattle)		Vulnerable (BC Act) Endangered (EPBC Act)	0.3	0
Acacia pubescens (Downy Wattle)		Vulnerable (BC Act & EPBC Act)	4.6	0
Eucalyptus benthamii (Camden White Gum)		Vulnerable (BC Act & EPBC Act)	2.0	0
Pimelea spicata (Spiked Rice-flower)		Endangered (BC Act & EPBC Act)	14.8	0
Pultenaea parviflora		Endangered (BC Act) Vulnerable (EPBC Act)	15.7	0
Pimelea curviflora var. *curviflora*		Vulnerable (BC Act & EPBC Act)	2.7	0
BIO Map Priority Investment Areas				
No BIO Map core or corridor areas have been identified on this site				
ANIMAL SPECIES				
There is one record of Cumberland Land Snail known from the site				
Threatened fauna species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pommerhelix duralensis (Dural Land Snail)		Endangered (BC Act & EPBC Act)	16.7	0

Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	17.0	0
Botaurus poiciloptilus (Australasian Bittern)	Endangered (BC Act & EPBC Act)	1.4	0
Petauroides volans (Greater Glider)	Vulnerable (EPBC Act)	0.4	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	18.6	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	18.6	0

CONSERVATION AND SPECIAL USE AREAS

There are no conservation or special use areas present on this site

The closest conservation or special use areas are:

- Area under a conservation agreement in Badgerys Creek (approximately 7.5km north)
- Kemps Creek Nature Reserve (approximately 5.5km northeast)
- Metro offset site (approximately 7km northeast)
- Biobanking agreement site in Mulgoa (approximately 8.5km north west)
- A number of biobanking agreement sites (approximately 8 northeast)
- A biobanking agreement site in Leppington (approximately 8.5km south east)
- Bents Basin and Gulguer Nature Reserves (approximately 8-10km west)
- A number of Metro offset sites (approximately 9km south)
- Edmondson Regional Park (approximately 10km south east)
- A Metro offset site (approximately 10.5km east)

HERITAGE PLACES AND ITEMS

It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having any heritage values

SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES

The site is an RAAF telecommunications unit. The telecommunications unit is no longer in use. The site is part of the future Aerotropolis Town Centre, within the South West Sydney Growth Centre

No Native Title Claims exist over this site (NNTT, 2020)

The following tenement exists on this site (NNTT, 2020): Mining tenement (EL8429)

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 9 due to the Plan.

Indirect and facilitated impacts

Site 9 occurs approximately 1.9 km from the nearest development under the Plan – urban and industrial, infrastructure and agribusiness development within WSA. The land surrounding Site 9 consists of low density, rural residential and commercial areas. The site is also located upstream of the nearest development and within a separate sub-catchment. The location of the site relative to the development and nature of the areas surrounding the site means:

- The site is very unlikely to be impacted by impacts typically associated with construction of the development in WSA such as air quality, noise, construction traffic, or the spread of weeds or disease
- The site will not be impacted by soil erosion of sedimentation, changes to surface and groundwater quantity and flows, or water quality impacts associated with the construction and operation of the development

Furthermore, the site no longer appears to be in use. If this is the case, the development would not disrupt any services or site operations or affect the health or safety of any person associated with the site.

The potential indirect or facilitated impacts associated with the development in WSA and the key values of the environment of Site 9 that are potentially impacted are shown in Table 35-9.

Table 35-9: Potential indirect impacts on Site 9 associated with the development

Potential indirect impact	Extent within site 1	Duration	Values of site potentially impacted
Construction			
Clearing of habitat during construction of the development that links the site to other areas of habitat, leading to impacts on biodiversity values	Whole of site	Long term	Biodiversity values

Biodiversity values

There are some areas of vegetation present on Site 9 which provide some habitat values for a number of native species. The habitat on Site 9 is primarily connected to the surrounding environment via a vegetated riparian corridor which continues to the north-east and south-west of the site.

The connectivity of this riparian corridor to the surrounding area will not be directly impacted by development under the Plan, and therefore the habitat values of the site are unlikely to be impacted indirectly by the Plan.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address the potential indirect impacts on the environment of Site 9 from the development under the Plan.

35.3.10 SITE 10

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	N/A
Site ID number	10
Area	10.5 ha
Address & Folio	221 Greendale Road, Greendale NSW
Folio	15/229293
General description	The site located at 221 Greendale Road, Greendale NSW. The site is potentially used for grazing. Approximately 19.1 per cent of the site is covered by native vegetation. The site occurs within the Strategic Assessment Area, approximately 45 km south-west of the Sydney CBD
Site map	The location of Site 10 is shown in Map 54.11
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
The site is directly impacted by the footprint of the OSO under the Plan. The area of impact is approximately 4 ha, and occurs along the north-eastern corner of the site	
LANDSCAPES AND LANDFORMS	
This site occurs in a landscape of gently undulating rises to rolling low hills on Wianamatta Group shales	
SOIL AND SUBSTRATES	
The soil landscape at Site 10 is made up of: • 10 ha of Blacktown soil – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • < 1 ha of Luddenham soil – Luddenham soils exist in varying forms depending on their location on a slope. Podzolic soils or earthy clays, yellow podzolic soils, and prairie soils are found on crests, upper slopes, and drainage lines respectively (OEH, 2018a)	
WATER	
The site occurs within the Hawkesbury-Nepean catchment. Water quality is variable throughout the area. The majority of the upper reaches of streams and rivers are healthy, while downstream reaches are affected by historical land uses (e.g. clearing, urbanisation) (GES, 2018) The site contains a number of dams, which appear likely to be stock dams based on aerial imagery. The site is located at the headwaters of two drainage lines, which feed into Duncans Creek, and from there enter the Nepean River	
VEGETATION	
Native vegetation primarily occurs on the southern half of the site, with some scattered paddock trees occurring in the northern half of the site. Areas with trees occupy approximately 2 ha of the site The remainder of the site is cleared and may be used for grazing cattle The site is located within a wider agricultural landscape, which includes completely cleared areas, paddocks with scattered paddock trees and small vegetation patches, and larger, more connected areas of vegetation which tend to be associated with riparian corridors. Overall, the landscape is significantly fragmented, with riparian corridors and small patches of vegetation serving as 'stepping stones' through otherwise cleared paddocks	

Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)				
PCT number	**PCT name**	**NSW TEC name**	**BC Act status**	**Area (ha)**
0	Cleared	N/A	N/A	8.5
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	0.4
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	1.6

Commonwealth listed threatened ecological communities (TECs)		
TEC name	**EPBC Act status**	**Area (ha)**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	1.3

Threatened flora species			
Name	**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Acacia pubescens (Downy Wattle)	Vulnerable (BC Act & EPBC Act)	1.7	0
Pimelea spicata (Spiked Rice-flower)	Endangered (BC Act & EPBC Act)	0.5	0

BIO Map Priority Investment Areas
No BIO Map core or corridor areas have been identified on this site

ANIMAL SPECIES
There are no threatened fauna records known from the site

Threatened fauna species			
Name	**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pommerhelix duralensis (Dural Land Snail)	Endangered (BC Act & EPBC Act)	1.8	0
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	1.8	0
Petauroides volans (Greater Glider)	Vulnerable (EPBC Act)	1.3	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	2.0	0
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	2.0	0

CONSERVATION AND SPECIAL USE AREAS
There are no conservation or special use areas present on this site The closest conservation or special use areas are: • Biobanking agreement site in Mulgoa (approximately 5.5km north) • Bents Basin and Gulguer Nature Reserves (approximately 3.5-4.5km south west)
HERITAGE PLACES AND ITEMS
It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having any heritage values
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The use of this site is unknown. There are several small buildings on the site. The site may be used for grazing The following tenement exists on this site (NNTT, 2020): • Mining tenement (EL8429) No Native Title Claims exist over this site (NNTT, 2020)

Impact assessment

Direct impacts

The OSO will directly impact up to 4.2 ha of Site 10 (39.8 per cent of the site).

Impacts to Site 10 will occur in the north-eastern corner of the site. This area includes pastures, some scattered paddock trees and a small area (approximately 0.1 ha) of Cumberland Plain Woodland. The south-west of the site, which contains approximately 2 ha of Cumberland Plain Woodland, will not be directly impacted.

The loss of a very small amount of Cumberland Plain Woodland (0.1 ha) is not considered notable. The landscape surrounding the site is significantly fragmented and the native vegetation on the site is isolated and provides little connectivity value to nearby areas of habitat.

The OSO will substantially disrupt any existing uses of the site. However, the use of the site is unknown, although it appears to be used for grazing. The grazing value of the site is very limited as the site is very small and any impacts on the use of the site for grazing are unlikely to be notable.

Indirect and facilitated impacts

Site 10 has the potential to be indirectly impacted by construction and operation of the OSO.

The nearest urban and industrial and infrastructure development is too distant (over 9 km) for the site to be impacted by the construction of this development.

The potential indirect and facilitated impacts associated with this development and the key values of the environment of Site 10 that are potentially impacted are shown in Table 35-10.

Table 35-10: Potential indirect impacts on Site 10 associated with the development

Potential indirect impact	Extent within Site 11	Duration	Values potentially impacted
Construction			
Soil erosion and disturbance from vegetation clearing and earthworks	Whole of site	Generally short term	People and communities Biodiversity values
Air quality, noise impacts, and visual or other impacts to amenity			
Construction traffic causing disruption or reduced			

Potential indirect impact	Extent within Site 11	Duration	Values potentially impacted
accessibility to the site			
Spread of weeds, disease, fauna disturbance and inadvertent impacts on adjacent habitat			
Disruption to land uses, services or infrastructure	Whole of site	Generally short term	People and communities
Operation			
Air quality, noise impacts, and visual or other impacts to amenity	Whole of site	Short to long term	People and communities

Biodiversity values

Construction of the OSO may cause indirect impacts to biodiversity values from the spread of weeds, disease, and inadvertent impacts on adjacent habitat or vegetation.

The most important biodiversity values within the tunnel footprint of Site 10 that may be indirectly impacted are small amounts of Cumberland Plain Woodland. The potential for notable impacts to this TEC is low (see above).

The Plan includes commitments that are expected to adequately address these potential impacts on biodiversity values in Site 10 resulting from construction and operation of the tunnel (see below).

People and communities

The OSO is likely to substantially disrupt any existing uses of the site from impacts such as air quality, noise impacts, and visual or other impacts to amenity associate with construction and operation, as well as construction traffic causing disruption or reduced accessibility to the site.

However, the use of the site is unknown, although it appears to be used for grazing. The grazing value of the site is very limited as the site is very small and any impacts on the use of the site for grazing are unlikely to be notable.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address any specific notable direct or indirect impacts on the environment of Site 10 from the development under the Plan.

However, the Plan includes commitments to avoid and minimise impacts from the transport corridors (Commitment 4) and mitigate indirect impacts from transport corridors (Commitment 6) and these are expected to adequately minimise impacts on the environment of Site 10.

35.3.11 SITE 11 (HOLSWORTHY DEFENCE BASE)

PROFILE

SITE DETAILS	
Owner	The Commonwealth of Australia
Site name	Holsworthy Defence Base
Site ID number	11
Area	18,826.0 ha
Address	Heathcote Road, Moorebank/Holsworthy NSW
Folio	100/104950, 1/1197707, 4/1130937, 2/1197707, 3/1197707, 4/1197707, 122/119451, 2/1186495, 2/1216308, 1/1216308
General description	Holsworthy Defence Base is located on Heathcote Rd, Moorebank in the Strategic Assessment Area. It is bounded on the south east by Heathcote National Park and by Georges River in the west. Native vegetation covers 95.8 per cent of the site. The site is part of two Commonwealth Heritage Listed sites and five areas listed on the NSW heritage list. The site contains high biodiversity values, supporting a range of threatened species and TECs. Holsworthy is located approximately 35 km south-west of the Sydney CBD
Site map	The location of Site 11 is shown in Map 54.12
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS	
The nearest development under the Plan to Site 11 is urban capable land at the northern end of GMAC (near Glenfield), which is located approximately 1.4 km from the boundary of the site. The land in between the urban capable land and Site 11 in this area consists of existing urban development In the middle section of GMAC (between Glen Alpine and Rosemeadow), the urban capable land is located approximately 2.5 km from the boundary of Site 11 at its closest point to the site. The land between the urban capable land and Site 11 in this area consists of areas of urban development in the north west, agricultural fields in the south west and riparian vegetation associated with the Georges River in the east In the southern section of GMAC (between Gilead and Appin), the urban capable land is located approximately 4 km from the boundary of Site 11 at its closest point to the site. The land in between the urban capable land and Site 11 in this area consists of agricultural fields, low density rural residential areas and native vegetation	
LANDSCAPES AND LANDFORMS	
Site 11 is a large site that occurs across numerous of different landscape types. It occurs in a landscape of undulating rolling rises and low hills through to rugged, rolling to very steep hills on Hawkesbury Sandstone. It contains areas of disturbed terrain, most likely as a result of military activity on the site	
SOIL AND SUBSTRATES	
The soil landscape at Site 11 is made up of: • 680 ha Berkshire Park soil – Berkshire Park soil consists of heavy clays and clayey sands that are made up of less than a third of soil aggregates (OEH, 2018a) • 448 ha Blacktown soil – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a) • 220 ha Bundeena soil – no soil landscape report available • 19 ha Disturbed Terrain – areas where the original soil has been highly disturbed, buried or removed (OEH, 2018a) • 253 ha Faulconbridge soil – Faulconbridge soils are shallow (<50 cm) earthy sands and yellow earths with some siliceous sands associated with rock outcrops (OEH, 2018a) • 510 ha Gymea soil – Gymea soils are approximately 30-100 cm deep. The particular soil characteristic depends on the location. Gymea soils are made up of yellow earths and earthy sands, shallow siliceous sands, water logged and yellow podzolic sands, and siliceous and leached sands of < 100 cm in depth (OEH, 2018a)	

- 6,763 ha Hawkesbury soil – Hawkesbury soils are shallow (<50 cm). Rock outcrops, earthy sands, and shale lenses are associated with different aspects of Hawkesbury soils (OEH, 2018a)
- 9,806 ha Lucas Heights soil – Lucas Heights soils are moderately deep (50-150 cm). The soils are hardsetting and consist of yellow podzolic and yellow soloth soils
- 117 ha Richmond soil – Richmond soils consist of orange to red clay loams, clays, and sands that are poorly structured (OEH, 2018a)

WATER

Site 11 occurs within the Georges River catchment. The site has an undulating to dissected topography and is bounded on the west by the Georges River and on the east by the Woronora River. All waterways on the site are tributaries of these two rivers (DoI, 2019; DTA, DCA et al., 2019)

VEGETATION

Site 11 is heavily vegetated with 95.8 per cent (18,027.7 ha) of the site covered by native vegetation. The site includes large areas of several Commonwealth-listed TECs, including Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest, Castlereagh Scribbly Gum and Agnes Banks Woodlands and Cooks River/Castlereagh Ironbark Forest.

The site is well connected to large areas of habitat and protected lands. Three national parks occur adjacent to the boundaries of the site, including Dharawal National Park (adjacent to the southern boundary), Heathcote National Park (adjacent to the eastern boundary) and Georges River National Park (adjacent to the north eastern boundary). The site connects Heathcote National Park in the east to Dharawal National Park and other large areas of habitat in the west, particularly habitat in the vicinity of the Georges River, and the Nepean River further west

Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)

PCT number	PCT name	NSW TEC name	BC Act status	Area (ha)
0	Cleared	N/A	N/A	798.3
724	Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion	Shale Gravel Transition Forest in the Sydney Basin Bioregion	Endangered	501.8
725	Broad-leaved Ironbark – Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	Endangered	65.3
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	4.8
		Sydney Freshwater Wetlands in the Sydney Basin Bioregion	Endangered	
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvium flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	32.9

849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically Endangered	185.2
881	Hairpin Banksia – Kunzea ambigua – Allocasuarina distyle heath on coastal sandstone plateaux, Sydney Basin Bioregion	N/A	N/A	10.9
883	Hard-leaved Scribbly Gum – Parramatta Red Gum healthy woodland of the Cumberland Plain, Sydney Basin Bioregion	Castlereagh Scribbly Gum Woodland in the Sydney Basin Bioregion	Vulnerable	193.8
		Castlereagh Swamp Woodland Community	Endangered	
920	Mangrove Forests in estuaries of the Sydney Basin Bioregion and South East Corner Bioregion	Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	0.1
941	Mountain Blue Gum – Thin-leaved Stringybark open forest on river flat alluvium in the Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	181.6
1067	Parramatta Red Gum on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion	Castlereagh Swamp Woodland Community	Endangered	34.4
1234	Swamp Oak swamp forest fringing estuaries, Sydney Basin Bioregion and South East Corner Bioregion	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	1.5
1250	Sydney Peppermint – Smooth-barked Apple – Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin Bioregion	N/A	N/A	2,002.7
1292	Water Gum – Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	N/A	N/A	201.2
1395	Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Critically Endangered	165.7

1777	Red Bloodwood – Scribbly Gum – Silvertop Ash open forests on sandstone ridges of the Woronora Plateau	N/A	N/A	2,531.9
1780	Sydney Peppermint / Coachwood – Water Gum open forest in protected sandstone gullies around Sydney and the Central Coast	N/A	N/A	145.1
1787	Red Bloodwood – Scribbly Gum – Stringybark open forest on sandstone ridges along the western side of the Woronora and Hornsby plateaus	N/A	N/A	2,651.9
1789	Smooth-barked Apple – Blackbutt – Red Bloodwood open forest in enriched sandstone gullies of the western Woronora plateau	N/A	N/A	3,591.3
1790	Red Bloodwood – Grey Gum – Stringybark open forest on enriched sandstone ridges of the western Woronora plateau and lower Blue Mountains	N/A	N/A	1,319.4
1798	Flax-leaved Paperbark open to closed mesic forest on alluvial riverflats in the Sydney region	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions	Endangered	5.4
1803	Banksia – Needlebush – Tea-tree damp heath swamps on coastal sandstone plateaus of the Sydney basin	Coastal Upland Swamp in the Sydney Basin Bioregion	Endangered	222.4
1804	Needlebush – Banksia wet heath swamps on coastal sandstone plateaus of the Sydney basin	N/A	N/A	21.2
1808	Common Reed on the margins of estuaries and brackish lagoons along the New South Wales coastline	Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	0.0
1824	Mallee – Banksia – Tea-tree – Hakea heath-woodland of the coastal sandstone plateaus of the Sydney basin	N/A	N/A	772.6

1826	Dwarf Apple – Banksia – Tea-tree – Hakea heath-woodland on the hinterland sandstone plateaus from southern Sydney to Mangrove Mountain	N/A	N/A	3,184.6

Commonwealth listed threatened ecological communities (TECs)		
TEC name	**EPBC Act status**	**Area (ha)**
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	Endangered	116.2
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered	49.5
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered	501.9
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	Critically Endangered	17.7
Coastal floodplain eucalypt forest of eastern Australia	Currently being assessed for listing under EPBC Act	32.9

Threatened flora species			
Name	**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Acacia bynoeana (Bynoe's Wattle)	Vulnerable (BC Act) Endangered (EPBC Act)	10,162.4	21
Acacia pubescens (Downy Wattle)	Vulnerable (BC Act & EPBC Act)	3,909.7	44
Allocasuarina diminuta subsp. *mimica* population in the Sutherland Shire and Liverpool City local government areas	Endangered Population (BC Act)	0.0	15
Callistemon linearifolius (Netted Bottle Brush)	Vulnerable (BC Act)	0.0	1
Dillwynia tenuifolia	Vulnerable (BC Act)	0.0	2
Grevillea parviflora subsp. *parviflora* (Small-flower Grevillea)	Vulnerable (BC Act & EPBC Act)	833.5	920
Hibbertia fumana	Critically Endangered (BC Act)	0.0	882
Hibbertia puberula	Endangered (BC Act)	0.0	905
Leucopogon exolasius (Woronora Beard-heath)	Vulnerable (BC Act & EPBC Act)	17.8	5
Leucopogon fletcheri subsp. *fletcheri*	Endangered (BC Act)	0.0	2
Melaleuca deanei (Deane's Melaleuca)	Vulnerable (BC Act & EPBC Act)	165.3	23
Persoonia hirsuta (Hairy Geebung)	Endangered (BC Act & EPBC Act)	4,601.7	2

Persoonia nutans (Nodding Geebung)	Endangered (BC Act & EPBC Act)	1,117.8	263
Prostanthera saxicola population in Sutherland and Liverpool local government areas	Endangered Population (BC Act)	0.0	2
Pterostylis saxicola (Sydney Plains Greenwood)	Endangered (BC Act & EPBC Act)	123.8	3
Pultenaea aristata (Prickly Bush-pea)	Vulnerable (BC Act & EPBC Act)	0.0	3
Pultenaea pedunculata (Matted Bush-pea)	Endangered (BC Act)	0.0	3
Eucalyptus benthamii (Camden White Gum)	Vulnerable (BC Act & EPBC Act)	1.0	0
Litoria aurea (Green and Golden Bell Frog)	Endangered (BC Act) Vulnerable (EPBC Act)	148.3	0
Micromyrtus minutiflora	Endangered (BC Act) Vulnerable (EPBC Act	299.0	0
Pimelea spicata (Spiked Rice-flower)	Endangered (BC Act & EPBC Act)	203.0	0
Pomaderris brunnea (Brown Pomaderris)	Endangered (BC Act) Vulnerable (EPBC Act)	3,396.0	0
Pultenaea parviflora	Endangered (BC Act) Vulnerable (EPBC Act)	749.8	0
Allocasuarina glareicola	Endangered (BC Act & EPBC Act)	338.7	0
Deyeuxia appressa	Endangered (BC Act)	2.4	0
Genoplesium baueri (Yellow Gnat-orchid)	Endangered (BC Act & EPBC Act)	54.3	0
Persicaria elatior (Tall Knotweed)	Vulnerable (BC Act & EPBC Act)	5.1	0

BIO Map Priority Investment Areas

The site has been identified on BIO Map as containing over 1,115 ha of core areas and 59 ha of corridors

Type	**Area (ha)**
Core areas	1,114.9
State and Regional Biodiversity Corridors	58.6

ANIMAL SPECIES

The site contains records and habitat for a wide range of threatened fauna species, and is likely to contain habitat and populations of many common native fauna species (Eco Logical Australia, 2012; ERM, 2012)

Threatened fauna species			
Name	**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Pommerhelix duralensis (Dural Land Snail)	Endangered (BC Act & EPBC Act)	895.1	0
Pteropus poliocephalus (Grey-headed Flying-fox)	Vulnerable (BC Act & EPBC Act)	7,883.4	27
Botaurus poiciloptilus (Australasian Bittern)	Endangered (BC Act & EPBC Act)	9.2	0
Hoplocephalus bungaroides (Broad-headed Snake)	Endangered (BC Act) Vulnerable (EPBC Act)	261.9	4
Heleioporus australiacus (Giant Burrowing Frog)	Vulnerable (BC Act & EPBC Act)	170.6	19
Petauroides volans (Greater Glider)	Vulnerable (EPBC Act)	781.9	0
Chalinolobus dwyeri (Large-eared Pied Bat)	Vulnerable (BC Act & EPBC Act)	1,084.8	2
Macquaria australasica (Macquarie Perch)	Endangered (BC Act & EPBC Act)	7.6	0
Anthochaera phrygia (Regent Honeyeater)	Critically Endangered (BC Act & EPBC Act)	1,199.1	0
Rostratula australis (Australian Painted Snipe)	Endangered (BC Act & EPBC Act)	4.2	0
Dasyurus maculatus maculatus (Spot-tailed Quoll)	Vulnerable (BC Act) Endangered (EPBC Act)	997.8	4
Lathamus discolor (Swift Parrot)	Endangered (BC Act) Critically Endangered (EPBC Act)	1,199.1	6
Artamus cyanopterus cyanopterus (Dusky Woodswallow)	Vulnerable (BC Act)	0.0	7
Burhinus grallarius (Bush Stone-curlew)	Endangered (BC Act)	0.0	2
Callocephalon fimbriatum (Gang-gang Cockatoo)	Vulnerable (BC Act)	0.0	3
Calyptorhynchus lathami (Glossy Black-Cockatoo)	Vulnerable (BC Act)	0.0	5
Cercartetus nanus (Eastern Pygmy-possum)	Vulnerable (BC Act)	0.0	3
Climacteris picumnus victoriae (Brown Treecreeper)	Vulnerable (BC Act)	0.0	2
Daphoenositta chrysoptera (Varied Sittella)	Vulnerable (BC Act)	0.0	19
Dasyornis brachypterus (Eastern Bristlebird)	Endangered (BC Act & EPBC Act)	0.0	2
Epthianura albifrons (White-fronted Chat)	Vulnerable (BC Act)	0.0	2
Falsistrellus tasmaniensis (Eastern False Pipistrelle)	Vulnerable (BC Act)	0.0	24
Glossopsitta pusilla (Little Lorikeet)	Vulnerable (BC Act)	0.0	41

Haliaeetus leucogaster (White-bellied Sea-eagle)	Vulnerable (BC Act)	0.0	1
Hieraaetus morphnoides (Little Eagle)	Vulnerable (BC Act)	0.0	3
Litoria aurea (Green and Golden Bell Frog)	Endangered (BC Act) Vulnerable (EPBC Act)	0.0	3
Litoria littlejohni (Littlejohn's Tree Frog)	Vulnerable (BC Act)	0.0	1
Lophoictinia isura (Square-tailed Kite)	Vulnerable (BC Act)	0.0	3
Meridolum corneovirens (Cumberland Plain Land Snail)	Endangered (BC Act)	0.0	43
Micronomus norfolkensis (Eastern Coastal Free-tailed Bat)	Vulnerable (BC Act)	0.0	9
Miniopterus australis (Little Bent-winged Bat)	Vulnerable (BC Act)	0.0	1
Miniopterus orianae oceanensis (Large Bent-winged Bat)	Vulnerable (BC Act)	0.0	9
Myotis macropus (Southern Myotis)	Vulnerable (BC Act)	0.0	10
Neophema pulchella (Turquoise Parrot)	Vulnerable (BC Act)	0.0	1
Ninox connivens (Barking Owl)	Vulnerable (BC Act)	0.0	1
Ninox strenua (Powerful Owl)	Vulnerable (BC Act)	0.0	9
Pachycephala olivacea (Olive Whistler)	Vulnerable (BC Act)	0.0	1
Petaurus australis (Yellow-bellied Glider)	Vulnerable (BC Act)	0.0	1
Petaurus norfolcensis (Squirrel Glider)	Vulnerable (BC Act)	0.0	2
Petrogale penicillata (Brush-tailed Rock-wallaby)	Endangered (BC Act) Vulnerable (EPBC Act)	0.0	1
Petroica boodang (Scarlet Robin)	Vulnerable (BC Act)	0.0	11
Petroica phoenicea (Flame Robin)	Vulnerable (BC Act)	0.0	1
Phascolarctos cinereus (Koala)	Vulnerable (BC Act & EPBC Act)	0.0	298
Pseudophryne australis (Red-crowned Toadlet)	Vulnerable (BC Act)	0.0	40
Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)	Vulnerable (BC Act)	0.0	20
Scoteanax rueppellii (Greater Broad-nosed Bat)	Vulnerable (BC Act)	0.0	22
Stagonopleura guttata (Diamond Firetail)	Vulnerable (BC Act)	0.0	2
Tyto novaehollandiae (Masked Owl)	Vulnerable (BC Act)	0.0	1
Varanus rosenbergi (Rosenberg's Goanna)	Vulnerable (BC Act)	0.0	4

CONSERVATION AND SPECIAL USE AREAS

The Moorebank Intermodal Terminal Biobanking Agreement site occurs in the north of the site.

The closest conservation or special use areas are:

- Dharawal National Park (adjacent to the southern boundary of the site)
- Heathcote National Park (adjacent to the eastern boundary of the site)
- Georges River National Park (adjacent to the north eastern boundary of the site)

HERITAGE PLACES AND ITEMS
The site partially contains two areas listed on the Commonwealth Heritage List for their outstanding cultural and natural value (DoEE, 2018a): • Old Army/ Internment Camp Group Holsworthy • Cubbitch Barta National Estate Area The site also contains areas listed by local government and state agencies on the NSW heritage list (OEH, 2019c): • Cubbitch Barta National Estate Area • Holsworthy (former) Corporals Club • Holsworthy (former) Officer's Mess • Holsworthy Group (Old Army/ Internment Camp Holsworthy) • Holsworthy Powder Magazine (Former Detention Block) Holsworthy Defence base contains two areas on the Register of the National Estate Area (non-statutory): • Cubbitch Barta National Estate Area – registered for its indigenous value • Defence National Storage and Distribution Centre – listed on the interim list for its historic value It is not known whether the site has any other historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having any other heritage values
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES
The site is a defence base, including a training area and artillery range, for the Australian Army. Activities carried out on the base include the use of firing ranges, chemical weapons testing, fire training, vehicle maintenance, and bulk chemical storage and distribution from numerous above ground and underground storage tanks. Holsworthy Military Airport is also located in the site. The site exists under the Native Title Claim of the South Coast of NSW by the South Coast People (Tribunal file no. NC2017/003) (NNTT, 2020). The following tenements exist on this site (NNTT, 2020): • Mining tenement (AUTH6) • Mining tenement (AUTH432CCL724)

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 11 due to the Plan.

Indirect and facilitated impacts

At the closest point, Site 11 occurs approximately 1.4 km from the nearest development under the Plan – a relatively small area of urban capable land in the northern part of GMAC. The land in between this urban capable land and Site 11 consists of existing high density residential areas.

The location of the site relative to the development and near existing high density residual areas means:

- The site is very unlikely to be impacted by impacts typically associated with construction of the development in GMAC, such as air quality, noise, construction traffic, or the spread of weeds or disease
- The heritage values of the site will not be impacted by alterations to the setting of the place inconsistent with its values, such as through changes to the surrounding landscape causing visual or amenity impacts

The potential indirect and facilitated impacts associated with these developments and the key values of the environment of Site 11 that are potentially impacted are shown in Table 35-11.

Table 35-11: Potential indirect impacts on Site 11 associated with the development

Potential indirect impact	Extent within Site 11	Duration	Values potentially impacted
Construction			
Changes to water quality from soil erosion or disturbance of contaminated soils	Waterways within the site	Generally short term	Water resources
Clearing of habitat during construction of the development that links the site to other areas of habitat, leading to impacts on biodiversity values	Whole of site	Long term	Biodiversity values
Operation			
Changes to surface water flows due to additional runoff from urban areas		Long term	Water resources
Disruption to land uses, services or infrastructure	Whole of site	Long term	People and communities

Biodiversity values

Site 11 has been identified on BIO Map as containing large areas of core areas and corridors, and is therefore a significant site for habitat connectivity across the subregion.

Clearing of habitat in GMAC associated with urban capable land has the potential to lead to impacts on the biodiversity values of the site due to a reduction in habitat connectivity to and from the site.

The site is well connected to large areas of habitat and protected lands, including Dharawal National Park, Heathcote National Park and Georges River National Park. The site connects Heathcote National Park in the east to Dharawal National Park and other large areas of habitat in the west in the vicinity of the Georges River and Nepean River.

The development under the Plan will not disrupt these habitat connectivity links from the site to the surrounding area, and therefore the habitat values of the site are unlikely to be impacted indirectly by the Plan. While development in GMAC will reduce habitat connectivity across the nominated area to some extent, large habitat corridors that occur along riparian corridors and gullies, including BIO Map core areas and corridors, will generally be maintained.

Water resources

Construction and operation of urban, industrial and infrastructure development in GMAC may result in changes to surface water flows and impact the water quality of the Georges River, which forms the western boundary of Site 11.

These impacts are discussed below separately in relation to the different areas of urban capable land within GMAC that may affect the Georges River, as these different areas are likely to have different risks. The Plan includes commitments that are expected to adequately address these potential impacts on water resources (see below).

Development in GPEC northern section (near Glenfield)

Development in the northern section of GPEC will be partially located in the catchment of Bunbury Curran Creek and Glenfield Creek, both of which discharge into the Georges River. These potential impacts are considered to be minor. Both these catchments, as well as the Georges River catchment, are already subject to significant levels of urban development, which reduces the consequence of any water quality impacts.

Middle section (development between Glen Alpine and Rosemeadow)

The majority of this section of urban development under the Plan is located within the catchment of the Nepean River, with only a small area (approximately 19 ha) located within the upstream tributary catchments of Bow Bowing Creek, which discharges into Bunbury Curran Creek and then the Georges River. The length of watercourse between the development site and the discharge point into the Georges River is approximately 20 km.

The catchment of Bow Bowing Creek and Bunbury Curran Creek is already heavily developed, with the vast majority of the catchment area covered by urban development. Bow Bowing Creek has also been developed, including an area of impoundment and development of the creek corridor to form drainage channels. Overall, the environmental values of this catchment are very limited. Therefore, it is not considered that the comparatively small area of urban development within this catchment under the Plan will significantly degrade the water quality of the Georges River.

Southern section (development between Gilead and Appin)

The southern section of urban development within GMAC is located within the Nepean Catchment, and therefore there is no risk that urban development in this area will result in a decline in water quality of the Georges River.

People and communities

Population increases associated with urban development in GMAC may lead to increased pressure on roads, transport and other infrastructure that service the army base. However, the Plan intends to provide for future transport needs by supporting the delivery of major transport projects for Western Sydney. It is also expected that future transport and infrastructure needs of the army base will be provided for through existing local and regional planning processes.

As Site 11 is a military facility that is not open to the public, there is no risk that population increases associated with urban development will result in increased pressures associated with visitation or use of the site by the public.

Commitments and mitigation measures

The Plan includes commitments to mitigate indirect impacts from construction and operation associated with urban and industrial development, and infrastructure development. These commitments and processes to deliver these comments are different for each type of development.

Urban and industrial development

The Plan includes a commitment to mitigate indirect and prescribed impacts from development to best practice standards (Commitment 5). This commitment will be delivered through development controls specified in Development Control Plans (DCPs) and implemented through the standard development application process that occurs under the NSW planning system. A description of the process is provided in Chapter 15, section 15.6.1.

Relevant councils will prepare a DCP for each nominated area in collaboration with the Department and in accordance with standard processes for developing DCPs in NSW. The DCP will include development controls relevant to addressing the indirect and facilitated impacts of the urban and industrial development that may affect Site 11.

The general environmental controls likely to be included in DCPs are set out in Chapter 15, section 15.6.1, and include:

- Preparation of Construction Environmental Management Plans to manage on-site construction impacts
- Controls for managing impacts to hydrology and water quality

These development controls and the process for implementing them are expected to adequately address the potential indirect and facilitated impacts of the urban and industrial development that will occur adjacent to Site 11.

A detailed description of the development controls and implementation process, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.1.

Infrastructure development

The Plan includes a commitment to mitigate indirect and prescribed impacts from infrastructure development (Commitment 5.3). This commitment will be delivered through an environmental assessment and approval process that will be applied to detailed design of each infrastructure project at the time the project is brought forward for development. This will be undertaken under Part 4 or Part 5 of the EP&A Act (or equivalent at the time). State Environmental Planning Policy (SEPP) (Infrastructure) 2007 provides a framework for determining how most types of infrastructure are assessed under the EPA Act.

This assessment process will assess and identify mitigation measures to manage the non-biodiversity related potential environmental impacts of the project. This will include the assessment and management of indirect impacts of any infrastructure projects that may affect Site 11, including impacts to hydrology and water quality.

This process therefore provides the mechanism to identify and implement mitigation measures to manage the potential indirect impacts on Site 11 from the infrastructure development.

A detailed description of the assessment and approval process for infrastructure, including Department oversight and assurance mechanisms, is provided in Chapter 15, section 15.6.2.

35.3.12 SITE 12

PROFILE

SITE DETAILS				
Owner	The Commonwealth of Australia			
Site name	N/A			
Site ID number	12			
Area	0.2 ha			
Address	Whittle Road, Edmondson Park NSW			
Folio	134/123070			
General description	The site located at the intersection of Whittle Road and Mckechnie Road. The site does not contain any native vegetation. The site occurs within the Strategic Assessment Area, approximately 35 km south-west of the Sydney CBD			
Site map	The location of Site 12 is shown in Map 54.13			
DISTANCE FROM URBAN CAPABLE LANDS/ TRANSPORT CORRIDORS				
The site is located approximately 1.8 km from the nearest development under the Plan – urban capable land in GMAC. The land between Site 12 and the nearest development primarily consists of existing urban development				
LANDSCAPES AND LANDFORMS				
The site is located in a suburban area and does not appear to have any landforms				
SOIL AND SUBSTRATES				
The soil landscape at Site 12 is made up of 0.2 ha of Blacktown soil – Blacktown soils are a hardsetting soils that have a shallow to moderately deep depth of > 100 cm (OEH, 2018a)				
WATER				
The site occurs within the Georges River catchment A minor non-perennial watercourse passes through the southern half of the site				
VEGETATION				
No native vegetation occurs on the site. However, a small area of potential habitat for three threatened flora species occurs on site.				
Plant Community Types (PCTs)/ NSW listed threatened ecological communities (TECs)				
PCT number	**PCT name**	**NSW TEC name**	**BC Act status**	**Area (ha)**
0	Cleared	N/A	N/A	0.2
Threatened flora species				
Name		**EPBC Act or BC Act status**	**Area of habitat (ha)**	**Number of BioNet records**
Acacia pubescens (Downy Wattle)		Vulnerable (BC Act & EPBC Act)	0.2	0
Micromyrtus minutiflora		Endangered (BC Act) Vulnerable (EPBC Act	0.2	0

Pimelea spicata (Spiked Rice-flower)	Endangered (BC Act & EPBC Act)	0.1	0
BIO Map Priority Investment Areas			
No BIO Map core or corridor areas have been identified on this site			
ANIMAL SPECIES			
No fauna species have been recorded on site			
CONSERVATION AND SPECIAL USE AREAS			
There are no conservation or special use areas present on this site The closest conservation or special use areas are: • Metro offset (approximately 1 km south and 2 km north-east) • Edmondson Regional Park (approximately 2 km south west)			
HERITAGE PLACES AND ITEMS			
It is not known whether the site has any historic or indigenous heritage values. The site is not listed in the Australian Heritage Database as having any heritage values			
SERVICES AND INFRASTRUCTURE/PEOPLE AND COMMUNITIES			
This site is a vacant block with no visible buildings or other infrastructure No tenement exists on this site (NNTT, 2020) No Native Title Claims exist over this site (NNTT, 2020)			

IMPACT ASSESSMENT

Direct impacts

There will be no direct impacts to Site 12 due to the Plan.

Indirect and facilitated impacts

Site 12 is located within an existing, heavily developed urban area, approximately 1.8 km from the nearest urban capable land associated with the Plan – urban capable land in GMAC. The land between Site 12 and the nearest development primarily consists of existing urban development. The site is also located upstream of the nearest urban development and within a separate sub-catchment.

The location of the site relative to the development and within a high density existing urban area means:

- The site is very unlikely to be impacted by impacts associated with construction of the development in GMAC, such as air quality, noise, construction traffic, or the spread of weeds or disease
- The site will not be impacted by soil erosion of sedimentation, changes to surface and groundwater quantity and flows, or water quality impacts associated with the construction and operation of the development

Furthermore, the site is unvegetated and has no or little biodiversity value and has no known heritage values. The site contains no buildings or other infrastructure and appears to be unused.

There are no potential indirect or facilitated impacts associated with the development considered relevant to the site.

Commitments and mitigation measures

No commitments or mitigation measures are considered necessary to address the potential indirect impacts on the environment of Site 12 from the development under the Plan.

36 Summary of transport program impacts

36.1 INTRODUCTION

This Chapter provides:

- A summary of the transport development
- A summary of the impacts of the transport program on MNES under the EPBC Act including:
  - Avoidance outcomes and commitments
  - Direct impacts and commitments to address these impacts
  - Indirect impacts and commitments to address these impacts
- An assessment of the direct and indirect impacts of the two transport corridor tunnels
- A conclusion about the overall outcome in relation to the transport corridors under the Plan

The summary draws on the detailed analysis of the impacts of the Plan and the adequacy of the commitments under the Plan to address these impacts on each MNES presented earlier in this Assessment Report.

These detailed impact assessments have shown that the direct, indirect and cumulative impacts of the transport (and urban) development under the Plan on MNES are acceptable and that the commitments under the Plan will adequately protect and conserve these matters in the context of these impacts.

Part 7 provides an evaluation of the overall adequacy and acceptability of the Plan in the context of the impacts of the development under the Plan and in accordance with the regulatory requirements of the BC Act and EPBC Act.

The transport program is described in Chapter 7.

Indicative locations of the transport corridors are shown in Figure 36-1.

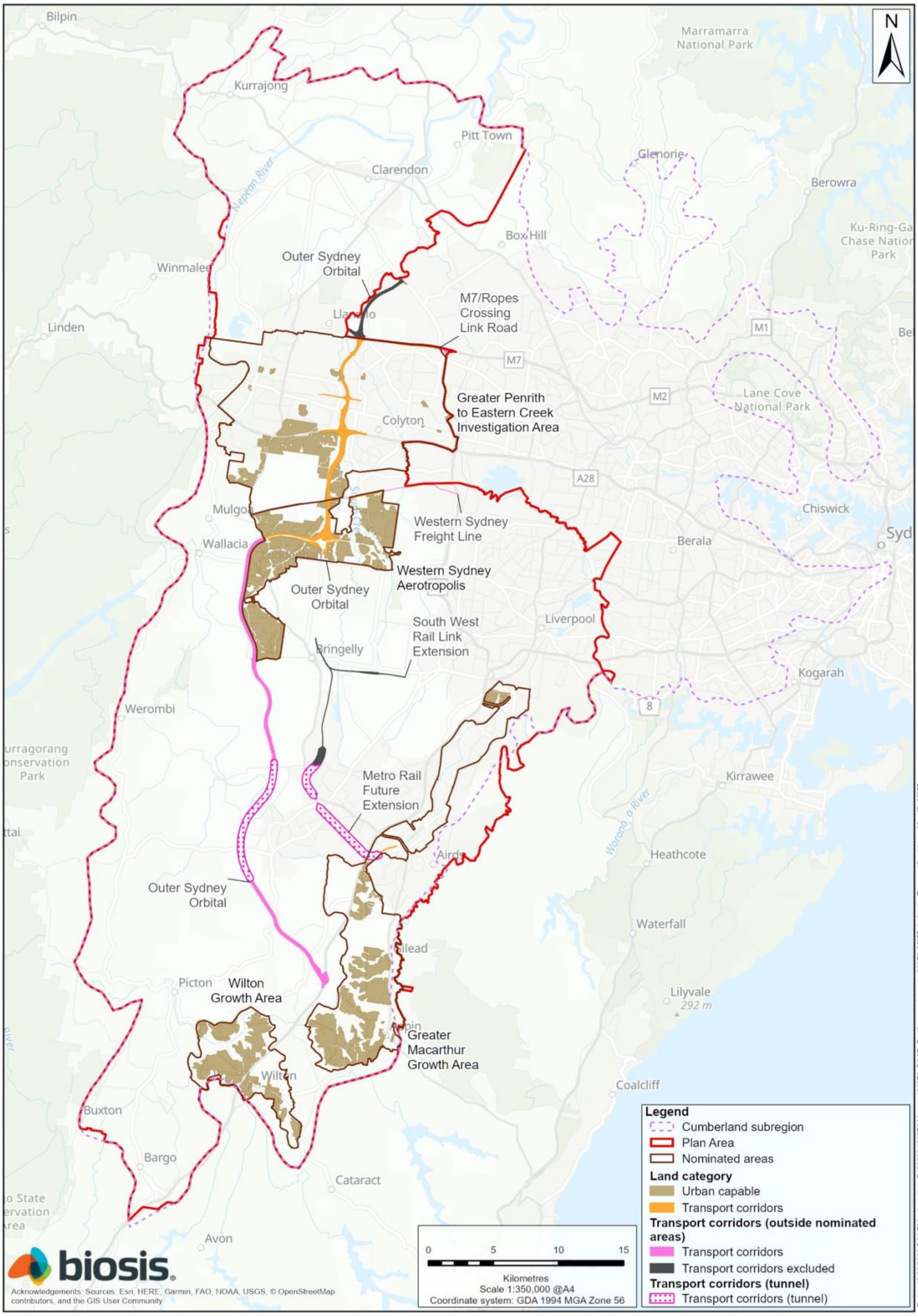

Figure 36-1: Indicative locations of transport corridors within the Strategic Assessment Area

36.2 SUMMARY OF THE TRANSPORT DEVELOPMENT

36.2.1 TRANSPORT CORRIDORS

The Plan includes the design, construction and operation of several major road and rail transport projects that will generally be located within the transport corridors shown in Figure 36-1. The transport projects are listed in Table 36-1.

Table 36-1: Transport projects covered under the Plan

<table>
<tr><th>Project</th><th>Description</th><th>Timing</th></tr>
<tr><td>Sydney Metro Greater West south from Western Sydney Aerotropolis to Macarthur (except for those areas within the existing South West Growth Area)</td><td>Provides for a commuter railway line</td><td>0 to 10 years</td></tr>
<tr><td>Western Sydney Freight Line corridor</td><td>Provides for a future freight rail line to connect Port Botany and Western Sydney</td><td rowspan="2">10 to 20 years</td></tr>
<tr><td>Outer Sydney Orbital (Stage 1) from Palmyra Avenue to the Hume Motorway</td><td rowspan="2">Provides for a future north south motorway and freight rail line</td></tr>
<tr><td>Remaining Outer Sydney Orbital 1</td><td rowspan="2">20 or more years</td></tr>
<tr><td>M7/Ropes Crossing Link Road</td><td>Provides for a future east-west motorway linking the M7 to the future Outer Sydney Orbital at Ropes Crossing</td></tr>
</table>

Development under the transport class of action includes all activities associated with the design, construction, and operation of the major road or rail projects. This includes any development on land within the transport corridors shown in the Plan (see Figure 36-1) or on any other land required for the transport project along these general alignments, as identified under the NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process).

The transport activities included under the Plan include, but are not limited to:

- Vegetation clearing
- Earthworks
- Utility works
- Landscaping
- Erosion and sediment control
- Laydown areas
- Road and rail construction
- Tunnel construction
- Construction of supporting infrastructure such as stations, car parks and pedestrian access
- Electricity infrastructure
- Site offices and access roads
- Dust and noise suppression
- Stormwater management (including detention basins, ponds and dams)
- Vehicle and train movements
- Maintenance and upgrade activities
- Installation and maintenance of traffic control and safety infrastructure

As each transport project is brought forward for investigation, the project will be subject to:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor

- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process under the EP&A Act)

The transport projects included in the Plan have not finalised implementing a process to avoid biodiversity values as the alignment for the corridors are not currently certain. Additional areas will be avoided during strategic planning and detailed design of the transport projects. The Plan includes commitments for further avoidance and minimisation of impacts to biodiversity values related to the transport corridors (see section 36.3).

36.2.2 TUNNELS

Development under the transport class of action includes tunnel construction and operation. Sections of two of the transport corridors are proposed to include tunnels. These are:

- Outer Sydney Orbital (OSO) tunnel – Cobbitty to Cawdor
- Metro Rail Future Extension (MRFE) tunnel – Oran Park to Narellan, and Narellan to Macarthur

The location of the tunnels are shown in Figure 36-1.

The activities associated with tunnelling may include but are not limited to the matters shown in Table 36-2.

Table 36-2: Construction activities and operational infrastructure associated with transport corridor tunnels

Project phase	Activities
Construction activities	• Site establishment and enabling work, including but not limited to utility work, fencing and hoarding, construction ancillary facilities and access, demolition of buildings and structures and clearance of vegetation where required • Erection of acoustic sheds (where relevant) over the temporary access tunnels and to contain noise and dust from tunnelling operations • Construction of temporary access tunnels • Construction of main tunnels, including but not limited to entry and exit ramps and associated tunnelled infrastructure • Spoil management and haulage • Finishing work in tunnel and provision of permanent tunnel services, including but not limited to mechanical and electrical fit out • Drainage work, including permanent water treatment facilities
Operational infrastructure	• Utilities infrastructure (including adjustments to, or relocation of, existing utilities infrastructure), electronic tolling facilities, signage, ventilation systems, emergency systems, systems for the control and management of roads, and tunnel control centre facilities • Entry and exit ramps (tunnel portals) • Connection to power, including construction of or connection to electrical substations • Connection and tie in with existing surface roads and infrastructure • Pedestrian and cyclist facilities • Drainage work, pavement and finishing work (including landscaping and urban design treatments)

As for the other parts of the transport corridors, development for the tunnels will generally occur within the footprints of the tunnels shown in Figure 36-1. In limited cases, development activities may be necessary adjacent to the footprint.

36.3 AVOIDANCE OF IMPACTS

36.3.1 SUMMARY OF AVOIDANCE PROCESSES

Avoidance and minimisation of impacts from the transport corridors is being undertaken in two stages:

- Processes to locate the transport corridors – this has already been undertaken
- Strategic planning and detailed design of each transport project within the transport corridors

Details of the processes to locate the transport corridors are provided in Chapter 14.

The future process to further avoid and minimise impacts through detailed design is summarised below.

36.3.2 COMMITMENTS FOR FURTHER AVOIDANCE

The transport corridors included in the Plan have not completed the process to avoid and minimise impacts to biodiversity values as the alignments of the transport projects within each corridor are not currently certain (see Part 2).

The Plan includes commitments for further avoidance and minimisation of impacts to biodiversity values related to the transport corridors. This will be undertaken through:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor
- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process)

For the parts of the transport corridors within the nominated areas, the Plan commits to avoiding and minimising impacts to TECs, species and habitat (Commitment 3). This includes avoiding where possible:

- Areas of high biodiversity value (defined by the Plan's 'avoidance criteria' – see Chapter 14)
- Areas of potential habitat connectivity, particularly vegetation in riparian corridors, for specific species
- Known flora populations for specific species in specific locations

For the parts of the transport corridors outside the nominated areas, the Plan commits to avoiding and minimising impacts to species and TECs in accordance with the major infrastructure corridors class of action description and the BC Act, including the BAM (Commitment 4). This includes avoiding where possible:

- Known flora populations for specific species in specific locations
- Other specific locations of high biodiversity value
- Commonwealth land at three sites

The commitments for future avoidance relating to the transport corridors are considered adequate to ensure the corridors avoid and minimise the risk of unacceptable impacts on biodiversity values. The commitments ensure:

- Avoidance outcomes are achieved consistent with the Plan's 'avoidance criteria' (see Chapter 14) or are assessed in assessed and determined in accordance with the BAM (for the transport corridors outside the nominated areas)
- Impacts to known key biodiversity values within the corridors are avoided and minimised where possible, including specific species and habitat, and/or specific locations of high biodiversity value
- Avoidance of biodiversity values as well as the costs of offsets is taken into account in the evaluation of the route options (e.g. multi-criteria analysis) during the planning phase of each project

36.4 DIRECT IMPACTS

36.4.1 SUMMARY OF IMPACTS

The direct impacts that may occur due to the transport corridors are associated with construction and are:

- Habitat loss
- Habitat fragmentation and loss of habitat connectivity

The direct impacts of the transport corridors on MNES are assessed in Chapters 29 to 35.

A summary of the direct impacts on Commonwealth-listed species and TECs is provided in:

- Table 36-4 – transport impacts to threatened fauna
- Table 36-5 – transport impacts to threatened flora
- Table 36-6 – transport impacts to TECs

These tables identify impacts in relation to each transport corridor, as well as the total impact of the transport corridors and the contribution of the transport program to the total impacts of the development under the Plan.

Impacts are calculated on a worst-case scenario basis by assuming the entirety of each transport corridor will be impacted (as described above, in practice, these impacts will be reduced through future avoidance processes).

Table 36-3 provides the meaning of the acronyms used in the impact tables.

Table 36-3: Acronyms used in impact tables

Transport project acronym	Description
Metro	Sydney Metro Greater West south from Western Sydney Aerotropolis to Macarthur (except for those areas within the existing South West Growth Area)
WSFL	Western Sydney Freight Line corridor
OSO	Outer Sydney Orbital (Stage 1) from Palmyra Avenue to the Hume Motorway
M7 Link	M7/Ropes Crossing Link Road

The transport corridors will not have notable direct impacts on other MNES, including:

- Migratory species (see Chapter 32)
- Ramsar wetlands (see Chapter 33)
- World and National Heritage (see Chapter 34)

There are direct impacts from the transport corridors on one Commonwealth land site – this comprises 4.2 ha on Site 11 at 221 Greendale Rd, Greendale NSW. This impact is not considered notable. The use of the site is unknown, although it appears to be used for grazing, and impacts on biodiversity values are minor (see Chapter 35).

There may also be direct impacts on Commonwealth land from the tunnels. These impacts are assessed in section 36.6.

THREATENED FAUNA

The following outlines the magnitude of impact to each threatened fauna species solely with regards to development of the transport program. Chapter 30 provides a detailed assessment of each species as a result of all development (transport in addition to urban capable development) under the Plan, and produces a risk ranking for each fauna species with regards to their magnitude of direct impacts under the Plan. It is noted that the risk ranking relates to both urban capable and transport development, rather than just transport, and so it is possible for a species to have low transport impacts yet a high risk rating as a result of impacts due to urban capable development (and vice versa).

The transport corridors will directly impact potential habitat for 10 of the 20 fauna species, including: Regent Honeyeater (low risk), Australasian Bittern (low risk), Swift Parrot (medium risk), Australian Painted Snipe (very low risk), Large-eared Pied Bat (low risk), Spot-tailed Quoll (low risk), Greater Glider (very low risk), Grey-headed Flying Fox (low risk), Green and Golden Bell Frog (very low risk) and the Dural Land Snail (very low risk).

The most notable direct impacts occur to:

- Regent Honeyeater (low risk) and Swift Parrot (medium risk) in habitat along Wianamatta (South Creek), in Wianamatta Regional Park and in Cobbitty due to the OSO
- Grey-headed Flying-fox (low risk) in habitat along Wianamatta (South Creek), in Wianamatta Regional Park and in Cobbitty due to the OSO

The largest impacts to potential habitat will occur to:

- Wide ranging species such as the Grey-headed Flying-fox (low risk) (346.9ha of impact) and Spot-tailed Quoll (low risk) (239.9 ha of impact)
- Species with broad associations with woodland habitats primarily for foraging, such as the Swift Parrot (430.6 ha of impact) and the Regent Honeyeater (low risk) (430.6 ha of impact)

The species most impacted in terms of the percentage of total habitat in the Strategic Assessment Area is the Australasian Bittern (low risk), which will have 2.9 per cent of its potential habitat impacted.

The transport corridors will directly impact known important populations of some fauna species, including:

- Grey-headed Flying-fox (low risk) (1 population)
- Spot-tailed Quoll (low risk) (1 population)

THREATENED FLORA

The following outlines the magnitude of impact to each threatened flora species solely with regards to development of the transport program. Similar to fauna, Chapter 29 provides a detailed assessment of each species as a result of all development (transport in addition to urban capable development) under the Plan, and produces a risk ranking for each flora species with regards to their magnitude of direct impacts under the Plan. It is noted that the risk ranking relates to both urban capable and transport development, rather than just transport, and so it is possible for a species to have low transport impacts yet a high risk rating as a result of impacts due to urban capable development (and vice versa).

The transport corridors will directly impact potential habitat for 14 of the 23 flora species. These include: *Acacia bynoeana* (very low risk), *Acacia pubescens* (very low risk), *Allocasuarina glareicola* (very low risk), *Cynanchum elegans* (medium risk), *Eucalyptus benthamii* (low risk), *Grevillea parviflora* subsp. *parviflora* (low risk), *Micromyrtus minutiflora* (very low risk), *Persicaria elatior* (very low risk), *Persoonia bargoensis* (low risk), *Persoonia hirsuta* (low risk), *Persoonia nutans* (medium risk), *Pimelea curviflora* var. *curviflora* (very low risk), *Pimelea spicata* (high risk), *Pomaderris brunnea* (low risk), *Pultenaea parviflora* (high risk).

The most notable direct impacts occur to:

- *Pimelea spicata* (high risk) in habitat along Wianamatta (South Creek), near Orchard Hills, Shanes Park near Horsley Park due to the OSO, eastern end of the M7 link and WSFL
- *Acacia pubescens* (very low risk) in habitat along Wianamatta (South Creek), near Orchard Hills and near Horsley Park due to the OSO and WSFL

The largest impacts to potential habitat will occur to:

- *Pimelea spicata* (high risk) (241.3 ha of impact)
- *Acacia pubescens* (very low risk) (188.8 ha of impact)
- *Pomaderris brunnea* (low risk) (168.8 ha of impact)
- *Pultenaea parviflora* (high risk) (157.9 ha of impact)

The species most impacted in terms of the percentage of total habitat in the Strategic Assessment Area is *Persicaria elatior* (very low risk), which will have 2.8 per cent of its potential habitat impacted.

The transport corridors will directly impact known important populations of some flora species, including:

- *Persoonia nutan*s (medium risk) (1 population)
- *Pultenaea parviflora* (3 populations, including 2 populations in GPEC and one outside nominated areas

THREATENED ECOLOGICAL COMMUNITIES

The following outlines the magnitude of impact to each TEC with solely with regards to development of the transport program. Chapter 31 provides a detailed assessment of each species as a result of all development (transport in addition to urban capable development) under the Plan. The following outlines the area of each TEC impacted by transport development under the Plan, with the total impact of all development under the Plan (transport in addition to urban development) provided in brackets to provide additional context.

The transport corridors will directly impact 4 of the TECs. These include:

- Coastal floodplain eucalypt forest of eastern Australia (FPAL): 166.8 ha impacted by transport (210.2 ha impacted in total by the Plan)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest: 51.5 ha impacted by transport (154.7 ha impacted in total by the Plan)

- Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion: 14.9 ha impacted by transport (26.3 ha impacted in total by the Plan)
- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community: 1.4 ha impacted by transport (1.8 ha impacted in total by the Plan)

The most notable direct impacts occur to:

- Coastal floodplain eucalypt forest of eastern Australia (FPAL) along Wianamatta (South Creek) due to the OSO
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest in habitat in Cobbitty and Shanes Park due to the OSO and M7/Ropes Crossing Link Road

The TEC most impacted by transport development in terms of the percentage of total TEC in the Strategic Assessment Area is Coastal floodplain eucalypt forest of eastern Australia (2.4 per cent) and Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion (1.9 per cent).

Table 36-4: Transport impacts to potential habitat for Commonwealth listed threatened fauna

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECTS				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
BIRDS											
Anthochaera phrygia	Regent Honeyeater	CE	59,460.4	1.2	14.5	381.3	33.7	**430.6**	**0**	**0.7%**	**33.5%**
Botaurus poiciloptilus	Australasian Bittern	E	2,524.4	0.4	2.0	70.8	0.0	**73.1**	**0**	**2.9%**	**83.3%**
Calidris canutus	Red Knot	E, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Calidris ferruginea	Curlew Sandpiper	CE, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Charadrius leschenaultii	Greater Sand-plover	V, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Lathamus discolor	Swift Parrot	CE	59,460.4	1.2	14.5	381.3	33.7	**430.6**	**0**	**0.7%**	**33.5%**
Limosa lapponica	Bar-tailed Godwit	V, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Numenius madagascariensis	Eastern Curlew	CE, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Rostratula australis	Australian Painted Snipe	E	2,230.9	0.0	0.2	16.2	0.0	**16.4**	**0**	**0.7%**	**41.5%**
MAMMALS											
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	25,555.0	1.0	0.0	3.5	0.0	**4.5**	0	**0.0%**	**1.4%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECTS				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (south eastern mainland population)	E	32,527.0	0.0	2.1	227.8	10.0	**239.9**	1	**0.7%**	**35.5%**
Petauroides volans	Greater Glider	V	25,762.9	0.0	4.8	57.5	3.0	**65.3**	0	**0.3%**	**48.7%**
Phascolarctos cinereus	Koala (combined populations of Qld, NSW and the ACT)	V	14,432.0	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
Pteropus poliocephalus	Grey-headed Flying-fox	V	26,873.3	0.5	11.8	307.8	26.9	**346.9**	1	**1.3%**	**48.0%**
REPTILES											
Hoplocephalus bungaroides	Broad-headed Snake	V	6,735.2	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
AMPHIBIANS											
Heleioporus australiacus	Giant Burrowing Frog	V	4,074.7	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
Litoria aurea	Green and Golden Bell Frog	V	5,500.9	0.0	0.1	2.3	0.5	**3.0**	0	**0.1%**	**21.3%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECTS				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
INVERTEBRATES											
Pommerhelix duralensis	Dural Land Snail	E	25,503.4	0.0	2.4	32.7	10.7	**45.8**	0	**0.2%**	**100.0%**
FISH											
Macquaria australasica	Macquarie Perch	E	20.5	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**

Note: The White-throated Needletail (*Hirundapus caudacutus*) is not included in this table, as it was not possible to produce a meaningful habitat map for this species as it is predominantly an aerial species. Refer to Chapter 30 for further information.

Table 36-5: Transport impacts to potential habitat for Commonwealth listed threatened flora

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECT				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	V	30,677.7	0.0	0.4	3.1	0.1	**3.5**	**0**	**0.0%**	**1.8%**
Acacia pubescens	Downy Wattle, Hairy Stemmed Wattle	V	35,102.3	1.1	29.0	146.9	11.8	**188.8**	**0**	**0.5%**	**23.8%**
Allocasuarina glareicola		E	4,417.6	0.0	0.0	0.1	4.4	**4.5**	**0**	**0.1%**	**37.9%**
Commersonia prostrata	Dwarf Kerrawang	E	61.9	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Cynanchum elegans	White-flowered Wax Plant	E	3,342.5	0.0	0.0	19.6	0.0	**19.6**	**0**	**0.6%**	**100.0%**
Deyeuxia appressa		E	19.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	V	4,799.7	0.0	0.5	46.8	0.0	**47.3**	**0**	**1.0%**	**100.0%**
Genoplesium baueri	Yellow Gnat-orchid	E	772.1	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	7,504.7	0.0	0.0	0.0	3.9	**3.9**	**0**	**0.1%**	**24.4%**
Hibbertia puberula subsp. *glabrescens*		CE	43.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECT				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
Leucopogon exolasius	Woronora Beard-heath	V	267.2	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Melaleuca deanei	Deane's Melaleuca	V	14,445.1	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Micromyrtus minutiflora		V	36,680.4	0.0	0.0	138.4	4.4	**142.8**	**0**	**0.4%**	**89.1%**
Persicaria elatior	Knotweed	V	1,703.4	0.0	0.6	47.1	0.0	**47.7**	**0**	**2.8%**	**98.7%**
Persoonia bargoensis	Bargo Geebung	V	12,338.6	0.0	0.0	0.0	0.4	**0.0**	**0**	**0.0%**	**0.0%**
Persoonia glaucescens	Mittagong Geebung	V	2,378.2	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Persoonia hirsuta	Hairy Geebung, Hairy Persoonia	E	11,433.3	0.0	5.2	0.0	0.9	**6.2**	**0**	**0.1%**	**100.0%**
Persoonia nutans	Nodding Geebung	E	14,874.7	0.0	0.0	4.1	4.4	**8.5**	1	**0.1%**	**20.6%**
Pimelea curviflora var. *curviflora*		V	13,064.1	0.0	0.0	38.7	15.0	**53.7**	**0**	**0.4%**	**70.8%**
Pimelea spicata	Spiked Rice-flower	E	34,859.0	4.6	38.2	163.3	35.2	**241.3**	**0**	**0.7%**	**25.3%**
Pomaderris brunnea	Rufous Pomaderris	V	26,092.1	0.9	1.1	165.8	1.0	**168.8**	**0**	**0.6%**	**83.4%**
Pterostylis saxicola	Sydney Plains Greenhood	E	11,792.4	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS BY TRANSPORT PROJECT				TOTAL IMPACTS			
				Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts to important populations	Total transport impacts as % of habitat in SAA	Transport % of total Plan impacts
Pultenaea parviflora		V	20,207.9	0.0	15.9	116.3	25.7	**157.9**	3	**0.8%**	**83.8%**

Table 36-6: Transport impacts to Commonwealth listed threatened ecological communities

TEC Name	Cth status	Total TEC in SAA (ha)	IMPACTS BY TRANSPORT PROJECT				TOTAL IMPACTS		
			Metro (ha)	WSFL (ha)	OSO (ha)	M7 Link (ha)	Total transport impacts (ha)	Total transport impacts as % of TEC in SAA	Transport % of total Plan impacts
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	E	2,769.0	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	E	271.0	0.0	0.0	1.4	0.0	**1.4**	**0.5%**	**77.1%**
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	CE	791.0	0.0	0.0	14.9	0.1	**14.9**	**1.9%**	**56.9%**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	9,737.2	0.0	0.2	41.5	9.7	**51.5**	**0.5%**	**33.3%**
Coastal floodplain eucalypt forest of eastern Australia	FPAL*	6,944.0	1.2	4.6	155.7	5.3	**166.8**	**2.4%**	**79.3%**
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE	8,214.1	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	CE	44.0	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	CE	960.8	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**

* Proposed for listing under the EPBC Act

36.4.2 COMMITMENTS TO ADDRESS DIRECT IMPACTS

The Plan includes commitments to address the direct impacts of the transport corridors on Commonwealth listed species and TECs. The key commitments apply to both the transport and other impacts of the Plan, and include to:

- Secure a minimum of 5,475 hectares of native vegetation in the Cumberland subregion (Commitment 8) to conserve biodiversity values in perpetuity, including specific amounts of habitat for Commonwealth-listed species and TECs
- Undertake ecological restoration of up to 25% of the offset target for native vegetation in areas secured for conservation within the Cumberland subregion (Commitment 13)
- Secure priority habitat corridors within the Cumberland subregion in perpetuity, to support habitat connectivity (Commitment 12)

Note that these commitments cover the impacts of the transport corridors within the entire corridor footprint (excluding the tunnels). As described in section 36.3, not all these areas will be directly impacted and the Department will track impacts and adjust offset requirements through the Plan's reconciliation accounting process (see Part 2).

36.5 INDIRECT IMPACTS

36.5.1 SUMMARY OF IMPACTS

Potential indirect impacts are assessed in detail for each Commonwealth listed matter in Chapters 29, 30 and 31, and for other protected matters in Chapters 32, 33, 34 and 35. Chapter 15 summarises the commitments and mitigation measures and processes to implement them for the transport development.

Species and TECs with specific mitigation measures related to the transport development, and that are therefore considered most likely to be impacted by this development, are:

- Fauna:
  - Greater Glider
  - Green and Golden Bell Frog
  - Spotted-tailed Quoll
- Flora:
  - *Cynanchum elegans*
  - *Dillwynia tenuifolia*
  - *Grevillea juniperina* subsp. *juniperina*
  - *Persoonia nutans*
  - *Pultenaea parviflora*
  - *Eucalyptus benthamii*
  - *Pimelea spicata*
  - *Pomaderris brunnea*
- TECs:
  - Cooks River/Castlereagh Ironbark Forest

The transport corridors tunnels have the potential to indirectly impact several Commonwealth land sites (see Chapter 35). The commitment under the Plan (Commitment 6.2 relating to specific flora and fauna populations that are at risk of impacts) and the process to mitigate indirect impacts are considered to adequately manage this risk.

The transport development will not have notable indirect impacts on other EPBC Act protected matters, including:

- Migratory species (see Chapter 32)
- Ramsar wetlands (see Chapter 33)
- World and National Heritage (see Chapter 34)

36.5.2 COMMITMENTS TO ADDRESS INDIRECT IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts from transport corridors on species and habitat (Commitment 6). This includes implementing mitigation measures as prescribed in Appendix E of the Plan to address indirect impacts on biodiversity values.

The commitment to manage indirect impacts of the transport corridors will be delivered through NSW environmental assessment and approval processes. As described in Part 2, each transport project will be subject to future strategic planning and detailed design and a process of environmental assessment and approval:

- For the transport corridors within the nominated areas (where biodiversity impacts under both the EPBC Act and BC Act have already been assessed in this Assessment Report – see Part 1), this process will involve assessment under the State Significant Infrastructure approval process (or equivalent)
- For the transport corridors outside the nominated areas (where biodiversity impacts have not been assessed under the BC Act - see Part 1), this process will involve assessment under both:
    - State Significant Infrastructure approval process (or equivalent)
    - BC Act and BAM (or equivalent)

The process under the BC Act and BAM will address potential indirect impacts on biodiversity values. The process under the State Significant Infrastructure approval process (or equivalent) will assess the other environmental impacts and matters that need to be considered prior to construction and operation of the transport project. This will include an assessment of risks to the environment and the identification of mitigation measures to manage these risks, such as impacts related to hydrological disturbance, noise, air quality, and construction activities.

36.6 ASSESSMENT OF IMPACTS OF TUNNELS

This section assesses the likelihood of impacts to MNES due to the tunnel sections of the transport corridors. The impacts of tunnels were assessed separately to the rest of the transport corridors as only small areas of the footprints will be disturbed and it is not possible to determine at this stage the nature and extent of those impacts.

As for the other parts of the transport corridors, the tunnel footprints are generally wider than needed and the final alignment of the tunnels within the footprint (and associated surface impacts from construction and infrastructure) will be subject to future processes of refinement during the strategic planning and detailed design phase.

The impacts of the tunnels have not been included in the impact statistics for transport corridors in this Chapter or in the assessments for Commonwealth listed species and TECs (see Chapters 29 to 31). Where this assessment identified a risk of notable direct or indirect impacts from the tunnels, this has been noted in the assessments in Chapters 29 to 31.

36.6.1 POTENTIAL IMPACTS TO BIODIVERSITY VALUES

POTENTIAL DIRECT IMPACTS

Nature and extent of direct impacts

It is not possible to determine at this stage the specific nature, extent and duration of the direct impacts of the tunnels on biodiversity values. The tunnels will generally reduce the direct impacts of the transport corridors as tunnelling substantially reduces disturbance to the land surface required to construct the transport corridors.

Development for the tunnels will generally occur within the footprints of the tunnels shown in Figure 36-1. In some circumstances development may be necessary adjacent to the footprint. Direct impacts to biodiversity values will only occur within small areas of the tunnel footprints and the majority of the footprints will not be disturbed.

Activities associated with tunnels are described in section 36.2.2. In summary, disturbance to the land surface due to the tunnels, including vegetation clearing, may occur due:

- Construction activities
- Ancillary infrastructure, including ventilation systems
- Other infrastructure, such as entry and exit ramps and connection and tie in with existing roads and infrastructure
- Pedestrian and cyclist facilities

- Drainage work, pavement and finishing work

Biodiversity values potentially directly impacted

Most areas of high biodiversity value within and adjacent to the tunnel footprints occur within several areas already recognised for their environmental values. These areas include three protected lands (these cover a total of 120 ha within both tunnel footprints), as well as the Nepean River and associated riparian corridor within the OSO footprint, and the Mount Annan Botanic Gardens within the MRFE footprint.

Importantly, the Plan includes a commitment to avoid and minimise impacts to these areas. The Plan includes a commitment (Commitment 4.1**)** to avoid and minimise impacts to species and TECs from tunnel construction activities in transport corridors. This includes avoiding disturbance to the following locations where possible:

- The three areas of protected lands within and adjacent to the tunnel footprints:
  - Mater Dei BioBank site within the OSO footprint near Camden
  - Registered Property Agreement site within the OSO footprint at Camden Airport
  - Metro Offset site within the OSO and MRFE footprints near Harrington Park
- Nepean River and associated riparian corridor within the OSO footprint
- Camden Golf Club at Narellan adjacent to the MRFE footprint
- Mount Annan Botanic Gardens within the MRFE footprint
- Populations and habitat within or adjacent to the OSO and MRFE footprints for:
  - *Eucalyptus benthamii*
  - *Pomaderris brunnea*
  - *Pimelea spicata*
  - Cumberland Plain Land Snail
- Commonwealth land at:
  - Camden Airport
  - Western Sydney University (Campbelltown Campus)
  - 12 Werombi Road, Grasmere

This commitment is considered to adequately address the potential direct impacts of the tunnels on biodiversity values as it ensures impacts to most important biodiversity values within and adjacent to the tunnel footprints, including several species potentially subject to notable impacts (see Table 36-7) are avoided and minimised where possible.

Table 36-7 assesses the potential direct impacts to the biodiversity values that occur within the tunnel footprints outside these areas avoided under the Plan, and that may be directly impacted by the tunnels.

Table 36-7: Biodiversity values within the tunnel footprints outside areas to be avoided under Commitment 4.1

TEC or species name	Area of potential habitat (ha) outside areas to be avoided			Assessment of potential direct impacts
	MRFE tunnel	OSO tunnel	Total	
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	15.3	25.2	40.5	Potential for notable impacts is low. Most impacts generally occur to smaller, generally isolated patches of the TEC in lower condition (thinned or scattered trees). The amount of impact that could potentially occur is very small in the context of the amount remaining in the Strategic Assessment Area. Commitment 4.1 ensure impacts are avoided and minimised to the largest and most intact patches of the TEC in the vicinity of the tunnels
Coastal floodplain eucalypt forest of eastern Australia* (currently being assessed for listing)	11.1	4.3	15.3	Potential for notable impacts is low. While there will be some impacts patches of the TEC in intact condition, impacts generally occur to smaller, generally isolated patches of the TEC. The amount of impact that could potentially occur is very small in the context of the amount remaining in the Strategic Assessment Area. Commitment 4.1 ensure impacts are avoided and minimised to the largest and most intact patches of the TEC in the vicinity of the tunnels, particularly along the Nepean River
Acacia bynoeana	1.7	0.6	2.3	Potential for notable impacts is low. Only small amounts of potential habitat are potentially impacted, and no populations are known to occur in the vicinity of the tunnels. Core areas for the species in the Cumberland subregion occur north and east of GPEC and WSA
Acacia pubescens	29.9	4.5	34.4	Potential for notable impacts is low. Only small amounts of potential habitat are potentially impacted, and no populations are known to occur in the vicinity of the tunnels. The species is concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon (OEH, 2019b)
Botaurus poiciloptilus (Australasian Bittern)	4.6	1.1	5.7	Potential for notable impacts is low. The tunnels will not impact areas known to support the species (freshwater or brackish swamps that are shallow and vegetated, with a preference for the presence of sedges, rushes, and reeds (Garnett, Szabo et al., 2011) and there will be only very small impacts to areas mapped as potential habitat
Meridolum corneovirens (Cumberland Plain Land Snail)	6.3	0.0	6.3	There is potential for notable impacts. Several records occur in the vicinity of the MRFE tunnel at Western Sydney University (Campbelltown Campus) suggesting a population may occur in the area (the notes attached to several of the records suggest the individuals recorded were not alive, however, there is potential for the population to occur at the site). The species is endangered and restricted to the Cumberland Plain. Little is known about its biology, including breeding biology and movement patterns (OEH, 2019a). Commitment 4.1 includes specifically avoiding and minimising disturbance to this species where possible, and is considered to adequately address these potential impacts

TEC or species name	Area of potential habitat (ha) outside areas to be avoided			Assessment of potential direct impacts
	MRFE tunnel	OSO tunnel	Total	
Cynanchum elegans	0.0	0.4	0.4	There is potential for notable impacts. While very little potential habitat and no populations are known to occur within the tunnel footprints, an important population of the species (#14) occurs about a kilometre to the north of the OSO tunnel. The species is associated with Forest Red Gum *Eucalyptus tereticornis* communities (OEH, 2018c), which occur along the Nepean River (as part of Coastal floodplain eucalypt forest of eastern Australia). Commitment 4.1 ensures that the largest and most intact areas of this community, which are most likely to provide habitat for the species in the vicinity of the tunnels, will be avoided and minimised, and is considered to adequately address these potential impacts
Cercartetus nanus (Eastern Pygmy Possum)	2.4	0.0	2.4	Potential for notable impacts is low. There are no records for the species within the vicinity of the tunnels and only very small amounts of potential habitat may be impacted. The species may disperse along creek lines within the Strategic Assessment Area (see Chapter 30), and may use the riparian corridor along the Nepean River. Commitment 4.1 includes specifically avoiding and minimising disturbance to the riparian corridor of the Nepean River, and is considered to adequately address these potential impacts
Eucalyptus benthamii	1.7	11.1	12.8	There is potential for notable impacts. A large important population of the species occurs within the OSO tunnel footprint. Species has a restricted distribution and individuals at Camden are important for genetic diversity of the species (DoE, 2014a). Commitment 4.1 includes specifically avoiding and minimising disturbance to this species where possible, as well as avoiding locations where the records for this species occurs (Registered Property Agreement site within the OSO footprint at Camden Airport and riparian corridor of the Nepean River), and is considered to adequately address these potential impacts
Petauroides volans (Greater Glider)	13.6	14.7	28.3	Potential for notable impacts is low. No records are known to occur in the vicinity of the tunnels. The species is associated with larger areas of eucalypt forest and woodlands and is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows (TSSC, 2016a)
Chalinolobus dwyeri (Large-eared Pied Bat)	13.4	0.0	13.4	Potential for notable impacts is low. The area is unlikely to support breeding habitat (the site is not within one kilometre of areas likely to contain caves, crevices and cliffs - see Chapter 24) and only a small amount of potential foraging habitat has the potential to be impacted. There is one recent record (recorded in 2016) in the vicinity of the tunnels at the Mater Dei BioBank site (and an older record (from 2001) to the east of the OSO tunnel in an urban area). This area will be avoided and minimised under Commitment 4.1
Micromyrtus minutiflora	171.7	0.0	171.7	Potential for notable impacts is low. While it is possible the species occurs in potential habitat within the footprints, no populations are known to occur in the vicinity of the tunnels. The core area for the species within the Cumberland subregion occurs in the Londonderry area north of GPEC

TEC or species name	Area of potential habitat (ha) outside areas to be avoided			Assessment of potential direct impacts
	MRFE tunnel	OSO tunnel	Total	
Persoonia bargoensis	0.1	0.0	0.1	Potential for notable impacts is low. Almost no potential habitat occurs in the tunnel footprints. The core area for the species within the Cumberland subregion occurs around Wilton, and south of Wilton
Pimelea spicata	261.5	49.1	310.6	There is potential for notable impacts. While no records occur within the footprint, it is considered that the species may occur within potential habitat. A very large population (of between 300 to over 1000 individuals) occurs immediately adjacent to the MRFE tunnel footprint at Camden Golf Club. The population at this location is of particular significance as it is one of the largest known populations and is covered by a conservation agreement between DAWE and Camden Golf Club (DEC, 2005). Commitment 4.1 includes specifically avoiding and minimising disturbance to this species where possible, and is considered to adequately address these potential impacts
Pomaderris brunnea	48.4	35.9	84.3	There is potential for notable impacts. A large important population of the species occurs within the OSO tunnel footprint. Only 10 to 14 populations of the species are known to occur in NSW (Sutter, 2011). Commitment 4.1 includes specifically avoiding and minimising disturbance to this species where possible, as well as avoiding locations where the records for this species occurs (Registered Property Agreement site within the OSO footprint at Camden Airport, and the riparian corridor of the Nepean River), and is considered to adequately address these potential impacts
Pommerhelix duralensis (Dural land snail)	9.7	28.8	38.5	Potential for notable impacts is low. No populations are known to occur in the vicinity of the tunnels. The core area for the species within the Cumberland subregion occurs north east of GPEC
Pteropus poliocephalus (Grey-headed Flying Fox)	30.6	35.1	65.7	Potential for notable impacts is low. There will be no impacts to known camps. There is potential for impacts to areas of potential foraging habitat. The scale of impacts to foraging habitat is small. The species is highly mobile, feeds on fruit and nectar from a variety of vegetation communities and has access to large areas of intact vegetation surrounding the Strategic Assessment Area
Pultenaea parviflora	0.0	0.4	0.4	Potential for notable impacts is low. No populations are known to occur in the vicinity of the tunnels. The core area for the species within the Cumberland subregion occurs north of the tunnels around WSA and GPEC, and particularly north of GPEC
Pultenaea pedunculata	0.1	0.0	0.1	Potential for notable impacts is low. One record for the species (3 individuals recorded in 2015) occurs at the north-eastern end of the OSO tunnel, in a disturbed area adjacent to a powerline. Although the species can be found in disturbed areas, there is almost no mapped potential habitat for the species within the tunnel footprints. Within the subregion, the main populations for the species are found at Villawood and Prestons, and north-west of Appin between the Nepean River and Devines Tunnel number 2 (OEH, 2018b)

TEC or species name	Area of potential habitat (ha) outside areas to be avoided			Assessment of potential direct impacts
	MRFE tunnel	OSO tunnel	Total	
Anthochaera phrygia (Regent Honeyeater)	34.9	53.2	88.1	Potential for notable impacts is low. There will be no impacts to known breeding habitat or key areas identified in the species Recovery Plan or Conservation Advice for the species. Any direct impacts to foraging habitat would be to more fragmented and degraded remnants unlikely to provide the ecological elements preferred or needed by the species. There is one old (1984) record of the species in the general vicinity of the tunnels (east of the MRFE tunnel). There are no areas mapped as important habitat by EES within the transport corridors (or nominated areas) (see Chapter 30)
Rostratula australis (Australian Painted Snipe)	6.0	2.4	8.4	Potential for notable impacts is low. There are no records for the species within the vicinity of the tunnels. Only very small amounts of potential foraging habitat may be impacted, and the Strategic Assessment Area is not recognised as a key location for the species (see Chapter 30)
Dasyurus maculatus maculatus (Spot-tailed Quoll)	9.4	5.2	14.6	Potential for notable impacts is low. There are no records for the species within the vicinity of the tunnels and only very small amounts of potential habitat may be impacted. The species may disperse along creek lines within the Strategic Assessment Area (Bruce Mullins, pers com), and may use the riparian corridor along the Nepean River. Commitment 4.1 includes specifically avoiding and minimising disturbance to the riparian corridor of the Nepean River, and is considered to adequately address these potential impacts
Lathamus discolor (Swift Parrot)	34.9	53.2	88.1	Potential for notable impacts is low. There are two records of the species recorded in 2014 and 2016 in the vicinity of the OSO tunnel footprint near Camden Airport. However, the higher number of records in coastal habitat to the east indicates a relatively lower reliance on the Cumberland subregion, and the scale of potential impacts on potential foraging habitat is very small. Commitment 4.1 includes specifically avoiding and minimising disturbance to locations where these records occur (the Registered Property Agreement site within the OSO footprint at Camden Airport and riparian corridor of the Nepean River), and is considered to adequately address these potential impacts

*Note that amounts of this TEC are likely to be overestimated as it has been mapped based on PCT 835 (see Part 3)

POTENTIAL INDIRECT IMPACTS

Nature and extent of indirect impacts

It is not possible to determine at this stage the specific nature, extent and duration of the indirect impacts of the tunnels on biodiversity values. The tunnels will generally reduce the risk of many indirect impacts associated with transport corridors on biodiversity values, as tunnelling substantially reduces the disturbance to the land surface required to construct the corridors. However, tunnelling will create larger risks associated with:

- Hydrological changes to groundwater
- Ground settlement potentially causing impacts to the land surface, including waterways
- Management of large quantities of spoil

Activities associated with tunnels are described in section 36.2.2. In summary, indirect impacts due to the tunnels may occur due:

- Construction activities
- Ancillary infrastructure, including ventilation systems
- Other infrastructure, such as entry and exit ramps and connection and tie in with existing roads and infrastructure
- Drainage work, pavement and finishing work

The main types of indirect impacts associated with these activities with the potential to indirectly impact biodiversity values within or adjacent to the tunnel footprints are shown in Table 36-8.

Table 36-8: Key activities associated with tunnels and associated potential indirect impacts

Type of indirect impact/threat	Description
Hydrological disturbance	Changes to surface water and groundwater flows and water quality. Potential for groundwater level drawdown into the tunnel void and water quality impacts from the disposal of poor quality groundwater and surface water drainage from the tunnel during operation
Soil erosion and sedimentation	Potential for soil erosion and sedimentation to lead to disturbance to vegetation and poor quality stormwater run-off, particularly associated with the management of spoil
Disturbance of contaminated soils	Potential for disturbance to contaminated sites, causing water quality impacts
Spread of weeds	Spread of invasive species due to edge effects, surface water run-off, or changed fire regimes
Spread of infection/disease	Spread of pathogens from contaminated clothing and equipment or surface water runoff
Fauna disturbance due to noise, dust or light	Noise, dust or light created by equipment during construction or generated through the tunnel ventilation system during operation
Fauna mortality and barriers to fauna movement	Potential for mortality of threatened fauna species by vehicle strike and reduced movement and connectivity between habitat areas from barriers
Inadvertent impacts on adjacent habitat or vegetation	Damage to adjacent habitat during construction activities
Ground settling or subsidence	Potential for the ground in the vicinity of the tunnels to settle or subside due to the tunnel void or groundwater removal, which may cause disturbance to the land surface

Biodiversity values potentially indirectly impacted

Table 36-9 identifies the biodiversity values that occur in the vicinity of the tunnel footprints that are most likely to be potentially indirectly impacted by the tunnels. These have been identified taking into account:

- The presence/abundance of species records, potential habitat and TECs in the vicinity of the tunnels
- Relevant threats to the species and TECs identified in Conservation Advices
- Proximity of the species and TECs to the tunnel footprints in the context of the indirect impact type (e.g. ground settling or disturbance is more likely to occur to biodiversity values within the tunnel footprint, weed invasion is a risk for values in proximity to construction sites that will generally be within the tunnel footprint)
- Importance of the location for the species and TEC at a local and regional scale

The Plan includes a commitment to mitigate indirect and prescribed impacts on species from the transport corridors (Commitment 6), including managing key threats to the following threatened species during construction of the tunnels (Commitment 6.2):

- *Eucalyptus benthamii*
- *Pimelea spicata*
- *Pomaderris brunnea*
- Cumberland Plain Land Snail

Key threats/indirect impacts that will be managed are:

- Hydrological/soil disturbance
- Spread of weeds
- Spread of infection/disease
- Ground settling or subsidence
- Disturbance to ground shelter habitat (e.g. removal of fallen logs, slashing)

As described above, this commitment will be delivered through the NSW environmental assessment and approval process. For the tunnels outside the nominated areas (where biodiversity impacts have not been assessed under the BC Act - see Part 1), this process will involve assessment under both:

- State Significant Infrastructure approval process (or equivalent)
- BC Act and BAM (or equivalent)

The process under the BC Act and BAM will address potential indirect impacts on biodiversity values. The process under the State Significant Infrastructure approval process (or equivalent) will assess the other environmental impacts and matters that need to be considered prior to construction and operation of the transport project. This will include an assessment of risks to the environment and the identification of mitigation measures to manage these risks, such as impacts related to hydrological disturbance, noise, air quality, and construction activities.

This commitment is considered adequate to address the potential indirect impacts of the tunnels as it:

- Includes a specific requirement to manage key threats to the species identified in Table 36-9 potentially indirectly impacted by the tunnels - *Eucalyptus benthamii*, *Pimelea spicata*, *Pomaderris brunnea* and Cumberland Plain Land Snail
- Specifies a process through these mitigation measures can be delivered and other broader risks to the environment relevant to these species, such as groundwater drawdown, are assessed and mitigated

Table 36-9: Key biodiversity values potentially indirectly impacted by tunnels

Biodiversity value	Key locations of TECs or species records	Relevant tunnel	Key relevant indirect impacts/threats	Assessment of potential indirect impacts
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Mater Dei BioBank site Sydney Metro offset site	OSO	• Hydrological/soil disturbance • Spread of weeds • Soil erosion and sedimentation • Spread of infection/disease • Ground settling or subsidence	Potential for notable impacts on these TECs is low. While several patches of these TECs, including several large (>20 ha) intact patches, have the potential to be indirectly impacted, particularly due to hydrological disturbance and ground settlement, the amount of impact that could potentially occur to these TECs is small in the context of the amount remaining in the Strategic Assessment Area. Commitment 6.1 is expected to adequately address the potential indirect impacts to these TECs
	Sydney Metro offset site Camden Golf Course, Narellan Mount Annan Botanic Gardens	MRFE		
Coastal floodplain eucalypt forest of eastern Australia	Mater Dei BioBank site Camden Airport Registered Property Agreement	OSO	• Hydrological/soil disturbance • Spread of weeds • Soil erosion and sedimentation • Spread of infection/disease • Ground settling or subsidence	
	Sydney Metro offset site Mount Annan Botanic Gardens Western Sydney University	MRFE		
Eucalyptus benthamii	Mater Dei BioBank site Camden Airport Registered Property Agreement Along the Nepean River in the vicinity of the OSO	OSO	• Hydrological/soil disturbance • Spread of weeds • Spread of infection/disease • Ground settling or subsidence	There is potential for notable impacts. As described above, a large important population of the species occurs within the OSO tunnel footprint. Commitment 6.1 includes specifically addressing key threats from the construction and operation of the tunnels on this species and is expected to adequately address potential indirect impacts

Biodiversity value	Key locations of TECs or species records	Relevant tunnel	Key relevant indirect impacts/threats	Assessment of potential indirect impacts
Pimelea spicata	Camden Golf Course, Narellan Mount Annan Botanic Gardens	MRFE	• Hydrological/soil disturbance • Spread of weeds	There is potential for notable impacts. As described above, a large important population of the species occurs at Camden Golf Club immediately adjacent to the MRFE tunnel footprint. Commitment 6.1 includes specifically addressing key threats from the construction and operation of the tunnels on this species and is expected to adequately address potential indirect impacts
Pomaderris brunnea	Camden Airport Registered Property Agreement Along the Nepean River in the vicinity of the OSO	OSO	• Spread of weeds • Soil erosion and sedimentation • Ground settling or subsidence	There is potential for notable impacts. As described above, a large important population of the species occurs within the Camden Airport Registered Property Agreement and within the riparian corridor of the Nepean River. Commitment 6.1 includes specifically addressing key threats from the construction and operation of the tunnels on this species and is expected to adequately address potential indirect impacts
Grey-headed Flying Fox	Mater Dei BioBank site	OSO	• Fauna disturbance due to noise	Potential for notable impacts is low. As described above, there are no known camps in the vicinity of the tunnels and potential indirect impacts relate to disturbance to individuals utilising foraging habitat only. The scale of impacts to foraging habitat is small. The species is highly mobile, feeds on fruit and nectar from a variety of vegetation communities and has access to large areas of intact vegetation surrounding the Strategic Assessment Area
	Mount Annan Botanic Gardens	MRFE		
Large-eared Pied Bat	Mater Dei BioBank site	OSO	• Fauna disturbance due to noise	Potential for notable impacts is low. As described above, the area is unlikely to support breeding habitat and potential indirect impacts relate to disturbance to individuals utilising foraging habitat only. Only one recent record of the species occurs in the area (at the Mater Dei BioBank site) and the scale of impacts to foraging habitat is small
Swift Parrot	Mater Dei BioBank site Camden Airport Registered Property Agreement	OSO	• Fauna disturbance due to noise	Potential for notable impacts is low. Potential indirect impacts relate to disturbance to individuals utilising foraging habitat only. The species is highly mobile, and the scale of impacts to potential foraging habitat is very small

Biodiversity value	Key locations of TECs or species records	Relevant tunnel	Key relevant indirect impacts/threats	Assessment of potential indirect impacts
Koala	Mount Annan Botanic Gardens	MRFE	• Hydrological/soil disturbance affecting feed trees • Fauna disturbance due to noise	Potential for notable impacts is low. While Koala has been recorded in the Botanic Gardens, the species is unlikely to be resident in the area. Habitat within the gardens is marginal, comprising supporting habitat only (see Chapter 30, Figure 38) and significant existing threats to Koalas are likely to exist in the area, including threats posed by roads, domestic dogs, barriers to movement (such as fences) and landscape hazards (such as swimming pools)

36.6.2 POTENTIAL IMPACTS TO OTHER MATTERS

Three areas of Commonwealth land occur within the tunnel footprints, including:

- Camden Airport within the OSO tunnel footprint
- Western Sydney University within the MRFE tunnel footprint
- 12 Werombi Road, Grasmere

The direct and indirect impacts of the tunnels on these matters are assessed in Chapter 35.

No other MNES occur in the vicinity of the tunnels or are likely to be directly or indirect impacted.

36.7 OVERALL OUTCOME UNDER THE PLAN

The detailed assessments for Commonwealth listed species and TECs and other protected matters have shown that the direct, indirect and cumulative impacts of the transport development under the Plan are acceptable and that the commitments under the Plan will adequately protect and conserve these matters in the context of these impacts.

37 Summary of urban program impacts

37.1 INTRODUCTION

This Chapter provides:

- A summary of the urban, industrial, infrastructure/essential infrastructure, and agribusiness development
- A summary of the impacts of the urban, industrial, infrastructure/essential infrastructure, and agribusiness development within urban capable lands on MNES under the EPBC Act including:
  - Avoidance outcomes and commitments
  - Direct impacts and commitments to address impacts
  - Indirect impacts and commitments to address impacts
- An assessment of the potential additional impacts of essential infrastructure within the nominated areas
- A conclusion about the overall outcome in relation to urban, industrial, infrastructure/essential infrastructure, and agribusiness development under the Plan

The summary draws on the detailed analysis of the impacts of the Plan and the adequacy of the commitments under the Plan to address these impacts on each MNES presented earlier in this Assessment Report.

These detailed impact assessments have shown that the direct, indirect and cumulative impacts of development within the nominated areas (and transport corridors) on MNES are acceptable and that the commitments under the Plan will adequately protect and conserve these matters in the context of these impacts.

Part 7 provides an evaluation of the overall adequacy and acceptability of the Plan in the context of the impacts of the development under the Plan and in accordance with the regulatory requirements of the BC Act and EPBC Act.

The urban, industrial, infrastructure/essential infrastructure, and agribusiness development is described in Chapter 7.

The locations of the nominated areas are shown in Figure 37-1.

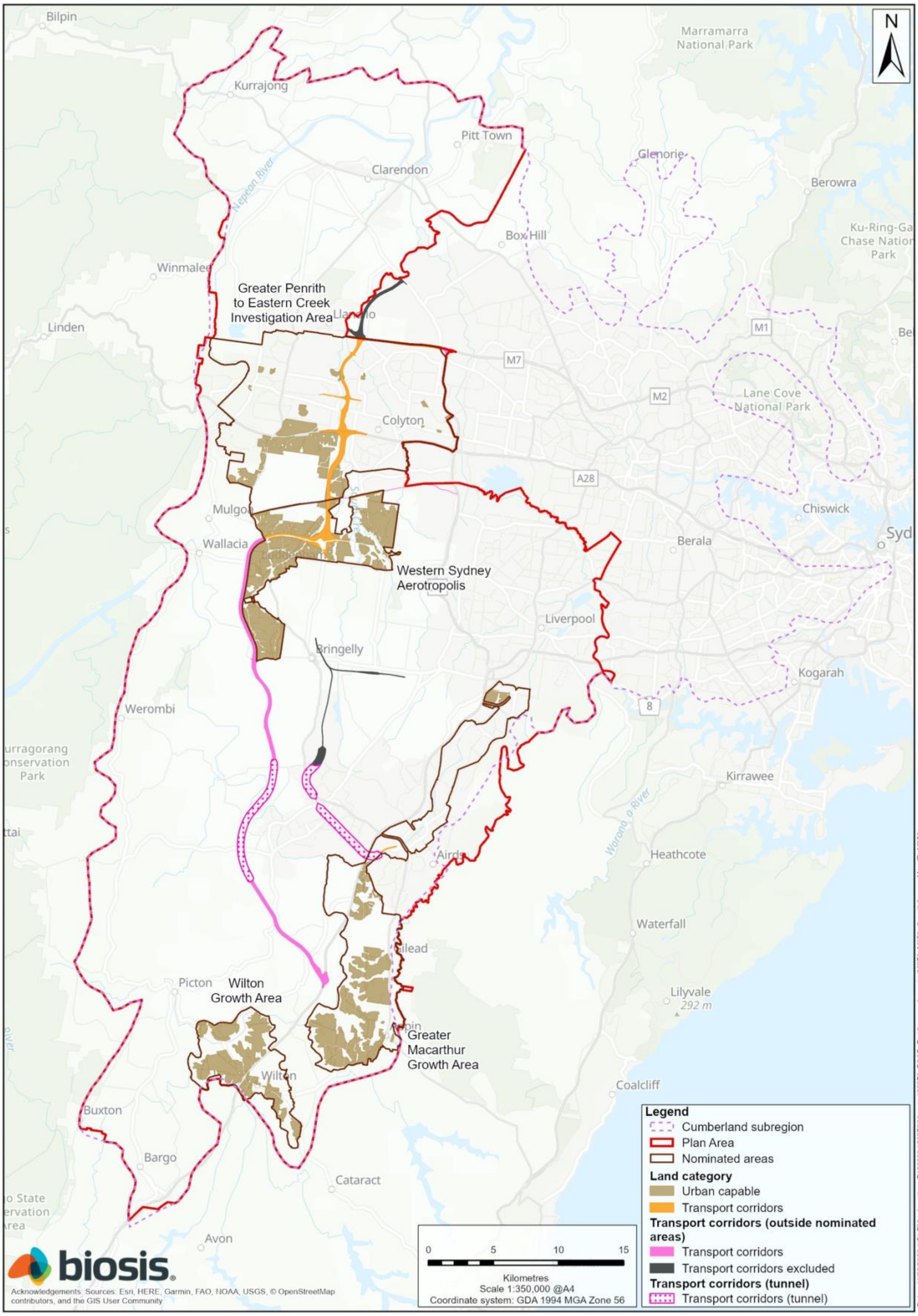

Figure 37-1: Locations of nominated areas within the Strategic Assessment Area

37.2 SUMMARY OF THE URBAN AND OTHER DEVELOPMENT

37.2.1 URBAN AND INDUSTRIAL DEVELOPMENT

Urban and industrial development will be confined to the urban capable lands within the nominated areas and includes any development permitted through residential, business, or industrial zones under relevant Local Environmental Plans, consistent with the structure plan and precinct plans for each nominated area.

Structure plans and precinct plans will be prepared for each nominated area by the relevant planning authority under the *Environmental Planning and Assessment Act 1979* (EP&A Act) and will map the boundaries of the urban capable land and the intended land use zones. Relevant planning authorities will rezone the land over time in stages.

37.2.2 AGRIBUSINESS

The Western Sydney airport presents an opportunity to invest in agriculture and agribusiness industries. The agribusiness precinct within WSA occurs on the northern and western edges of the airport and supports the long-term retention and growth of agriculture and agribusiness in the Western Parkland City.

Agribusiness will be confined to the agribusiness precinct within WSA and may include:

- Intensive plant agriculture, including protective structures used for production of fruit, vegetables or flowers
- Agribusiness – businesses associated with the production, processing, marketing and distribution of agricultural products, such as biotechnology research and development, food processing and export enabling infrastructure
- Advanced food manufacturing and logistics
- Wholesale markets, such as retail, distribution centres, cold stores, ripening rooms, and treatment facilities

37.2.3 INFRASTRUCTURE

Infrastructure development will generally be limited to urban capable land within the nominated areas and includes:

- Electricity transmission or distribution networks
- Gas pipelines
- Road or road infrastructure facilities, including public transport facilities (this is limited to local roads)
- Water reticulation systems, water storage facilities, water treatment facilities, or water supply systems
- Telecommunications facilities or telecommunication networks
- Supporting infrastructure for parks and public reserves (environmental facility, information and education facility, kiosk, recreation area, recreation facilities (outdoor), water recreation structure, road)

ESSENTIAL INFRASTRUCTURE

Certain essential infrastructure may be carried out by or on behalf of a public authority on land outside the urban capable land (not including land excluded from the Plan) within the nominated areas (i.e. on land avoided for biodiversity purposes or other reasons) provided specific requirements under the Plan are followed.

These requirements limit the scope of essential infrastructure development within these areas and will ensure that any infrastructure development in these areas avoids and mitigates and offsets any impacts to biodiversity values.

The potential impacts of essential infrastructure are assessed at Section 37.6.

37.3 AVOIDANCE OF IMPACTS

37.3.1 SUMMARY OF AVOIDANCE OUTCOMES

Consistent with Section 8.1.1.2 of the BAM, the process to identify the urban capable land boundaries within the nominated areas was an iterative one that began early in the assessment process before the final data on biodiversity values was completed. The urban capable land boundaries were identified in three phases:

- Strategic planning to locate the nominated areas
- Initial development of footprints through Land Use and Infrastructure Implementation Plans (LUIIP)

- Iterative refinement of the footprints through development of the Plan and assessment of impacts

Details of the process to design the urban capable land within the nominated areas are provided in Chapter 14.

Urban, industrial, infrastructure and agribusiness development in urban capable land within nominated areas has avoided the majority of native vegetation and key areas of high biodiversity values, including Commonwealth-listed TECs important populations and habitat connectivity.

Within the nominated areas, total avoidance (not including excluded lands) is summarised in Table 37-1.

Table 37-1: Avoidance outcomes for urban, industrial, infrastructure and agribusiness development within nominated areas

Biodiversity values	Summary of avoidance outcome in the nominated areas*
Native vegetation	67.2% avoided
High (intact) condition native vegetation	95.2% avoided
Commonwealth-listed TECs (critically endangered/endangered)	87.5% avoided
Commonwealth important populations	12 of the 14 species avoided (either wholly or partially)
Habitat connectivity (Bio Map areas)	88.3% of Bio Map core areas
	86.0% of Bio Map corridors

*Note that these figures include the amount of land 'avoided' for other purposes (e.g. riparian corridors and steep land) and not just biodiversity purposes. The figures do not include excluded land

37.3.2 COMMITMENTS FOR AVOIDANCE

The Plan includes a commitment (Commitment 2) to avoid and minimise impacts from urban and industrial, and infrastructure development, to at least 4,315 hectares of land within the nominated areas. This includes

- Avoiding 3,670 hectares of native vegetation comprising:
  - 2,735 hectares of native vegetation because of its biodiversity value
  - 935 hectares of riparian corridors and steep land
- Avoiding specific amounts of habitat for Commonwealth and NSW listed TECs
- Limiting cumulative direct impacts from essential infrastructure within non-certified land to the Commonwealth listed Shale Sandstone Transition Forest TEC and prioritising the avoidance of impacts from this infrastructure to specific known populations of flora species and important Koala corridors

37.4 DIRECT IMPACTS

37.4.1 SUMMARY OF IMPACTS

The direct impacts that may occur due to the nominated areas are associated with construction and are:

- Habitat loss
- Habitat fragmentation and loss of habitat connectivity

The direct impacts of the nominated areas on MNES are assessed in Chapters 29 to 35.

A summary of the direct impacts from urban development on Commonwealth-listed species and TECs is provided in:

- Table 37-2 – urban impacts to threatened fauna
- Table 37-3 – urban impacts to threatened flora
- Table 37-4 – urban impacts to TECs

These tables identify impacts in relation to each nominated area, as well as the total impact of the nominated areas and the contribution of the urban program to the total impacts of the development under the Plan.

The urban development will not have notable direct impacts on other EPBC Act protected matters, including:

- Migratory species (see Chapter 32)
- Ramsar wetlands (see Chapter 33)
- World and National Heritage (see Chapter 34)
- Commonwealth land (see Chapter 35)

THREATENED FAUNA

The following outlines the magnitude of impact to each threatened fauna species solely with regards to the urban capable development program. Chapter 30 provides a detailed assessment of each fauna species as a result of all development (urban capable in addition to transport development) under the Plan, and produces a risk ranking for each fauna species with regards to their magnitude of direct impacts under the Plan. It is noted that the risk ranking relates to both urban capable and transport development, rather than just urban capable development, and so it is possible for a species to have low urban capable development impacts yet a high risk rating as a result of impacts due to transport development (and vice versa).

Urban development within the nominated areas will directly impact potential habitat for 11 of the 20 fauna species. These include: Regent Honeyeater (low risk), Australasian Bittern (low risk), Swift Parrot (medium risk), Australian Painted Snipe (very low risk), Large-eared Pied Bat (low risk), Spot-tailed Quoll (low risk), Greater Glider (very low risk), Koala (high risk), Grey-headed Flying Fox (low risk), Giant Burrowing Frog (very low risk) and Green and Golden Bell Frog (very low risk).

The most notable direct impacts occur to:

- Regent Honeyeater (low risk) and Swift Parrot (medium risk) within GMAC and Wilton
- Grey-headed Flying-fox (low risk) within WSA
- Large-eared Pied Bat (low risk) in Wilton and GMAC

The largest impacts to potential habitat will occur to:

- Species with broad associations with woodland habitats primarily for foraging, such as the Swift Parrot (medium risk) (832.1 ha of impact) and the Regent Honeyeater (low risk) (832.1 ha of impact)
- Wide ranging species such as the Spot-tailed Quoll (low risk) (416.3 ha of impact) and Grey-headed Flying-fox (low risk) (364.8 ha of impact)

The species most impacted in terms of the percentage of total habitat in the Strategic Assessment Area is the Koala (high risk), which will have 1.7% of its potential habitat impacted.

THREATENED FLORA

The following outlines the magnitude of impact to each threatened flora species solely with regards to development of the urban capable land program. Similar to fauna, Chapter 29 provides a detailed assessment of each species as a result of all development (transport in addition to urban capable development) under the Plan, and produces a risk ranking for each flora species with regards to their magnitude of direct impacts under the Plan. It is noted that the risk ranking relates to both urban capable and transport development, rather than just urban capable development, and so it is possible for a species to have low urban capable impacts yet a high risk rating as a result of impacts due to transport development (and vice versa).

The nominated areas will directly impact potential habitat for 14 of the 23 flora species.

The most notable direct impacts occur to:

- *Pimelea spicata* (high risk) within Wilton and WSA
- *Acacia pubescens* (very low risk) within Wilton, GMAC, WSA and GPEC

The largest impacts to potential habitat will occur to:

- *Pimelea spicata* (high risk) (714.3ha)

- *Acacia pubescens* (very low risk) (602.9 ha)
- *Acacia bynoeana* (very low risk) (195.2 ha)

The species most impacted in terms of the percentage of total habitat in the Strategic Assessment Area is *Pimelea spicata* (high risk), which will have 2.0% of its potential habitat impacted.

The nominated areas will directly impact known important populations of some flora species, including: *Pimelea spicata* (high risk) (1 population).

THREATENED ECOLOGICAL COMMUNITIES

The following outlines the magnitude of impact to each TEC with solely with regards to development of the urban capable land program. Chapter 31 provides a detailed assessment of each species as a result of all development (transport in addition to urban capable development) under the Plan. The following outlines the area of each TEC impacted by urban capable development under the Plan, with the total impact of all development under the Plan (transport in addition to urban development) provided in brackets to provide additional context.

The transport corridors will directly impact 5 of the TECs. These include:

- Shale Sandstone Transition Forest of the Sydney Basin Bioregion 191.8 ha impacted by urban capable land (191.8 ha impacted in total by the Plan)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest: 103.3 ha impacted by urban capable land (154.7 ha impacted in total by the Plan)
- Coastal floodplain eucalypt forest of eastern Australia (FPAL): 43.5 ha impacted by urban capable land (210.2 ha impacted in total by the Plan)
- Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion: 11.3 ha impacted by urban capable land (26.3 ha impacted in total by the Plan)
- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community: 0.4 ha impacted by urban capable land (1.8 ha impacted in total by the Plan)

The most notable direct impacts occur to:

- Shale Sandstone Transition Forest of the Sydney Basin Bioregion within Wilton and GMAC
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest within GMAC, WSA and GPEC

The TEC most impacted in terms of the percentage of total TEC in the Strategic Assessment Area is Shale Sandstone Transition Forest of the Sydney Basin Bioregion (2.3 per cent).

Table 37-2: Urban impacts to potential habitat for Commonwealth listed threatened fauna

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS			
				Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts to important populations	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
BIRDS											
Anthochaera phrygia	Regent Honeyeater	CE	59,460.4	170.3	282.8	278.1	123.1	**854.3**	**0**	**1.4%**	**66.5%**
Botaurus poiciloptilus	Australasian Bittern	E	2,524.4	0.0	3.6	6.9	4.1	**14.6**	**0**	**0.6%**	**16.7%**
Calidris canutus	Red Knot	E, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Calidris ferruginea	Curlew Sandpiper	CE, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Charadrius leschenaultii	Greater Sand-plover	V, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Lathamus discolor	Swift Parrot	CE	59,460.4	170.3	282.8	278.1	123.1	**854.3**	**1**	**1.4%**	**66.5%**
Limosa lapponica	Bar-tailed Godwit	V, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Numenius madagascariensis	Eastern Curlew	CE, Migratory	182.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Rostratula australis	Australian Painted Snipe	E	2,230.9	0.9	6.5	14.3	1.3	**23.1**	**0**	**1.0%**	**58.4%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS			
				Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts to important populations	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
MAMMALS											
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	25,555.0	123.5	187.4	0.0	0.9	**311.8**	0	**1.2%**	**98.6%**
Dasyurus maculatus maculatus (SE mainland population)	Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (south eastern mainland population)	E	32,527.0	120.3	157.2	78.6	79.5	**435.6**	0	**1.3%**	**64.5%**
Petauroides volans	Greater Glider	V	25,762.9	15.8	48.4	4.4	0.1	**68.7**	0	**0.3%**	**51.3%**
Phascolarctos cinereus	Koala (combined populations of Qld, NSW and the ACT)	V	14,432.0	116.7	143.9	0.0	0.0	**260.6**	0	**1.8%**	**100.0%**
Pteropus poliocephalus	Grey-headed Flying-fox	V	26,873.3	30.9	106.0	181.2	58.2	**376.2**	1	**1.4%**	**52.0%**
REPTILES											
Hoplocephalus bungaroides	Broad-headed Snake	V	6,735.2	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS			
				Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts to important populations	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
AMPHIBIANS											
Heleioporus australiacus	Giant Burrowing Frog	V	4,074.7	0.3	0.3	0.0	0.0	**0.6**	0	**0.0%**	**100.0%**
Litoria aurea	Green and Golden Bell Frog	V	5,500.9	0.0	0.0	0.0	11.0	**11.0**	1	**0.2%**	**78.7%**
INVERTEBRATES											
Pommerhelix duralensis	Dural Land Snail	E	25,503	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	0.0%
FISH											
Macquaria australasica	Macquarie Perch	E	21	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	0.0%

Note: The White-throated Needletail (*Hirundapus caudacutus*) is not included in this table, as it was not possible to produce a meaningful habitat map for this species as it is predominantly an aerial species. Refer to Chapter 30 for further information.

Table 37-3: Urban impacts to potential habitat for Commonwealth listed threatened flora

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS			
				Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts to important populations	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
Acacia bynoeana	Bynoe's Wattle, Tiny Wattle	V	30,677.7	122.2	63.0	8.3	1.6	**195.2**	**0**	**0.6%**	**98.2%**
Acacia pubescens	Downy Wattle, Hairy Stemmed Wattle	V	35,102.3	167.5	120.6	226.3	88.4	**602.9**	**0**	**1.7%**	**76.2%**
Allocasuarina glareicola		E	4,417.6	0.0	0.0	0.0	7.4	**7.4**	**0**	**0.2%**	**62.0%**
Commersonia prostrata	Dwarf Kerrawang	E	61.9	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Cynanchum elegans	White-flowered Wax Plant	E	3,342.5	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Deyeuxia appressa		E	19.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Eucalyptus benthamii	Camden White Gum, Nepean River Gum	V	4,799.7	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Genoplesium baueri	Yellow Gnat-orchid	E	772.1	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	7,504.7	3.9	1.1	7.0	0.1	**12.1**	**0**	**0.2%**	**75.7%**
Hibbertia puberula subsp. *glabrescens*		CE	43.3	0.0	0.0	0.0	0.0	**0.0**	**0**	**0.0%**	**0.0%**

Scientific name	Common name	Cth status	Total potential habitat in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS			
				Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts to important populations	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
Leucopogon exolasius	Woronora Beard-heath	V	267.2	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
Melaleuca deanei	Deane's Melaleuca	V	14,445.1	46.3	56.2	0.0	0.0	**102.5**	0	**0.7%**	**100.0%**
Micromyrtus minutiflora		V	36,680.4	0.0	0.0	10.9	6.6	**17.5**	0	**0.0%**	**10.9%**
Persicaria elatior	Knotweed	V	1,703.4	0.0	0.0	0.0	0.6	**0.6**	0	**0.0%**	**1.3%**
Persoonia bargoensis	Bargo Geebung	V	12,338.6	39.4	42.0	0.0	0.0	**81.4**	0	**0.7%**	**100.0%**
Persoonia glaucescens	Mittagong Geebung	V	2,378.2	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
Persoonia hirsuta	Hairy Geebung, Hairy Persoonia	E	11,433.3	0.0	0.0	0.0	0.0	**0.0**	0	**0.0%**	**0.0%**
Persoonia nutans	Nodding Geebung	E	14,874.7	0.0	0.0	25.4	7.2	**32.7**	0	**0.2%**	**79.3%**
Pimelea curviflora var. *curviflora*		V	13,064.1	0.0	0.0	0.0	22.2	**22.2**	0	**0.2%**	**29.2%**
Pimelea spicata	Spiked Rice-flower	E	34,859.0	398.4	61.2	195.7	59.1	**714.3**	1	**2.0%**	**74.7%**
Pomaderris brunnea	Rufous Pomaderris	V	26,092.1	16.3	17.4	0.0	0.0	**33.7**	0	**0.1%**	**16.6%**
Pterostylis saxicola	Sydney Plains Greenhood	E	11,792.4	14.3	31.3	0.0	0.9	**46.6**	0	**0.4%**	**100.0%**
Pultenaea parviflora		V	20,207.9	0.0	0.0	22.8	7.7	**30.5**	2	**0.2%**	**16.2%**

Table 37-4: Urban impacts to Commonwealth listed threatened ecological communities

TEC Name	Cth status	Total TEC in SAA (ha)	IMPACTS FROM URBAN DEVELOPMENT IN NOMINATED AREAS				TOTAL URBAN IMPACTS		
			Wilton (ha)	GMAC (ha)	WSA (ha)	GPEC (ha)	Total nominated area impacts (ha)	Total nominated area impacts as % of habitat in SAA	Nominated area % of total Plan impacts
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	E	2,769.0	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	E	271.0	0.0	0.0	0.0	0.4	**0.4**	**0.2%**	**22.8%**
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	CE	791.0	0.0	0.0	7.0	4.4	**11.3**	**1.4%**	**43.1%**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	9,737.2	7.0	17.0	57.6	21.7	**103.3**	**1.1%**	**66.7%**
Coastal floodplain eucalypt forest of eastern Australia	FPAL*	6,944.0	0.0	4.2	22.4	16.9	**43.5**	**0.6%**	**20.7%**
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	CE	8,214.1	88.1	103.7	0.0	0.0	**191.8**	**2.3%**	**100.0%**
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	CE	44.0	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**
Western Sydney Dry Rainforest in the Sydney Basin Bioregion	CE	960.8	0.0	0.0	0.0	0.0	**0.0**	**0.0%**	**0.0%**

* Proposed for listing under the EPBC Act

37.4.2 COMMITMENTS TO ADDRESS IMPACTS

The Plan includes commitments to address the direct impacts of the nominated areas on Commonwealth listed species and TECs. The key commitments apply to both the urban and transport program and include to:

- Secure a minimum of 5,475 hectares of native vegetation in the Cumberland subregion (Commitment 8) to conserve biodiversity values in perpetuity, including specific amounts of habitat for Commonwealth-listed species and TECs
- Undertake ecological restoration of up to 25 per cent of the offset target for native vegetation in areas secured for conservation within the Cumberland subregion (Commitment 13)
- Secure priority habitat corridors within the Cumberland subregion in perpetuity, to support habitat connectivity (Commitment 12)

There are also a range of specific commitments for the species and TECs at the highest risk of adverse direct impacts.

37.5 INDIRECT IMPACTS

37.5.1 SUMMARY OF IMPACTS

Potential indirect impacts are assessed in detail for each Commonwealth-listed matter in Chapters 29, 30 and 31, and for other protected matters in Chapters 32, 33, 34 and 35. Chapter 15 summarises the commitments and mitigation measures and processes to implement them for the development in the urban capable lands.

Species and TECs and other protected matters with specific mitigation measures related to the urban and other development in the urban capable land, and that are therefore considered most likely to be impacted by this development, are:

- Fauna:
  - Koala
  - Macquarie Perch
  - Green and Golden Bell Frog
  - Grey-headed Flying Fox
  - Regent Honeyeater
  - Swift Parrot
  - Spotted-tailed Quoll
  - Greater Glider
- Flora:
  - *Persoonia nutans*
  - *Pimelea spicata*
  - *Pultenaea parviflora*
  - *Grevillea parviflora* subsp. *parviflora*
  - *Persoonia bargoensis*
  - *Genoplesium baueri*
  - *Melaleuca deanei*
  - *Pterostylis saxicola*
- TECs:
  - Cooks River Castlereagh Ironbark Forest
  - Cumberland Plain Woodland
  - Coastal floodplain eucalypt forest
  - Shale Sandstone Transition Forest
  - Coastal Swamp Oak Forest

Development within the nominated areas will not have notable indirect impacts on other EPBC Act protected matters, including:

- Migratory species (see Chapter 32)
- Ramsar wetlands (see Chapter 33)
- World and National Heritage (see Chapter 34)

37.5.2 COMMITMENTS TO ADDRESS IMPACTS

The Plan includes a commitment to mitigate indirect and prescribed impacts on TECs and species from development within the nominated areas to best practice standards (Commitment 5), including implementing development controls in the nominated areas to protected species, as prescribed in Appendix E of the Plan (Commitment 5.1)

Two broad types of development controls will be implemented:

- General environmental controls that will benefit the environment generally, including biodiversity values
- Specific controls that apply to specific species and TECs in specific locations or broader nominated areas. These controls have been identified through this Assessment Report and are needed to address residual risks to species or TECs that remain after implementation of the general environmental controls

The commitment to manage indirect impacts of urban, industrial and agribusiness development within the nominated areas will be delivered primarily through the NSW planning system, and specifically, the nominated areas planning delivery framework. The overarching planning delivery framework is described in Chapter 9.

The key mechanism to implement the general environmental controls and the specific controls in the nominated areas is Development Control Plans (DCPs). DCPs will be prepared for each nominated area and set out the controls that need to be addressed by neighbourhood plans and development applications to mitigate indirect impacts.

37.6 ASSESSMENT OF POTENTIAL ADDITIONAL IMPACTS OF ESSENTIAL INFRASTRUCTURE

37.6.1 INTRODUCTION

This section assesses the potential additional impacts to protected matters under the EPBC Act due to essential infrastructure projects within non-certified lands avoided lands in the nominated areas.

Planning for essential infrastructure to support the nominated areas, such as water and electricity utilities, is in various stages of development, and this infrastructure may need to be located outside urban capable lands.

The Plan is seeking approval under the EPBC Act (but not the BC Act) for certain essential infrastructure development to occur within the nominated areas outside urban capable lands (i.e. within avoided or non-certified land but not excluded lands).

The Plan specifies that:

- Every effort should be made to ensure that essential infrastructure development is limited to urban capable lands
- Where essential infrastructure occurs outside urban capable lands (i.e. within avoided lands), the development must comply with the 'Guidelines for essential infrastructure development' in Appendix A of the Plan. This includes a requirement (if necessary) to assess the biodiversity impacts of each project under the BC Act
- Cumulative impacts from essential infrastructure on EPBC Act-listed Shale Sandstone Transition Forest is capped and avoidance of impacts is prioritised for certain species (Commitment 2.3 and Commitment 2.4)

This Section:

- Provides definitions of the different land types in the nominated areas
- Sets out the scope of essential infrastructure development
- Describes the planning, assessment and implementation processes set out in the guidelines for essential infrastructure development (the Guidelines) and relevant commitments
- Analyses the potential impacts to EPBC Act threatened species and TECs

- Analyses the potential impacts to other matters protected by the EPBC Act
- Provides a conclusion about the likely outcomes for protected matters arising out of essential infrastructure development

37.6.2 DEFINITIONS OF LAND TYPES IN THE NOMINATED AREAS

There are different land types in the nominated areas. These are relevant to the scope of the essential infrastructure process.

CERTIFIED LANDS

Certified lands within the nominated areas are referred to as 'certified-urban capable land'. These areas are proposed to be approved under both the EPBC Act and BC Act and include the development footprints for urban development.

Essential infrastructure that occurs within the urban capable lands is assessed (in relation to the EPBC Act) as part of Chapters 27-35.

NON-CERTIFIED LANDS

Not all of the nominated areas are proposed for urban development. These areas are non-certified lands and comprise land that has been avoided and land that is excluded from the assessment.

Avoided lands

The definition of what constitutes avoidance has been adopted from the BCAR process. Under the BAM, avoidance refers to land that is suitable for development and included in the area proposed for development or biodiversity certification, but has been avoided because of its biodiversity value. This is referred to as avoidance for 'biodiversity purposes' in this assessment.

Land not impacted because it is not suitable for development or biodiversity certification, or land that has been excluded from the area proposed for development is not considered to have been avoided under the BAM. This land is referred to as avoidance for 'other purposes' and includes:

- Riparian corridors consistent with the *Water Management Act 2000*:
  - Strahler stream order 2 - buffer 20 m either side
  - Strahler stream order 3 - buffer 30 m either side
  - Strahler stream order 4 and above - buffer 40 m either side
- State protected land (>18 degrees slope, considered too steep for urban development)

The assessment in this section considers the potential impacts of essential infrastructure on avoided lands in the nominated areas.

Excluded lands

Some land within the nominated areas was not considered for inclusion in the area proposed for development and has therefore been identified as 'excluded' land. These lands include:

- Existing protected land, including reserves and established offset sites
- Council owned land which is zoned for environmental conservation, environmental management or recreation
- Commonwealth land, such as Defence Establishment Orchard Hills
- Lands within the nominated areas already assessed as part of another development approval (Bingara Gorge), or lands progressing through an alternate assessment (Mount Gilead, Menangle Park, Sydney Metro Stage 1)
- Lands already developed (existing urban areas, urban land zones and roads)

Other non-certified land

This relates to land in WSA that has been identified as 'Environment and Recreation' lands within the updated Western Sydney Aerotropolis Stage 1 Structure Plan. These lands have not been included in urban capable lands. However, it is proposed that the lands may be used for public open space or passive recreation, including supporting infrastructure such as information facilities, kiosks, or recreational areas.

37.6.3 SCOPE OF ESSENTIAL INFRASTRUCTURE

The spatial scope, types of actions and activities, and criteria that must be met for essential infrastructure projects that are assessed in this report are described below. These are largely taken from the Guidelines in Appendix A of the Plan.

SPATIAL SCOPE

The spatial scope of essential infrastructure that is assessed here applies to projects that occur on avoided lands within each of the four nominated areas.

The assessment does not address the potential impacts of essential infrastructure projects that occur:

- On excluded lands within the nominated areas
- Outside of the nominated areas
- On other non-certified land in WSA which has not been included in the assessment of essential infrastructure at this point due to a late change in the Plan that did not provide sufficient time for a detailed assessment to be carried out. The potential implications of essential infrastructure on these lands will be considered after public comment

It is important to note that the potential impacts of essential infrastructure projects on EPBC Act protected matters within the urban capable lands of each nominated area are assessed in Chapters 27-35.

It is also important to note that the Guidelines make reference to essential infrastructure projects that occur "wholly or mostly within the nominated areas". Given the uncertainty about the scale, nature and extent of potential impacts outside the nominated areas, the spatial scope of the assessment within this report is restricted to activities that occur within the nominated areas (on avoided lands). Potential impacts of activities that might occur outside the nominated areas have not been assessed.

TYPES OF ACTIONS AND ACTIVITIES

Actions

The Guidelines define essential infrastructure as including the following types of actions:

- Electricity generating works or solar energy systems
- Electricity transmission or distribution
- Pipelines and pipeline corridors
- Roads and traffic
- Sewerage systems
- Stormwater management systems
- Telecommunications and other communication facilities
- Waste or resource management facilities
- Water supply systems
- Recreation works (environmental facility, information and education facility, kiosk, recreation area, recreation facilities (outdoor), water recreation structure and other supporting development) only on non-certified land in the Western Sydney Aerotropolis

Activities

Development of the essential infrastructure projects includes all activities associated with the design, construction and operation of the actions listed above.

Specific activities that may be carried out under the Plan for these projects include, but are not limited to:

- Vegetation clearing
- Earthworks

- Utility works
- Landscaping
- Erosion and sediment control
- Laydown areas
- Road construction
- Construction of supporting infrastructure such as stations, car parks and pedestrian access
- Electricity infrastructure
- Site offices and access roads
- Pipelines
- Construction of buildings that form part of the permitted actions
- Dust and noise suppression
- Stormwater management (including detention basins, ponds and dams)
- Maintenance and upgrade activities

CRITERIA

The Guidelines constrain the types of actions that may be undertaken through a set of criteria that must be met. Any essential infrastructure project that is included in the list of possible projects above must also be a development by a public authority which includes:

- Local development
- Part 5 activities (5.1) under the EP&A Act (except for Road Activities)

Projects may not include:

- State significant development
- State significant infrastructure
- Classified Roads
- Division 5.1 Road Activities (EP&A Act) which are subject to an existing Part 10 approval under the EPBC Act.

In practice, these criteria restrict the scope of essential infrastructure development to smaller scale projects that are carried out by public authorities to facilitate growth in the nominated areas where the activities cannot be accommodated within the urban capable lands.

37.6.4 PLANNING, ASSESSMENT AND IMPLEMENTATION PROCESSES FOR ESSENTIAL INFRASTRUCTURE

GUIDELINES

The Guidelines set out what is required to protect biodiversity in terms of planning, assessment and implementation as each essential infrastructure project is brought forward.

Each project will be managed through the NSW planning and approvals framework as current at the time of the project. This process will be critical to adequately avoiding, minimising, mitigating and offsetting any impacts to MNES as a result of essential infrastructure projects on avoided lands.

The Guidelines state that:

Essential infrastructure may be carried out by or on behalf of a public authority on non-certified land, if:

- *Environmental impacts of the activities are considered under the Environmental Planning and Assessment Act, and an 'avoid and mitigate' process is applied*
- *MNES are considered through the 'avoid and mitigate' process and any relevant MNES-specific requirements of the Plan are applied* [Commitment 1, Commitment 2, Commitment 5 and Commitment 7; Appendix C – Plan Commitments]
- *The biodiversity impacts of the activities will be assessed under the Biodiversity Conservation Act, if triggered, and an 'avoid, mitigate, offset' process will be applied*
- *The public authority has notified the department of the development.*

The Guidelines also require the following procedures to be applied:

- ***Environmental impact assessment*** *(pre-construction) - the impacts of proposed activities on the environment must be considered along with identified mechanisms to deliver environmental solutions. The environmental assessment process aims to:*
  - *Identify environmental impacts at the earliest possible stage in project development*
  - *Take steps to avoid or minimise potential impacts as the first priority*
  - *Assess the unavoidable impacts of a proposed activity on the environment before making a decision on whether it should proceed, including consideration of cumulative impacts*
  - *Ensure the community is appropriately consulted and that their input is taken into account in decision-making*
  - *Provide appropriate offset measures to ensure that any residual impacts that cannot be avoided or minimised do not have an unacceptable environmental impact*
- ***Environmental management and compliance*** *(during construction and operation) – to ensure that activities comply with legislative requirements and deliver effective implementation of identified safeguards and mitigation measures during project construction and future on-going maintenance*

These future impact assessment and environmental management processes will be undertaken in accordance with NSW planning and assessment laws current at the time the development is proposed.

The Guidelines also set out what is required for essential infrastructure projects to meet the Plan's commitments. This includes but is not limited to:

- *Avoid land for biodiversity or other environmental purposes within the nominated areas where possible; this includes specific consideration of nationally threatened species, ecological communities and their habitats. These areas will be zoned for environmental purposes and should be avoided where possible*
- *Where an action cannot feasibly or practicably avoid impacts on non-certified land, the public authority shall ensure the impacts are minimised as far as possible. This includes by refining design elements to reduce the overall impact*
- *Fulfil biodiversity offset requirements under the Biodiversity Conservation Act 2016 or any subsequent legislative scheme in place at the time*
- *Implementing impact mitigation measures based on the outcomes of environmental assessment of detailed designs, including consideration to Plan Commitments 4 and 6.*

Finally, the Guidelines also set out a number of specific constraints around potential impacts to MNES in relation to essential infrastructure projects on avoided lands. These constraints are:

- *Limit the total cumulative direct impacts within avoided lands to Shale Sandstone Transition Forest in the Sydney Basin Bioregion over the life of the Plan to no more than 20 ha in Wilton and 20 ha in GMAC*
- *Consider the of connectivity of important Koala corridors within avoided lands in Wilton and GMAC*

COMMITMENTS

The Plan also includes commitments related to essential infrastructure that support the Guidelines. These are:

- Commitment 1: Development will be undertaken in accordance with the Plan and any conditions of approval.
- Commitment 1.1: Essential infrastructure in non-certified land will be implemented consistent with the Plan's Essential Infrastructure Guidelines.
- Commitment 2.3: Limiting cumulative direct impacts over the life of the Plan from essential infrastructure to Shale Sandstone Transition Forest in avoided lands to no more than:
  - 20 ha in Wilton
  - 20 ha in GMAC

- Commitment 2.4: Prioritising the avoidance of impacts from essential infrastructure in avoided lands to:
  - Known populations of the following threatened flora species:
    - *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea)
    - *Persoonia bargoensis* (Bargo Geebung)
    - *Persoonia nutans* (Nodding Geebung)
    - *Genoplesium baueri* (Yellow Gnat-orchid)
    - *Pimelea spicata* (Spiked Rice-flower)
    - *Pultenaea parviflora*
  - Important Koala corridors within Wilton and GMAC to maintain their integrity

37.6.5 POTENTIAL IMPACTS TO THREATENED SPECIES AND TECS

POTENTIAL DIRECT IMPACTS

The potential direct impacts to threatened species and TECs due to essential infrastructure projects include habitat loss and fragmentation. Given that it is not possible at this stage to know the location, scale and nature of specific projects, the following approach was used to understand the potential direct impacts to threatened species and TECs. For each nominated area:

- The presence of known populations of threatened species (i.e. where records exist) and mapped TECs on avoided lands was determined. This was based on the baseline data that was prepared for each species and TEC (see Chapters 29-31 for details)
- The potential for direct impacts to these species and TECs due to essential infrastructure was assessed. This included consideration of:
  - The location, extent and sensitivity of MNES values and judgement about the likelihood that impacts could occur. For example, flora populations occurring within corridors away from the urban capable lands may be less likely to be directly impacted than flora populations on flat land near the edge of urban capable lands
  - How the requirements of the Guidelines may apply to each relevant MNES
- The likely outcome for each MNES following the application of the criteria in the Guidelines and the NSW planning and approvals framework was determined

The following tables set out the analysis for each nominated area:

- Table 37-5 - Wilton
- Table 37-6- GMAC
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Table 37-5: Potential direct impacts to biodiversity values in Wilton

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
TECS				
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	CE	Significant areas of the TEC occur within avoided lands in Wilton (753.7 ha). Of the 753.7 ha, 455.5 ha is in good (intact) condition, 292.8 ha is in moderate (thinned) condition, and 5.4 ha is in poor (scattered) condition. Given the extent of the TEC on avoided lands, it is probable that impacts from essential infrastructure will occur to the TEC. The likelihood of impact is reduced for those areas of the TEC that occur in riparian or steep areas (69.8 ha). See Map 48.6 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines: • Require efforts to avoid and minimise impacts to the TEC • Limit the maximum cumulative impact to 20 ha within avoided lands in Wilton The Guidelines require any residual impacts to be offset.	Commitment 2.3 specifies that a maximum of 20 ha of the TEC may be impacted by essential infrastructure projects within Wilton over the life of the Plan. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
THREATENED FLORA				
Grevillea parviflora subsp. *parviflora* (Small-flower Grevillea)	V	Two known populations of the species occur within avoided lands in Wilton. Population 104 is important and contains 13 records comprising 339 individuals. Of these 13 records, 8 (331 individuals) occur within avoided lands in the north of Wilton approximately 300 m from urban capable land. Without commitments to protect it, impacts to this population from essential infrastructure in this area could be possible. Population 518 is important and contains 1 record comprising 1 individual. Without commitments to protect it, impacts to this population from essential infrastructure in this area could be possible although unlikely because the population occurs on the western edge of Wilton, approximately 600 m from the nearest urban capable land, and close to steep areas and sandstone cliffs. See Map 36.10 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Given the limited distribution of the species within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Persoonia bargoensis (Bargo Geebung)	V	One known population of the species occurs within avoided lands in Wilton. Population 114 is important and contains 343 records comprising 1,461 individuals. Of these records, 3 (8 individuals) occur within avoided lands in the north west and east of Wilton. Without commitments to protect it, impacts to this population from essential infrastructure in this area could be possible. See Map 36.16 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Given the limited distribution of the species within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
THREATENED FAUNA				
Phascolarctos cinereus (Koala)	V	Important Koala habitat occurs extensively on avoided lands in Wilton. The habitat is closely associated with the occurrence of Shale Sandstone Transition Forest in the Sydney Basin Bioregion and essential infrastructure projects have the potential to impact areas of Koala habitat. See Map 37 and Map 40 for mapped habitat and species records across the Strategic Assessment Area.	To constrain potential impacts to the species within avoided lands, the Guidelines: • Require efforts to avoid and minimise impacts to biodiversity (including Koala habitat) • Consider the connectivity of important Koala corridors within avoided lands in Wilton In addition, given the close association between important Koala habitat and Shale Sandstone Transition Forest in the Sydney Basin Bioregion the impact limit for the TEC (20 ha within Wilton) will help reduce any potential direct impacts to Koala habitat. Any residual impacts need to be offset.	It is possible that Koala habitat will be impacted by essential infrastructure projects. However, the Guidelines and Commitment 2.4 together will: • Constrain the scale of potential impacts • Prioritise avoidance of important Koala corridors in Wilton to maintain their integrity Where impacts occur they will be offset in accordance with the requirements of the BAM.
Pteropus poliocephalus (Grey-headed Flying-fox)	V	The species has been recorded on avoided lands in Wilton, and areas of foraging habitat (54.4 ha) for the Grey-headed Flying-fox are present. There are no known camps or important roosting sites for the species in these areas. Direct impacts to foraging habitat are possible, especially where it occurs near to urban capable lands. See Map 36.32 and Map 36.33 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including foraging habitat for the Grey-headed Flying-fox). In addition, given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within Wilton) will help reduce any potential direct impacts to foraging habitat for the species. Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.

Table 37-6: Potential direct impacts to biodiversity values in GMAC

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
TECs				
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	Small areas of the TEC occur within avoided lands in GMAC (22.5 ha). Of the 22.5 ha, 10.3 ha is in good (intact) condition and 12.2 ha is in moderate (thinned) condition. Impacts to the TEC are possible from essential infrastructure as the majority of it occurs: • Between areas of urban capable lands • On flatter lands that have been avoided for biodiversity purposes See Map 48.4 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	CE	Significant areas of the TEC occur within avoided lands in GMAC (1,192.8 ha). Of the 1,192.8 ha, 981.9 ha is in good (intact) condition, 199.9 ha is in moderate (thinned), and 11 ha is in poor (scattered) condition. Given the extent of the TEC on avoided lands, it is probable that impacts from essential infrastructure will occur to the TEC. The likelihood of impact is reduced for those areas of the TEC that occur in riparian or steep areas (185.4 ha). See Map 48.6 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines: • Require efforts to avoid and minimise impacts to the TEC • Limit the maximum cumulative impact to 20 ha within avoided lands in GMAC The Guidelines require any residual impacts to be offset.	Commitment 2.3 specifies that a maximum of 20 ha of the TEC may be impacted by essential infrastructure projects within GMAC over the life of the Plan. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
Western Sydney Dry Rainforest and Moist Woodland on Shale	CE	Small areas of the TEC occur within avoided lands in GMAC (15.4 ha). Of the 15.4 ha, 2.2 ha is in good (intact) condition and 13.2 ha is in moderate (thinned) condition. Impacts to the TEC are possible as it occurs on avoided lands in the centre of GMAC between urban capable land. The likelihood of impact is reduced where the TEC occurs in riparian corridors or on steep areas (4.2 ha). See Map 48.8 or mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Coastal floodplain eucalypt forest of eastern Australia	FPAL	Small areas of the potential TEC occur within avoided lands in GMAC (14.4 ha). Of the 14.4 ha, 9.9 ha is in good (intact) condition and 4.5 ha is in moderate (thinned) condition. Impacts to the potential TEC are possible as it occurs on avoided lands in the centre of GMAC between urban capable land. The likelihood of impact is reduced where the potential TEC occurs in riparian corridors or on steep areas (9.6 ha). See Map 48.5 for mapping of the EC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the potential TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
THREATENED FLORA				
Genoplesium baueri (Yellow Gnat-orchid)	E	One known population of the species occurs within avoided lands in GMAC. Population 21 is important and contains 1 record comprising 1 individual. The whole population occurs within avoided lands. Without commitments to protect it, impacts to this population from essential infrastructure in this area could be possible although unlikely because the population occurs on the far eastern edge of GMAC approximately 400 m away from the nearest urban capable	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Given the limited distribution of the species within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
		land. See Map 36.9 for mapped potential habitat and populations across the Strategic Assessment Area.		requirements of the BAM.
Grevillea parviflora subsp. *parviflora* (Small-flower Grevillea)	V	One known population of the species occurs within avoided lands in GMAC. Population 519 is not important and contains 6 records comprising 6 individuals. Of these records, 1 (1 individual) occurs within avoided lands in GMAC. The area where the record occurs will be protected as part of the proposed Koala reserve. Based on this, direct impacts to the species will not occur. See Map 36.10 for mapped potential habitat and populations across the Strategic Assessment Area.	Once the Koala reserve is established, the Guidelines will not be applicable as essential infrastructure projects will not occur in the reserve.	No direct impacts to the species will occur as a result of essential infrastructure projects.
Pimelea spicata (Spiked Rice-flower)	E	One known population of the species occurs within avoided lands in GMAC. Population 533 is important and contains 1 record comprising 1 individual. The area where the record occurs will be protected as part of the proposed Koala reserve. Based on this, direct impacts to the species will not occur. See Map 36.21 for mapped potential habitat and populations across the Strategic Assessment Area.	Once the Koala reserve is established, the Guidelines will not be applicable as essential infrastructure projects will not occur in the reserve.	No direct impacts to the species will occur as a result of essential infrastructure projects.
Pomaderris brunnea (Rufous Pomaderris)	V	Seven known populations of the species occur within avoided lands in GMAC. Population 470 is not mapped as important and contains 1 record comprising 1 individual. Impacts to the population are possible as population occurs on avoided land in between and approximately 20 m from urban capable lands. Population 471 is not mapped as important and contains 3 records comprising 3 individuals. Impacts are possible as the entire	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Four populations of the species are at risk of direct impacts from essential infrastructure in GMAC. Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Where impacts do occur they will be offset in accordance with the

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
		population occurs on avoided lands in the south west of GMAC. Impacts are more likely where one record occurs 20 m from the development footprint. The likelihood of impacts to the other two records are reduced as they are located in steeper areas closer to the boundary of GMAC. Three populations occur to the east of Appin Road in the area proposed to be included in the George's River Koala Park. Impacts are unlikely to these populations. They are: • Population 513 - not important, 8 records comprising 8 individuals • Population 514 - not important, 2 records comprising 2 individuals • Population 515 - not important, 2 records comprising 2 individuals Population 586 is important and contains 7 records comprising 7 individuals. Of these records, 3 records (3 individuals) occur on avoided land in the centre of GMAC. Impacts to this population are possible as some records occur <100 m from urban capable land. Population 587 is important and contains 2 records comprising 2 individuals. The entire population occurs within avoided lands in the south-west of GMAC. Impacts to the population are possible as it occurs on the edge of urban capable land. See Map 36.22 for mapped potential habitat and populations across the Strategic Assessment Area.		requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
THREATENED FAUNA				
Chalinolobus dwyeri (Large-eared Pied Bat)	V	The species has been recorded on avoided lands in GMAC, and areas of potential foraging habitat (1,723.2 ha) for the Large-eared Pied Bat are present. It is important to note that there are no known roost or breeding sites for the species within the Strategic Assessment Area. The habitat is closely associated with the occurrence of Shale Sandstone Transition Forest in the Sydney Basin Bioregion and essential infrastructure projects have the potential to impact areas of the species. See Map 46.1 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including foraging habitat for the Large-eared Pied Bat). In addition, given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to foraging habitat for the species. Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Dasyurus maculatus (Spot-tailed Quoll)	E	The species has been recorded on avoided lands to the east of Appin Road in GMAC, and areas of potential habitat (1,673.5) for the Quoll are present. Potential habitat is closely associated with the occurrence of Shale Sandstone Transition Forest in the Sydney Basin Bioregion and essential infrastructure projects have the potential to impact these areas. See Map 46.4 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including potential habitat for the Spot-tailed Quoll). In addition: • Given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to potential habitat for the species • The requirement of the Guidelines to consider the connectivity of important Koala corridors within avoided lands in GMAC will help maintain any	It is possible that potential habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
			connectivity for the Spot-tailed Quoll Any residual impacts need to be offset.	
Lathamus discolor (Swift Parrot)	CE	The species has been recorded on avoided lands in GMAC, and areas of potential foraging habitat (1,811.6 for the Swift Parrot are present. Direct impacts to potential foraging habitat are possible, especially where it occurs near to urban capable lands. See Map 46.5 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including potential foraging habitat for the Swift Parrot). In addition, given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to foraging habitat for the species. Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Petauroides volans (Greater Glider)	V	The species has been recorded on avoided lands to the east of Appin Road in GMAC, and areas of potential habitat (1,462.5) for the Greater Glider are present. Direct impacts to potential habitat are possible, especially where it occurs near to urban capable lands. Direct impacts to the location of the population on avoided lands are less likely because of its location to the east of Appin Road. See Map 36.30 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including potential habitat for the Greater Glider). In addition, given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to foraging habitat for the species. Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
Phascolarctos cinereus (Koala)	V	Important Koala habitat occurs extensively on avoided lands in GMAC. The habitat is closely associated with the occurrence of Shale Sandstone Transition Forest in the Sydney Basin Bioregion and essential infrastructure projects have the potential to impact areas of Koala habitat. See Map 37 and Map 40 for mapped habitat and species records across the Strategic Assessment Area.	To constrain potential impacts to the species within avoided lands, the Guidelines: • Require efforts to avoid and minimise impacts to biodiversity (including Koala habitat) • Consider the connectivity of important Koala corridors within avoided lands in GMAC In addition, given the close association between important Koala habitat and Shale Sandstone Transition Forest in the Sydney Basin Bioregion the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to Koala habitat. Any residual impacts need to be offset.	It is possible that Koala habitat will be impacted by essential infrastructure projects. However, the Guidelines and Commitment 2.4 together will: • Constrain the scale of potential impacts • Prioritise avoidance of important Koala corridors in GMAC to maintain their integrity Where impacts occur they will be offset in accordance with the requirements of the BAM.
Pteropus poliocephalus (Grey-headed Flying-fox)	V	The species has been recorded on avoided lands in GMAC, and areas of foraging habitat (762.1 ha) for the Grey-headed Flying-fox are present. There are no known camps or important roosting sites for the species in these areas. Direct impacts to foraging habitat are possible, especially where it occurs near to urban capable lands. See Map 36.32 and Map 36.33 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including foraging habitat for the Grey-headed Flying-fox). In addition, given the extensive nature of Shale Sandstone Transition Forest in the Sydney Basin Bioregion on avoided lands, the impact limit for the TEC (20 ha within GMAC) will help reduce any potential direct impacts to foraging habitat for the species. Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.

Table 37-7: Potential direct impacts to biodiversity values in WSA

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
TECs				
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	E	Small areas of the TEC occur within the avoided lands of WSA. Of the 29.1 ha, 27.9 ha is in moderate (thinned) condition and 1.2 is in low (scattered) condition. Impacts to the TEC are possible where it occurs within land avoided for biodiversity purposes (4.3 ha). The likelihood of impact is reduced where the TEC occurs in riparian corridors (24.8 ha). See Map 48.2 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Cooks River / Castlereagh Ironbark Forest in the Sydney Basin Bioregion	CE	Small areas of the TEC occur within the avoided lands of WSA. Of the 26.1 ha, 19.4 ha is in good (intact) condition and 6.7 ha is in moderate (thinned) condition. Impacts to the TEC are possible where it occurs between urban capable lands. See Map 48.3 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	Small areas of the TEC occur within the avoided lands of WSA. Of the 20.1 ha, 0.2 ha is in good (intact) condition and 19.8 ha is in moderate (thinned) condition. Impacts to the TEC are possible where it occurs between urban capable lands. The likelihood of impact is reduced where the TEC occurs in riparian corridors (11.7 ha). See Map 48.4 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
Coastal floodplain eucalypt forest of eastern Australia	FPAL	Areas of the potential TEC occur within avoided lands in WSA (101 ha). Of the 101 ha, 12 ha is in good (intact) condition, 77.2 ha is in moderate (thinned) condition, and 11.7 ha is in poor (scattered) condition. Impacts to the potential TEC are possible where it occurs between urban capable lands. The likelihood of impacts are reduced where the TEC occurs in riparian corridors (68.1 ha). See Map 48.5 for mapping of the EC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Avoidance processes will be important to minimise the risk of impacts as essential infrastructure projects proceed. Where impacts do occur they will be offset in accordance with the requirements of the BAM.
THREATENED FLORA				
Persoonia nutans (Nodding Geebung)	E	One known population of the species occurs within avoided lands in WSA. Population 60 is mapped as important and contains 7 records comprising 7 individuals. Of these, 1 record (1 individual) occurs within avoided lands in the south east of WSA. Without commitments to protect it, impacts to this population could be possible as it occurs on the edge of urban capable land. See Map 36.19 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Where impacts do occur they will be offset in accordance with the requirements of the BAM.
Pultenaea parviflora	V	One known population of the species occurs within avoided lands in WSA. Population 181 is not mapped as important and contains 78 records comprising 78 individuals. Of these, 11 records (11 individuals) occur within avoided lands in the south east of WSA (in a similar location to *Persoonia nutans*). Without commitments to protect it, impacts to this population could be possible as it occurs on the edge of urban capable land. See Map 36.24 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Where impacts do occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
THREATENED FAUNA				
Petauroides volans (Greater Glider)	V	The species has been recorded on avoided lands in the south of WSA. The record for population 585 (not mapped as important) occurs in a riparian corridor in an area where there is no mapped habitat for the species. See Map 36.30 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity. Any residual impacts need to be offset.	Given the limited mapped habitat for the species within WSA, it is considered unlikely that it will be impacted by essential infrastructure projects. Should any impacts occur they will be offset in accordance with the requirements of the BAM.

Table 37-8: Potential direct impacts to biodiversity values in GPEC

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
TECs				
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	E	Very small areas (3.3 ha) of the TEC occur within the avoided lands of GPEC. It is all in moderate (thinned) condition. Impacts to the TEC are possible although relatively unlikely as 3 ha occurs in riparian corridors. See Map 48.2 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Given the limited distribution of the TEC within avoided lands it is considered likely that avoidance of direct impacts will be possible. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	CE	Small areas of the TEC occur within the avoided lands of WSA. Of the 51.1 ha, 7.4 ha is in good (intact) condition, 43.7 ha is in moderate (thinned) condition and 0.03 ha is in poor (scattered) condition. The TEC is located in the south of GPEC and impacts from essential infrastructure are possible. See Map 48.4 for mapping of the TEC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Avoidance processes will be important to minimise the risk of impacts as essential infrastructure projects proceed. Where impacts do occur they will be offset in accordance with the requirements of the BAM.
Coastal floodplain eucalypt forest of eastern Australia	FPAL	Areas of the potential TEC occur within avoided lands in GPEC (54.9 ha) Of the 54.9 ha, 11.7 ha is in good (intact) condition, 43 ha is in moderate (thinned) condition, and 0.2 is in poor (scattered) condition. Impacts to the potential TEC are possible where it occurs between urban capable lands. The likelihood of impacts are reduced where the TEC occurs in riparian corridors (31.8 ha). See Map 48.5 for mapping of the EC across the Strategic Assessment Area.	To constrain potential impacts to the TEC, the Guidelines require efforts to avoid and minimise impacts. Any residual impacts need to be offset.	Avoidance processes will be important to minimise the risk of impacts as essential infrastructure projects proceed. Where impacts do occur they will be offset in accordance with the requirements of the BAM.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
THREATENED FLORA				
Pultenaea parviflora	V	One known population of the species occurs within avoided lands in GPEC. Population 226 is not mapped as important and contains 1 record comprising 150 individuals. The whole population occurs within avoided lands in the south east of GPEC. Impacts to this population are possible as it occurs on the edge of urban capable land. See Map 36.24 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to known locations and habitat. Any residual impacts need to be offset.	Commitment 2.4 specifies that avoidance of known populations of this species will be prioritised. Where impacts do occur they will be offset in accordance with the requirements of the BAM.
THREATENED FAUNA				
Lathamus discolor (Swift Parrot)	CE	The species has been recorded on avoided lands in GPEC, and areas of potential foraging habitat (153.8 ha) for the Swift Parrot are present. Direct impacts to potential foraging habitat are possible, especially where it occurs near to urban capable lands. See Map 46.5 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity (including potential foraging habitat for the Swift Parrot). Any residual impacts need to be offset.	It is possible that foraging habitat for the species will be impacted by essential infrastructure projects. However, the Guidelines will constrain the scale of potential impacts. Where impacts occur they will be offset in accordance with the requirements of the BAM.
Litoria aurea (Green and Golden Bell Frog)	V	One population of the species is potentially present on avoided lands associated with Ropes Creek within GPEC. The Plan includes a species-specific commitment to avoid, protect and enhance key habitat features identified within and adjacent to the Ropes Creek corridor if the population is confirmed present. Based on this commitment, direct impacts to the species will be avoided. See Map 36.31 for mapped potential habitat and populations across the Strategic Assessment Area.	Any essential infrastructure projects will need to meet both the requirements of the Guidelines and the species-specific commitment in the Plan.	No direct impacts to the species will occur as a result of essential infrastructure projects.

EPBC matter	EPBC status	Occurrence and possible impacts	Application of the Essential Infrastructure Guidelines	Likely outcome
Petauroides volans (Greater Glider)	V	The species has been recorded on avoided lands in GPEC. The record for population 584 (not mapped as important) occurs in an area where there is no mapped habitat for the species. See Map 36.30 for mapped potential habitat and populations across the Strategic Assessment Area.	To constrain potential impacts to the species, the Guidelines require efforts to avoid and minimise impacts to biodiversity. Any residual impacts need to be offset.	Given the limited mapped habitat for the species within GPEC, it is considered unlikely that it will be impacted by essential infrastructure projects. Should any impacts occur they will be offset in accordance with the requirements of the BAM.

POTENTIAL INDIRECT IMPACTS

Nature and extent of potential indirect impacts

It is not possible to determine at this stage the specific nature, extent and duration of the indirect impacts of essential infrastructure projects on biodiversity values. However, the main types of indirect impacts associated with essential infrastructure actions are shown in Table 37-9.

Table 37-9: Potential indirect impact types for essential infrastructure projects

Indirect impact type	Nature of indirect impact	Extent/general location of indirect impact and/or high risk areas	Duration of indirect impact
Hydrological disturbance	Changes to surface water and groundwater flows and quality	Waterways, wetlands, flood-prone areas within or downstream of essential infrastructure projects	Short term to long-term
Spread of infection/disease	Spread of pathogens from contaminated clothing and equipment or surface water runoff	Native vegetation retained within or adjacent to essential infrastructure projects	Likely long-term
Spread of weeds	Spread of invasive species due to edge effects, surface water run-off, or changed fire regimes	Native vegetation retained within or adjacent to essential infrastructure projects	Likely long-term
Predation / competition by pest / domestic fauna	Increased predation and competition of species by pest / domestic fauna	Habitat retained within or adjacent to essential infrastructure projects, including well-connected habitat corridors	Likely long-term
Altered fire regimes	Altered fire regimes as a result of increased burns for asset protection or reduced ability to burn due to risk to surrounding urban areas	Native vegetation retained within or immediately adjacent to essential infrastructure projects, particularly asset protection zones	Long-term
Fauna mortality, fauna displacement and barriers to fauna movement	Potential for mortality of threatened fauna species by vehicle strike and reduced movement and connectivity between habitat areas from barriers	Habitat intersected by essential infrastructure projects	Long-term
Fauna disturbance due to noise, dust or light	Noise, dust or light created by equipment during construction or by new structures during operation	Habitat retained within or immediately adjacent to essential infrastructure projects	Short-term to long-term
Inadvertent impacts on adjacent habitat or vegetation	Damage to adjacent habitat during construction activities or during ongoing management	Native vegetation immediately adjacent to essential infrastructure projects	Short-term to long-term

Commitments to address indirect impacts

In relation to indirect impacts, the Guidelines specify that each essential infrastructure project must:

- Apply an 'avoid and mitigate' process in considering the environmental impacts of the project under the EP&A Act
- If triggered, apply an 'avoid, mitigate, offset' process to biodiversity values under the BC Act
- Implement mitigation measures based on the outcomes of the environmental assessments of each infrastructure project based on detailed design of the project, in compliance with legislative requirements

The Plan also includes commitments to mitigate indirect and prescribed impacts from development on TECs, species and their habitat to best practice standards. They include:

- Commitment 5 which relates to the general mitigation of indirect and prescribed impacts from development on TECs, species and their habitat to best practice standards. This includes mitigation measures to address impacts during construction and operation of infrastructure projects, as prescribed in Appendix E of the Plan (Commitment 5.3). These commitments apply to both infrastructure and essential infrastructure under the Plan
- Commitment 7 which relates to the mitigation of indirect and prescribed impacts from urban, infrastructure and major infrastructure (transport) development on the Southern Sydney Koala population to best practice standards and in line with the Chief Scientist Koala Report

The future process of environmental assessment and approval for each essential infrastructure project will assess and identify mitigation measures to manage the potential indirect impacts of the project identified in Table 37-9 on biodiversity values, including Commonwealth-listed matters.

This process will, for example, assess the potential for the project to result in soil erosion and sedimentation, water quality impacts, the spread of weeds and disease, and disturbance to fauna in relation to relevant biodiversity values in the vicinity of the project, and will identify mitigation measures to address these risks.

In identifying mitigation measures, the commitments specify that measures meet best practice standards and mitigation measures prescribed in Appendix E of the Plan are implemented where relevant to addressing indirect impacts on the biodiversity values specified in the commitment, including Commonwealth-listed matters.

For infrastructure projects affecting biodiversity values, the BC Act and BAM process will generally be triggered. This process requires an assessment of the risks and consequences of indirect impacts on biodiversity values protected under the Act, and identification of mitigation measures to address these risks. Requirements to implement mitigation measures are typically incorporated into the approval, and the Act includes an enforcement and compliance framework for ensuring the mitigation measures are implemented in accordance with the approval.

The future process of environmental assessment and approval is considered adequate to effectively manage the risks of indirect impacts of essential infrastructure projects on biodiversity values identified in Table 37-5 to Table 37-8.

37.6.6 POTENTIAL IMPACTS TO OTHER MATTERS

No other protected matters will be potentially impacted by essential infrastructure projects. This is because:

- There is no important habitat for listed migratory species within the nominated areas (see Chapter 32)
- Development within the nominated areas will not affect any Ramsar sites (see Chapter 33)
- Development within the nominated areas will not affect any World or National Heritage sites (see Chapter 34)
- Essential infrastructure projects will not be able to be carried on Commonwealth land which is a type of excluded land

37.6.7 CONCLUSION

It is considered the Guidelines and supporting commitments 2.3 and 2.4, as they apply to essential infrastructure outside urban capable lands, will lead to acceptable outcomes for MNES as they:

- Provide for only a limited amount of development outside the urban capable lands, which has been assessed in this Assessment Report. This development must be necessary to support the urban and industrial development under the Plan. This limited scope reduces the potential for impacts to biodiversity values from the development
- Require implementation of assessment and ongoing environmental management processes, including:
  - An environmental impact assessment process to be applied prior to construction to assess and manage the impacts of the development. The assessment process is considered to be robust as it will be undertaken under NSW planning and assessment laws current at the time the development is proposed
  - An environmental management and compliance process to be applied during construction and operation to ensure activities comply with assessment requirements and mitigation measures are implemented effectively
- Will achieve avoidance and outcomes consistent with the Plan
- Will ensure mitigation measures are put in place to address all relevant indirect impacts

- Require unavoidable impacts to be offset in accordance with the BAM. As these impacts are not accounted for in terms of commitments under the Plan, these offsets would be additional to the offsets that are required for the development under the Plan. The process to determine the offset amounts and deliver the offsets is considered to be robust as it will be implemented:
    - Through existing offsetting processes under the BC Act or any subsequent legislative scheme, or
    - Consistent with the 'Implementation Strategy for Conservation Lands' to be established under the Plan
- Are supported by governance arrangements that will clarify roles and responsibilities, including for compliance, and ensure the development is consistent with the guidelines (these are set out in Appendix A of the Plan)

37.7 OVERALL OUTCOME UNDER THE PLAN

Urban capable land has generally avoided the vast majority of native vegetation and areas of high biodiversity values, including high condition vegetation, Commonwealth-listed TECs, species habitats, important populations and habitat connectivity. Within the nominated areas (not including excluded lands) this includes:

- 67.2 per cent of native vegetation
- 95.2 per cent of high condition (intact) native vegetation
- 87.5 per cent of critically endangered and endangered Commonwealth-listed TECs
- An average of 77.8 per cent of potential habitat for three species with a very high biodiversity risk weighting (>3), and an average of 78.6 per cent of potential habitat for 31 species with a high biodiversity risk weighting (>/=2)
- Of 14 species with important populations identified outside excluded land 12 have important populations represented (either wholly or partially) on land avoided for biodiversity purposes
- Approximately 88.3 per cent of Bio Map core areas and 86.0 per cent of Bio Map corridors

The detailed assessments for Commonwealth listed species and TECs concluded that despite the direct and indirect impacts of the transport corridors, the commitments under the Plan to address these impacts are adequate, and the Plan would be unlikely to reduce the long-term viability of these matters in the Cumberland subregion.

38 Cumulative Impact Assessment

38.1 INTRODUCTION

This Chapter provides an assessment of the cumulative impacts of development under the Plan with other current key major projects in the Cumberland subregion on MNES. The Chapter:

- Sets out the regulatory requirements for cumulative impact assessment
- Describes the assessment approach
- Assess cumulative impacts of the Plan on threatened species and TECs with other major projects
- Provides an overall conclusion and evaluation of these impacts to threatened species and TECs
- Addresses cumulative impacts on other MNES

The purpose of the cumulative impact assessment is to identify the MNES most impacted under the Plan that are also impacted by other major projects in the Cumberland subregion to:

- Assess the significance of cumulative impacts across the Plan and these major projects on these matters
- Determine whether the commitments under the Plan to address direct impacts to each matter are adequate in the context of the cumulative impacts on those matters

38.2 REGULATORY REQUIREMENTS

The terms of reference (ToR) requires:

- Identification of MNES that may be cumulatively impacted by the Plan (Section 3.2)
- An analysis of the likely adverse cumulative impacts to MNES (Section 4.5.3)

Due to the large spatial scale and long timeframes of the Plan, this Assessment Report itself is a form of cumulative impact assessment. The report considers in detail the potential impacts of urban and industrial, infrastructure, agribusiness, and transport development under the Plan, and the conservation benefits of the Plan on relevant MNES.

To support that analysis, this Assessment Report also takes a broader view and examines the cumulative impacts and conservation benefits of other current and reasonably foreseeable major development on the Cumberland Plain.

38.3 APPROACH TO THE ASSESSMENT

The approach to the cumulative assessment involved:

- Identifying current major projects within the Strategic Assessment Area
- Identifying key species and TECs most likely at risk of cumulative impacts across the Plan and major projects
- Evaluating the significance of the cumulative impacts and the adequacy of the commitments under the Plan in the context of these cumulative impacts for each key species and TEC

38.3.1 IDENTIFICATION OF MAJOR PROJECTS

The cumulative assessment considers impacts from current major projects in the Strategic Assessment Area:

- That have been approved for development or have been subject to impact assessment for pending approval
- Where clearing for development has not yet occurred or has only occurred over part of the project area to date. The assessment takes into account future impacts from December 2019. Where clearing has only occurred over part of the project area to date, these areas were excluded from the analysis
- Where data is available on impacts and offsets (the Sydney Metro EIS is still being prepared. Data on this project is therefore unavailable and has not been included in this assessment)

Table 38-1 identifies the major projects included in the cumulative impact assessment and data availability for each project. The location of each major project is shown in Figure 38-1.

CUMULATIVE IMPACTS FROM OTHER DEVELOPMENT

It is acknowledged that other major projects (such as the Sydney Metro – Western Sydney Airport) and many other types of development, including smaller scale residual areas and infrastructure, will be developed in the foreseeable future within the Cumberland subregion. It is not possible to estimate the cumulative impacts of these developments and the Plan on Commonwealth-listed species and TECs or other MNES due to either a lack of available data on biodiversity impacts (e.g. Sydney Metro – Western Sydney Airport is currently subject to early investigations) or uncertainty over the extent and location of development. However, future developments are likely to lead to:

- Additional cumulative impacts on MNES that are impacted by the Plan
- Increased demand for offsets that will compete with the demand created by the Plan

In this context, it is important to note that the Plan supports the delivery of the NSW Government nominated areas program, which consolidates future urban and industrial, infrastructure, agribusiness and transport development within defined areas. This consolidation of development through a process to avoid and minimise impacts to biodiversity contributes to reducing the risk of cumulative impacts from future development in Western Sydney.

38.3.2 IDENTIFICATION OF KEY SPECIES AND ECOLOGICAL COMMUNITIES MOST LIKELY AT RISK

The approach to identify the key species and TECs most likely at risk of cumulative impacts involved:

- Identifying the species and TECs directly impacted by the Plan in terms of impacts on total potential habitat (ha) or impacts on potential habitat relative to available potential habitat within the Cumberland subregion (per cent)
- Identifying the top 15 species and all TECs directly impacted by the Plan that are also being directly impacted by other major projects. Impacts were presented in terms of:
    - Impacts on habitat (ha) due to each major project and total impacts across all major projects
    - Total impacts on habitat relative to available potential habitat within the Cumberland subregion (per cent)
- Identifying cumulative impacts across the Plan and major projects. Impacts were presented in terms of:
    - Total cumulative impacts (ha)
    - Per cent additional impact due to major projects (%)
    - Total impact as per cent of subregion habitat
- Assessing the significance of cumulative impacts and determining whether the commitments under the Plan are adequate in the context of the cumulative impacts

Note that Coastal floodplain eucalypt forest of eastern Australia was not assessed as this TEC is currently FPAL and there was very little data on impacts in relation to the major projects.

The analysis was done based on habitat rather than impacts to records or populations because habitat was most widely available information to enable comparison between the Plan and across the major projects.

The species and TECs that are most likely at risk from cumulative impacts and that may need additional commitments under the Plan in the context of those impacts are those matters where:

- The Plan is having a notable impact (it is not within the scope of the Plan to address cumulative impacts from other projects on species/TECs that are subject to negligible or minor impacts under the Plan), and
- The major projects make a significant contribution to cumulative impacts (species/TECs not substantially impacted by major projects only need to be addressed in terms of the impacts of the Plan). This was considered to be where:
    - Major projects have a total impact greater than 100 per cent of the impact of the Plan, or
    - Major projects have a total impact greater than 2 per cent of remaining Cumberland subregion habitat, and
- There is a significant total cumulative impact from the Plan and major projects – this was considered to be where cumulative impacts were greater than 5 per cent of remaining Cumberland subregion habitat

Table 38-1: Major projects included in the cumulative impact assessment and data availability

Major project	Comments	Data source	Data used in the cumulative impact assessment			
			Impact data		Offset data	
			TEC	Species habitat	TEC	Species habitat
Western Sydney Airport	Clearing for development of the Western Sydney Airport commenced in November 2018. The project is predicted to be completed in 2024. No data is available on the clearing that has occurred to date	Western Sydney Airport Environmental Impact Statement (DIRD, 2016b)	Extent within development footprint	Known habitat within development footprint	Extent	Known habitat
Existing North West and South West Growth Areas	Clearing for development within the existing North West and South West Growth Areas has commenced. Impacts were determined for the precincts where clearing has not yet occurred or where clearing has commenced but not been completed.	Biodiversity Offset Program Annual Report 2017–18 (NSW OEH, 2018)	Extent within South West Growth Area precincts*	Extent within the South West* and North West** Growth Area precincts	Extent within and outside the Growth Areas	No data
M12 Motorway	Construction is expected to start in the 2022 and finish in 2025 (RMS, 2019).	M12 Motorway EIS (RMS, 2019)	Extent within development footprint	Known habitat within development footprint	Ecosystem Credits required for EPBC TEC impacts^	Species Credits required for EPBC species^
The Northern Road	Infrastructure approval was granted in May 2018.	The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park - NSW Environmental Impact Statement / Commonwealth Draft Environmental Impact Statement (NSW Government, 2017)	Extent within development footprint	Extent within development footprint	Ecosystem Credits required for PCTs associated with EPBC TEC impacts^	Species Credits required for EPBC species^

<table>
<tr><th rowspan="3">Major project</th><th rowspan="3">Comments</th><th rowspan="3">Data source</th><th colspan="4">Data used in the cumulative impact assessment</th></tr>
<tr><th colspan="2">Impact data</th><th colspan="2">Offset data</th></tr>
<tr><th>TEC</th><th>Species habitat</th><th>TEC</th><th>Species habitat</th></tr>
<tr><td>Figtree Hill</td><td>Construction is proposed to commence in two stages, with stage 1 commencing in 2018/2019 (Eco Logical Australia, 2018b)</td><td>Mt Gilead Residential Development – EPBC Preliminary Documentation (EPBC 2015/7599) (Eco Logical Australia, 2018b)</td><td>Extent within development footprint</td><td>Known and potential habitat within development footprint</td><td>Ecosystem Credits required for PCTs associated with EPBC TEC impacts^</td><td>Species Credits required for EPBC species^</td></tr>
<tr><td>Bingara Gorge</td><td>The ongoing development of Bingara Gorge is expected to occur over 7 years from the time of approval (Eco Logical Australia, 2018a)</td><td>Bingara Gorge – EPBC Assessment Report (EPBC 2014/7400) (Eco Logical Australia, 2018a)
EPBC Act referral document (EPBC 2014/7400) (Eco Logical Australia, 2015)</td><td>Extent within development footprint and 30m buffer</td><td>Potential habitat</td><td>Secured offsets at Fernhill North West Biobank site and onsite offsets</td><td>Pre-existing habitat area at Bingara Gorge known as the Environment Protection and Recreation Lands</td></tr>
</table>

*Existing South West Growth Area precincts: Austral, Bringelly, Catherine Fields, Future, Industrial, Kemps Creek, Leppington, Leppington North, Lowes Creek, Marylands, North Bringelly, North Rossmore, Rossmore

**Existing North West Growth Area precincts: Box Hill, Box Hill Industrial, Marsden Park North, Riverstone, Riverstone East, Riverstone West, Shanes Park, Vineyard, West Schofields

^See Table **38-2** for offset credit conversion factor

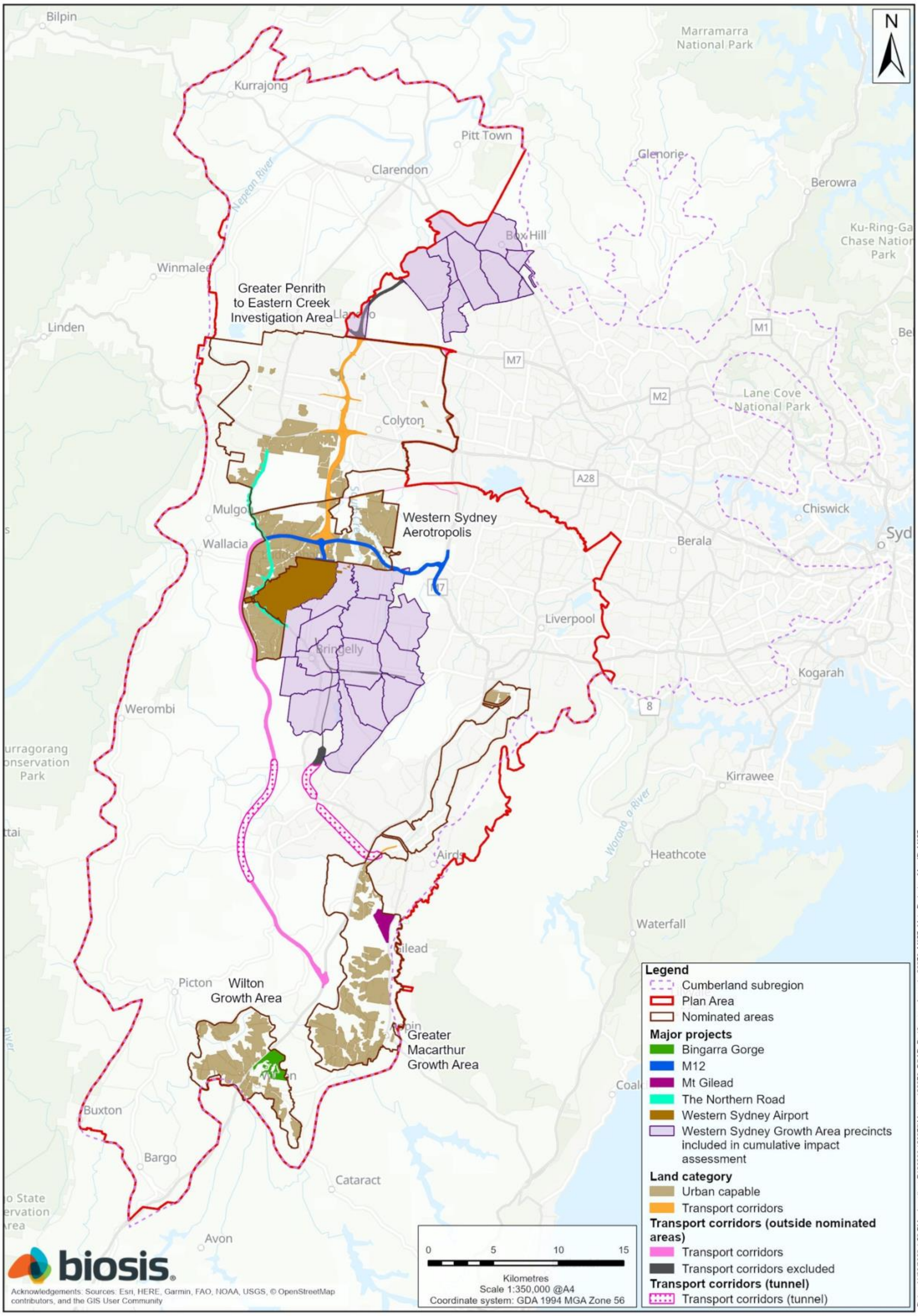

Figure 38-1: Location of major projects included in the cumulative impact assessment

38.3.3 EVALUATION OF CUMULATIVE IMPACTS

The approach to the evaluation of cumulative impacts involved using information in conservation advices, recovery plans and threat abatement plans for each species or TEC to evaluate the significance of cumulative impacts across the Plan and major projects and determine whether measures should be undertaken under the Plan to reduce these impacts.

The evaluation was undertaken considering the following questions:

- What is the significance of the total cumulative impact across the Plan and major projects, taking into account:
  - Information in conservation advices, recovery plans and threat abatement plans for each species or TEC?
  - Distribution or spread of impacts across the Cumberland subregion?
- To what extent is the Plan contributing to cumulative impacts?
- To what extent are the impacts of the Plan known or likely?
- Do the current offset and mitigation measures under the Plan deal adequately with the cumulative impact?
- Whether additional mitigation measures are required to adequately address cumulative impacts?

38.3.4 LIMITATIONS

The cumulative impact assessment has the following key limitations:

- Data in relation to impacts or offsets was not always available for each major project
- Data was not always available in a form that allowed consistent comparison across major projects or the Plan. For example, the Plan assesses species habitat in terms of potential habitat, whereas some major projects assess species habitat in terms of known or likely habitat (as these assessments are done at a finer scale) or a combination of both
- Due to data availability, cumulative impacts were not considered in terms of indirect impacts
- Impact data on the existing North West and South West Growth Areas program was based on an assumption that the entire precincts covered in the analysis (see Table 38-1) were impacted, as development footprints were not available for the analysis. This is likely to greatly overestimate the impacts on potential habitat from this program
- A number of major projects have based their offset programs on acquiring biodiversity credits under the BBAM. Where conservation commitments are based on acquiring credits, a conversion factor was needed to describe the intended outcomes in terms of hectares of land conserved (see Table 38-2). This factor is an approximation only

Table 38-2: Offset credit conversion factors

Credit scheme	Number of credits	Equivalent number of hectares
BBAM	10	1

38.4 IMPACT ASSESSMENT

38.4.1 DIRECT IMPACTS

Table 38-3 and Table 38-4 identify the top 15 species and all TECs directly impacted by the Plan (in terms of impacts to potential habitat relative to available habitat within the Cumberland subregion) that are also impacted by major projects.

For each species and TEC, the tables show:

- Impacts from each major project in terms of hectares impacted and as per cent of subregion habitat, and the total impacts
- Total cumulative impacts across the major projects and Plan in terms of:
  - Total impact in hectares
  - 'Per cent additional impact due to major projects'
  - Total impact as 'per cent of remaining subregion habitat'

The table shows that the major projects make a significant contribution to cumulative impacts in relation to most of the top 15 species impacted by the Plan (the major projects have a total impact greater than 100 per cent of the impact of the Plan or greater than '2 per cent of remaining Cumberland subregion habitat') but only to one TEC – Cumberland Plain Woodland.

Of these species and this TEC, there is a significant total cumulative impact across the Plan and major projects (an impact on 'per cent of remaining Cumberland subregion habitat' of greater than 5 per cent) in relation to:

- Downy Wattle
- White-flowered Wax Plant
- *Micromyrtus minutiflora*
- Spiked Rice-flower
- *Pultenaea parviflora*
- Regent Honeyeater
- Swift Parrot
- Dural Land Snail
- Grey-headed Flying-fox
- Cumberland Plain Shale Woodland and Shale-Gravel Transition Forest

Table 38-3: Potential cumulative impacts to top 15 species impacted by Plan

Species	Total habitat in the SAA	Plan impacts		Major project impacts								Cumulative impacts Plan and major projects		
		Impact (ha)	Impact as % of subregion habitat	Western Sydney Airport (ha)	Existing Growth Areas* (ha)	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total impact (ha)	Total impact as % of subregion habitat	Total impact (ha)	% additional impact due to major projects	Impact as % of subregion habitat
Flora														
Acacia bynoeana (Bynoe's Wattle)	30,677.7	198.7	0.6%	N/A	565.1	N/A	N/A	N/A	41.3	606.4	2.0%	**805.1**	**305.2**	**2.6**
Acacia pubescens (Downy Wattle)	35,102.3	791.7	2.3%	5.0	3,586.6	N/A	N/A	N/A	N/A	3,591.6	10.2%	**4,383.2**	**453.7**	**12.5**
Cynanchum elegans (White-flowered Wax Plant)	3,342.5	19.6	0.6%	289.9	N/A	N/A	N/A	N/A	N/A	289.9	8.7%	**309.5**	**1,475.4**	**9.3**
Eucalyptus benthamii (Camden White Gum)	4,799.7	47.3	1.0%	N/A	81.5	N/A	N/A	N/A	N/A	81.5	1.7%	**128.8**	**172.2**	**2.7**
Micromyrtus minutiflora	36,680.4	160.3	0.4%	N/A	2,256.7	N/A	N/A	N/A	N/A	2,256.7	6.2%	**2,417.1**	**1,407.5**	**6.6**
Pimelea curviflora var. *curviflora*	13,064.1	75.9	0.6%	N/A	425.4	N/A	N/A	N/A	N/A	425.4	3.3%	**501.3**	**560.6**	**3.8**
Pimelea spicata (Spiked Rice-flower)	34,859.0	955.6	2.7%	247.8	4,922.9	N/A	N/A	N/A	N/A	5,170.7	14.8%	**6,126.3**	**541.1**	**17.6**
Pomaderris brunnea (Brown Pomaderris)	26,092.1	202.5	0.8%	N/A	831.2	N/A	N/A	N/A	13.2	844.4	3.2%	**1,046.8**	**417.1**	**4.0**

Species	Total habitat in the SAA	Plan impacts		Major project impacts								Cumulative impacts Plan and major projects		
		Impact (ha)	Impact as % of subregion habitat	Western Sydney Airport (ha)	Existing Growth Areas* (ha)	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total impact (ha)	Total impact as % of subregion habitat	Total impact (ha)	% additional impact due to major projects	Impact as % of subregion habitat
Pultenaea parviflora	20,207.9	188.4	0.9%	247.8	3,525.8	N/A	N/A	0.6	N/A	3,774.2	18.7%	**3,962.6**	**2,003.7**	**19.6**
Fauna														
Anthochaera phrygia (Regent Honeyeater)	59,460.4	1,284.9	2.2%	N/A	3,331.1	N/A	N/A	26.3	41.3	3,398.7	5.7%	**4,683.6**	**264.5**	**7.9**
Chalinolobus dwyeri (Large-eared Pied Bat)	25,555.0	316.4	1.2%	0.0	414.7	N/A	10.9	26.3	33.0	484.7	1.9%	**801.1**	**153.2**	**3.1**
Lathamus discolor (Swift Parrot)	59,460.4	1,284.9	2.2%	141.8	3,331.1	N/A	10.9	26.3	33.0	3,543.0	6.0%	**4,827.9**	**275.7**	**8.1**
Petauroides volans (Greater Glider)	25,762.9	134.0	0.5%	N/A	644.5	N/A	N/A	N/A	N/A	644.5	2.5%	**778.5**	**481.0**	**3.0**
Pommerhelix duralensis (Dural Land Snail)	25,503.4	45.8	0.2%	N/A	3,775.3	N/A	N/A	N/A	N/A	3,775.3	14.8%	**3,821.1**	**8,240.6**	**15.0**
Pteropus poliocephalus (Grey-headed Flying-fox)	26,873.3	723.1	2.7%	141.8	2,723.6	55.2	10.9	26.3	33.0	2,990.6	11.1%	**3,713.8**	**413.6**	**13.8**

* The Strategic Assessment Report for existing North West and South West Growth Areas program notes that impacts may occur to an undetermined quantity of low quality habitat for these species

Table 38-4: Potential cumulative impacts to TECs impacted by the Plan

Matter	Total habitat in the SAA	Plan impacts		Major project impacts								Cumulative impacts Plan and major projects		
		Impact (ha)	Impacts as % of subregion habitat	Western Sydney Airport	Existing Growth Areas	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total impact (ha)	Total impact as % of subregion habitat	Total impact (ha)	% additional impact due to major projects	Impacts as % of subregion habitat
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	271.4	1.8	0.7%	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.0%	**1.8**	**0.0**	**0.7**
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	790.7	26.3	3.3%	N/A	1.4	N/A	N/A	N/A	N/A	1.4	0.2%	**27.7**	**5.3**	**3.5**
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	9,737.2	154.7	1.6%	104.9	503.5	38.5	0.1	16.4	N/A	663.4	6.8%	**818.1**	**428.8**	**8.4**
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	8,214.1	191.8	2.3%	N/A	N/A	N/A	5.3	N/A	57.2	62.5	0.8%	**254.3**	**32.6**	**3.1**

38.4.2 OFFSETS FOR MAJOR PROJECTS

Table 38-5 and Table 38-6 show the offset commitments under major projects (ha) for the top 15 species and TECs impacted by the Plan. For each species and TEC, the tables show:

- Offsets from each major project (in hectares) and the total offsets from major projects
- Total cumulative offsets across the major projects and the Plan in terms of:
  - Total offsets in hectares
  - Total offsets as a per cent of remaining Cumberland subregion habitat

It is important to note that:

- Under the Plan some species have specific offset targets to secure either a certain number of offset locations or potential foraging habitat (see Chapter 8). Other species do not have targets, but are likely to benefit from the targets for NSW TECs/PCTs, as those PCTs provide potential habitat for the species. The amount of potential habitat (ha) for each species that will be secured in the SCAs because of the TEC/PCT targets is shown the table (see column 4)
- Some major projects included offsets involving securing of populations rather than known or potential habitat. This has not been included in the analysis, as the analysis was done based on habitat

Table 38-5: Offset commitments for top 15 species impacted by Plan

Matter	Total habitat in the SAA	Plan offsets		Major project offsets (ha)^							Cumulative offsets Plan and major projects	
		Specific target (ha or site locations)	Potential habitat secured through NSW TEC/PCT targets (ha)	Western Sydney Airport	Existing Growth Areas*	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total - major projects	Total offset (ha)	Offsets as % of subregion habitat
Flora												
Acacia bynoeana (Bynoe's Wattle)	30,677.7	No	4,125.0	N/A	N/A	N/A	N/A	N/A	117.0	117.0	4,242.0	13.8
Acacia pubescens (Downy Wattle)	35,102.3	No	4,970.0	N/A	0.0	N/A	N/A	N/A	N/A	0.0	4,970.0	14.2
Cynanchum elegans (White-flowered Wax Plant)	3,342.5	2 offset locations	3,620.2	N/A	N/A	N/A	N/A	N/A	N/A	0.0	3,620.2	108.3
Eucalyptus benthamii (Camden White Gum)	4,799.7	No	2,775.0	N/A	N/A	N/A	N/A	N/A	N/A	0.0	2,775.0	57.8
Micromyrtus minutiflora	36,680.4	No	260.0	N/A	N/A	N/A	N/A	N/A	N/A	0.0	260.0	0.7
Pimelea curviflora var. *curviflora*	13,064.1	No	4,015.0	N/A	N/A	N/A	N/A	N/A	N/A	0.0	4,015.0	30.7
Pimelea spicata	34,859.0	3 offset locations	3,170.2	N/A	0.0	N/A	N/A	N/A	N/A	0.0	3,170.2	9.1

Matter	Total habitat in the SAA	Plan offsets		Major project offsets (ha)^							Cumulative offsets Plan and major projects	
		Specific target (ha or site locations)	Potential habitat secured through NSW TEC/PCT targets (ha)	Western Sydney Airport	Existing Growth Areas*	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total - major projects	Total offset (ha)	Offsets as % of subregion habitat
Pomaderris brunnea (Brown Pomaderris)	26,092.1	No	2,040.0	N/A	N/A	N/A	N/A	N/A	N/A	0.0	2,040.0	7.8
Pultenaea parviflora	20,207.9	2 offset locations	260.0	N/A	N/A	135.0	N/A	6.0	N/A	141.0	401.0	2.0
Fauna												
Anthochaera phrygia (Regent Honeyeater)	59,460.4	4,470 ha of potential foraging habitat	5,470.2	N/A	N/A	N/A	N/A	202.0	N/A	202.0	5,672.2	9.5
Chalinolobus dwyeri (Large-eared Pied Bat)	25,555.0	No	5,470.2	N/A	0.0	N/A	26.0	N/A	117.0	143.0	5,613.2	22.0
Lathamus discolor (Swift Parrot)	59,460.4	4,470 ha of potential foraging habitat	5,470.2	N/A	0.0	N/A	26.0	N/A	117.0	143.0	5,613.2	9.4
Petauroides volans (Greater Glider)	25,762.9	No	5,160.2	N/A	N/A	N/A	N/A	N/A	N/A	0.0	5,160.2	20.0

Matter	Total habitat in the SAA	Plan offsets		Major project offsets (ha)^							Cumulative offsets Plan and major projects	
		Specific target (ha or site locations)	Potential habitat secured through NSW TEC/PCT targets (ha)	Western Sydney Airport	Existing Growth Areas*	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total - major projects	Total offset (ha)	Offsets as % of subregion habitat
Pommerhelix duralensis (Dural Land Snail)	25,503.4	No	4,970.2	N/A	N/A	N/A	N/A	N/A	N/A	0.0	4,970.2	19.5
Pteropus poliocephalus (Grey-headed Flying-fox)	26,873.3	No	5,475.2	410.0	0.0	N/A	26.0	N/A	117.0	553.0	6,028.2	22.4

* The offset commitments for the existing North West and South West Growth Areas included small targets for the protection of these species that have already been met – *Acacia pubescens*, *Pimelea spicata*, Swift Parrot, Large-eared Pied Bat, and Grey-headed Flying Fox

^ The offset targets for species and TECs are based on commitments to protect PCTs under the Plan

Table 38-6: Offset commitments for TECs impacted by Plan

Matter	Total habitat in the SAA	Plan offsets (ha)	Major project offsets (ha)							Cumulative offsets Plan and major projects	
			Western Sydney Airport	Existing Growth Areas*	M12	Figtree Hill	The Northern Road	Bingara Gorge	Total - major projects	Total offset (ha)	Offsets as % of subregion habitat
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	271.4	4.8	N/A	N/A	N/A	N/A	N/A	N/A	0.0	4.8	1.8
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	790.7	103.4	N/A	N/A	N/A	N/A	N/A	N/A	0.0	103.4	13.1
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	9,737.2	573.7	355.0	2,605.0*	181.0	0.8	94.0	N/A	3,235.8	3,809.5	39.1
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	8,214.1	717.4	N/A	132.0	N/A	13.9	N/A	92.5	238.4	955.8	11.6

*Note that the commitments under the existing North West and South West Growth Areas are for 1) At least 2400 hectares of Commonwealth-listed Cumberland Plain Woodland or other 'grassy woodland' communities, with preference given to Cumberland Plain Woodland, followed by White Box–Yellow Box–Blakely's Red Gum Grassy Woodland and Derived Native Grassland 2) At least 205 hectares of high quality Commonwealth-listed Cumberland Plain Woodland

38.5 EVALUATION FOR THREATENED SPECIES AND TECS

38.5.1 KEY MATTERS OF CONCERN

The purpose of the cumulative impact assessment is to identify the key species and TECs under the Plan that are also impacted by other major projects in the Cumberland subregion to:

- Assess the significance of cumulative impacts
- Determine whether the commitments under the Plan are adequate in the context of the cumulative impacts

The species and TECs that are most likely at risk from cumulative impacts and that may need additional commitments under the Plan in the context of those impacts are those matters where (see Section 38.3):

- The Plan is having a notable impact, and
- The major projects make a significant contribution to cumulative impacts, and
- There is a significant total cumulative impact from the Plan and major projects

The species and TECs that meet these criteria are:

- Species
    - Downy Wattle
    - White-flowered Wax Plant
    - *Micromyrtus minutiflora*
    - Spiked Rice-flower
    - *Pultenaea parviflora*
    - Regent Honeyeater
    - Swift Parrot
    - Dural Land Snail
    - Grey-headed Flying-fox
- TECs: Cumberland Plain Shale Woodlands and Shale Gravel Transition Forest

The significance of the cumulative impacts on each of these species and TECs is evaluated in Section 38.5.2.

38.5.2 EVALUATION OF EACH KEY MATTER

For each species and TEC, the evaluation considers:

- Extent, nature and risks of the impacts under the Plan. As potential habitat was used to assess cumulative impacts, this provides a better understanding of the significance of the likely or actual impacts of the Plan
- Significance of the cumulative impacts across the Plan and major projects, taking into account:
    - Cumulative impact as per cent of subregion habitat
    - Distribution of the species and likely importance of the Cumberland subregion for persistence
    - Amount of habitat in existing protected lands
- The overall outcome of the commitments made under the Plan and the offsets provided under the major projects that may address the cumulative impacts, taking into account:
    - Total offset amounts across the Plan and major projects
    - Per cent amount of increase in levels of protection in the subregion for the matter
    - The relative contribution of the Plan to total offsets and increasing levels of protection for the matter

ACACIA PUBESCENS (DOWNY WATTLE)

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for *Acacia pubescens* is moderate compared to the other major projects (17 per cent of the total impact).

However, the risk of impacts to this species under the Plan is low. The Plan will not result in any direct impacts to records or important populations. There is a direct impact to 791.7 ha of potential habitat for this species, which amounts to 2.3 per cent of the mapped habitat in the Strategic Assessment Area.

This loss of potential habitat generally relates to small and scattered patches. The risk of impacts to higher quality larger patches of habitat within Wianamatta Regional Park are considered to be low because the species has never been recorded on this site, despite significant survey effort.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on *Acacia pubescens* is considered to be moderate because:

- The total cumulative impact is moderate (greater than 10 per cent of total potential habitat in the subregion)
- The species is largely restricted to the Cumberland subregion
- The species is not well represented in existing protected lands (approximately 8 per cent of total potential habitat in the Strategic Assessment Area, or 13 of 97 important populations, occurs in existing protected lands)

Known records for *Acacia pubescens* are distributed across two core areas which have been identified for site management under the NSW Saving our Species (SOS) program:

- One area associated with the Hawkesbury SOS site, comprising approximately 3,736 ha in the north-east of the Strategic Assessment Area, including Windsor Downs, Pitt Town and Scheyville National Park
- The second associated with the Bankstown-Liverpool SOS site, comprising an area of approximately 5,842 ha that straddles the central-east boundary of the Strategic Assessment Area around Lansdowne

These areas are generally not impacted by the Plan or major projects.

It is also important to note that cumulative impact from other major projects are primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

Offsets of potential habitat for *Acacia pubescens* are only provided under the Plan (and not under major projects).

Due to the risk of impacts being low, the Plan does not include a species-specific commitment to secure offset locations for *Acacia pubescens*. However, the Plan includes a commitment to protect 4,970 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

Given the low risk of impacts to the species under the Plan, it is considered that the Plan adequately contributes to addressing the cumulative impacts to this species. In particular, the Plan will:

- Lead to the protection of 5 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 8 per cent to 13 per cent

CYNANCHUM ELEGANS (WHITE-FLOWERED WAX PLANT)

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for *Cynanchum elegans* is low compared to the other major projects (7 per cent of the total impact).

The risk of impacts to this species under the Plan is medium. The Plan will not result in any direct impacts to records or important populations, however, one important population will be fragmented by the OSO at Cobbitty. There is a direct impact to 19.6 ha of potential habitat for this species, which amounts to 0.6 per cent of the mapped habitat in the Strategic Assessment Area. This impact generally relates to small and isolated areas.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on *Cynanchum elegans* is considered to be low because:

- The total cumulative impact is relatively small (less than 10 per cent of total potential habitat in the subregion)
- The species is not restricted to the Cumberland subregion (the species occurs in eastern NSW from Brunswick Heads on the north coast to the Illawarra region south of Sydney) and therefore the cumulative impacts in the subregion are less likely to impact species persistence within NSW
- At least 40 populations of the species are known to occur within existing protected lands in NSW, and under the SOS program, current management is considered sufficient to protect *Cynanchum elegans* in NSW in the long-term

Adequacy of the cumulative offsets

Offsets of potential habitat for *Cynanchum elegans* are only provided under the Plan (and not under major projects).

The Plan includes a species-specific commitment to secure 2 offset locations for *Cynanchum elegans* to address the residual impacts of the development. The Plan also includes a commitment to protect 4,148 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

Given the low contribution of the Plan to cumulative impacts, it is considered that the Plan adequately contributes to addressing the cumulative impacts to this species. In particular the Plan will:

- Secure 2 offset locations for *Cynanchum elegans*
- Lead to the protection of 2 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 13 per cent to 15 per cent

MICROMYRTUS MINUTIFLORA

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for *Micromyrtus minutiflora* is low compared to the other major projects (7 per cent of the total impact).

Furthermore, the risk of impacts to this species under the Plan is very low. The Plan will not result in any direct impacts to records or important populations. The most notable impacts to potential habitat occur due to the OSO within Wianamatta Regional Park. The risk of impacts in this location is considered low because:

- The species has not been recorded in the area despite the area forming part of a Regional Park which is managed by the NSW National Parks and Wildlife Service and would be well traversed
- The species was not observed as part of surveys conducted through sections of suitable habitat within the OSO corridor as part of this Assessment Report

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on *Micromyrtus minutiflora* is considered to be moderate. Although less than 10 per cent of total potential habitat for the species in the Cumberland subregion is cumulatively impacted, the species:

- Is restricted to the north-western parts of the Cumberland Plain
- Not well represented in existing protected lands (only approximately 5 per cent of total potential habitat in the Cumberland subregion occurs in existing protected lands)

It is important to note that the cumulative impact from other major projects is primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

Offsets of potential habitat for *Micromyrtus minutiflora* are only provided under the Plan (and not under major projects).

The Plan includes a commitment to protect 260 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

Given the low contribution of the Plan to cumulative impacts, and the very low risk of impacts to the species under the Plan, it is considered that the Plan adequately contributes to addressing cumulative impacts to this species. The Plan will increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 5 per cent to 7 per cent.

***PIMELEA SPICATA* (SPIKED RICE-FLOWER)**

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for *Pimelea spicata* is moderate compared to the other major projects (15 per cent of the total impact).

Furthermore, the risk of impacts to this species under the Plan is high. The Plan will result in direct impacts to one important population and 955.6 ha of potential habitat for the species, which is 2.7 per cent of potential habitat across the Strategic Assessment Area.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on *Pimelea spicata* is considered to be high because:

- The total cumulative impact is moderate (greater than 10 per cent of total potential habitat in the subregion)
- The risk of impacts to this species under the Plan is high
- The species is relatively restricted in NSW, with the majority of known populations of the species occurring in the Cumberland subregion
- The species is not well represented in existing protected lands (only approximately 9 per cent of total potential habitat in the Strategic Assessment Area occurs in existing protected lands)

It is important to note that the cumulative impact from other major projects is primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

Offsets for *Pimelea spicata* are only provided under the Plan (no offsets are provided through the major projects).

The Plan includes a species-specific commitment to secure 3 offset locations for *Pimelea spicata* to address the residual impacts of the development. In addition to this commitment, the Plan includes a commitment to protect 3,170.2 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

It is considered that the Plan adequately contributes to addressing cumulative impacts to this species. In particular, the Plan will:

- Secure 3 offset locations for *Pimelea spicata*
- Lead to the protection of 7 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 9 per cent to 16 per cent

PULTENAEA PARVIFLORA

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for *Pultenaea parviflora* is low compared to the other major projects (5 per cent of the total impact).

Despite this, the risk of impacts to this species under the Plan is high. The Plan will result in direct impacts to several important populations. There will be direct impacts on 188.4 ha of potential habitat for the species, which is 0.9 per cent of potential habitat across the Strategic Assessment Area. Habitat loss is generally to small patches exposed to edge effects, however, in Wianamatta Regional Park habitat loss will result in some fragmentation.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on *Pultenaea parviflora* is considered to be moderate because:

- The total cumulative impact is moderate (greater than 10 per cent of total potential habitat in the subregion)
- The species is restricted to the Cumberland subregion
- The Strategic Assessment Area is the core location for the species. Records occur in the northern half of the Strategic Assessment Area, with the majority of records occurring in the locality of Londonderry/Marsden Park
- The species is not well represented in existing protected lands (only approximately 11 per cent of total potential habitat in the Strategic Assessment Area occurs in existing protected lands)

It is important to note that the cumulative impact from other major projects is primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

The major projects provide total offsets of 141 hectares of potential habitat for *Pultenaea parviflora*.

The Plan includes a species-specific commitment to secure 2 offset locations for *Pultenaea parviflora* to address the residual impacts of the development. In addition to this commitment, the Plan includes a commitment to protect 260 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

It is considered that the Plan adequately contributes to addressing cumulative impacts to this species. In particular, the Plan, together with the major projects, will:

- Secure 2 offset locations for *Pultenaea parviflora* and 401 hectares of potential habitat for the species
- Lead to the protection of 3 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 11 per cent to 15 per cent

REGENT HONEYEATER (ANTHOCHAERA PHRYGIA) AND SWIFT PARROT (LATHAMUS DISCOLOR)

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for Regent Honeyeater and Swift Parrot is high compared to the other major projects (about 27 per cent of the total impact for both species).

The risk of impacts to these species under the Plan is low for Regent Honeyeater and medium for Swift Parrot. The Plan will result in the removal of 1,284.9 ha of potential foraging habitat for both these species, which amounts to 2.2 per cent of potential habitat across the Strategic Assessment Area.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on Regent Honeyeater and Swift Parrot is considered to be low because:

- Total cumulative impact is relatively low (less than 10 per cent of total potential habitat in the subregion)

- The species are not restricted to the Cumberland subregion (both species have a broad range during their non-breeding seasons) and the Strategic Assessment Area is outside identified breeding locations for both species

It is important to note that the cumulative impact from other major projects is primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

The major projects provide total offsets of 202 hectares of potential habitat for Regent Honeyeater and 143 hectares of potential habitat for Swift Parrot.

The Plan includes a species-specific commitment to secure 4,470 ha of potential foraging habitat for Regent Honeyeater and Swift Parrot to address the residual impacts of the development. The Plan also includes a commitment to incorporate a requirement in Development Control Plans to retain large trees (>50cm DBH) in urban areas, which are likely to provide high sources of nectar and therefore comprise primary foraging habitat for both these species.

It is considered that the Plan adequately contributes to addressing cumulative impacts to this species. In particular, the Plan together with the major projects, will:

- Lead to the protection of 8 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 13 per cent to 21 per cent

Dural Land Snail (Pommerhelix duralensis)

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for Dural Land Snail is small compared to the other major projects (1 per cent of the total impact).

Furthermore, the risk of impacts to this species under the Plan is very low. The Plan will not result in any direct impacts to records or important populations. There is a direct impact to 45.8 ha of potential habitat for this species, which amounts to 0.2 per cent of the potential habitat within the Strategic Assessment Area. Furthermore, this habitat is over 5 km from the nearest record, and over 30 km from the nearest important population.

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on Dural Land Snail is considered to be low because, while the total cumulative impact is moderate (greater than 10 per cent of total potential habitat in the subregion), records occur predominantly along the north-east fringes of the Cumberland subregion and generally outside areas that are cumulatively impacted, and the Strategic Assessment Area is not recognised as a key location for the species.

It is important to note that the cumulative impact from other major projects is primarily due to the existing North West and South West Growth Areas, and the impacts associated with these areas are likely to be greatly overestimated (see Section 38.3). This reduces the significance of the total cumulative impacts.

Adequacy of the cumulative offsets

Offsets for Dural Land Snail are only provided under the Plan (no offsets are provided through major projects).

Due to the risk of impacts being very low, the Plan does not include a species-specific commitment to offset known habitat or populations of Dural Land Snail. However, the Plan includes a commitment to protect 4,970.2 hectares of NSW TECs/PCTs that are associated with potential habitat for the species.

Given the very low risk of impacts to the species under the Plan, it is considered that the Plan adequately contributes to addressing cumulative impacts to this species.

GREY-HEADED FLYING-FOX (PTEROPUS POLIOCEPHALUS)

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on potential habitat for Grey-headed Flying Fox is moderate compared to the other major projects (19 per cent of the total impact).

Despite this, the risk of impacts to this species under the Plan is low. The Plan will not result in any direct impacts to Grey-headed Flying-fox camps. There is a direct impact to 723.1 ha of potential foraging habitat, which amounts to 2.7 per cent of the potential habitat within the Strategic Assessment Area. The risk from this loss is considered to be low, because:

- Development will proceed in stages over the life of the Plan. Impacts will be at a rate of approximately 20 ha of habitat clearing per year. The annual loss of habitat will not be large
- There are large areas of habitat that support the highest nectar rank vegetation communities within 20 km of the nationally important and high priority camps (including large areas outside the Strategic Assessment Area)

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on Grey-headed Flying Fox is considered to be moderate because:

- Total cumulative impact is moderate (greater than 10 per cent of total potential habitat in the subregion)
- The Strategic Assessment Area supports a large number of Grey-headed Flying-fox camps (11 camps in total), including one nationally important camp in Bingara Reserve in Macquarie Fields
- 14 camps occur within 20 km of the Strategic Assessment Area, including three nationally important camps

The nationally important camp and high priority camp in the Strategic Assessment Area have significant mapped foraging resources (highest nectar rank) within 20 km. Much of this occurs outside the Strategic Assessment Area and is unlikely to be cumulatively impacted by the Plan or major projects as it largely comprises defence or protected lands.

Adequacy of the cumulative offsets

The major projects provide total offsets of 553 hectares of potential habitat for Grey-headed Flying Fox.

A species-specific commitment has been made under the Plan for Grey-heading Flying Fox to address potential impacts to foraging habitat from the development. The commitment is to incorporate a requirement in Development Control Plans to retain large trees (>50cm DBH) in urban areas, which are likely to provide high sources of nectar and therefore comprise primary foraging habitat for this species. In addition to this commitment, the Plan includes a commitment to protect 5,475.2 hectares of NSW TECs/PCTs that are associated with potential foraging habitat for these species.

Given the low risk of impacts to this species under the Plan, it is considered that the Plan adequately contributes to addressing cumulative impacts to this species. In particular, the Plan, together with the major projects, will:

- Lead to the protection of 8 per cent of the total potential habitat for the species in the Cumberland subregion
- Increase existing levels of protection of habitat for the species in the Strategic Assessment Area from 13 per cent to 21 per cent

CUMBERLAND PLAIN SHALE WOODLANDS AND SHALE GRAVEL TRANSITION FOREST

Nature and extent of impacts under the Plan

The Plan's contribution to cumulative impacts on Cumberland Plain Woodland is moderate compared to the other major projects (19 per cent of the total impact).

However, the Plan is not considered to have notable impacts on this TEC. The Plan will directly impact 154 ha of the TEC, which amounts to 1.6 per cent of the remaining TEC in the Strategic Assessment Area. The majority of the TEC impacted is in thinned condition and comprises small patches (less than 5 hectares). Most of the impacted TEC is of lower viability, and only 12 ha of higher viability TEC will be impacted (0.3 per cent of higher viability TEC in the Strategic Assessment Area).

Significance of cumulative impacts

The significance of the cumulative impacts across the Plan and major projects on Cumberland Plain Woodland is considered to be low because:

- The total cumulative impact is relatively low (less than 10 per cent of total potential habitat in the subregion):
- The TEC is relatively well represented in existing protected lands (approximately 21 per cent of total TEC in the Strategic Assessment Area occurs in existing protected lands). Note that this figure will significantly increase once the proposed offset in Orchid Hills for Stage 1 of the Western Sydney Airport is secured

Adequacy of the cumulative offsets

The major projects provide total offsets of 3,236 hectares of Cumberland Plain Woodland under the existing North West and South West Growth Areas program. It is important to note that the commitments under the program are for:

- At least 2,400 hectares of Commonwealth-listed Cumberland Plain Woodland or other 'grassy woodland' communities, with preference given to Cumberland Plain Woodland, followed by White Box–Yellow Box–Blakely's Red Gum Grassy Woodland and Derived Native Grassland
- At least 205 hectares of high-quality Commonwealth-listed Cumberland Plain Woodland

A species-specific commitment has been made under the Plan to address residual impacts on Cumberland Plain Woodland. The commitment is to secure 575 hectares of the TEC in conservation lands.

It is considered that the Plan adequately contributes to addressing cumulative impacts to this species. In particular, the Plan, together with the major projects (noting the qualification above), will:

- Lead to the protection of 39 per cent of the total TEC in the Cumberland subregion
- Increase existing levels of protection for the TEC in the Strategic Assessment Area from 20 per cent to 60 per cent

38.6 CONCLUSION IN RELATION TO THREATENED SPECIES AND TECS

While cumulative impacts to some species are considered to be moderate, the commitments under the Plan, together with the offsets through the major projects, are considered to adequately address these cumulative impacts. It is also considered that the Plan makes an adequate and substantial contribution to addressing these impacts.

38.7 CUMULATIVE IMPACTS ON OTHER MNES

The MNES that are most likely at risk from cumulative impacts and that may need additional commitments under the Plan in the context of those impacts are those matters where:

- The Plan is having a notable impact, and
- The major projects make a significant contribution to cumulative impacts, and
- There is a significant total cumulative impact from the Plan and major projects

Where the Plan is only having a minor or negligible impact on MNES, it is not within the scope of the Plan to address cumulative impacts from other major projects on those MNES.

Table 38-7 summarises the impacts of the Plan on other MNES and the potential for cumulative impacts resulting from additional urban or other development in the surrounding area.

Detailed assessments of the impacts of the Plan on each of these MNES are set out in Chapters 32, 33, and 34.

Table 38-7: Potential cumulative impacts from the Plan and major projects on other MNES

<table>
<tr><th>Other MNES</th><th>Summary of impact of Plan and potential for cumulative impacts from additional development in the Cumberland subregion</th></tr>
<tr><td>Migratory species</td><td>Migratory birds
Cumulative impacts are unlikely as potential impacts on migratory species from Plan are considered to be negligible.
Nine species listed in the migratory bird referral guidelines (DoE, 2015) have been observed within the Strategic Assessment Area. Potential impacts to the nine species from the Plan are considered to be negligible. No important habitat will be lost, and the risk of indirect impacts is considered to be negligible. Only one of the species (White-throated Needletail) has been observed in ecologically significant numbers in the Cumberland subregion. This species is almost exclusively aerial and found over a wide range of habitats including extensively modified and urban areas, and therefore the development under the Plan is considered unlikely to disrupt this species' use of the Strategic Assessment Area
See Chapter 32 for a detailed assessment of the impacts of the Plan on migratory birds
Migratory shorebirds
Cumulative impacts are unlikely as potential impacts on migratory species from Plan are considered to be negligible.
Twenty-one species of migratory shorebirds have been recorded in the Cumberland subregion. Two of those have been recorded at a site level in important numbers – Sharp-tailed Sandpiper and Latham's Snipe. No important habitat will be lost, and the risk of indirect impacts such as degradation of habitat and disturbance of birds is considered to be low
See Chapter 32 for a detailed assessment of the impacts of the Plan on migratory shorebirds</td></tr>
<tr><td>Ramsar</td><td>One Ramsar site is relevant to the Plan – Towra Point Nature Reserve. Towra Point Nature Reserve is located outside of the Strategic Assessment Area approximately 23 km from the nearest nominated area. A small part of the Strategic Assessment Area is located within the Georges River sub-catchment that flows directly into Botany Bay and the waters surrounding Towra Point Nature Reserve. This includes 170 ha of land for urban development within parts of GMAC and 9 ha of land within transport corridors
Potential cumulative impacts on Towra Point Nature Reserve from further development in the Cumberland subregion relate to:
• Increased number of visitors to Towra Point Nature Reserve due to increased populations in the surrounding area
• Further development in the Georges River sub-catchment and associated potential impacts on water quality due to urban run-off
Cumulative impacts from the Plan and other development in the surrounding area are unlikely to be notable.
The Botany Bay catchment currently supports an existing population of approximately 2 million people, and therefore has already experienced considerable levels of development (OEH, 2012; SMCMA, 2011). It is likely that additional development will continue to occur within this catchment over the next 36 years. However, it is not possible to predict the locations, nature or timing of these potential future developments, and as such the exact cumulative impact upon the hydrological character of the catchment cannot be quantified at this time
Despite this, the contribution of development within the Strategic Assessment Area to overall cumulative impacts on Towra Point Nature Reserve is likely to be small. The Plan provides for up to 179 ha of development within the Botany Bay catchment. The total size of the catchment is 1,165 km^2 (OEH, 2012; SMCMA, 2011). The urban capable land and transport corridors within the catchment therefore account for only 0.15 per cent of the total catchment area. It is unlikely that development across this small area of the catchment area will result in significant impacts to the wetland
Furthermore, development in the catchment area will not all occur at the same time, reducing the potential for a large increase in urban run-off carrying large quantities of sediment or pollutants into the catchment in any one event. Development under the Plan will occur over 36 years in stages,</td></tr>
</table>

Other MNES	Summary of impact of Plan and potential for cumulative impacts from additional development in the Cumberland subregion
	and other development in the catchment will also occur over many years. Most developments are subject to similar mitigation and management requirements under the EP&A Act that manage construction impacts, hydrological changes and water quality impacts The characteristics of Towra Point Nature Reserve also contribute to the resilience of the wetland and decrease its susceptibility to cumulative impacts. In particular, as the wetland is a tide-dominated estuary environment, the site is subject to regular flushing which significantly reduces the likelihood of build-up of pollutants at the site. Further, Towra Point Nature Reserve has a high level of adaptive site management consistent with best practice, which further protects the site from potential future impacts from wider landscape changes Pressures from increased visitor numbers to the Towra Point Nature Reserve are already occurring due to existing high population densities in proximity to the wetland. As a result, Towra Point Nature Reserve already implements a wide range of ongoing and comprehensive management measures to protect the reserve from disturbances associated with human visitation and recreational use. Therefore, the potential risk to the ecological character of Towra Point Nature Reserve as a result of an increased number of visitors is considered minimal See Chapter 33 for a detailed assessment of the impacts of the Plan on Towra Point Nature Reserve
World and National Heritage	There are three World and/or National Heritage listed sites in or near the Strategic Assessment Area that could potentially be impacted by development under the Plan. The Greater Blue Mountains World Heritage Area (GBMWHA) is located close to the nominated areas. The other heritage sites are further from the urban capable land and transport corridors and are unlikely to be impacted Potential cumulative impacts on GBMWHA from further development in the surrounding area relate to increased number of visitors to GBMWHA due to increased populations in the surrounding area. The potential impacts from increased visitors are: • Disturbance from people, vehicles and horses • Increased frequency of fires • Removal of bushrock and fallen timber • Introduced plants • Development or increased maintenance of visitor or management facilities or infrastructure The population of Sydney is already growing, and the overarching Strategic Plan and the plans of management for each individual reserve within the GBMWHA recognise the pressure from increasing visitors as a major management challenge. The management plans set out a range of management actions and monitoring programs that will support adaptive management of the threats related to increased visitors to GBMWHA over the life of the Plan (see Chapter 34). The protection arrangements for each of the reserves are considered adequate to manage potential cumulative impacts due to increased populations from further development in the surrounding area See Chapter 34 for a detailed assessment of the impacts of the Plan on World and National Heritage sites

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CUMBERLAND PLAIN ASSESSMENT REPORT

PART 6B: ATTACHMENT

ATTACHMENT A - ECOLOGICAL CHARACTER OF TOWRA POINT

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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Part 6B Attachment Contents

A. Ecological character of Towra Point

This section draws heavily on the ecological character description (ECD) for Towra Point (DECCW, SMCMA et al., 2010) and attempts to summarise the key points to facilitate impact assessment. As outlined in the ECD, wetlands are dynamic, changing, and interactive systems. Some components and interactions that contribute to the ecological character of Towra Point exist outside of the Ramsar site boundaries in the adjacent Towra Point Aquatic Reserve. Certain components of the Aquatic Reserve are therefore included in the following description although they may not occur within the Site boundary.

COMPONENTS AND PROCESSES

The components and processes that contribute to the ecological character of Towra Point are:

- Geomorphology
- Hydrology
- Physiochemical environment
- Biota
- Climate

GEOMORPHOLOGY

Towra Point was formed as a result of dynamic wind, wave, and tidal processes over time. The key drivers of geomorphology at Towra Point are:

- Geology and morphology
- Topography and microtopography
- Sedimentation

GEOLOGY AND MORPHOLOGY

The basis of Towra Point was formed from the dynamic movement of marine sand from Botany Bay and fluvial mud from the Georges River. Freshwater swamps formed in the lower lying areas as sea levels rose. River born sediments were deposited in areas with lower rates of water movement, such as Quibray and Woolooware bays. This provided the nutrient rich sediments necessary to support mangrove and salt marsh communities. Progressive erosion of Towra Beach followed by the accretion on the western side of Towra Point formed a sand spit.

Since its listing in 1984, there have been a range of anthropogenic and natural processes that continue to alter Towra Point's geomorphology. Towra Spit Island was formed in 1991 due to erosion by wind and waves. Accretion of sediment reconnected the island to the mainland in 1997, allowing land based predators access to important bird roosting and nesting habitat. The sediment connecting Towra Spit Island to the mainland was dredged in 2004 and needs to continuously be managed to maintain the ecological value of the Island.

TOPOGRAPHY AND MICROTOPOGRAPHY

Towra Point is generally a low-lying area. The elevation varies a little, providing environmental conditions that have led to the type and distribution of flora and fauna in the wetland depending on their tolerance to salt water. There are sand dunes located in the northern centre part of Towra Point. They surround terrestrial vegetation and reach a height of up to 5 m. Low lying areas and mudflats provide favourable environmental conditions for mangroves. Natural processes intensified by anthropogenic changes continue to change the topography, such as the erosion at Towra Beach.

SEDIMENTATION

The sediments in Botany Bay are made up of different sized marine sand, mud, and products of living organisms and biological processes. The erosion and accretion of sediments is caused by the natural processes of wind, waves, and currents. This movement depends on the size and type of sediment, the depth and velocity of water and vegetation cover. Most of the sediment from the Georges River is released into the ocean with a small amount entering the low energy systems of Woolooware and Weeney bays. A significant proportion of the sediment from Quibray bay has been moved around Towra Point to the Elephants Trunk.

Before Botany Bay underwent anthropogenic changes, sand transport in the bay occurred in a south-easterly direction. It now occurs in a westerly direction, causing increased erosion at Towra Beach.

The sedimentation processes of erosion and accretion facilitate the movement and colonisation of vegetation. It also creates mudflats that provide favourable habitat for migratory birds and mangroves.

LIMITS OF ACCEPTABLE CHANGE (LAC)

Maintaining the natural cycle of erosion and accretion has been identified as an aim for the limits of acceptable change for geomorphology. It focuses on maintaining the separation of Towra Spit Island from the mainland. The LAC for geomorphology is the same as those set for the little tern because the spit is an important breeding and roosting habitat for migratory birds including the little tern. The LAC is the 'successful annual breeding in one out of every two years' of the little tern.

HYDROLOGY

Towra Point Ramsar site and its surrounds are a dynamic system that rely on hydrological processes. The key components of hydrology at Towra Point are:

- Tides
- Wave action
- Groundwater

TIDES

Botany Bay is a tide dominated estuary that experiences semi-daily tides. Two high and low tides of equal size occur per lunar day, making it a well flushed system. Tidal movement is key to maintaining good water quality in the system.

The tidal currents are fairly slow and cannot solely cause sediment movement without the assistance of wave energy to suspend the sediments first.

The dynamic nature of hydrology means the tides have a direct influence on the following:

- Geomorphology: with the help of wave energy, tides facilitate sediment movement through the system by means of erosion and accretion
- Groundwater: tidal flooding determines groundwater properties such as salinity
- Physiochemical environment: the bay's physiochemical environment consists mostly of saltwater, with some freshwater on the surface from the river discharge and rainfall. Tides regulate the saltwater to freshwater ratio and consequently, the salinity levels. Tidal movement also ensures that excess nutrients, pollutants, and suspended sediment entering the system via the Georges river is flushed out and does not accumulate in the system
- Biota: tides facilitate the movement of phytoplankton and crab larvae. These are important food sources for zooplankton, invertebrates, fish, and birds. High tides help restock these food sources, while low tides expose mudflats that are important foraging habitat for birds at Towra Point. Tides also assist in seed disbursal

Anthropogenic changes prior to the listing of Towra Point under the Ramsar Convention have caused changes to tidal actions. These changes are included in the Site's baseline condition described in the ECD as they occurred prior to listing. These changes include a causeway that was built through the middle of Towra Point in 1952 that prevents undisturbed tidal flow through the wetland.

Further anthropogenic changes to parts of Botany Bay after the site's listing, such as dredging at the bay's entrance, have again impacted tidal speeds and water quality.

WAVE ACTION

Wave action is a product of the transfer of wind energy to surface water. Waves in Botany Bay are largely influenced by storms that originate from the south-east and enter the bay from the same direction. Wave direction entering into Botany Bay has shifted from impacting the north-west shore to impacting more to the southern shore. This is a result of the construction of Sydney Airport and Sydney Port on the northern shoreline and dredging that also occurred in that area of the bay in the 1960s. The change in direction and intensity of waves entering the bay have caused higher rates of erosion to occur in areas such as Towra Point Beach. These changes have also meant that storms have a greater impact, demonstrated by the intrusion of salt water into Towra Lagoon following severe storms in 1974.

Mudflats are created through the accretion of sediment in low energy areas. Increased wave energy entering the system has the potential to erode mudflats causing the resuspension of these sediments, and result in reduced light availability for seagrass.

GROUNDWATER

The groundwater table is fed by surface water filtering through the soil. Factors that influence water table levels are tides, rainfall, surface layer evaporation, transpiration from plants, and groundwater extraction. Groundwater is critical in providing plants with freshwater and nutrients, particularly during periods of low rainfall.

Towra Point is situated on the Botany Bay Sand Aquifer that extends from Centennial Park in the north, to Botany Bay and Kurnell Peninsula in the south, and west to Rockdale. It is a shallow aquifer, approximately two meters deep. Long term changes in ground water levels can impact the topography above the aquifer, reducing surface elevation. This would alter the extent of tidal inundation and therefore the extent and distribution of the flora and fauna that are supported at Towra Point.

The northern section of the aquifer is most frequently used for residential and industrial water extraction. Botany Bay Industrial Park is located in this section and drains into the aquifer. This has resulted in the contamination of groundwater by volatile chlorinated hydrocarbons in particular. The groundwater in the aquifer flows in a north-westerly direction. Towra Point is therefore unlikely to be directly affected by contamination in the northern zone but rather from the southern zone. The southern part of the aquifer covers a relatively small area, which includes Towra Point. The importance of Towra Point in the process of groundwater recharge and filtering of contaminants for the Botany Bay Sand Aquifer will grow as more of the surrounding area becomes developed with impermeable surfaces that prevent recharge. Other areas that have the potential to contaminate the aquifer are the Caltex oil refinery located east of Towra Point, Kurnell Landfill Company on Captain Cook Drive, and contaminated runoff from roads and industries in the sub-catchment.

Sandmining next to Towra Point at Kurnell Peninsula continued until 2005. This activity exposed the water table, which increased evaporation and the risk of contamination. It has since been filled with demolition waste.

LIMITS OF ACCEPTABLE CHANGE (LAC)

Limits of acceptable change for groundwater are determined by the relevant water quality guidelines (ANZECC & ARMCANZ, 2000; ANZG, 2018).

PHYSIOCHEMICAL ENVIRONMENT

At Towra Point the physiochemical environment determines water quality, which is vital for sustaining the diverse range of flora and fauna. There are some components that have a big impact on water quality such as chlorophyll-a, pH and dissolved oxygen and are critical to the upper parts of the Botany Bay catchment. However, these components are not considered critical for Towra Point due to the well-flushed nature of Botany Bay.

The key components of the physiochemical environment at Towra Point are:

- Salinity
- Nutrients
- Heavy metals
- Turbidity

SALINITY

The average ocean salinity is 35 parts per million (ppm). The salinity range in the water surrounding Towra Point is 20-35 ppm with an average of 33 ppm. Salinity reduces the risk of algal blooms. Botany Bay is less at risk of algal blooms than the upper parts of the catchment because it is well-flushed and has a high salinity level. The tidal flushing of Botany Bay means that freshwater from the Georges River only has an effect on Towra Point after long periods of rain or after heavy rainfall events in the catchments.

There are three named freshwater ponds at Towra Point. These include Towra Lagoon, Weedy Pond, and Mirrormere Pond. The salinity level of freshwater should be close to zero parts per million. In 1992 Towra Lagoon's salinity was 2 and 9.5 ppm in 2007 as a result of ongoing saltwater intrusion since a large storm event in 1974. This is well above the level of tolerance of many freshwater species. Attempts to restore the lagoon to a freshwater system continue to be made through a number of different means such as sandbagging and sand replenishment at Towra Beach.

The flora at Towra Point have varying levels of salt tolerance. There are distinct vegetation zones that can partially be attributed to soil salinity levels amongst other factors. The salt marsh vegetation zone is due to limiting factors such as light availability, rather than soil salinity levels. The distribution of mangroves has increased landward at Towra Point, indicating that salinity levels have changed since it became Ramsar listed.

NUTRIENTS

Nutrients that are important to ecosystems are nitrogen, phosphorus, carbon, silica and iron. Nutrients of particular importance to Towra Point are inorganic and organic forms of nitrogen and phosphorus. Forms of phosphorus that are readily available for plant uptake are inorganic orthophosphate and organic compounds containing phosphorus that are water soluble. Other forms of phosphorus are ionic phosphorus that are absorbed by sediment to settle onto seabeds for uptake by seagrass and other primary producers.

Towra Point wetland system has a high nutrient demand and plays an important role in the cycling of nutrients. The source of the majority of nutrients in Botany Bay is the Georges River, where it enters as runoff from the catchment. This includes agricultural runoff, stormwater and sewer overflows, runoff from urban and industrial areas, groundwater discharge, and decomposition of organic matter. Three sewage treatment plants exist in the catchment at Liverpool, Fairfield, and Glenfield. They treat waste water entering the Georges River during wet weather and are susceptible to occasional overflows for different reasons. In the instance of an overflow, high nutrient waste is discharged directly into the waterway and transferred into Botany Bay. Periods of high nutrient concentrations generally occur after recent rainfall.

Excess nutrients combined with a low energy system can result in algal blooms and eutrophication. This is unlikely to occur in Botany Bay due to the high energy nature of the system. However, Woolooware and Weeney bays that are adjacent to Towra Point are at a higher risk of eutrophication as they experience a lower rate of tidal flushing. Terrestrial weed growth increases with increased nutrient levels.

Insufficient data is available on the trend of total nutrient levels in Botany Bay. However, total nitrogen and phosphorus has decreased in Woolooware bay by 50-60% in Woolooware bay from 1984 to 2007.

HEAVY METALS

Wetlands play a critical role in absorbing and filtering heavy metals out of water. Some organisms need small amounts of heavy metals such as copper, iron, and zinc. Greater than trace amounts of these heavy metals can be toxic. Copper, lead and zinc are generally found close to residential and industrial areas. Heavy metals accumulate in organisms and are passed up the food chain. The cultivation of oysters at Woolooware and Quibray bays can be used as an indicator of the low concentration of heavy metals around Towra Point.

Changes in concentrations of heavy metals recorded in Woolooware Bay in 1977 and circa 2007 are displayed in Woolooware Bay is adjacent to Towra Point and along with Weeney Bay experiences less tidal flushing than other areas in Botany Bay. Concentrations of heavy metals recorded in 1977 in Woolooware Bay exceeded the current LAC.

TURBIDITY

Salinity reduces the presence of suspended particles in water, known as turbidity. The sodium and chloride ions bind suspended particles and metal ions causing them to settle. This increases water clarity and as a result water quality.

Seagrass beds in the Ramsar site occur at Weeney Bay. The majority of the seagrass occurs outside the Ramsar site in the Aquatic Reserve. It occurs below the low tide mark to a depth of 3 m in Woolooware Bay, around Towra Spit, off the shoreline from Towra Beach, and in Quibray Bay. Seagrass is a primary producer and has a high light requirement. It relies on high water quality to allow sunlight to filter through in order to photosynthesise. It also has a high nutrient requirement which it utilises from groundwater discharge areas. Too much turbidity and nutrients will cause the seagrass to dieback. The presence of seagrass at Towra Point therefore provides a good indicator of water quality.

Spikes in nutrient levels and turbidity occur following storm events that increase surface runoff from the catchment and wave action in the bay. These levels have been known to exceed the levels set by the water quality guidelines (ANZECC & ARMCANZ, 2000; ANZG, 2018). They are monitored when they exceed these levels and usually return to normal levels within a number of days.

LIMITS OF ACCEPTABLE CHANGE (LAC)

Water quality guidelines for marine water have been used to determine limits of acceptable change for the physiochemical environment (ANZECC & ARMCANZ, 2000; ANZG, 2018).

BIOTA

The biota at Towra Point is one of the components and processes that makes the wetland internationally significant. The key components of biota at Towra Point are:

- Flora
- Fauna

FLORA

Towra Point supports a number of regionally significant flora that occur as distinct vegetation zones across the wetland. The critical components of flora at Towra Point are:

- Seagrass
- Mangroves
- Saltmarsh

There are substantial areas of terrestrial vegetation at Towra Point that also play an important role in the wetland system.

Seagrass

Seagrass mostly occurs in the Towra Point Aquatic Reserve, next to Towra Point Ramsar site. Although seagrass exists mainly outside of the official boundary, it contributes to the ecological character of the Site. There are three seagrass species present in and around Towra Point. They are *Posidonia australis*, *Zostera capricorni*, and *Halophila ovalis*. At the time of listing in 1984, seagrass covered an area of approximately 516 ha along the southern shore of Botany bay.

Seagrass provides protection for fish at a critical stage in their life cycle, as well as crustaceans. It is also important in maintaining biodiversity at Towra Point and a critical link in the food chain. The organic matter produced by seagrass is an important food source for invertebrates and bacteria, and subsequently fish and birds. The loss of seagrass would mean the wetland is unable to continue to support the diversity and abundance of fauna present at Towra Point.

Light availability is important to the presence of seagrass. In Botany Bay, seagrass can be found in areas up to three meters deep. Water turbidity is a limiting factor for the distribution of seagrass in the bay. Turbidity determines light availability and is in turn regulated by rainfall and pollution levels.

Seagrass also have a high nutrient requirement. They acquire these nutrients from groundwater discharge and nutrients that have settled on the seabed. Seagrass is important in the cycling of nutrients and stabilising of sediment, which encourages accretion. This helps stabilise the geomorphology of the bay against waves and storms.

Anthropogenic changes to Botany Bay such as the construction of Sydney Airport's third runway have led to the decline of seagrass in the bay. The area of seagrass along the southern shore of Botany Bay was recorded as 458 ha in 2008.

Mangroves

Towra Point supports approximately 40% of the remaining mangroves in the Sydney region. They are also considered the largest and healthiest in the region. This is equivalent to 6% of the extent in NSW. There are two mangrove species present at Towra Point, *Avicennia marina* and *Aegiceras corniculatum.*

Mangroves trap and stabilise sediment as well as providing important nursery habitat for juvenile fish. Areas with seagrass, mangroves, and saltmarsh adjacent to one another (as is seen at Towra Point) support a larger diversity and abundance of species compared to other remnant patches of these flora types in the Sydney region.

Tidal inundation and salinity are determining factors for mangrove distribution. Mangrove distribution has increased since 1984 and is encroaching on the saltmarsh area at Towra Point.

Aerial photographs have been used to retrospectively calculate the area of mangroves at Towra Point at different points in time. In 1983 there was 395.2 ha of mangroves at Towra Point, which is around the time of the Site's listing. In 1999 470.5 ha was recorded using the same methodology. In 2008, 385 ha was recorded. However, this most recent number was generated using a different method and therefore cannot be reliably compared to the previous records.

Saltmarsh

Towra Point supports approximately 60% of saltmarsh areas in the Sydney region and 2% of the NSW extent. It is one of the largest remaining saltmarsh areas in NSW. Several saltmarsh species are found at Towra Point.

The key limiting factor for saltmarsh species is light. They prefer full light. The presence of mangroves and terrestrial trees limit their distribution seaward and landward respectively. The surface features at and around Towra Point combined with hydrological movement are critical for seed dispersal and distribution. Tides spread seeds to other suitable areas that are at an elevation to be influenced by tidal inundation.

Migratory shorebirds use the saltmarsh vegetation at Towra Point as roosting and foraging habitat. It is in close proximity to other foraging areas for these migratory species within Towra Point such as the mudflats. This means these areas are important for migratory birds to preserve energy on their migratory routes. Saltmarsh at Towra Point is also considered important habitat for other species that are regionally significant. For example, crab species that release larvae into the outgoing tides and certain fish species that are considered to be of commercial and economic significance that use these same tides to access this reliable food. The saltmarsh community provides habitat for crabs that release larvae in the outgoing tides that are a food source for birds and fish.

Aerial photographs have been used to retrospectively calculate the area of saltmarsh at Towra Point in 1983 and 1999. It was calculated at 141 ha and 88.1 ha respectively. A different methodology was used in 2008 which recorded saltmarsh over a 134 ha area. The main cause of loss of saltmarsh at Towra Point is mangrove encroachment. The spread of mangroves limits light availability for other plant species. This reduces the area of suitable habitat for saltmarsh.

Terrestrial vegetation

Over 150 species of terrestrial vascular plants are found at Towra Point. In 1983 the area covered by terrestrial vegetation was calculated at approximately 166 ha. This vegetation provides roosting and foraging habitat for fauna species such as the Masked Owl, Greater Broad-nosed Bat, Grey-headed Flying-fox, and a number of honeyeater species.

The magenta Lilly Pilly (*Syzygium paniculatum*) occurs at Towra Point and is one of the three threatened species listed under the EPBC Act for which the site was originally listed.

The plant community types found on the site are:

- Swamp oak forest
- Littoral strand
- Littoral rainforest
- Dune sclerophyll forest
- Bangalay forest with swamp oak (*Casuarina glauca*)

Surveys conducted around 2006 mapped 185 ha of terrestrial vegetation at Towra Point. The vegetation has been found to be in good to average condition with some areas dominated by weeds.

FAUNA

Towra Point is one of the last remaining wetlands of its type in the Sydney region and provides important habitat for a number of threatened and migratory species. The species present at the Site include:

- Macro-invertebrates
- Fish
- Reptiles and amphibians
- Mammals
- Birds

Macro-invertebrates

Macro-invertebrates are an important link in the food chain at Towra Point. Species such as molluscs, polychaetes, and crustaceans are a food source for fish and birds. These species also help to aerate the soil, improving the health of flora. Macro-invertebrates are associated with particular sediment types. They are therefore a good indicator of changes in sediment and disturbance.

Limited information is available about macro-invertebrates at Towra Point at the time of listing. This is still the case in the present day as no targeted studies have been conducted in the area. It has been identified as a knowledge gap.

Fish

Seagrass, saltmarsh and mangroves at Towra Point Ramsar site and the adjacent Aquatic Reserve are important in the provision of food and shelter for numerous fish species; most of which are in the juvenile stage of their life cycle.

75 species of fish were recorded in the seagrass surrounding Towra Point in 1981 and 46 species in the mangroves in 1984. Approximately 25 species of fish considered of economic and recreational importance use Towra Point.

Reptiles and amphibians

Studies at Towra Point in 1984 found 12 reptile and amphibian species. Amongst the amphibians recorded was the Green and Golden Bell Frog (*Litoria aurea)*. It is one of the three threatened species listed under the EPBC Act for which the site was originally listed. This population was identified as a key population in Sydney. The population at Towra Point has reduced as a result of loss of habitat from the intrusion of salt water into Towra Point Lagoon in 1974.

Mammals

A lack of historical data for mammals at Towra Point has been identified and robust surveys are still lacking. A Grey-headed Flying-fox *(Pteropus poliocephalus)* camp occurs on Kurnell Peninsula. The species has a foraging radius of 25 km and has been found in 14 different locations at Towra Point. It is one of the three threatened species listed under the EPBC Act for which the site was originally listed.

Birds

Towra Point supports at least 189 species of birds. This includes 34 migratory bird species listed under international agreements. In 1984 the Site supported at least 1% of the estimated international population of eastern curlew. The site no longer supports this proportion as an increase in the estimated population has occurred. Despite this, the number of visiting curlews recorded at Towra Point having increased.

Towra Point has been identified as part of one of the four most important migratory shorebird habitats in NSW. Migratory shorebirds use Towra Point as a critical stopover on migratory routes from Korea, Japan, China, Russia, Siberia and Alaska during September to April. Number of birds recorded at Towra Point fluctuate from year to year and depending on the season.

Towra Spit Island was formed in 1991 and has since been identified as the second most important little tern *(Sternula albifrons)* nesting site in NSW following the loss of nesting habitat at the location where Sydney Airport's third runway was built.

Loss of migratory shorebird habitat elsewhere in Botany Bay has placed increased pressure on Towra Point.

LIMITS OF ACCEPTABLE CHANGE (LAC)

Limits of acceptable change have been developed for biota where sufficient information is available.

These include hectare thresholds for:

- Seagrass
- Mangroves
- Saltmarsh
- Mixed mangrove and saltmarsh

The LACs for Magenta Lilly Pilly and the Grey-headed Flying-fox are no loss of the species.

The LAC for the green and golden bell frog is the species being recorded every year, or when surveys are undertaken.

The LACs for migratory shorebirds relate to net loss, percentage loss, or breeding success:

- In summer (December to February)
    - *Abundance*: no decline of more than 50% from the baseline condition for Botany Bay (1668 ± 472) in 5 consecutive years
    - *Diversity:* no net loss of species over 5 consecutive years
- In winter (June to August)
    - *Abundance:* no decline of more than 50% from the baseline condition for Botany Bay (604 ± 148) in 5 consecutive years
    - *Diversity:* no net loss of species over 5 consecutive years
- Eastern Curlew: no decline of more than 50% from the baseline condition for Botany Bay (133 ± 77) in 5 consecutive years
- Little tern (breeding numbers): successful annual breeding in one out of every two years

CLIMATE

Climate exists as an ecosystem regulator and plays an important role in maintaining equilibrium. The flora and fauna at Towra Point have adapted to the temperate climate of the region. Climate change and anthropogenic changes around Botany Bay are altering the intensity of climatic parameters. The key components that are regulated by climate are:

- Temperature
- Rainfall
- Storm events

TEMPERATURE

Temperature is a determining factor for species distribution at Towra Point. In 1977 the mean daily temperatures in winter varied from 6.2°C to 17°C and the mean daily temperature range in summer was 18.4°C to 26.2°C. Increases in temperature can increase the rate of evaporation, and as a result levels of soil salinity.

RAINFALL

Rainfall replenishes soil moisture content, offsets surface and soil salinity levels, and assists in the recharge of groundwater levels. It is the primary source of freshwater for Towra Point. In 1977 Towra Point received an average rainfall of 1,100 mm with the most rainfall usually occurring from March to June.

STORMS

Severe storm events have been key to the significant erosion at Towra Beach and the intrusion of salt water into Towra Point Lagoon, prior to 1984. Thunderstorms occurred once a month in winter and three times a month in summer around 1977. More intense storms with stronger winds and more rough, higher seas occur around five times a year. These are the storms that have the greatest detrimental impact on Towra Point as they cause increased rates of erosion.

These changes have the potential to place further stress on the system, forcing components and processes at Towra Point outside of their boundaries of natural variation.

LIMITS OF ACCEPTABLE CHANGE (LAC)

Parameters for climate cannot be managed at a local scale. It has therefore been identified that limits of acceptable change cannot be set for climate for Towra Point Nature Reserve Ramsar site.

SERVICES AND BENEFITS

Components and processes contribute to services and benefits. The services and benefits that are present at Towra Point Ramsar site and contribute to its ecological character as described in the ECD (DECCW, SMCMA et al., 2010) are:

- Provisioning services
- Regulating services
- Cultural services
- Supporting services

PROVISIONING SERVICES

Provisioning services of Towra Point Ramsar site include:

- Fisheries production: Towra Point and the adjacent Aquatic Reserve provide important habitat for the protection of juvenile fish, crustaceans, and molluscs and are of economic importance when they move to areas that are allowed to be commercially fished. This area also provides habitat for a small number of leases to cultivate Sydney rock oysters
- Trophic relay: the transfer of energy and nutrients at Towra Point to different parts of the estuary through a complex food web is critical to maintaining biodiversity

REGULATING SERVICES

Regulating services of Towra Point Ramsar site include:

- Maintenance of hydrological regimes: Towra Point plays an important role in maintaining the hydrological regimes of Botany Bay and the region. These hydrological processes include rainfall, ties, evapotranspiration, runoff, infiltration and groundwater flow
- Shoreline stabilisation and storm protection: vegetation at Towra Point such as mangroves and seagrass prevent erosion from tides, storms, and high rainfall
- Biological control of pests and disease: Towra Point provides habitat for native predators such as the masked owl, white-bellied sea eagle, and whistling kite that prey on introduced rodents
- Pollution control: mangroves at Towra Point act as sediment traps and contaminant filter. They contribute to the water quality and health of the waterway by providing a buffer between land and water. This helps filter contaminants before entering the waterway

CULTURAL SERVICES

Cultural services of Towra Point Ramsar site include:

- Recreation and tourism: Botany Bay and its tributaries are popular recreational areas for activities such as swimming, boating, and fishing due to their proximity to Sydney. The day-use area at Towra Point is the only publicly accessible area. It is only accessible by boat but is a popular recreational area
- Science and education: access to the majority of Towra Point Ramsar site is by permit only, which are granted for scientific and educational purposes
- Aesthetic amenity: the surrounds of Towra Point Ramsar site are highly developed and urbanised. Towra Point remains an example of the wetland types that used to be more common in the area and provides pleasant views of nature so close to Sydney's CBD
- Aboriginal heritage: the southern shore of Botany Bay is the country of the Gweagal clan of the Dharawal nation. This area is of significance to the Aboriginal people. Middens, rock shelters, engravings and burial sites can be found at Towra Point, indicating its importance to Aboriginal heritage

- Non-Aboriginal heritage: Captain James Cook and the crew of the *Endeavour* sailed into Botany Bay in 1770. Towra Point was the site of some of the first recorded botanical and zoological samples of Australia. The oyster industry in the water surrounding Towra Point is also a part of the cultural heritage of the area

SUPPORTING SERVICES

Supporting services of Towra Point Ramsar site include:

- Hydrological processes: Towra Point is key in maintaining hydrological processes including evapotranspiration, runoff, infiltration, and groundwater. These hydrological processes are also important in conserving the ecological character of the Ramsar site
- Food webs: the biodiversity at Towra Point is as a result of the interactions between organisms and the transfer of nutrients and energy. Critical links in the food chain include seagrass meadows and mangroves as they provide organic matter and detritus which is an important food source for invertebrates. Critical interactions include seed dispersal and pollination by the Grey-headed Flying-fox as well as export of crab larvae from the saltmarsh areas in outgoing tides. Tides play an important role in facilitation the transportation of organic and detritus matter and crab larvae export
- Physical habitat: Towra Point wetland provides particular habitat that can no longer be found elsewhere in the Sydney region. The suitable conditions support remnant habitats, threatened species, and endangered ecological communities. These include but are not limited to a diverse range of shorebirds, seagrass, mangroves, and saltmarsh
- Nutrient cycling: Maintaining a balance of nutrients is critical to the health of the ecosystem. Nutrients enters the system from the catchment in the form of runoff, sewage overflow and stormwater, and groundwater discharge. Flora and fauna found at Towra Point and the surrounding hydrological processes are critical to the cycling of nutrients. Primary producers such as phytoplankton, seagrass, mangroves, and saltmarsh have high nutrient requirements. They convert the nutrients to different forms that are more useable for other species. Botany Bay is a well flushed system, preventing the excess build-up of nutrients or sediment. This is maintained by the semi-diurnal tides
- Primary production: Towra Point supports primary producers such as phytoplankton, mangroves, saltmarsh, seagrass, and terrestrial vegetation. These in turn support a number of other processes
- Sediment trapping and stabilisation: seagrass, saltmarsh, and mangroves at Towra Point trap sediment and filter contaminants
- Biodiversity: the high level of biodiversity at Towra Point is supported by its size in relation to other areas of remnant vegetation in Sydney. Because of its size, the wetland supports a large variety of flora and fauna species. The importance of how the components at Towra Point contribute to its biodiversity are illustrated through the food web
- Special ecological, physical or geomorphic features: The Towra Point saltmarsh community is a threatened community listed under the BC Act. This community along with seagrass and mangroves are part of the features at Towra Point that provide habitat and nourishment for migratory shorebirds on their annual migration routes. This habitat also is an important nursery for fish and crustaceans. Oyster leases and other structures in the bays surrounding Towra Point (Quibray, Weeney, and Woolooware bays) provide additional roosting sites
- Threatened wetland species, habitats and ecosystems: The species and ecosystems supported at Towra Point include
  - 3 threatened species listed under the EPBC Act
  - 23 threatened species listed under the BC Act
  - 5 endangered ecological communities listed under the BC Act
- Priority wetland species: Towra Point Ramsar site and surrounding areas support 30 of the 80 migratory bird species listed a number of bilateral agreements including JAMBA, CAMBA, and ROKAMBA
- Ecological connectivity: Towra Point Ramsar site provides connectivity to other natural areas in the surrounding area that is otherwise highly urbanised. These natural areas include Kamay Botany Bay National Park, Royal National Park, Georges River National Park, Taren Point Shorebird Community, and Heathcote National Park. It also provides connectivity to foraging resources including shorebirds and the Grey-headed Flying-fox.

Part 6B Attachment References

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OPENLINES
Environmental consulting

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 7: EVALUATION OF THE PLAN

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

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39 Introduction

In considering approval of the Plan, the Commonwealth and NSW environment ministers must take into account various matters under the *Biodiversity Conservation Act 2016* (BC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in relation to the impacts and benefits of the Plan on biodiversity values and other protected matters.

This Part:

- Analyses the Plan against the principles of Ecologically Sustainable Development (ESD) (see Chapter 40)
- Evaluates the adequacy and acceptability of the Plan in the context of the impacts of the development and in accordance with the regulatory requirements of the BC Act and EPBC Act (see Chapter 41)

This Chapter sets out:

- The regulatory context for evaluating the Plan
- The overall approach to the evaluation

39.1 REGULATORY CONTEXT FOR THE EVALUATION

Under both the BC Act and EPBC Act processes, the Assessment Report must evaluate the overall outcomes and acceptability of the Plan on biodiversity values and other protected matters.

39.1.1 BIODIVERSITY CONSERVATION ACT

Under section 8.7 of the BC Act, the NSW Environment Minister may only confer biodiversity certification if satisfied that the 'approved conservation measures' adequately address the likely impacts on biodiversity values.

Under a strategic application for biodiversity certification, the BC Act does not require that the 'value' of the commitments be calculated in terms of credits and provides broad discretion around defining commitments. Commitments under strategic certification are not constrained by the offset rules (clause 6.2(5)(b) BC Regulation) and the NSW Environment Minister can determine any measure to be a commitment (section 8.3(2)(b) BC Act).

EES has prepared the *Draft Guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification* (draft version 6) ('draft guidelines for planning authorities') (EES, 2019). These provide guidance on how to evaluate whether the conservation measures adequately address the likely impacts on biodiversity values.

The 'draft guidelines for planning authorities' (EES, 2019) include a set of principles that must be considered in evaluating the Plan.

These principles are summarised in Table 41-1 and addressed in Chapter 41.

39.1.2 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT

Under the EPBC Act, the Commonwealth Environment Minister:

- May endorse a policy, plan or program if satisfied that the Impact Assessment Report 'adequately addresses the impacts' on protected matters to which the agreement (to undertake a strategic assessment) relates (s146(2)(f))
- May approve the taking of actions in accordance with the endorsed policy, plan or program (s146B(1)) subject to a range of considerations under Part 10 Division 1, Subdivision C, including:
    - General considerations under s 146F, including any matters relevant to MNES that the Minister considers is relevant to the approval, taking into account the principles of ecologically sustainable development
    - Constraints on decision-making discretion under ss 146 G, H, J, K, L and M, including that the Minister must not act inconsistently with the provisions of a recovery plan or threat abatement plan (s 146K)

The Agreement and Terms of Reference (ToR) require the Assessment Report to evaluate the commitments and outcomes for protected matters taking into account likely impacts on protected matters under the Plan. The ToR includes other matters that must be considered in evaluating the Plan. These matters are summarised in Table 41-1.

The ToR (section 5.2(4)) also requires the Assessment Report to evaluate the extent to which the Plan meets the endorsement criteria under clause 8 of the Agreement. The endorsement criteria specifies that, in determining whether the Assessment Report adequately addresses the impacts of the Plan, the Commonwealth Minister must have regard to the extent to which the Plan meets the objectives of the EPBC Act, including how the Plan:

- Protects the environment, particularly protected matters
- Promotes ESD through the conservation and ecologically sustainable use of natural resources
- Promotes the conservation of biodiversity
- Provides for the protection and conservation of heritage
- Promotes a co-operative approach to the protection and management of the environment
- Assists in the co-operative implementation of Australia's international environmental responsibilities

The matters required to be addressed by the Agreement and ToR are addressed in Chapter 40 and Chapter 41.

39.2 DEFINING 'ADEQUATE' IN THE CONTEXT OF THE PLAN

The commitments under the Plan are not driven solely by meeting the credit requirements of the Biodiversity Assessment Method (BAM), which is a key part of the definition of 'no net loss' under the BAM.

This recognises that strategic biodiversity certification supports development and planning priorities, and provides significant opportunities to maximise benefits to biodiversity and address landscape scale conservation challenges, which are not provided by site-by-site assessment processes.

The key commitments under the Plan have been developed in recognition of these potential benefits.

The biodiversity benefits of these types of commitments may not be realised, and are likely to be undervalued in an evaluation of the Plan, by focusing only on the credit balance of the Plan. This is recognised in the 'draft guidelines for planning authorities' (EES, 2019). While Principle 2 (see Section 41.5) requires consideration of the credit output of the Plan, this is only one of eight principles that the guidelines require to be taken into account in evaluating the Plan.

It is also important to note that due to the large scale of the Plan Area and the voluntary mechanisms proposed to secure conservation lands under the Plan, the location and boundaries of conservation lands are not yet final, and it has not yet been possible to undertake surveys within Strategic Conservation Areas (SCAs) to confirm biodiversity values. This means that it is not yet possible to determine the credits generated by securing conservation land under the Plan.

The Department developed an approach for defining offset targets to ensure that the commitments address the biodiversity values being impacted (see Chapter 8). The adequacy of these offset targets is evaluated in Section 41.5.

39.3 BROAD APPROACH TO THE EVALUATION

Evaluation of the overall outcomes and acceptability of the Plan was undertaken at three levels:

- In relation to the principles of Ecologically Sustainable Development (see Chapter 40)
- In relation to the overall adequacy of the Plan in accordance with the 'draft guidelines for planning authorities' (EES, 2019) and requirements of the Agreement and ToR (see Chapter 41)
- For individual Commonwealth protected matters under the EPBC Act. This analysis is provided in Chapters 29 – 35

Details of the approach to evaluating ESD and the overall adequacy of the Plan are set out in Chapters 40 and 41.

40 Ecologically sustainable development

40.1 INTRODUCTION

ESD is defined as:

> *'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased' (COAG, 1992).*

This Chapter:

- Sets out the legal and other requirements for assessing ESD
- Sets out the approach used to analyse the principles of ESD
- Provides an analysis of the Plan against each of the principles of ESD:
  - *Principle 1 – integration of social, economic and environmental considerations*
  - *Principle 2 – precautionary principle*
  - *Principle 3 – intergenerational and intragenerational equity*
  - *Principle 4 – conservation of biodiversity and ecological integrity*
  - *Principle 5 – valuation, pricing and incentive mechanisms*

In analysing the Plan, this Chapter describes how the principles of ESD have been considered and promoted in the development of the Plan, both in guiding the planning process and informing the commitments under the Plan.

40.2 REQUIREMENTS FOR ASSESSING ESD

The assessment of the Plan against the principles of ESD is a requirement under:

- Commonwealth and NSW legislation
- Commonwealth ToR
- 'Draft guidelines for planning authorities' (EES, 2019)

40.2.1 LEGISLATION

COMMONWEALTH LEGISLATION

The EPBC Act incorporates the promotion of ESD within the key objectives of the Act, which states (in Part 1, Section 3):

> *"The objects of this Act are … to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources"*

The Act requires that the Commonwealth Environment Minister must consider economic and social matters, including taking the principles of ESD into account, when considering the approval of the taking of actions in accordance with an endorsed program or plan under the EPBC Act (section 146F).

The definition of ESD under Section 3A of the EPBC Act is:

Commonwealth definition of ESD – EPBC Act

Part 1 Preliminary

Section 3A Principles of ecologically sustainable development

The following principles are principles of ecologically sustainable development:

(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;

(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

(c) *the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;*

(d) *the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;*

(e) *improved valuation, pricing and incentive mechanisms should be promoted.*

NSW LEGISLATION

The principles of ESD underpin the central objectives of the BC Act. ESD is integrated into the purpose of the BC Act (section 1.3), which states:

> *"The purpose of this Act is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development (described in section 6 (2) of the Protection of the Environment Administration Act 1991)"*

The definition of ESD described in section 6(2) of the *Protection of the Environment Administration Act 1991* (POEA Act) is outlined below.

NSW definition of ESD – POEA Act

Part 3 Objectives of the Environment Protection Authority

6 Objectives of the Authority

…

2) *For the purposes of subsection (1) (a), ecologically sustainable development requires the effective integration of social, economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:*

a) *the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:*

i) *careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*

ii) *an assessment of the risk-weighted consequences of various options,*

b) *inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,*

c) *conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,*

d) *improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:*

i) *polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,*

ii) *the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,*

iii) *environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems*

COMPARISON OF COMMONWEALTH AND NSW DEFINITIONS

There are some differences in the descriptions of ESD outlined under the EPBC Act and POEA Act. The EPBC Act includes additional detail to the definition of the principle of social, economic and environmental considerations, whilst the POEA Act includes additional detail to the definitions of the precautionary principle and the principle of improved valuation, pricing and incentive mechanisms. Despite this, the meaning of ESD under both Acts are generally consistent, and the following sections evaluate the Plan in accordance with the requirements of both Acts.

40.2.2 OTHER REQUIREMENTS

COMMONWEALTH TERMS OF REFERENCE

The ToR require the Assessment Report to: *"…describe how the principles of ecologically sustainable development (as set out in section 3A of the EPBC Act) are considered and promoted in the development of the Plan"*.

NSW STRATEGIC ASSESSMENT GUIDELINES

The EES draft *Guidelines for planning authorities for proposing conservation measures in strategic applications for strategic biodiversity certification* (EES, 2019) require the Assessment Report to explain how the commitments and actions under the Plan responds to ESD. The guidelines state:

> *"… the conservation measures and biodiversity certification as a whole must respond to the principles of ESD with reference to section 6(2) of the Protection of the Environment Administration Act 1991 … The biodiversity certification assessment report (BCAR) will explain how the conservation measures respond to ESD, particularly including but not limited to:*
>
> - *Bioregional and State scale conservation outcomes*
> - *Maintain diversity and quality of ecosystems and enhance capacity of change for future generations*
> - *Support biodiversity in a changing climate*
> - *Support conservation and threat abatement actions to slow the rate of biodiversity loss and conserve threatened species and ecological communities in nature*
> - *Support and guide prioritised and strategic investment in biodiversity conservation outcomes*
> - *Establish a framework to avoid, minimise and offset the impacts of proposed development and land use change*
> - *Support public consultation and participation in biodiversity conservation and decision-making about biodiversity conservation"*

40.3 APPROACH TO EVALUATION OF ESD

The evaluation of the Plan against each principle is undertaken by:

- Describing what the principle means
- Setting out the available legal and policy guidance to assist interpretation of the requirements of each principle
- Evaluating the Plan in accordance with the requirements of each principle

40.4 EVALUATION OF PLAN AGAINST THE PRINCIPLES OF ESD

This section provides an evaluation of the Plan against each of the principles of ESD.

40.4.1 PRINCIPLE 1: INTEGRATION OF SOCIAL, ECONOMIC AND ENVIRONMENTAL CONSIDERATIONS

Principle 1 requires decisions to integrate economic, environmental, social and equitable considerations.

Specifically, the EPBC Act defines Principle 1 of ESD as "decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations" (Sec 3A(a)).

Principle 1 has a similar (although less comprehensive) definition in the POEA Act (Section 6(2)).

GUIDANCE TO ASSIST INTERPRETATION OF PRINCIPLE

There are several issues associated with balancing economic, environmental and social considerations (Preston, 2016):

- Environmental, economic, social and equitable considerations are interconnected and interdependent, such that changes in one can affect the capacity to achieve the goals of others
- It may not always be appropriate to accord equal weight to economic, environmental, social and equitable considerations. Doing this assumes that ecological processes can always sustain ongoing development. However, there are thresholds at which environmental processes may deteriorate

- Ecological, economic, social and equitable objectives cannot practically be balanced in all decisions made, or for each area of land. For example, some areas may be set aside completely for environmental objectives, whereas other parcels of land may be utilised for intensive economic development

EVALUATION OF PRINCIPLE

The Plan is considered to be consistent with Principle 1 of ESD as it:

- Supports the delivery of programs and regional strategic plans that integrate economic, social and environmental considerations and objectives and address key planning challenges facing Greater Sydney
- Has been developed through processes that integrate economic, social and environmental considerations, including:
  - A strategic assessment process
  - A Structured Decision Making process
  - A cost-benefit analysis

Supports delivery of programs and plans that address key planning challenges facing Greater Sydney

The Plan is needed to support the delivery of:

- Nominated areas program and the development of major transport infrastructure that deliver key social and economic objectives identified under the Greater Sydney Region Plan and Future Transport 2056
- Several key regional planning strategies and plans for Western Sydney that integrate economic, social and environmental considerations and address key planning challenges facing Greater Sydney

The need for the Plan is set out in Chapter 6.

The nominated areas program represents the strategic prioritisation and delivery of new development as part of the long-term growth of Greater Sydney. The nominated areas are the key focus for urban development over the coming decades and will be the centres of economic and social activity in Western Sydney. Major transport infrastructure is planned to be delivered to respond to the economic and social needs of Western Sydney over the next 40 years. This Plan includes key transport corridors that will generate economic activity and support employment opportunities in Western Sydney.

The key regional planning strategies and plans that the Plan supports the delivery of include:

- Western Sydney City Deal
- Greater Sydney Region Plan
- Western City District Plan
- NSW Koala Strategy in Western Sydney

These strategies and plans are the NSW Governments response to address several key economic, social and environmental planning challenges facing Greater Sydney, including:

- Population growth and housing needs, including housing affordability and choice
- Job opportunities
- Access to transport
- Protecting the natural environment and amenity

By supporting the delivery of programs and regional strategic, the Plan is supporting a planning process that integrates economic, social and environmental considerations and is addressing key planning challenges facing Greater Sydney.

Developed through processes that integrate economic, social and environmental considerations

The Plan was developed through three main processes that ensured economic, social and environmental considerations were effectively integrated in decisions relating to the Plan:

- A Structured Decision Making process
- A cost-benefit analysis

Furthermore, the Plan was developed through a strategic assessment process. Environmental impact assessment processes such as strategic assessments are a well-recognised mechanism to incorporate environmental considerations alongside economic, social and equitable considerations into policies, plans and programs (Preston, 2016). The strategic assessment processes is discussed further below under section 40.4.4.

Structured Decision Making

The Department applied a structured decision-making process during early development of the Plan to define a high-level biodiversity outcome for the Cumberland subregion that set the context and direction for the development of the Plan. The structured decision-making process provides a systematic method to identify and compare a range of conservation options available to the NSW Government, taking into account social, economic and environmental considerations.

The structured decision-making process is described in Chapter 6.

The key decision for the structured decision-making work integrated social, economic and environmental considerations, and was:

> *"What is the optimal biodiversity outcome for Western Sydney that will enable planned and existing development (including both in and beyond the nominated areas in the Cumberland Plain) to proceed in an affordable and sustainable way?"*

The process found that the best approach to achieving the optimal biodiversity outcome while balancing economic and social considerations is to apply a broad mix of commitments and actions to maximise the biodiversity values that are protected, maximise certainty of delivery and alleviate the pressure on offset supply and demand. This includes:

- Securing one or more new national parks in the Plan Area
- Investing in biodiversity stewardship in the best remaining vegetation in the Plan Area
- Restoring key parts of the landscape within the Plan Area
- Providing dedicated funding for a set of actions to protect Koalas
- Investing a smaller proportion of the funding on biodiversity stewardship outside the Plan Area, within the allowable variation rules under the BC Regulation

This mix of approaches is reflected in the conservation program for the Plan (see Chapter 8).

Cost-benefit analysis

In developing the Plan, the Department commissioned UTS (UTS Institute for Sustainable Futures, 2019) to undertake an indicative social cost-benefit analysis of two potential conservation scenarios under the Plan. The aim of the analysis was to assess whether the scenarios would bring net positive social and economic outcomes for Western Sydney.

A quantitative model was developed to undertake the analysis. The analysis assessed two potential conservation scenarios under the Plan against a base case that assumed ongoing site-by-site assessment and approval of development in Western Sydney through NSW Biodiversity Offsets Scheme (BOS) under the BC Act.

The two potential conservation scenarios reflected the wider array of conservation measures available through the strategic conservation planning option under the BC Act, including:

- Extensions or additions to the reserve system
- Private land conservation secured through Biodiversity Stewardship Agreements
- Restoration of degraded sites, incorporating landscape management
- Threat management measures, including pest and weed management

The results of the analysis indicated that the two potential conservation scenarios under the Plan would bring net positive outcomes for Western Sydney and would be a viable approach for the NSW Government to achieve the dual goals of delivering biodiversity outcomes and facilitating housing supply to support social and economic outcomes.

40.4.2 PRINCIPLE 2: PRECAUTIONARY PRINCIPLE

Principle 2 is articulated in Section 3A(b) of EPBC Act as: "if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".

The POEA Act, (Section 6(2)(a)) further articulates how the precautionary principle should be interpreted by decision-makers, which applies in the administration of the BC Act:

> *"in the application of the precautionary principle, public and private decisions should be guided by:*
>
> *i. careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and*
>
> *ii. an assessment of risk-weighted consequences of various options."*

DEFINITION OF SERIOUS AND IRREVERSIBLE ENVIRONMENTAL DAMAGE

Definition under BC Act

Serious and irreversible impacts (SAII) have been specifically defined in NSW under 6.7(2) of the BC Regulation as:

> *An impact is to be regarded as serious and irreversible if it is likely to contribute significantly to the risk of a threatened species or ecological community becoming extinct because:*
>
> *(a) it will cause a further decline of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to be in a rapid rate of decline, or*
>
> *(b) it will further reduce the population size of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very small population size, or*
>
> *(c) it is an impact on the habitat of the species or ecological community that is currently observed, estimated, inferred or reasonably suspected to have a very limited geographic distribution, or*
>
> *(d) the impacted species or ecological community is unlikely to respond to measures to improve its habitat and vegetation integrity and therefore its members are not replaceable.*

NSW Environment Energy and Science (EES) has developed further guidance for decision-makers on how to apply the principles to NSW-listed Threatened Ecological Communities (TECs) and species (DPIE, 2019). These guidelines identify a list of matters that may be subject to SAII – these matters are called 'SAII entities'. Table 40-1 identifies the relevant SAII entities that may be impacted by the Plan.

Under the BC Act, the consent authority (for the Plan, this is the NSW environment minister) makes the determination regarding SAII, based on:

- BC Regulation principles
- SAII guidance (DPIE, 2019) and the list of potential SAII entities
- Extent of the remaining impact after measures to avoid or mitigate have been taken

An assessment of the impacts of the development on NSW-listed SAII entities is provided in Chapter 25.

Definition under EPBC Act

Section 5.2(3) of the ToR requires that the evaluation of the overall outcomes of the Plan must consider whether there will be SAII on any protected matter.

SAII are not specifically defined at a Commonwealth level. For the purpose of this assessment, where a NSW-listed matter was also Commonwealth-listed Category 1 matter, it was also considered to be an SAII entity potentially subject to serious and irreversible impacts. However, seven Commonwealth-listed matters are not NSW-listed and so have not been considered in terms of the principles under 6.7(2) of the BC Regulation. These matters are:

- Red Knot (Endangered, migratory shorebird)
- Curlew Sandpiper (Critically Endangered, migratory shorebird)
- White-throated Needletail (Vulnerable)

- Bar-tailed Godwit (Vulnerable, migratory shorebird)
- Macquarie Perch (Endangered)
- Eastern Curlew (Critically Endangered, migratory shorebird)
- Greater Glider (Vulnerable)

The impacts of the Plan on these matters have been assessed in Chapter 32 (for migratory species) and Chapter 30 (for White-throated Needletail, Macquarie Perch, and Greater Glider). The risk of impacts to these species due to development under the Plan is considered to be negligible or low and therefore these species are not considered to be potentially subject to serious and irreversible impacts under the Plan.

WHEN AND HOW IS THE PRECAUTIONARY PRINCIPLE REQUIRED TO BE IMPLEMENTED?

Principle 2 is required to be applied when two conditions are met (Preston, 2017):

- There is a threat of SAII to the environment
- There is scientific uncertainty as to the environmental damage associated with the threat

Where both these conditions are met, the decision-maker must:

- Assume there will be impacts to the environment
- Put in place avoidance, mitigation and offset measures to manage these impacts

It is possible that SAII may be predicted to occur with a high degree of certainty as a result of a proposal. This may occur where systems are well understood, and causal links can be established with confidence. In these situations, Principle 2 is not triggered, as significant uncertainty is not present (Preston, 2017). While measures will still need to be taken to avoid and minimise damage in these cases, these measures are considered to be 'preventative' measures rather than 'precautionary' measures applied under the precautionary principle (Preston, 2017).

EVALUATION OF PRINCIPLE

The Plan is considered to be consistent with Principle 2 as the Plan or this Assessment Report:

- Identifies matters potentially subject to SAII entities
- Takes steps to avoid impacts to SAII entities to reduce the threat of SAII
- Considers the nature and extent of the threat of SAII by assessing the residual impacts to SAII entities
- For matters where there is some scientific uncertainty around residual impacts, assumes that impacts will occur and puts in place mitigation and offset measures to manage these impacts

Matters potentially subject to serious and irreversible impacts

Table 40-1 identifies the NSW and Commonwealth-listed SAII entities that may be subject to serious and irreversible impacts and that are potentially impacted by the development under the Plan. NSW-listed SAII entities are assessed in Chapter 25 and Commonwealth listed SAII entities are assessed in Chapters 29 to 31.

Table 40-1: NSW and Commonwealth matters that may be subject to serious and irreversible impacts

SAII entities
• Cooks River/Castlereagh Ironbark Forest (NSW/Cth) • Cumberland Plain Woodland (NSW)/ Cumberland Plain Shale Woodlands and Shale-Gravel Transition forest (Cth) • Shale Sandstone Transition Forest (NSW/Cth) • *Allocasuarina glareicola* (NSW/Cth) • *Hibbertia fumana* (NSW) • *Micromyrtus minutiflora* (NSW/Cth) • Large-eared Pied Bat (NSW/Cth) • Green and Golden Bell Frog (NSW/Cth)

SAII entities
• Three raptors; White-bellied Sea-Eagle, Little Eagle and Square-tailed Kite (NSW) • Red-crowned Toadlet (NSW)

Steps taken to avoid serious and irreversible impacts

The Department and Transport for NSW have undertaken a strategic planning process to locate and design the urban capable lands of the nominated areas and transport corridors to avoid and minimise impacts on biodiversity values. The highest priority for avoidance was critically endangered TECs and species, including SAII entities.

The steps taken to avoid and minimise impacts to biodiversity values is set out in Chapter 14. An evaluation of avoidance outcomes for NSW SAII entities is provided in Chapter 25 and for Commonwealth listed TECs and species in Chapters 29 to 31.

Assessment of threat of serious and irreversible impacts

An assessment of the nature and extent of the residual threat of serious and irreversible impacts on NSW SAII entities is provided in Chapter 25 and Commonwealth listed TECs and species is provided in Chapters 29 to 31.

For some NSW and Commonwealth matters potentially subject to SAII, the nature and extent of impacts cannot be predicted with a high degree of certainty. These matters are identified in Table 40-2. For these matters, the precautionary principle is triggered.

Table 40-2: NSW and Commonwealth TECs and species that trigger the precautionary principle

Matter	Reason for uncertainty
Allocasuarina glariecola	Some uncertainty about presence within urban capable land and the transport corridors
Hibbertia fumana	
Hibbertia puberula	
Micromyrtus minutiflora	
Green and Golden Bell Frog	
Raptors - White-bellied Sea-Eagle, Little Eagle and Square-tailed Kite	Some uncertainty about presence within urban capable land and the transport corridors
Koala	Some uncertainty about the nature and extent of the impacts, including the importance of various movement corridors and risks of indirect impacts

For the other SAII entities, impacts can be predicted to a relatively high degree of certainty because:

- Knowledge about presence of the TEC or species is relatively certain
- Nature and extent of the impacts are relatively well understood, including because the risk of impacts is clearly very low, or because the impacts can be relatively easily predicted

Although the precautionary principle is not triggered for these matters, a range of 'preventative' measures relevant to these matters will be implemented under the Plan to offset and mitigate the impacts of the development (see Chapter 25 for NSW SAII entities and Chapters 29 to 31 for Commonwealth listed TECs and species).

Mitigation of impacts where there is scientific uncertainty

For the SAII entities in Table 40-2, the Plan assumes that the potential impacts of the development under the Plan will occur and puts in place commitments and mitigation measures that mitigate and offset these impacts (see Chapter 25 for NSW SAII entities and Chapters 29 to 31 for Commonwealth listed TECs and species). This is consistent with the precautionary principle and is expected to adequately reduce the risk of impacts to these matters to an acceptable level.

40.4.3 PRINCIPLE 3: INTERGENERATIONAL AND INTRAGENERATIONAL EQUITY

Principle 3 is articulated in Section 3A(c) of EPBC Act as: "The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations".

The POEA Act provides the same definition for Principle 3.

GUIDANCE TO ASSIST INTERPRETATION OF PRINCIPLE

Principle 3 contains two key elements (Preston, 2016):

- Intergenerational equity – this relates to equity between current and future generations
- Intragenerational equity – this relates to equity within current generations

There are three sub-principles that inform the basis of intergenerational and intragenerational equity (Preston, 2016):

- Conservation of options – this provides that each generation should conserve the diversity and robustness of the resource base to ensure future generations have the same access to alternatives and options when solving problems
- Conservation of quality – this provides that the quality of natural and cultural environments should be maintained, so they are passed on in the same or better condition than they were received
- Conservation of access – this provides that each generation has the right to reasonable and equitable access to natural and cultural resources to improve their own social and economic wellbeing

EVALUATION OF PRINCIPLE

The Plan is considered to be consistent with Principle 3 of ESD as it conserves alternatives and options in relation to environmental resources, maintains the quality of natural and cultural environments, and conserves access to natural and cultural resources by establishing a conservation program (see Chapter 8 for details) that:

- Avoids and minimises impacts on high biodiversity value areas
- Mitigates indirect and prescribed impacts
- Conserves flora and fauna and associated habitat
- Manages landscape threats
- Builds knowledge and research to improve management of biodiversity

The purpose of the conservation program is to achieve the Plan's objective and conservation outcomes, and offset the impacts of the development on biodiversity values. The conservation program has been designed to maximise ecological function and resilience at the landscape scale in the Cumberland subregion.

The key focus of the conservation program (comprising 90 per cent of the program funding) is conserving 5,475 ha of flora and fauna and associated habitat in perpetuity by securing strategic conservation areas in the Cumberland subregion.

The outcomes of the conservation program are evaluated in Chapter 41. The evaluation suggests the Plan is consistent with Principle 3, as it will substantially increase the protection of high value biodiversity areas in the Cumberland subregion in perpetuity and therefore contribute to conserving the diversity and robustness of the resource base and maintaining the quality of natural environments in the subregion.

The Plan is proposing to establish a number of new reserves as part of the conservation program. These include the Georges River Koala Reserve, the Gulguer Reserve Investigation Area, and Confluence Reserve Investigation Area. Other areas within the SCAs have also been identified for further investigation as future reserves to provide greater landscape connectivity, such as the Bargo area.

Reserves provide the highest level of in-perpetuity biodiversity protection and a range of social benefits, such as enabling public access to natural areas and open space. This is consistent with Principle 3, because it provides increased opportunities for residents of Western Sydney to access natural resources and improve social wellbeing.

The conservation program also includes several other commitments that are consistent with Principle 3, including:

- Provide opportunities for the residents of Western Sydney to participate in biodiversity conservation

- Provide opportunities for Aboriginal communities of Western Sydney to participate in biodiversity conservation and related economic opportunities arising from the Plan

As part of developing the Plan, a 'trend analysis' was undertaken to model long-term changes in native vegetation extent and condition across the Cumberland subregion (see Supporting Document D).

The modelling examined various scenarios that approximate the development impacts of the nominated areas and the benefits of the conservation areas under the Plan. The analysis suggests generally that:

- Existing landscape scale threats across the Cumberland subregion, such as weed invasion, illegal activities, rubbish dumping, disturbance from recreational activities, are causing substantial declines
- The conservation areas to be established under the Plan have the potential to compensate for the impacts of the nominated areas and contribute to addressing the decline of native vegetation from existing landscape scale threats
- High intensity restoration of native vegetation provides significant potential for conservation outcomes

The trend analysis further suggests that the Plan is consistent with Principle 3 as it is likely to contribute to maintaining the health, diversity and productivity of the Cumberland subregion for future generations.

It is important to note that this Plan does not cover cultural resources other than areas of biodiversity value and matters of national environmental significance such as World Heritage and National Heritage sites. Other cultural resources, such as archaeological, built, and Aboriginal cultural heritage are regulated in NSW under other legislation and are subject to separate assessment and approval processes that are not part of this Plan (see Chapter 1).

40.4.4 PRINCIPLE 4: CONSERVATION OF BIODIVERSITY AND ECOLOGICAL INTEGRITY

Principle 4 is articulated in Section 3A(d) of EPBC Act as: *the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making*.

The POEA Act provides the same definition for Principle 4.

GUIDANCE TO ASSIST INTERPRETATION OF PRINCIPLE

Section 528 of the EPBC Act provides the following definition of biodiversity:

> *Biodiversity means the variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part) and includes:*
>
> *a) diversity within species and between species; and*
>
> *b) diversity of ecosystems.*

The Biodiversity Indicator Program for NSW (OEH, 2019b) defines ecological integrity as:

> *Ecological integrity is about maintaining the diversity and quality of ecosystems and enhancing their capacity to adapt to change and provide for the needs of future generations. It covers the extent, condition and connectivity of habitats; the effectiveness of on-ground conservation actions; and how well ecosystems respond to change, including climate change…*

As Commonwealth and NSW legislation articulates that Principle 4 should be a 'fundamental consideration' in decision making, courts have recognised that Principle 4 is one to which "significant weight should be assigned" (Preston, 2016). Although it is recognised that priority is to be given to the conservation of biodiversity and ecological integrity, this does not mean that a project must be refused if it is likely to impact on these matters (Preston, 2016).

EVALUATION OF PRINCIPLE

The Plan is considered to be consistent with Principle 4 of ESD as it:

- Has a conservation objective and strong conservation outcomes and establishes a comprehensive conservation program that is designed to achieve this objective and outcomes
- Has been developed through a strategic assessment process that ensured biodiversity was given fundamental consideration in decisions relating to the Plan

It is also important to note that the legislation regulating approval of the Plan requires decision-makers to provide significant consideration to biodiversity. For example:

- Under the BC Act, the NSW Environment Minister must be satisfied that the 'approved draft conservation measures' under the biodiversity certification adequately address the likely impacts on biodiversity values
- Under the EPBC Act, the Commonwealth Environment Minister can only approve the taking of actions in accordance with the endorsed Plan subject to a range of constraints on decision-making, including to not act inconsistently with a recovery plan or threat abatement plan for a protected matter (s 146K)

Conservation objective and conservation program

The Plan includes a conservation objective to "deliver biodiversity outcomes and support the ecological function of the Cumberland Plain" and strong conservation outcomes related to maintaining and enhancing biodiversity and other environmental values in the Cumberland subregion (see Chapter 8).

As described in section 40.4.3, the Plan establishes a conservation program to deliver this objective and these conservation outcomes. The outcomes of the conservation program are evaluated in Chapter 41.

The evaluation concludes that the Plan will:

- Avoid substantial areas of high biodiversity value and SAII entities
- Adequately offset the impacts of the development on biodiversity values
- Protect significant areas of high biodiversity value in the Cumberland subregion that are likely to maintain and enhance ecological function and processes, such as habitat connectivity
- Has the potential to contribute to addressing the decline of native vegetation from existing landscape scale threats

The evaluation suggests that biodiversity has been given fundamental consideration in decisions relating to the Plan, as the Plan will deliver substantial conservation outcomes for the Cumberland subregion.

Strategic assessment

The development of the Plan was informed by a strategic assessment process that ensured biodiversity was given fundamental consideration in decisions relating to the Plan.

A strategic assessment process provides an improved mechanism to address key landscape-scale conservation challenges over a site-by-site assessment and approval process. Strategic assessments can have the following benefits:

- Enable effort to be focused on the highest biodiversity value areas of the landscape
- Address ecological function and landscape-scale ecological processes, such as habitat connectivity
- Manage threats at a landscape scale that can maximise benefits to multiple species
- Be designed and implemented strategically, such as by consolidating offsets into large and more viable patches
- Be implemented ahead of impacts occurring from development, to help reverse any trend of decline

The strategic assessment process substantially informed the conservation program under the Plan by:

- Providing a comprehensive information base on biodiversity values to inform the development of the Plan
- Identifying key risks to biodiversity values from the impacts of the development
- Informing avoidance, mitigation and offset measures needed to adequately manage and offset impacts
- Informing conservation priorities, including offset priorities and targets

40.4.5 PRINCIPLE 5: VALUATION, PRICING AND INCENTIVE MECHANISMS

Principle 5 is articulated in Section 3A(e) of EPBC Act as: *improved valuation, pricing and incentive mechanisms should be promoted*.

The POEA Act (Section 6(2)(d)) further articulates how Principle 5 should be interpreted by decision-makers:

> *improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:*

i. *polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,*

ii. *the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,*

iii. *environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.*

Preston (2016) notes that Principle 5 is designed to account for environmental damage caused by market failure. Market failure occurs where the output of one entity acts as a negative input into one or more other entities without accompanying payment of compensation. Negative outputs are referred to as negative externalities.

Principle 5 emphasises the promotion of mechanisms to internalise the costs of negative externalities. The rationale for this is if the real value of environmental resources is included in the total costs for using those resources, then environmental resources will be more sustainably used and the risk of exploitation will be reduced.

GUIDANCE TO ASSIST INTERPRETATION OF PRINCIPLE

The element in relation to Principle 5 subject to most guidance relates to the 'polluter pays' principle. This principle is the best-known means for internalising external environmental costs. The principle says that those who generate pollution and waste should bear the costs of containment, avoidance or abatement (Preston, 2016).

Under this principle, the polluter should pay for the costs of (Preston, 2016):

- Preventing pollution or reducing pollution to comply with relevant laws and standards
- Preventing, controlling, abating and mitigating pollution
- Making good any environmental damage caused by pollution
- Making reparation (including compensatory damages and compensatory restoration) for irremediable injury

Evaluation of the Plan in relation to Principle 5 is based on considering whether the Plan has developed mechanisms to achieve internalisation of negative externalities associated with the development under the Plan.

EVALUATION OF PRINCIPLE

The Plan is considered to be generally consistent with Principle 5 of ESD as environmental factors have been included in the valuation of assets and services. This has been achieved through:

- Applying the polluter pays principle
- Achieving environmental goals in cost-effective ways

Polluter pays principle

The conservation program under the Plan includes commitments to:

- Avoid areas of high biodiversity value (preventing or reducing 'pollution')
- Mitigate threats (controlling, abating and mitigating 'pollution')
- Offset impacts (making good any environmental damage caused by 'pollution')

The Plan is consistent with the polluter pays principle as funding to implement the conservation program involves substantive cost-recovery from developers through a Special Infrastructure Contribution (SIC) levy.

The SIC is broadly described in Chapter 9.

The SIC generally ensures that those who generate 'pollution and waste' bear the costs of 'containment, avoidance or abatement' by largely imposing the costs of the conservation program on developers.

It is important to note that the SIC may not account for the full cost of the conservation program, with any remaining shortfall to be funded by the NSW Government. In this case, the costs of avoiding, mitigating and offsetting impacts are not borne solely by developers but rather all NSW taxpayers. This approach ensures the Plan balances environmental objectives with economic and social objectives in 'facilitating urban development in Western Sydney' (such as through supporting housing supply and reducing pressure on housing affordability).

Cost-effective environmental goals

The Plan achieves environmental goals to minimise the costs of development and maximise benefits to biodiversity by:

- Using a strategic assessment process to assess and approve the Plan
- Using an existing market-based mechanism to help deliver the conservation program
- Identifying priority conservation areas to maximise benefits to biodiversity at least cost

Strategic assessment process

Strategic assessments provide a cost-effective mechanism to assess and seek approval for development. Access Economics undertook a cost-benefit analysis of seven strategic assessments based on net present value (NPV) over a 30-year period (2010-11 to 2039-40), comparing site-by-site assessment processes with the alternative strategic assessment process. The analysis (Access Economics, 2011) found that strategic assessments provide a net benefit of:

- $4.5 million for the Australian Government
- $0.57 million for State governments
- $5.92 billion for developers, reflecting the commercial benefits from reducing uncertainty, risk and delays

Across all entities, the NPV of the net benefit for the seven programs was estimated as $5.93 billion.

The cost benefit analysis undertaken for the Plan (UTS Institute for Sustainable Futures, 2019) also indicated that the two potential conservation scenarios under the Plan would bring net positive social and economic outcomes for Western Sydney when assessed against the base case of site-by-site assessments.

Use of market-based mechanisms

The Plan uses an existing market-based mechanism under the BC Act, the Biodiversity Offsets Scheme, to deliver a substantial part of the conservation program through Biodiversity Stewardship Agreements (BSAs).

BSAs are voluntary cooperative agreements between a private landholder and the NSW Government. BSAs are registered on the title of a property to provide in-perpetuity protection of biodiversity values. Landholders are responsible to ongoing management of the land using funding provided by the NSW Government. The Biodiversity Conservation Trust (BCT) will be responsible for the delivery and management of BSAs under the Plan.

By using the Biodiversity Offsets Scheme, the Plan ensures efficient delivery of conservation areas because:

- Land is not required to be purchased – land purchase is very expensive in Western Sydney
- The process is competitive – the BCT is more likely to enter into agreements with landholders who can deliver conservation outcomes at the least cost (where other factors are equal)
- BSAs are voluntary, meaning that only willing landholders, who may be more likely to deliver conservation outcomes effectively, will participate in the process and enter agreements with the BCT

Identifying priority conservation areas to maximise benefits

The Department developed a Conservation Priorities Method that was used to identify SCAs within which conservation areas will be secured under the Plan. The method is summarised in Chapter 8.

The priorities method combines spatial information about biodiversity values with an analysis of constraints and opportunities to identify an optimal mix of potential conservation areas to offset the impacts of the development. It builds strategic conservation planning in the Cumberland subregion over the last decade, including the Cumberland Plain Recovery Plan (DECCW, 2011) and Biodiversity Investment Opportunities Map (OEH, 2015).

Use of the method aims to ensure that the conservation areas secured under the Plan maximise biodiversity benefits for a given cost of implementing the conservation program. SCAs represent the areas in the Cumberland subregion containing habitat for biodiversity values impacted by the development that are considered most likely to be viable in the long-term and maximise ecological function and connectivity across the landscape.

41 Evaluation of the adequacy of the Plan

This Chapter:

- Identifies evaluation themes consistent with the regulatory requirements of the BC Act and EPBC Act
- Sets out the approach and assumptions involved in the evaluation
- Evaluates the adequacy and acceptability of the Plan against each theme
- Provides an overall conclusion about the adequacy and acceptability of the Plan

41.1 EVALUATION THEMES

The evaluation has been undertaken on the basis of a set of themes that are drawn from the 'draft guidelines for planning authorities' (EES, 2019) relevant to the BC Act and the ToR relevant to the EPBC Act (see Chapter 39).

The requirements of the 'draft guidelines for planning authorities' (EES, 2019) and ToR are similar or overlap in some cases. Where requirements are similar, they have been grouped and addressed together as a theme for this evaluation.

Table 41-1 identifies the requirements and how they have been grouped and addressed together.

Table 41-1: Summary of requirements and theme groupings for evaluating the adequacy of commitments in the Plan

Theme	**NSW requirements** ('draft guidelines for planning authorities')	**Commonwealth requirements (ToR)**
Theme 1: *Are serious and irreversible impacts avoided and minimised?*	SAII are avoided and minimised (Principle 1)	Whether there will be SAII on any protected matter (ToR, section 5.2(3))
Theme 2: *Do the commitments address the values being impacted?*	Commitments address the biodiversity values being impacted (Principle 2)	Extent to which commitments involving offsets meet the principles of the EPBC Environmental Offsets Policy, 2012 (ToR, section 4.6(3))
		Extent to which protected matters are represented in areas to be protected through the commitments or in existing protected areas (ToR, section 5.2(1))
Theme 3: *Do the commitments address the most important values?*	Commitments prioritise preservation of important conservation values (Principle 3)	-
Theme 4: *Do the commitments improve values and ecological function in the long-term?*	Commitments improve biodiversity values and ecological function in the long-term (Principle 4)	Extent to which the Plan maintains and improves landscape connectivity (ToR, section 4.6(4))
		Extent to which the areas to be protected through the commitments or existing protected areas ensure long-term viability of protected matters (ToR, section 5.2(2))

Theme	**NSW requirements** ('draft guidelines for planning authorities')	Commonwealth requirements (ToR)
Theme 5: *Are the commitments additional to existing requirements?*	Commitments are additional to existing requirements (Principle 5)	-
Theme 6: *Do development controls proposed as commitments conserve the environment?*	Development controls proposed as commitments conserve the environment (Principle 6)	-
Theme 7: *Are proposed new national parks consistent with the CAR reserve framework?*	Any proposed new national parks are consistent with the CAR reserve framework (Principle 7)	-
Theme 8: *Will the Plan be effectively implemented and will outcomes be certain?*	Delivery of commitments is timely and certain (Principle 8)	Extent to which the commitments are enforceable and achievable over the life of the Plan (Agreement, clause 8.2)
		Adequacy of the commitments in protecting protected matters, including the effectiveness of implementation and funding arrangements (ToR, section 4.6(2))
		Likely effectiveness of the commitments in protecting and managing protected matters (ToR, section 5.3(2))
		Key uncertainties and risks associated with implementing the Plan, including implementation effectiveness and capacity (ToR, section 6.1(4))
		Adequacy of the adaptive approach to implementation of the Plan (ToR, section 6.2)
		Adequacy of monitoring, reporting, review and auditing of the Plan (ToR, section 7.1)
Theme 9: *Does the Plan facilitate adaptation to climate change?*	-	Extent to which the Plan has considered adaptation to climate change (ToR, section 4.6(5))
		Extent to which the commitments facilitate adaptation of biodiversity to climate change (ToR, section 5.3(1))

41.2 APPROACH TO EVALUATION OF OVERALL ADEQUACY

The evaluation involved an analysis of the commitments and actions (including the implementation arrangements) under the Plan against each of the key themes identified in Table 41-1.

For each theme, the evaluation:

- Describes the context and method used to undertake the evaluation
- Provides an analysis of the theme
- Provides a conclusion in relation to the theme

41.3 ASSUMPTIONS AND LIMITATIONS

There are several assumptions and limitations of the analysis. The key ones are:

- The evaluation of themes was often based on biodiversity values contained in SCAs. Not all land within the SCAs will be secured for conservation. However, as the location and boundaries of conservation lands are not yet final due to the large scale of the Plan Area and the voluntary mechanisms proposed to secure conservation lands under the Plan, the analysis of SCAs is a feasible and appropriate approach for evaluating the themes
- Surveys have not been done within the SCAs – biodiversity values are based on broad scale mapping of TECs and species habitat, or existing native vegetation (PCT) maps for NSW matters that are not also Commonwealth matters
- BAM plot data has not been collected within the SCAs – calculations for theme 2 were based on BAM plot data within the nominated areas and the assumption that these represent the data in the SCAs
- The general limitations with the data used in the Assessment Report as described in Chapter 13

41.4 THEME 1: ARE SERIOUS AND IRREVERSIBLE IMPACTS AVOIDED AND MINIMISED?

41.4.1 CONTEXT AND METHOD

The ToR requires the Assessment Report to show how impacts to protected matters are avoided. The Plan must therefore demonstrate that suitable avoidance has taken place to minimise biodiversity impacts to protected matters.

Furthermore, the 'draft guidelines for planning authorities' (EES, 2019) (Principle 1) also requires that the Plan specifically avoid and minimise serious and irreversible impacts (SAII).

The steps taken and future processes to be implemented under the Plan to avoid and minimise impacts on biodiversity values are described in Chapter 14. This chapter also summarises overall avoidance outcomes for biodiversity values under the Plan. Avoidance outcomes for NSW-listed SAII entities are provided in Chapter 25, and for each Commonwealth listed species and TEC, in Chapters 29 to 31.

This section summarises these avoidance processes and outcomes, particularly in relation to SAII.

41.4.2 ANALYSIS

AVOIDANCE RELATING TO URBAN, INDUSTRIAL, AND INFRASTRUCTURE DEVELOPMENT

<u>Steps taken to avoid biodiversity values</u>

The Department has undertaken a strategic planning process to design and locate the urban capable lands within the nominated areas. Consistent with section 8.1.1.2 of the BAM, the process was iterative and began early in the assessment process before the final data on biodiversity values was completed. The process involved three phases:

- Strategic planning to locate the nominated areas
- Initial development of footprints through Land Use and Infrastructure Implementation Plans (LUIIP)
- Iterative refinement of the footprints through development of the Plan

The process is described in detail in Chapter 14.

Commitments for avoidance

The Plan includes a commitment (Commitment 2) to avoid and minimise impacts from urban and industrial, and infrastructure development, to at least 4,315 hectares of land within the nominated areas. This includes

- Avoiding 3,670 hectares of native vegetation comprising:
  - 2,735 hectares of native vegetation because of its biodiversity value
  - 935 hectares of riparian corridors and steep land
- Avoiding specific amounts of habitat for Commonwealth and NSW listed TECs
- Limiting cumulative direct impacts from essential infrastructure within non-certified land to the Commonwealth listed Shale Sandstone Transition Forest TEC and prioritising the avoidance of impacts from this infrastructure to specific known populations of flora species and important Koala corridors (see Chapter 37)

This commitment will be delivered through several actions, including:

- Introducing a planning provision to require that the urban capable lands in the precinct plans are consistent with the areas of certified land and avoided lands identified in the Plan
- Applying environment (E2) conservation zoning to avoided lands (see below)
- Applying further planning controls through the NSW planning system if the avoidance targets are not being met

The Plan will apply environment (E2) conservation zoning to land avoided for biodiversity purposes and other purposes (riparian corridors, steep land) to strengthen the protection of avoided lands from the impacts of development. Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land.[1]

Environment zoning will be implemented through the proposed State Environmental Planning Policy (SEPP) for strategic conservation planning or the relevant place based Environmental Planning Instrument (EPI), such as the Growth Centres SEPP or the draft Aerotropolis SEPP (see Part 2).

The Plan also includes several commitments related to mitigation of indirect impacts that would lead to avoidance and minimisation of impacts on key habitat features within or adjacent to urban capable land. These include:

- Retain large trees (≥50cm DBH) during precinct planning where possible and avoid impacts to soil within the dripline of these trees during construction
- Retain areas of high density proteaceae shrubs where possible, particularly along riparian corridors
- If Green and Golden Bell Frog is confirmed present along Ropes Creek, consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced

Avoidance outcomes

The planning process to avoid and minimise impacts has led to substantial avoidance outcomes for native vegetation, TECs, species habitats, and habitat connectivity.

Urban capable land has generally avoided the vast majority of native vegetation and key areas of high biodiversity values, including NSW and Commonwealth-listed TECs, species habitats, important populations and habitat connectivity. Within the nominated areas, total avoidance (not including excluded lands) includes:

- Approximately 67.2 per cent of all native vegetation, including 95.2 per cent of high (intact) condition native vegetation

[1] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10% to allow for potential future development of essential infrastructure in non-certified land

- Approximately 87.5 per cent of critically endangered and endangered Commonwealth-listed TECs and 71.7 per cent of critically endangered and endangered NSW-listed TECs
- An average of 77.8 per cent of potential habitat for three species with a very high biodiversity risk weighting (>3), and an average of 78.6 per cent of potential habitat for 31 species with a high biodiversity risk weighting (≥2)
- Of 14 species with important populations identified outside excluded land, 12 have important populations represented (either wholly or partially) on land avoided for biodiversity purposes
- Approximately 88.3 per cent of Bio Map core areas and 86.0 per cent of Bio Map corridors

Note that these figures include the amount of land 'avoided' for other purposes and not just biodiversity purposes (i.e. the figures include land that is not suitable for urban development because it is steep land or riparian corridors).

It is considered these avoidance outcomes are adequate and generally consistent with the guidance under the BAM and requirements of the ToR. Furthermore, commitments under the Plan ensure:

- The amount of avoidance to be achieved is clear and transparent
- Precinct planning proceeds in a way that ensures avoided lands are clearly identified and avoided
- The protection of avoided lands from the impacts of development is strengthened through environmental zoning

AVOIDANCE RELATING TO THE TRANSPORT CORRIDORS

Steps taken to avoid biodiversity values

Avoidance and minimisation of impacts from the transport corridors is being undertaken in two stages:

- Processes to locate the transport corridors, which has already been undertaken
- Detailed design of the footprints within the transport corridors for each transport project to further avoid and minimise impacts – this will be undertaken through future environmental impact assessments for each transport project under NSW planning and assessment laws (see Chapter 7)

The process to locate the transport corridors is described in Chapter 14.

Commitments for avoidance

The transport corridors included in the Plan have not completed the process to avoid and minimise impacts to biodiversity values as the alignments of the transport projects within each corridor are not currently certain (see Part 2).

The Plan includes commitments for further avoidance and minimisation of impacts to biodiversity values related to the transport corridors. This will be undertaken through:

- A process of strategic planning and detailed design, which will determine the final alignment of each transport project that will generally occur within each transport corridor
- NSW environmental assessment and approval process for each project current at the time the project is brought forward (this is currently the State Significant Infrastructure approval process)

For the parts of the transport corridors within the nominated areas, the Plan commits to avoiding and minimising impacts to TECs, species and habitat (Commitment 3). This includes avoiding where possible:

- Areas of high biodiversity value (defined by the Plan's 'avoidance criteria' – see Chapter 14)
- Areas of potential habitat connectivity, particularly vegetation in riparian corridors, for specific species
- Known flora populations for specific species in specific locations

For the parts of the transport corridors outside the nominated areas, the Plan commits to avoiding and minimising impacts to species and TECs in accordance with the major infrastructure corridors class of action description and the BC Act, including the BAM (Commitment 4). This includes avoiding where possible:

- Known flora populations for specific species in specific locations
- Other specific locations of high biodiversity value

Avoidance outcomes

The commitments for future avoidance relating to the transport corridors are considered adequate to ensure the corridors avoid and minimise the risk of unacceptable impacts on biodiversity values. The commitments ensure:

- Avoidance outcomes are achieved consistent with the Plan's 'avoidance criteria' (see Chapter 14) or are assessed in assessed and determined in accordance with the BAM (for the transport corridors outside the nominated areas)
- Impacts to known key biodiversity values within the corridors are avoided and minimised where possible, including specific species and habitat, and/or specific locations of high biodiversity value
- Avoidance of biodiversity values as well as the costs of offsets is taken into account in the evaluation of the route options (e.g. multi-criteria analysis) during the planning phase of each project

AVOIDANCE RELATING TO ESSENTIAL INFRASTRUCTURE

Planning for essential infrastructure to support the nominated areas, such as water and electricity utilities, is in various stages of development, and this infrastructure may need to be located outside urban capable lands and on areas that are identified as avoided lands.

The Plan is seeking approval under the EPBC Act for certain essential infrastructure development to occur within the nominated areas outside urban capable lands (i.e. within avoided lands but not excluded lands).

Steps taken to avoid biodiversity values

The Plan specifies that:

- Every effort should be made to ensure that essential infrastructure development is limited to urban capable lands
- Where essential infrastructure occurs outside urban capable lands (i.e. within avoided lands), the development must comply with the 'Guidelines for essential infrastructure development' in Appendix A of the Plan. This includes a requirement (if necessary) to assess the biodiversity impacts of each project under the BC Act and BAM, which requires an avoid, mitigate and offset process to be applied

Commitments for avoidance

Under Commitment 2, the Plan will avoid and minimise impacts from urban, industrial and infrastructure development to at least 3,670 hectares of native vegetation on non-certified land.

As part of this, cumulative direct impacts over the life of the Plan from essential infrastructure to Shale Sandstone Transition Forest within non-certified land will be limited to no more than (Commitment 2.3):

- 20 ha in Wilton Growth Area (Wilton)
- 20 ha in Greater Macarthur Growth Area (GMAC)

Furthermore, avoidance of several known populations of flora and important Koala corridors within Wilton and GMAC will be prioritised to maintain their integrity (Commitment 2.4).

Avoidance outcomes

It is considered the Guidelines and supporting Commitment 2.3 and Commitment 2.4 will lead to acceptable avoidance outcomes for biodiversity values as they ensure:

- Avoidance outcomes are achieved consistent with the Plan
- Impacts to Shale Sandstone Transition Forest (which is widespread in avoided lands in Wilton and GMAC and has the potential to be notably impacted by essential infrastructure) are capped to 20 ha in each nominated area
- Impacts to known key biodiversity values within the corridors are avoided and minimised where possible
- The impacts of each project will be assessed under the BC Act and BAM (where triggered under the Act), which requires an avoid, mitigate and offset process to be applied to ensure avoidance outcomes are acceptable

AVOIDANCE OF SAII ENTITIES

The NSW and Commonwealth-listed SAII entities that may be subject to serious and irreversible impacts and that are potentially impacted by the development under the Plan are:

- Cooks River/Castlereagh Ironbark Forest (NSW/Cth)
- Cumberland Plain Woodland (NSW)/ Cumberland Plain Shale Woodlands and Shale-Gravel Transition forest (Cth)
- Shale Sandstone Transition Forest (NSW/Cth)
- *Allocasuarina glareicola* (NSW/Cth)
- *Hibbertia fumana* (NSW)
- *Micromyrtus minutiflora* (NSW/Cth)
- Large-eared Pied Bat (NSW/Cth)
- Green and Golden Bell Frog (NSW/Cth)
- Three raptors; White-bellied Sea-Eagle, Little Eagle and Square-tailed Kite (NSW)
- Red-crowned Toadlet (NSW)

Steps taken to avoid SAII entities

The planning process that the Department undertook to design and locate the urban capable lands within the nominated areas was also applied to SAII entities. The process gave priority to avoiding SAII entities as the criteria gave highest priority to the avoidance and minimisation of critically endangered matters (see Chapter 14).

Future avoidance processes for the transport corridors and essential infrastructure (see above) will also apply to SAII entities. Commitment 2.3 caps the cumulative direct impacts over the life of the Plan from essential infrastructure to Shale Sandstone Transition Forest to no more than 20 ha in Wilton and 20 ha in GMAC.

Avoidance outcomes for SAII entities

Table 41-2 and Table 41-3 summarise the avoidance outcomes for each SAII entity within the nominated areas (avoidance outcomes for the transport corridors outside the nominated areas and essential infrastructure in avoided lands is not identified as avoidance for these projects has not yet occurred).

Chapter 25 analyses avoidance outcomes for each SAII entity in more detail.

41.4.3 CONCLUSION

The avoidance outcome achieved through the process to design and locate the urban capable lands within the nominated areas is considered adequate and generally consistent with the guidance under the BAM and requirements of the ToR.

The avoidance process was detailed and robust and based on the best available data on biodiversity values, and achieved substantial avoidance outcomes for native vegetation, high (intact) condition native vegetation, the majority of Commonwealth-listed and NSW-listed TECs, including the most endangered TECs and potential habitat for species with a very high and high biodiversity risk weighting (>3).

As discussed for each TEC and species in Chapter 25 (SAII entities) and Chapters 29 to 31 (Commonwealth listed species and TEC), avoidance effort has generally focused on native vegetation and TECs in higher condition that are more likely to be viable in the long-term, with residual impacts from the development generally occurring to:

- Smaller patches
- Native vegetation or TECs in lower condition
- Only the edges of larger, contiguous patches associated with waterways and gullies and gorges, particularly in Wilton and GMAC, which minimises fragmentation and impacts on habitat connectivity

Despite this overall conclusion, for some SAII entities, about half or less of the TEC or potential species habitat was avoided and residual impacts remain. This includes:

- Cumberland Plain Woodland
- Cooks River/ Castlereagh Ironbark Forest

- *Allocasuarina glareicola*
- Green and Golden Bell Frog

For these TECs, the scale of impacts are relatively minor when considering the extent of these TECs across the Plan Area, and the majority of impacts are to lower viability areas. The offsets proposed by the Plan for these TECs (Commitment 8) will provide a substantial addition to the level of protection of these TECs and address key threats to the TECs identified in BioNet profiles and Conservation Advices.

For *Allocasuarina glareicola*, there are no impacts to records or important populations of the species (one important population occurs on excluded lands and will not be impacted).

While there will be direct impacts to small areas of Green and Golden Bell Frog habitat for a potential population in GPEC, it is not known whether this population still exists. Under Commitment 5, the Department will undertake surveys for this species along Ropes Creek, and if confirmed present, the Plan includes a species specific measure to consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced.

Table 41-2: Assessment of avoidance outcomes for SAII TECs within the nominated areas

SAII entity	Listing	Summary of TEC avoidance within nominated areas (without excluded lands)				Comment on avoidance outcomes within the nominated areas
		Total in nominated areas (ha)	Total avoided (ha / %)	Avoided for bio. reasons (ha / %)	Avoided for other reasons (ha / %)	
Cooks River/ Castlereagh Ironbark Forest	NSW	65 ha	27 / 43%	27 / 43%	0.2 / <1%	Between 43 - 50% of the TEC has been avoided For the NSW-listed TEC, of the 35 ha of intact condition TEC within the nominated areas (not including excluded land), the majority (19.4 ha or 55%) has been avoided (see Chapter 25) For the Commonwealth-listed TEC, of the 31 ha of intact condition TEC within the nominated areas (not including excluded land), the majority (19.4 ha or 62.6%) has been avoided (see Chapter 31)
	Cth	52 ha	26 ha / 50%	26 ha / 50%	0 ha / 0%	
Cumberland Plain Woodland	NSW	1,488 ha	474 ha / 32%	394 ha / 26%	80 ha/ 5%	Between 32 - 46% of the TEC has been avoided For the NSW-listed TEC, of the 147 ha of intact condition TEC within the nominated areas (not including excluded land), the majority (109 ha or 74%) has been avoided (see Chapter 25) For the Commonwealth-listed TEC, of the 26.8 ha of intact condition TEC within the nominated areas (not including excluded land), the majority (18.0 ha or 67.2%) has been avoided (see Chapter 31)
	Cth	204 ha	94 ha / 46%	74 ha / 36%	19 ha / 9%	
Shale Sandstone Transition Forest	NSW	2,623 ha	2,135 ha / 81%	1,865 ha / 71%	270 ha / 10%	Between 81% - 91% of the TEC has been avoided For the NSW-listed TEC, of the 1,511 ha of intact condition TEC within the nominated areas (not including excluded land), the vast majority (1,466 ha or 97%) has been avoided For the Commonwealth-listed TEC, of the 1,480 ha of intact condition and 1,379 ha of high viability TEC within the nominated areas (not including excluded land), 1,437 ha of intact condition (or 97.1%) and 1,346 ha of high viability (or 97.6%) TEC, have been avoided Furthermore, Commitment 2.3 caps the cumulative direct impacts over the life of the Plan from essential infrastructure to Shale Sandstone Transition Forest to no more than 20 ha in Wilton and GMAC
	Cth	2,138 ha	1,947 ha / 91%	1691 ha / 79%	255 ha / 12%	

Table 41-3: Assessment of avoidance outcomes for SAII species within the nominated areas

SAII entity	Summary of habitat avoidance (without excluded lands)				Comment on avoidance outcomes
	Total in nominated areas (ha)	**Total avoided (ha / %)**	**Avoided for bio. reasons (ha / %)**	**Avoided for other reasons (ha / %)**	
Allocasuarina glareicola	22 ha	10 ha / 46%	10 ha / 45%	0 ha / 0 %	About half the potential habitat has been avoided There are no impacts to records or important populations of the species (one important population occurs on excluded lands and will not be impacted).
*Chalinolobus dwyeri**	889 ha	882 ha / 99%	452 ha / 51%	429 ha / 48%	Almost all potential breeding habitat has been avoided An important population has been partially avoided. Population 424 occurs as a single important population across the Plan Area and surrounds. The majority of records lie outside of the nominated areas. Nine records occur within excluded lands and 2 records are located on avoided lands within central GMAC (see Chapter 14)
Hibbertia fumana	1,245 ha	1,207 ha / 97%	1,064 ha / 85%	143 ha / 11%	Almost all potential habitat has been avoided There are no impacts to records of the species
Litoria aurea	25 ha	11 ha / 46%	11 ha / 46%	0 ha / 0%	About half the potential habitat has been avoided. It is important to note that much of the potential habitat mapped comprises existing urban areas (houses and roads), as the mapping was done by applying a buffer to records along Ropes Creek (see Chapter 25) There will be direct impacts to habitat for a potential population in Greater Penrith to Eastern Creek Investigation Area (GPEC), although it is not known whether this population still exists If Green and Golden Bell Frog is confirmed present along Ropes Creek, the Plan includes a species specific measure to consult with land managers of the riparian corridor to ensure key habitat features are protected and enhanced
Micromyrtus minutiflora	50 ha	28 ha / 56%	28 ha / 56%	<1 ha / <1%	Over half the potential habitat has been avoided There are no impacts to records or important populations of the species (one important population occurs on excluded lands and will not be impacted).

SAII entity	Summary of habitat avoidance (without excluded lands)				Comment on avoidance outcomes
	Total in nominated areas (ha)	**Total avoided (ha / %)**	**Avoided for bio. reasons (ha / %)**	**Avoided for other reasons (ha / %)**	
*Haliaeetus leucogaster**	1,679 ha	1,661 ha / 99%	1,066 ha / 64%	596 ha / 35 %	Almost all potential breeding habitat has been avoided There are no impacts to known breeding sites (stick nests)
*Hieraaetus morphnoides**	3,026 ha	3,006 ha / 99%	2,311 ha / 76%	696 ha / 23%	
*Lophoictinia isura**	2,983 ha	2,955 ha / 99%	2,279 ha / 76%	676 ha / 23 %	
Pseudophryne australis	884	875 ha / 99%	652 ha / 74%	223 ha / 25%	Almost all potential habitat has been avoided There are no impacts to records of the species

*Impacts relate to potential breeding habitat only

41.5 THEME 2: DO THE COMMITMENTS ADDRESS THE VALUES BEING IMPACTED?

41.5.1 CONTEXT AND METHOD

NSW REQUIREMENTS

The BC Act requires an assessment of the impacts on biodiversity values of the development and the number and class of credits that would be required to be retired if the offset rules under the BC Act applied.

The Act does not require that the 'value' of commitments be calculated in terms of credits (see Section 39.1). However, the 'draft guidelines for planning authorities' (EES, 2019) specify that it should be explained how the biodiversity values that benefit from the commitments are relevant to the values impacted, and provides that commitments should aim to secure land that contains vegetation and species 'equivalent to the biodiversity values being impacted'.

The Plan includes offset targets (see Chapter 8) for each impacted NSW-listed TEC, which will be delivered within SCAs through a range of commitments, including reserves and biodiversity stewardship agreements.

The analysis of Theme 2 involved an assessment of the adequacy of the offset targets for each impacted NSW listed TEC by examining three key questions:

- Do all impacted TECs have offset targets?
- Are offset targets equivalent to the biodiversity values being impacted?
- Can the SCAs deliver the offset targets?

The question:

- 'Are the offset targets equivalent to the biodiversity values being impacted?' was addressed by undertaking an analysis of the credit requirements of the BAM
- Of whether the SCAs can deliver the offset targets was addressed by considering the available land within the SCAs for offsets and restoration actions, and the overall balance between impacts and offset availability

Both analyses used NSW TECs/PCTs as a surrogate for all biodiversity values and did not examine species outcomes in detail.

<u>Analysis of BAM credit requirements</u>

The purpose of this analysis was to examine whether the offset targets are equivalent to the biodiversity values being impacted. The analysis only covered the impacts within the nominated areas, as BAM plot data that is needed to calculate the credits required for impacts outside the nominated areas was not collected. The offset targets for this analysis were therefore reduced to only account for the nominated area impacts. The approach involved:

- Calculating the number of credits that would be required to be retired to offset the impacts per vegetation zone within the nominated areas. This was done as part of the Assessment Report in accordance with the BAM
- Estimating the number of credits generated within the SCAs per vegetation zone. As surveys of the SCAs have not been undertaken, this was done on the basis of the BAM plot data gathered in the nominated areas, which was input into the stewardship component of the BAM Calculator
- Determining the amount (ha) of each vegetation zone needed in the SCAs to meet the estimated credit requirements of the BAM and comparing this to the offset targets

There are several limitations to the analysis:

- The analysis was based on plot data collected within development lands rather than within SCAs. Plots completed within SCAs may change the results of the analysis (e.g. if high levels of African Olive is present within an offset site in the SCAs, credit generation is likely to decrease significantly)

- In estimating the number of credits potentially generated within the SCAs per vegetation zone, an assumption was made that active management would be undertaken on the offset sites to the highest standard allowed by the BAM Calculator. This is considered to be a reasonable assumption as landholders in NSW are often choosing to undertake active management at offset sites in order to generate the highest possible credits (and associated income from selling those credits). However, this may not be likely or possible on all offset sites

COMMONWEALTH REQUIREMENTS

The ToR requires an analysis of the extent to which commitments involving offsets meet the principles of the EPBC Act Environmental Offsets Policy (DSEWPC, 2012). The policy includes eight principles (see Table 41-4) and is accompanied by the EPBC offsets assessment guide (available on the DAWE website). The guide provides a 'balance sheet' approach to estimate the impacts and offsets for threatened species and ecological communities under the EPBC Act.

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment (DSEWPC, 2012). Under the offsets policy and guide, suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the environment that is protected by national environmental law and affected by the proposed action (DSEWPC, 2012).

The analysis was undertaken by applying the EPBC offsets assessment guide to principles 1, 3 and 4 of the EPBC Act offsets policy. The other principles are addressed elsewhere in the Assessment Report as shown in Table 41-4.

Consistent with the approach used to analyse matters listed under the BC Act for this theme, the analysis of Commonwealth matters focused on EPBC Act TECs as a surrogate for biodiversity values more broadly and did not examine species outcomes in detail. The appropriateness of offsets for species are discussed in Chapters 29 and 30.

Table 41-4: Principles in the EPBC offsets policy

Principle Suitable offsets must…	Approach to analysis
1. Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the development	Offsets assessment guide was applied to each Commonwealth listed TEC
2. Be built around direct offsets but may include other compensatory measures	This is described in Part 2
3. Be in proportion to the level of statutory protection that applies to the protected matter	Offsets assessment guide was applied to each Commonwealth listed TEC
4. Be of a size and scale proportionate to the residual impacts on the protected matter	Offsets assessment guide was applied to each Commonwealth listed TEC
5. Effectively account for and manage the risks of the offset not succeeding	Implementation arrangements for the conservation program under the Plan include a process to track delivery of offsets and implement an adaptive response if the delivery of offsets is not keeping pace with development impacts (see section 41.11) The Plan includes a monitoring, evaluation, reporting and improvement program (see Part 2 and section 41.11) that will monitor and evaluate the delivery of commitments and actions and the achievement of the Plan's outcomes and implement an adaptive response where necessary to ensure successfully

Principle Suitable offsets must…	Approach to analysis
	delivery of the conservation program, including offsets
6. Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs	This is evaluated under Theme 5
7. Be efficient, effective, timely, transparent, scientifically robust and reasonable	Implementation arrangements for the conservation program under the Plan include a process to track delivery of offsets and implement an adaptive response if the delivery of offsets is not keeping pace with development impacts (see section 41.11) The Plan includes a monitoring, evaluation, reporting and improvement program (see Part 2 and section 41.11) that will evaluate the efficiency and effectiveness of the delivery of commitments and actions, including offsets, and report on progress of delivery The method to determine the location of SCAs (the Conservation Priorities Method) where offsets will be secured was based on sound conservation planning principles and is set out in Part 2 and in Appendix D of the Plan. Confirmation of the values present at offset sites and the management of offset sites secured as BSAs under the conservation program will be undertaken in accordance with the requirements of the BAM (an agreed method underpinned by science)
8. Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	This is evaluated under Theme 8

Applying the EPBC Act offsets assessment guide

An assessment using the offsets assessment guide was completed for the Commonwealth-listed TECs impacted by the development under the Plan, including:

- Coastal floodplain eucalypt forest of eastern Australia (FPAL)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
- Cooks River/Castlereagh Ironbark Forest
- Coastal Swamp Oak (*Casuarina glauca*) Forest
- Shale Sandstone Transition Forest

To complete the assessment the data entered into the offsets assessment guide was derived from a range of sources, most notably the plot data (and associated vegetation integrity score) captured for each vegetation zone assessed in the BAM assessment. The BAM vegetation integrity score data provides a robust data set and improves the reliability of the calculations completed within the offsets assessment guide.

Assessment of impacts

For the assessment of impacts under the offsets assessment guide (impact calculator), the impacts to each TEC (i.e. total quantum of impact) were calculated for each condition state impacted, including intact, thinned and scattered trees (where relevant). The results for each condition state were then summed to calculate a total quantum of impact for the TEC.

The data entered into the impact calculator is provided in Table 41-5 and includes:

- The status for each TEC (for Coastal floodplain eucalypt forest of eastern Australia a listing status of Endangered has been assumed)
- The area of impact for each TEC condition state consistent with the area calculated in this report
- The quality of the community entered as a score between 0 and 10. The quality data entered for each TEC condition state is based on the vegetation integrity score obtained through the application of the BAM and the associated BAM plots and vegetation integrity scores. As vegetation integrity is measure out of 100 for each TEC condition state the vegetation integrity score was divided by ten and then rounded (following standard rounding rules) to obtain a score out of 10

The total quantum of impact for each TEC condition state is also provided in Table 41-5. The highest total quantum of impact amounts relate to thinned Shale Sandstone Transition Forest and thinned Coastal floodplain eucalypt forest of eastern Australia due to the amount of clearing recorded and relatively high vegetation quality scores.

Assessment of offsets

As the exact location of offsets under the Plan is currently not known, and therefore the condition of vegetation protected is also unknown, it was not possible to conduct an assessment per condition state for the offset calculator. Therefore, a single assessment was conducted using the offset calculator for each TEC. As condition states on offset sites are likely to vary this approach is considered appropriate.

The data entered into the offset calculator is provided in Table 41-6 and includes:

- The area of proposed offset based on the targets defined under the Plan for each EPBC TEC
- A risk-related time horizon set at the maximum of 20 years and a time until ecological benefit of 10 years
- The start quality of the TEC based on the vegetation integrity score obtained through the application of the BAM and the associated BAM plots and vegetation integrity scores. As a single assessment was completed for each TEC the average vegetation integrity score calculated across the intact, thinned and scattered tree condition states was used to derive the start quality. Consistent with the impact calculator the score was divided by 10 and rounded (using standard rounding rules) to calculate a score out of 10
- The future quality (without offset) of the TEC. In all cases this was one less than the start quality calculated
- The future quality (with offset) of the TEC. To calculate the expected improvement of an offset site the BAM plot data was entered into the stewardship side of BAM credit calculator, as described in above. The improvement predicted by the BAM credit calculator was used to estimate the likely improvement of the EPBC TEC. Consistent with the impact calculator the score was divided by 10 and rounded (using standard rounding rules) to calculate a score out of 10. The analysis revealed that one EPBC TEC (Coastal floodplain eucalypt forest of eastern Australia) could achieve an average future quality (with offset) of 10/10 based on the data entered. As such a high condition level would be difficult to achieve within the Cumberland subregion this score was manually reduced to 9/10
- A risk of loss (without offset) of 20 per cent and a risk of loss (with offset) of 5 per cent
- The confidence in result for both the change in habitat quality and averted loss set to 85 per cent

Table 41-5: Attributes entered into EPBC offsets assessment guide – impact calculator

Threatened Ecological Community	Condition	EPBC Act Status	Quantum of impact (ha)	Quantum of impact (quality)	Justification	Total quantum of impact (adjusted ha)
Coastal floodplain eucalypt forest of eastern Australia*	Intact	Endangered	28.6	8 / 10	Impacts of 28.6 ha are calculated to intact condition CFEF. Average vegetation integrity of PCT 835 from BAM plots conducted in intact condition is 77/100, rounded to 8/10 for use in the EPBC offsets assessment guide	22.88
	Thinned		141.3	6 / 10	Impacts of 141.3 ha are calculated to thinned condition CFEF. Average vegetation integrity of PCT 835 from BAM plots conducted in thinned condition is 57/100, rounded to 6/10 for use in the EPBC offsets assessment guide	84.78
	Scattered trees		40.4	7 / 10	Impacts of 40.4 ha are calculated to scattered tree condition CFEF. Average vegetation integrity of PCT 835 from BAM plots conducted in scattered tree condition is 69/100, rounded to 7/10 for use in the EPBC offsets assessment guide	28.28
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Intact	Critically Endangered	22.6	6 / 10	Impacts of 22.5 ha are calculated to intact condition CPW. Average vegetation integrity of PCT 724, PCT 849 and PCT 850 from BAM plots conducted in intact condition is 57/100, rounded to 6/10 for use in the EPBC offsets assessment guide	13.56
	Thinned		128.1	4 / 10	Impacts of 129.9 ha are calculated to thinned condition CPW. Average vegetation integrity of PCT 724, PCT 849 and PCT 850 from BAM plots conducted in thinned condition is 43/100, rounded to 4/10 for use in the EPBC offsets assessment guide	51.24
	Scattered trees		4.1	2 / 10	Impacts of 4.0 ha are calculated to scattered tree condition CPW. Average vegetation integrity of PCT 724, PCT 849 and PCT 850 from BAM plots conducted in scattered tree condition is 24.7/100, rounded to 2/10 for use in the EPBC offsets assessment guide	0.82

Threatened Ecological Community	Condition	EPBC Act Status	Quantum of impact (ha)	Quantum of impact (quality)	Justification	Total quantum of impact (adjusted ha)
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	Intact	Critically Endangered	11.6	5 / 10	Impacts of 11.6 ha are calculated to intact condition CRCIF. Average vegetation integrity of PCT 725 from BAM plots conducted in intact condition is 49/100, rounded to 5/10 for use in the EPBC offsets assessment guide	5.80
	Thinned		12.9	4 / 10	Impacts of 12.9 ha are calculated to thinned condition CRCIF. Average vegetation integrity of PCT 725 from BAM plots conducted in thinned condition is 43/100, rounded to 4/10 for use in the EPBC offsets assessment guide	5.16
	Scattered trees		1.7	2 / 10	Impacts of 1.7 ha are calculated to scattered tree condition CRCIF. Average vegetation integrity of PCT 725 from BAM plots conducted in scattered tree condition is 20/100, rounded to 2/10 for use in the EPBC offsets assessment guide	0.34
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	Thinned	Endangered	1.7	4 / 10	Impacts of 1.3 ha are calculated to thinned condition CSOF. Average vegetation integrity of PCT 1800 from BAM plots conducted in thinned condition is 43/100, rounded to 4/10 for use in the EPBC offsets assessment guide	0.68
	Scattered trees		0.1	4 / 10	Impacts of 0.1 ha are calculated to scattered tree condition CSOF. Average vegetation integrity of PCT 1800 from BAM plots conducted in scattered tree condition is 41/100, rounded to 4/10 for use in the EPBC offsets assessment guide	0.04
Shale Sandstone Transition Forest in the Sydney Basin Bioregion	Intact	Critically Endangered	43.1	7 / 10	Impacts of 34.6 ha are calculated to intact condition SSTF. Average vegetation integrity of PCT 1395 from BAM plots conducted in intact condition is 73/100, rounded to 7/10 for use in the EPBC offsets assessment guide	30.17
	Thinned		135.7	6 / 10	Impacts of 126.7 ha are calculated to thinned condition SSTF. Average vegetation integrity of PCT 1395 from BAM plots conducted in thinned condition is 64/100, rounded to 6/10 for use in the EPBC offsets assessment guide	81.42

Threatened Ecological Community	Condition	EPBC Act Status	Quantum of impact (ha)	Quantum of impact (quality)	Justification	Total quantum of impact (adjusted ha)
	Scattered trees		13.0	3 / 10	Impacts of 13.1 ha are calculated to scattered tree condition SSTF. Average vegetation integrity of PCT 1395 from BAM plots conducted in scattered tree condition is 30/100, rounded to 3/10 for use in the EPBC offsets assessment guide	3.90

* Based on mapping for PCT 835

Table 41-6: Attributes entered into EPBC offsets assessment guide – offsets calculator

EPBC offsets assessment guide attribute	Value entered	Justification
Coastal floodplain eucalypt forest of eastern Australia*		
Time horizon – Risk-related time horizon (years)	20 years	The offset sites identified, conserved and managed under the Plan will either be dedicated as a reserve under the *National Parks and Wildlife Act 1974* or protected under a Biodiversity Stewardship Agreement (BSA). The longest possible risk-related time horizon of 20 years was therefore selected
Time horizon – Time until ecological benefit (years)	10 years	All offset sites will be funded and managed in perpetuity. The initial phase of active management is likely to lead to a reasonably rapid improvement in site condition in the short to medium term due to the implementation of up-front management activities such as fencing, weed management and supplementary planting. Over the longer term the level of improvement is likely to be more gradual as the sites enter a maintenance phase. Ten years has been entered as the time until ecological benefit as the initial phase of active management is expected to increase site condition noticeably in the short to medium term
Start area and quality - Start area (ha)	575 ha	The target committed to in the Plan for Coastal floodplain eucalypt forest of eastern Australia
Start area and quality - Start quality (scale of 0 – 10)	7 / 10	Average vegetation integrity of PCT 835 from BAM plots conducted in all condition states is 67/100, rounded to 7/10 for use in the EPBC offsets assessment guide
Future area and quality without offset – Risk of loss (%)	20%	The lands identified as potential offset sites within the SCA are generally located in western Sydney and are predominantly zoned for rural land uses. Should lands not be protected and managed as offset sites there will be an ongoing risk of loss of the biodiversity values of these lands due to ongoing agricultural practises and continued weed encroachment, grazing pressure and inappropriate access. A risk of loss of 20% is considered appropriate
Future area and quality without offset – Future quality (scale of 0 – 10)	6 / 10	If land is not protected and managed as a reserve or BSA it is highly likely that land will continue to degrade through weed encroachment, grazing pressure and inappropriate access etc. A reduction of 1/10 has been applied
Future area and quality with offset – Risk of loss (%)	5%	All offset land under the Plan will be protected as a reserve or BSA. The risk of loss is therefore considered to be low
Future area and quality with offset – Future quality (scale of 0 – 10)	9 / 10	Average vegetation integrity increase of PCT 835 from BAM plots conducted in all condition states (assuming active management is undertaken) is 26/100, rounded to 3/10 for use in the offsets assessment guide. This increase results in a future quality of 10/10 (i.e. increase from the current condition of 7/10 to 10/10). Assuming a condition of 10/10 may not be achievable in the context of the Cumberland subregion 9/10 was entered into the offsets assessment guide
Confidence in result (change in habitat quality and averted loss) (%)	85%	There is a relatively high level of confidence in the data entered into the offsets assessment guide. Much of the data entered is based on plot data collected and the calculations performed as part of the BAM. The BAM provides a scientifically robust and repeatable method to conduct biodiversity assessment. In

EPBC offsets assessment guide attribute	Value entered	Justification
		addition, offset sites are to be protected and managed through reservation or a BSA. The offset sites will be fully funded and managed through an approved management plan
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest		
Time horizon – Risk-related time horizon (years)	20 years	The offset sites identified, conserved and managed under the Plan will either be dedicated as a reserve under the *National Parks and Wildlife Act 1974* or protected under a Biodiversity Stewardship Agreement (BSA). The longest possible risk-related time horizon of 20 years was therefore selected
Time horizon – Time until ecological benefit (years)	10 years	All offset sites will be funded and managed in perpetuity. The initial phase of active management is likely to lead to a reasonably rapid improvement in site condition in the short to medium term due to the implementation of up-front management activities such as fencing, weed management and supplementary planting. Over the longer term the level of improvement is likely to be more gradual as the sites enter a maintenance phase. Ten years has been entered as the time until ecological benefit as the initial phase of active management is expected to increase site condition noticeably in the short to medium term
Start area and quality - Start area (ha)	575 ha	The target committed to in the Plan for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest
Start area and quality - Start quality (scale of 0 – 10)	4 / 10	Average vegetation integrity of PCT 724, PCT 849 and PCT 850 from BAM plots conducted in all condition states is 42/100, rounded to 4/10 for use in the EPBC offsets assessment guide
Future area and quality without offset – Risk of loss (%)	20%	The lands identified as potential offset sites within the SCA are generally located in western Sydney and are predominantly zoned for rural land uses. Should lands not be protected and managed as offset sites there will be an ongoing risk of loss of the biodiversity values of these lands due to ongoing agricultural practises and continued weed encroachment, grazing pressure and inappropriate access. A risk of loss of 20% is considered appropriate
Future area and quality without offset – Future quality (scale of 0 – 10)	3 / 10	If land is not protected and managed as a reserve or BSA it is highly likely that land will continue to degrade through weed encroachment, grazing pressure and inappropriate access etc. A reduction of 1/10 has been applied
Future area and quality with offset – Risk of loss (%)	5%	All offset land under the Plan will be protected as a reserve or BSA. The risk of loss is therefore considered to be low
Future area and quality with offset – Future quality (scale of 0 – 10)	7 / 10	Average vegetation integrity increase of PCT 724, PCT 849 and PCT 850 from BAM plots conducted in all condition states (assuming active management is undertaken) is 33/100, rounded to 3/10 for use in the EPBC offsets assessment guide. This increase results in a future quality of 7/10 (i.e. increase from the current condition of 4/10 to 7/10)
Confidence in result (change in habitat quality and averted loss) (%)	85%	There is a relatively high level of confidence in the data entered into the EPBC offsets assessment guide. Much of the data entered is based on plot data collected and the calculations performed as part of the BAM. The BAM provides a scientifically robust and repeatable method to conduct biodiversity assessment. In addition, offset sites are to be

EPBC offsets assessment guide attribute	Value entered	Justification
		protected and managed through reservation or a BSA. The offset sites will be fully funded and managed through an approved management plan
Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion		
Time horizon – Risk-related time horizon (years)	20 years	The offset sites identified, conserved and managed under the Plan will either be dedicated as a reserve under the *National Parks and Wildlife Act 1974* or protected under a Biodiversity Stewardship Agreement (BSA).The longest possible risk-related time horizon of 20 years was therefore selected
Time horizon – Time until ecological benefit (years)	10 years	All offset sites will be funded and managed in perpetuity. The initial phase of active management is likely to lead to a reasonably rapid improvement in site condition in the short to medium term due to the implementation of up-front management activities such as fencing, weed management and supplementary planting. Over the longer term the level of improvement is likely to be more gradual as the sites enter a maintenance phase. Ten years has been entered as the time until ecological benefit as the initial phase of active management is expected to increase site condition noticeably in the short to medium term.
Start area and quality - Start area (ha)	105 ha	The target committed to in the Plan for Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion
Start area and quality - Start quality (scale of 0 – 10)	4 / 10	Average vegetation integrity of PCT 725 from BAM plots conducted in all condition states is 37/100, rounded to 4/10 for use in the EPBC offsets assessment guide
Future area and quality without offset – Risk of loss (%)	20%	The lands identified as potential offset sites within the SCA are generally located in western Sydney and are predominantly zoned for rural land uses. Should lands not be protected and managed as offset sites there will be an ongoing risk of loss of the biodiversity values of these lands due to ongoing agricultural practises and continued weed encroachment, grazing pressure and inappropriate access. A risk of loss of 20% is considered appropriate
Future area and quality without offset – Future quality (scale of 0 – 10)	3 / 10	If land is not protected and managed as a reserve or BSA it is highly likely that land will continue to degrade through weed encroachment, grazing pressure and inappropriate access etc. A reduction of 1/10 has been applied
Future area and quality with offset – Risk of loss (%)	5%	All offset land under the Plan will be protected as a reserve or BSA. The risk of loss is therefore considered to be low
Future area and quality with offset – Future quality (scale of 0 – 10)	7 / 10	Average vegetation integrity increase of PCT 725 from BAM plots conducted in all condition states (assuming active management is undertaken) is 32/100, rounded to 3/10 for use in the EPBC offsets assessment guide. This increase results in a future quality of 7/10 (i.e. increase from the current condition of 4/10 to 7/10)
Confidence in result (change in habitat quality and averted loss) (%)	85%	There is a relatively high level of confidence in the data entered into the EPBC offsets assessment guide. Much of the data entered is based on plot data collected and the calculations performed as part of the BAM. The BAM provides a scientifically robust and repeatable method to conduct

EPBC offsets assessment guide attribute	Value entered	Justification
		biodiversity assessment. In addition offset sites are to be protected and managed through reservation or a BSA. The offset sites will be fully funded and managed through an approved management plan.
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community		
Time horizon – Risk-related time horizon (years)	20 years	The offset sites identified, conserved and managed under the Plan will either be dedicated as a reserve under the *National Parks and Wildlife Act 1974* or protected under a Biodiversity Stewardship Agreement (BSA). The longest possible risk-related time horizon of 20 years was therefore selected
Time horizon – Time until ecological benefit (years)	10 years	All offset sites will be funded and managed in perpetuity. The initial phase of active management is likely to lead to a reasonably rapid improvement in site condition in the short to medium term due to the implementation of up-front management activities such as fencing, weed management and supplementary planting. Over the longer term the level of improvement is likely to be more gradual as the sites enter a maintenance phase. Ten years has been entered as the time until ecological benefit as the initial phase of active management is expected to increase site condition noticeably in the short to medium term
Start area and quality - Start area (ha)	5 ha	The target committed to in the Plan for Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community
Start area and quality - Start quality (scale of 0 – 10)	4 / 10	Average vegetation integrity of PCT 1800 from BAM plots conducted in all condition states is 44/100, rounded to 4/10 for use in the EPBC offsets assessment guide
Future area and quality without offset – Risk of loss (%)	20%	The lands identified as potential offset sites within the SCA are generally located in western Sydney and are predominantly zoned for rural land uses. Should lands not be protected and managed as offset sites there will be an ongoing risk of loss of the biodiversity values of these lands due to ongoing agricultural practises and continued weed encroachment, grazing pressure and inappropriate access. A risk of loss of 20% is considered appropriate
Future area and quality without offset – Future quality (scale of 0 – 10)	3 / 10	If land is not protected and managed as a reserve or BSA it is highly likely that land will continue to degrade through weed encroachment, grazing pressure and inappropriate access etc. A reduction of 1/10 has been applied
Future area and quality with offset – Risk of loss (%)	5%	All offset land under the Plan will be protected as a reserve or BSA. The risk of loss is therefore considered to be low
Future area and quality with offset – Future quality (scale of 0 – 10)	7 / 10	Average vegetation integrity increase of PCT 1800 from BAM plots conducted in all condition states (assuming active management is undertaken) is 28/100, rounded to 3/10 for use in the EPBC offsets assessment guide. This increase results in a future quality of 7/10 (i.e. increase from the current condition of 4/10 to 7/10)
Confidence in result (change in habitat quality and averted loss)	85%	There is a relatively high level of confidence in the data entered into the EPBC offsets assessment guide. Much of the data entered is based on plot data collected and the calculations

EPBC offsets assessment guide attribute	Value entered	Justification
(%)		performed as part of the BAM. The BAM provides a scientifically robust and repeatable method to conduct biodiversity assessment. In addition offset sites are to be protected and managed through reservation or a BSA. The offset sites will be fully funded and managed through an approved management plan
Shale Sandstone Transition Forest in the Sydney Basin Bioregion		
Time horizon – Risk-related time horizon (years)	20 years	The offset sites identified, conserved and managed under the Plan will either be dedicated as a reserve under the *National Parks and Wildlife Act 1974* or protected under a Biodiversity Stewardship Agreement (BSA). The longest possible risk-related time horizon of 20 years was therefore selected.
Time horizon – Time until ecological benefit (years)	10 years	All offset sites will be funded and managed in perpetuity. The initial phase of active management is likely to lead to a reasonably rapid improvement in site condition in the short to medium term due to the implementation of up-front management activities such as fencing, weed management and supplementary planting. Over the longer term the level of improvement is likely to be more gradual as the sites enter a maintenance phase. Ten years has been entered as the time until ecological benefit as the initial phase of active management is expected to increase site condition noticeably in the short to medium term
Start area and quality - Start area (ha)	715 ha	The target committed to in the Plan for Shale Sandstone Transition Forest in the Sydney Basin Bioregion
Start area and quality - Start quality (scale of 0 – 10)	6 / 10	Average vegetation integrity of PCT 1395 from BAM plots conducted in all condition states is 56/100, rounded to 6/10 for use in the EPBC offsets assessment guide
Future area and quality without offset – Risk of loss (%)	20%	The lands identified as potential offset sites within the SCA are generally located in western Sydney and are predominantly zoned for rural land uses. Should lands not be protected and managed as offset sites there will be an ongoing risk of loss of the biodiversity values of these lands due to ongoing agricultural practises and continued weed encroachment, grazing pressure and inappropriate access. A risk of loss of 20% is considered appropriate.
Future area and quality without offset – Future quality (scale of 0 – 10)	5 / 10	If land is not protected and managed as a reserve or BSA it is highly likely that land will continue to degrade through weed encroachment, grazing pressure and inappropriate access etc. A reduction of 1/10 has been applied
Future area and quality with offset – Risk of loss (%)	5%	All offset land under the Plan will be protected as a reserve or BSA. The risk of loss is therefore considered to be low
Future area and quality with offset – Future quality (scale of 0 – 10)	9 / 10	Average vegetation integrity increase of PCT 1395 from BAM plots conducted in all condition states (assuming active management is undertaken) is 28/100, rounded to 3/10 for use in the EPBC offsets assessment guide. This increase results in a future quality of 9/10 (i.e. increase from the current condition of 6/10 to 9/10)
Confidence in result (change in habitat quality and averted loss)	85%	There is a relatively high level of confidence in the data entered into the EPBC offsets assessment guide. Much of the data entered is based on plot data collected and the calculations

EPBC offsets assessment guide attribute	Value entered	Justification
(%)		performed as part of the BAM. The BAM provides a scientifically robust and repeatable method to conduct biodiversity assessment. In addition, offset sites are to be protected and managed through reservation or a BSA. The offset sites will be fully funded and managed through an approved management plan

* Based on mapping for PCT 835

41.5.2 ANALYSIS

NSW REQUIREMENTS

Do all impacted PCTs have offset targets?

Each impacted PCT has an associated offset target and therefore the commitments are addressing each value being impacted (see Table 41-8). The SCAs also contain substantial areas of each impacted PCT (see Table 41-8).

Are offset targets equivalent to the biodiversity values being impacted?

The Department developed an approach for defining offset targets to ensure that the commitments address the biodiversity values being impacted. The offset target method determined offset targets on the basis of the amount (ha) of each impacted matter, the conservation status of the impacted matter and the condition of the impacted matter.

Credit analysis

To determine whether the offset targets are equivalent to the biodiversity values being impacted, the Department undertook an analysis based on the estimated credit requirements of the BAM.

It is important to note that this analysis only took into account the impacts within the nominated areas, including the impacts from urban development and the transport corridors.

Table 41-7 shows:

- The credits required to be retired to offset the impacts of each impacted PCT within the nominated areas
- The amount of offset land (ha) needed to generate the required credits to offset the impacts on each PCT under the high intensity management scenario. The range of values shown in the table (columns 4 and 5) reflect the different amounts of credits generated at the offset site for the different condition states of each vegetation zone that is part of a PCT (e.g. based on the BAM data collected within the nominated areas, the area to offset 1 ha of impact to 725 intact condition state requires 3.5 ha of 725 scattered trees, while the amount of thinned condition 725 is 2.5 ha)
- The offset targets (these account only for impacts within the nominated areas)
- The difference (ha) between the amount of offset land needed to generate the required credits to offset the impacts on each PCT and the current offset targets

The table shows that the total offset target for PCTs (5,475 ha) is estimated to be broadly within the range required to satisfy the BAM credit requirements (between 4,698 ha and 9,820 ha). However, the offset target is at the lower end of the range, which suggests that high intensity management for a proportion of offset sites may potentially be needed to ensure the Plan satisfies the BAM credit requirements (noting this is not a requirement of the BC Act).

The offset targets are estimated to generally satisfy the minimum credit requirements of the BAM for seven of the nine impacted PCTs (including for three of the nine impacted PCTs where there is a negligible shortfall (< 6 ha)). However, the offset targets are estimated not to meet the minimum credit requirements of the BAM for two PCTs:

- PCT 835: there is an estimated shortfall of about 167.4 ha
- PCT 1395: there is an estimated shortfall of about 134.1 ha

Table 41-7: Analysis of adequacy of offset targets for impacts within the nominated areas on the basis of credits

Impacted PCTs	Area impacted (ha)	Total credits required	Minimum amount of PCT needed to generate required credits (high intensity management scenario)^ (ha)	Maximum amount of PCT needed to generate required credits (high intensity management scenario)^ (ha)	Offset target (ha)*	Difference between offset target and minimum amount of PCT needed to generate required credits (ha)
724	52.2	1218	152.3	152.3	150.0	-2.3
725	36.9	809	80.9	115.6	110.0	29.1
781	2.1	65	8.1	8.1	5.0	-3.1
830	0.1	1	0.3	0.3	0.2	-0.1
835	165.1	4939	617.4	987.8	450.0	-167.4
849	729.8	14901	1,490.1	3,725.3	2,325.0	834.9
850	284.8	5575	619.4	1,393.8	845.0	225.6
1395	487.7	13393	1,674.1	3,348.3	1,540.0	-134.1
1800	19.2	446	55.7	89.1	50.0	-5.7
Total	**1,777.8**	**41,347**	**4,698.3**	**9,820.4**	**5,475**	**776.9**

^ High intensity management scenario assumes that all offset sites are subject to ongoing and intensive conservation management

*These offset targets account for development impacts within the nominated areas only (excluding transport corridors outside the nominated areas). Also, this figure represents the target that is proposed to be met through land-based measures (90 per cent of the total offset target). The other 10 per cent of the offset target will be met through other non-land based measures, such as threat management

Can the SCAs deliver the offset targets?

This question is addressed by analysing the available land within the SCAs for offsets and restoration actions, and the overall balance between impacts and offset availability for each impacted PCT.

Table 41-8 shows the offset targets for each PCT impacted by the nominated areas and transport corridors within the nominated areas and the overall balance between offset target and offset availability within the SCAs.

The table shows that the majority of PCTs (5 of 9) have enough PCT available within the SCAs to meet the offset targets. For 4 of those 5 PCTs, there is significantly more PCT available in the SCAs than needed to meet the targets.

For the 5 PCTs with enough PCT available in the SCAs, achieving the offset targets would require an average of only 25 per cent of the total amount of each PCT available within the SCAs to be secured (i.e. the SCAs contain an average of almost four times the amount of PCT needed to meet the offset targets for these PCTs).

Three PCTs have small shortfalls in availability in the SCAs:

- PCT 724 – there is a shortfall of about 44 ha
- PCT 725 – there is a shortfall of about 19 ha
- PCT 1800 – there is a shortfall of about 35 ha

One PCT (PCT 849) has a large shortfall of about 713 ha.

Addressing the shortfall through ecological restoration

The Plan aims to largely address the offset target shortfall for these four PCTs through ecological restoration.

Table 41-8 shows an initial estimate of restoration potential in the SCAs for each PCT. This is an initial estimate only, and was made by limited ground-truthing and intersecting a map of pre-1750 native vegetation (Tozer, Turner et al., 2010) with cleared or highly degraded land to identify cleared or degraded areas where PCTs may have previously occurred. The suitability of these areas for restoration will be confirmed during implementation of the Plan, including on the basis of site investigations.

The initial estimate of restoration potential in the SCAs indicates restoration has the potential to:

- Negate the shortfall for PCTs 725 and 849 in the SCAs
- Reduce the shortfall for PCT 724 to about 29 ha (see Table 41-8)

For PCT 1800, it is important to note the mapping within the Plan Area may be inaccurate as the PCT was not mapped by some regional vegetation maps being used in this assessment, and is likely to be mapped in the Cumberland subregion as part of other PCTs.

Potential shortfall in PCT 849

While restoration may negate the offset target shortfall for PCT 849, an additional option to address any residual shortfall for the PCT is by securing the excess amount of PCT 850 in the SCAs.

PCT 849 and PCT 850 are both part of Cumberland Plain Woodland, meaning that PCT 849 may be addressed through commitments that secure PCT 850 under the offset rules under the BC Regulation. This option is likely to be feasible as the SCAs contain over 2,800 ha of surplus PCT 850 (after the offset target for PCT 850 has been met (see Table 41-8)).

Availability of PCTs in SCAs estimated not to meet BAM credit requirements

Table 41-9 shows the two PCTs whose offset targets are estimated to not meet the minimum credit requirements of the BAM (see above) and whether there is enough PCT in the SCAs to potentially satisfy the BAM credit requirements.

The table shows that there are sufficient amounts of each PCT available in the SCAs to meet the estimated amount needed to satisfy the minimum BAM credit requirements. This suggests that the SCAs have the potential to achieve the minimum BAM credit requirements for these PCTs. As the Plan also has targets for TECs and species, there is the potential for the shortfall in these PCTs to be meet through these other targets.

Table 41-8: Availability of PCTs impacted by the nominated areas and transport corridors in the SCAs relative to offset targets, and showing restoration potential

Impacted PCTs	Area impacted^ (ha)	Offset target (ha)*	Area of PCT available in SCAs (ha)	Difference between offset target and available PCT in SCAs (ha)	Offset target as percentage of total area of PCT in SCA (%)	Initiate estimate of restoration potential in SCAs (ha)	Residual gap if restoration potential achieved (ha)
724	52.2	150	106.2	-43.8	141.2	14.8	-29.0
725	36.9	110	91.4	-18.6	120.4	47.0	28.4
781	2.1	5	62.5	57.5	8.0	33.3	90.8
830	0.1	0.2	708.2	708	0.0	117.5	825.5
835	165.1	450	1,017.70	567.70	44.2	1,816.4	2,384.1
849	729.8	2,325	1,611.80	-713.20	144.2	2,040.2	1,327.0
850	284.8	845	3,661.10	2,816.10	23.1	2,153.7	4,969.8
1395	487.7	1,540	4,930.50	3,390.50	31.2	1,765.4	5,155.9
1800	19.2	50	15	-35	333.3	0.0	-35.0
Total	**1,777.8**	**5,475.2**	**12,204.4**	**-**	**-**	**7,988.3**	**-**

^This includes all impacts in nominated areas

*These offset targets account for development impacts within the nominated areas only (excluding transport corridors outside the nominated areas). Also, this figure represents the target that is proposed to be met through land-based measures (90 per cent of the total offset target).

Table 41-9: Availability of PCTs in SCAs estimated not to meet the minimum credit requirements of the BAM

Target PCTs	Minimum amount of PCT needed to generate required credits (high intensity management scenario) (ha)	Offset target*	Difference between offset target and minimum amount of PCT needed to generate required credits (ha)	Area of PCTs in SCA (ha)	Difference between minimum amount of PCT needed to generate required credits (ha) and area of PCT available in SCA (ha)
835	617.4	450	-167.4	1,017.7	400.3
1395	1,674.1	1,540	-134.1	4,930.5	3,256.4

*Offset targets for the nominated areas only (excluding transport corridors outside the nominated areas)

COMMONWEALTH REQUIREMENTS

Consistency with EPBC Act environmental offsets policy

The results of the EPBC Act environmental offsets policy analysis are provided in Table 41-10. Based on the requirements of the offsets assessment guide, all of the TECs meet the offset requirements needed to be consistent with the EPBC Environmental Offsets Policy by achieving a score greater than 100 per cent (the minimum required to meet the EPBC Environmental Offsets Policy is 90 per cent).

The highest of these is Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland (216.7 per cent), followed by Cooks River/Castlereagh Ironbark Forest (153.2 per cent), Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (144.4 per cent).

The results for Shale Sandstone Transition Forest and Coastal floodplain eucalypt forest of eastern Australia are lower, but are still greater than 100 per cent (106.3 per cent and 114.8 per cent respectively).

Table 41-10: Results of EPBC offsets assessment

TEC	Condition	Listing Status	EPBC offsets assessment guide – impact calculator			EPBC offsets assessment guide – offsets calculator		
			Total impact (ha)	Total quantum of impact (adjusted ha)	Summed quantum of impact (adjusted ha)	Offset target (90%) (ha)	Total net present value of the offset (adjusted ha)	% of impact offset
Coastal floodplain eucalypt forest of eastern Australia*	Intact	Endangered	28.6	22.88	135.94	575	156.1	114.8
	Thinned		141.3	84.78				
	Scattered trees		40.4	28.28				
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Intact	Critically Endangered	22.6	13.56	65.62	575	94.8	144.4
	Thinned		128.1	51.24				
	Scattered trees		4.1	0.82				
Cooks River/Castlereagh Ironbark Forest	Intact	Critically Endangered	11.6	5.8	11.3	105	17.3	153.2
	Thinned		12.9	5.16				
	Scattered trees		1.7	0.34				
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland	Thinned	Endangered	1.7	0.68	0.72	5	1.6	216.7
	Scattered trees		0.1	0.04				
Shale Sandstone Transition Forest	Intact	Critically Endangered	43.1	30.17	115.49	715	122.7	106.3
	Thinned		135.7	81.42				
	Scattered trees		13	3.9				

Availability of EPBC TECs in SCAs

A further assessment of Commonwealth-listed TECs was conducted to determine if the offset target for each TEC was present and feasible within the SCAs. The results are shown in Table 41-11.

The SCAs are estimated to have enough available habitat to broadly satisfy the offset required for four of the five TECs.

Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland has a negligible shortfall of 0.6 ha, and as discussed above is not broadly mapped outside the nominated areas. It is expected that this community has a wider distribution outside of the nominated areas and should therefore be available in the SCAs.

Cooks River/Castlereagh Ironbark Forest has a shortfall of 26 ha. As discussed above and displayed in Table 41-8, 47 ha of restoration potential for PCT 725 is available in the SCAs. This additional area of restoration would assist in meeting the offset requirement for Cooks River/Castlereagh Ironbark Forest.

Table 41-11: Area in SCAs of impacted Commonwealth-listed TECs

TEC Name	TEC offset target (ha)	Area of TECs in SCAs	Difference between offset target and area of TECs available in SCA (ha)
Coastal floodplain eucalypt forest of eastern Australia*	575	1,044.6	469.6
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland	5	4.4	-0.6
Cooks River/Castlereagh Ironbark Forest	105	79.3	-25.8
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	575	2,076.8	1,501.8
Shale Sandstone Transition Forest	715	4,063.1	3,348.1
Total	**1,975**	**7,268.1**	**5,293.1**

41.5.3 CONCLUSION

The analysis demonstrates that the commitments broadly address the values being impacted because:

NSW requirements

- Each impacted NSW TEC/PCT has an associated offset target
- The total offset target for NSW TECs/PCTs (5,475 ha) is estimated to be broadly within the range required to satisfy the BAM credit requirements (between 4,698 ha and 9,820 ha)
- The offset targets are estimated to generally satisfy the minimum credit requirements of the BAM for the majority (7 of 9) of the impacted NSW TECs/PCTs (for three of these seven PCTs, there is a negligible shortfall (< 6 ha))
- The majority of NSW TECs/PCTs (5 of 9) have enough PCT available within the SCAs to meet the offset targets. For 4 of those 5 PCTs, there is significantly more PCT available in the SCAs than needed to meet the targets
- For the 5 NSW TECs/PCTs with enough PCT available in the SCAs, achieving the offset targets would require an average of only 25 per cent of the total amount of each PCT available within the SCAs to be secured (i.e. the SCAs contain an average of almost four times the amount of PCT needed to meet the offset targets for these PCTs)
- For the four NSW TECs/PCTs with a shortfall of available PCTs in the SCAs:
  - Three of the PCTs – PCT 724, 725 and 1800 – have only small shortfalls (less than 45 ha)
  - An initial estimate of restoration potential in the SCAs indicates restoration has the potential to negate the shortfall for PCT 725 and reduce the shortfall for PCT 724 to about 29 ha
  - The offset for PCT 1800 is likely to be met as shortfall is generally a result of a lack of available mapping outside of the nominated areas

- While PCT 849 has a large shortfall:
  - An initial estimate of restoration potential in the SCAs indicates restoration can negate this shortfall
  - The SCAs contain over 2,800 ha of surplus PCT 850, which may be secured instead of PCT 849 to meet the shortfall, consistent with the offset rules under the BC Regulation

Commonwealth requirements

- The Commonwealth-listed TEC offset targets meet the requirements of the EPBC Act Environmental Offsets Policy when assessed on the basis of the requirements of the offsets assessment guide
- The SCAs contain enough Commonwealth-listed TECs to broadly satisfy the offset target for four of the five TECs. The shortfall for Cooks River/Castlereagh Ironbark Forest (26 ha) could potentially be negated through the restoration of PCT 725 within SCAs, which is estimated to be 47 ha

In concluding that the commitments broadly address the values being impacted, it is important to note that the Plan will implement several commitments to manage broad landscape threats in strategic locations in the Cumberland subregion, particularly to reduce threats to land secured in SCAs, including:

- Weeds (Commitment 16)
- Pest animals (Commitment 17)
- Fire (Commitment 18)
- Disease (Commitment 19)

These commitments are expected to substantially enhance the biodiversity benefits of securing land in the SCAs.

Furthermore, while only initial estimates of restoration potential in the SCAs have been made so far, the Plan includes a range of actions to ensure restoration is effective, including developing a Restoration Implementation Strategy (Commitment 13) in consultation with key stakeholders and delivery partners to:

- Provide a clear purpose for undertaking restoration, including how the Plan will meet its restoration target for impacted native vegetation communities
- Identify restoration potential of land within priority sites
- Provide guidance on restoration expectations at priority sites

Despite this overall conclusion that the commitments broadly address the values being impacted, there are several key risks with achieving the offset targets:

- A substantial proportion of private landholders within the SCAs must be willing to either voluntarily secure their land as offsets or sell their land to the NSW Government to establish reserves
- The SCAs cover large parts of the remaining native vegetation within the Cumberland subregion and there is likely to be demand from other development projects for offsets within these areas. This may reduce the actual availability of offsets within the SCAs for the development under the Plan
- Native vegetation mapping within the SCAs outside the nominated areas is based broadly on existing maps with rapid assessments conducted at key locations. Detailed site assessment of the SCAs may increase or reduce the actual amount of each TEC contained within the SCAs

Applying appropriate mechanisms for securing offsets within the SCAs will be critical in achieving the offset targets over the life of the Plan. Implementation arrangements for the conservation program are discussed in Section 41.11.

41.6 THEME 3: DO THE COMMITMENTS ADDRESS THE MOST IMPORTANT VALUES?

41.6.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 3) provide that commitments should prioritise the protection of important biodiversity values and set out a range of matters that commitments should be designed to protect, including:

- Habitat for threatened matters, particularly critically endangered matters

- Biodiversity values that are poorly represented in existing reserves within the subregion
- Areas identified as high priority by governments for conservation

The analysis of Theme 3 involved determining the extent to which the SCAs contain each of these categories of matters:

- Habitat for threatened matters within the SCAs was analysed using GIS on the basis of TEC, PCT and/or species habitat maps developed for this Assessment Report
- Biodiversity values poorly represented in existing reserves was analysed using GIS on the basis of data on the distribution of PCTs in the Cumberland subregion and the boundaries of existing reserves (including reserves under the *National Parks and Wildlife Act 1974* (NP&W Act), BioBank sites and Biodiversity Stewardship Agreements)
- Areas identified as high priority by governments for conservation were analysed using GIS on the basis of BioMap core and corridors (OEH, 2015) and the EES biodiversity values map (OEH, 2019a)

The analysis also included analysis of the potential feasibility of achieving the offsets targets for species with specific offset targets (see Part 2). This was done by compiling the following information for each species:

- Number of Biobank sites with 'issued' credits for the species
- Number of Biobank site Expressions of Interest (EOI) for the species (only EOIs since January 2017)
- Number of Biodiversity Stewardship sites with 'issued' credits for the species
- Number of Biodiversity Stewardship sites with credits 'pending' for the species
- Number of Biodiversity Stewardship sites site Expressions of Interest (EOI) for the species
- Number of BioNet and project records in SCAs
- Number of SCAs in which BioNet and project records occur

Note that searches of public registers for this analysis were limited to the Cumberland and adjacent subregions.

41.6.2 ANALYSIS

HABITAT FOR THREATENED MATTERS

The SCAs were designed to include Commonwealth and NSW-listed TECs and potential habitat for species to ensure the offset targets for matters impacted by the development can be met. Offset targets have been established for:

- The five Commonwealth-listed TECs directly impacted under the Plan
- The 9 PCTs/eight NSW-listed TECs directly impacted under the Plan
- The Commonwealth and NSW-listed species likely to be at risk of residual impacts from direct impacts

Threatened ecological communities

Table 41-12 and Table 41-13 show:

- Each impacted Commonwealth and NSW-listed TEC (critically endangered TECs are highlighted in blue)
- Amount (ha) of each TEC in the SCAs
- The offset target specific to the TEC

The tables show that the SCAs contain each impacted TEC, and that each TEC has an offset target.

Table 41-12: Area in SCAs of impacted Commonwealth-listed TECs

Associated PCTs	TEC	Cth status	Area of TEC in SCAs (ha)	Specific offset target (ha)
1800	Coastal Swamp Oak (*Casuarina glauca*) Forest of NSW and South East Queensland	E	4	5
725	Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion	CE	79	105
724, 849,	Cumberland Plain Shale Woodlands and Shale-	CE	2,077	575

Associated PCTs	TEC	Cth status	Area of TEC in SCAs (ha)	Specific offset target (ha)
850	Gravel Transition Forest			
792, 1281, 1395	Shale Sandstone Transition Forest in the Sydney Basin Bioregion	CE	4,063	715
835	River-flat Eucalypt Forest	FPAL	1,044	575

Table 41-13: Area in SCAs of impacted NSW-listed TECs

Associated PCTs	NSW TEC	NSW status	Area of TEC in SCAs (ha)	Specific offset target (ha)
724	Shale Gravel Transition Forest	E	106	150
725	Cooks River/Castlereagh Ironbark Forest	E	91	110
781	Freshwater Wetlands on Coastal Floodplains	E	63	5
830	Moist Shale Woodland	E	708	0.2
835	River-flat Eucalypt Forest	E	1,018	450
849, 850	Cumberland Plain Woodland	CE	5,273	3,170
1395	Shale Sandstone Transition Forest	CE	4,930	1,540
1800	Swamp Oak Floodplain Forest	E	15	50

Threatened species

Amount of potential habitat for each species in SCAs

Table 41-14 shows:

- Each Commonwealth and NSW-listed species (critically endangered species are highlighted in blue) assessed in this Assessment Report and potentially impacted by the development under the Plan
- Amount (ha) of potential habitat for each species in the SCAs
- Any offset targets relevant to the species

In relation to offset targets, some species have specific offset targets to secure areas of known habitat or offset locations (see Chapter 8). Other species do not have specific offset targets, but are likely to benefit from the offset targets for NSW TECs/PCTs and Commonwealth-listed TECs, as those PCTs are identified in the Threatened Biodiversity Data Collection as being associated with that species and provide potential habitat for the species.

The amount of potential habitat (ha) for each species that will be secured in the SCAs because of the NSW TEC/PCT targets is shown in the last column of the Table 41-14.

The table shows that:

- The SCAs contain potential habitat for the vast majority of potentially impacted species
- Most species also either have a specific offset target or will benefit from the NSW TEC/PCT offset targets, which will lead to the securing of potential habitat in the SCAs for these species under the Plan

Table 41-14: Area of potential habitat in SCAs for Cth and NSW listed species assessed in the report

Scientific name	Common name	Cth status	NSW status	Area of potential habitat in SCAs (ha)	Offset target	
					Specific target	Potential habitat secured through NSW TEC/PCT target
Acacia bynoeana	Bynoe's Wattle	V	E	5,842	No	4,125
Acacia pubescens	Downy Wattle	V	V	3,475	No	4,970
Allocasuarina glareicola		E	E	572	No	260
Anthochaera phrygia	Regent Honeyeater	CE	CE	17,403	No	5,470
Botaurus poiciloptilus	Australasian Bittern	E	E	349	No	455
Callocephalon fimbriatum	Gang-gang Cockatoo		V	15,725	No	5,420
Calyptorhynchus lathami	Glossy Black-Cockatoo		V	8,958	No	1,690
Cercartetus nanus	Eastern Pygmy-possum		V	17,196	No	5,160
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	11,436	No	5,470
Commersonia prostrata	Dwarf Kerrawang	E	E	0	No	0
Cynanchum elegans	White-flowered Wax Plant	E	E	1,502	2 offset locations	3,620
Dasyurus maculatus maculatus	Spot-tailed Quoll	E	V	11,850	No	5,475
Deyeuxia appressa		E	E	7	No	50
Dillwynia tenuifolia			V	6,317	3 offset locations	4,125
Epacris purpurascens var. *purpurascens*			V	9,019	1 offset location	1,650
Eucalyptus benthamii	Camden White Gum	V	V	1,495	No	2,775
Genoplesium baueri	Yellow Gnat-orchid	E	E	465	No	0
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea		V	5,576	3 offset locations	3,430
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	2,975	No	1,800
Haliaeetus leucogaster	White-bellied Sea-Eagle		V	13,952	No	5,475
Heleioporus australiacus	Giant Burrowing Frog	V	V	2,086	No	1,800

Scientific name	Common name	Cth status	NSW status	Area of potential habitat in SCAs (ha)	Offset target	
					Specific target	Potential habitat secured through NSW TEC/PCT target
Hibbertia fumana			CE	1,779	1 offset location	260
Hibbertia puberula			E	7,919	1 offset location	1,540
Hibbertia puberula subsp. *Glabrescens*		CE	CE	6	No	560
Hieraaetus morphnoides	Little Eagle		V	18,020	No	5,475
Hoplocephalus bungaroides	Broad-headed Snake	V	E	3,686	No	0
Lathamus discolor	Swift Parrot	CE	E	17,403	4,470 ha of potential foraging habitat	5,470
Leucopogon exolasius	Woronora Beard-heath	V	V	132	No	0
Litoria aurea	Green and Golden Bell Frog	V	E	660	No	5,475
Lophoictinia isura	Square-tailed Kite		V	17,783	No	5,475
Macquaria australasica	Macquarie Perch	E		13	No	50
Marsdenia viridiflora subsp. *viridiflora - endangered population*			E	10,606	1 offset location	5,470
Maundia triglochinoides			V	8	No	55
Melaleuca deanei	Deane's Melaleuca	V	V	7,289	No	1,540
Meridolum corneovirens	Cumberland Plain Land Snail		E	13,492	3 offset locations	5,420
Micromyrtus minutiflora		V	E	3,818	No	260
Myotis macropus	Southern Myotis		V	16,209	2 offset locations	5,475
Ninox connivens	Barking Owl		V	15,402	No	5,470
Ninox strenua	Powerful Owl		V	15,602	No	5,470
Persicaria elatior	Tall Knotweed	V	V	267	No	505
Persoonia bargoensis	Bargo Geebung	V	E	5,174	No	3,865
Persoonia glaucescens	Mittagong Geebung	V	E	1,362	No	0
Persoonia hirsuta	Hairy Geebung	E	E	2,690	No	5,210

Scientific name	Common name	Cth status	NSW status	Area of potential habitat in SCAs (ha)	Offset target	
					Specific target	Potential habitat secured through NSW TEC/PCT target
Persoonia nutans	Nodding Geebung	E	E	1,617	2 offset locations	1,800
Petauroides volans	Greater Glider	V		9,773	No	5,160
Petaurus norfolcensis	Squirrel Glider		V	16,394	No	5,470
Phascolarctos cinereus	Koala	V	V	7,347	610 ha of important habitat	5,470
Pimelea curviflora var. *curviflora*		V	V	4,466	No	4,015
Pimelea spicata	Spiked Rice-flower	E	E	2,296	3 offset locations	3,170
Pomaderris brunnea	Rufous Pomaderris	V	E	7,606	No	2,040
Pommerhelix duralensis	Dural Land Snail	E	E	3,481	No	4,970
Pseudophryne australis	Red-crowned Toadlet		V	8,593	No	1,540
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	5,911	No	5,475
Pterostylis saxicola	Sydney Plains Greenhood	E	E	6,074	No	3,865
Pultenaea parviflora		V	E	1,371	2 offset locations	260
Pultenaea pedunculata	Matted Bush-pea		E	8,697	1 offset location	4,970
Rostratula australis	Australian Painted Snipe	E	E	231	No	5
Tyto novaehollandiae	Masked Owl		V	15,615	No	5,470

Feasibility of achieving species-specific offsets targets

To further understand the potential availability of offsets for species with specific offset targets, the availability of each species in current offset locations was assessed, along with the presence of species records within the SCAs.

Table 41-15 provides the following information for each species:

- Number of Biobank sites with 'issued' credits for the species
- Number of Biobank site Expressions of Interest (EOI) for the species (only EOIs since January 2017)
- Number of Biodiversity Stewardship sites with 'issued' credits for the species
- Number of Biodiversity Stewardship sites with credits 'pending' for the species
- Number of Biodiversity Stewardship sites site Expressions of Interest (EOI) for the species
- Number of BioNet and project records in SCAs
- Number of SCAs in which BioNet and project records occur

The data in Table 41-15 indicates that offset sites for 9 of the 16 species with specific offsets are currently available (or are soon to be available) on Biobank or Stewardship sites and/or are represented within the SCAs. The data indicates that sourcing offsets for these species should be achievable under the Plan.

The 7 species highlighted in Table 41-15 are likely to be more difficult to secure on offset sites as they are currently not well represented on existing (or planned) Biobank or Stewardship sites and significant records for the species are not currently known within the SCAs. Further consideration of each of these species is provided in Table 41-16.

For these species, populations are known within and/or outside the Cumberland subregion and it is considered that securing the offset targets is possible, including outside the subregion if necessary. Furthermore, the Plan acknowledges that in some cases it may be challenging to meet some of the offset targets in the Plan. Rather than committing to a reduced offset target, the Plan allows for flexibility in reaching those targets through a set of conservation 'selection steps' and principles developed by the Department to guide implementation decisions (see section 41.11).

Table 41-15: Offset targets and potential availability on offset sites

Scientific name	Common name	Specific offset target	Number of Biobank Sites - current issued*	Number of Biobank EOIs (January 2017 - current)*	Number of Stewardship Sites*	Number of Stewardship Sites – Pending*	Number of Stewardship Sites – EOIs*	No. of BioNet and project records in SCAs	No. of SCAs in which BioNet and project records occur
Cynanchum elegans	White-flowered Wax Plant	2 offset locations	0	1	0	0	0	7	2
Dillwynia tenuifolia	Dillwynia tenuifolia	3 offset locations	3	0	0	0	0	277	6
Epacris purpurascens var. *purpurascens*	Epacris purpurascens var. purpurascens	1 offset location	3	0	0	0	0	99	4
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	3 offset locations	6	0	0	0	1	47	3
Hibbertia fumana	Hibbertia fumana	1 offset location	1	0	0	0	0	0	0
Hibbertia puberula	Hibbertia puberula	1 offset location	1	0	0	0	0	0	0
Lathamus discolor	Swift Parrot	4,470 ha of potential foraging habitat	0	0	0	0	0	12	12
Marsdenia viridiflora subsp. *viridiflora* - endangered population	Marsdenia viridiflora subsp. viridiflora - endangered population	1 offset location	0	1	0	0	0	0	0
Meridolum corneovirens	Cumberland Plain Land Snail	3 offset locations	13	2	0	2	2	102	22

Scientific name	Common name	Specific offset target	Number of Biobank Sites - current issued*	Number of Biobank EOIs (January 2017 - current)*	Number of Stewardship Sites*	Number of Stewardship Sites – Pending*	Number of Stewardship Sites – EOIs*	No. of BioNet and project records in SCAs	No. of SCAs in which BioNet and project records occur
Myotis macropus	Southern Myotis	2 offset locations	2	0	0	3	1	180	15
Persoonia nutans	Nodding Geebung	2 offset locations	2	0	0	0	0	106	6
Phascolarctos cinereus	Koala	610 ha of important habitat	5	0	0	1	1	682	15
Pimelea spicata	Spiked Rice-flower	3 offset locations	1	0	0	0	0	5	4
Pultenaea parviflora	Pultenaea parviflora	2 offset locations	1	0	0	0	0	53	3
Pultenaea pedunculata	Matted Bush-pea	1 offset location	0	0	0	0	0	5	2

* Cumberland subregion and surrounding subregions only

Table 41-16: Comment on species currently not well represented on Biobank/Stewardship sites and SCAs (as indicated by records)

Species	Comment
Cynanchum elegans	This species is widespread along coast and ranges north from the Illawarra. The offset target is likely to be achievable outside the Cumberland subregion if necessary
Hibbertia fumana	The species was known from 2 locations (Bankstown, Moorebank) but is cryptic and may have been confused with other *Hibbertia* species. As a result of recent surveys, populations have been detected over a wider range within greater Sydney stretching from Richmond to Mittagong (OEH, 2020)
Hibbertia puberula	Widely recorded in the Cumberland subregion, particularly within PCT 1081 south of Appin and through Wilton and in the northern and eastern (e.g. Simmos Beach) edge of the Cumberland subregion. Abundant in a local BSA site. Note that many known records are not yet in Bionet
Persoonia nutans	Species occurs in a number of locations in the Cumberland subregion, including at a local BSA site, Simmos Beach, Kemps Creek (bushland patch with *Dillwynia sp*. population) and in the general Castlereagh area
Pimelea spicata	Species occurs in a number of locations in the Cumberland subregion, including four populations (no.'s 31, 34, 534 and 51 – see Chapter 29) within excluded lands and one population (no. 533) within land avoided for biodiversity purposes (in GMAC)
Pultenaea parviflora	Species occurs in a number of locations in the Cumberland subregion, including around Luddenham and Kemps Creek, and also in areas of Llandilo/Castlereagh/Wianamatta. Several populations occur in excluded lands in GPEC and several populations occur in avoided lands
Pultenaea pedunculata	Known from sites at Villawood and Prestons, and north-west of Appin, although the species may be in the Kemps Creek and/or Luddenham/Orchard Hills area (lack of recent fire or soil disturbance in these areas will have reduced seed germination, which may be present in the seedbank). Species also occurs in the Southern Tablelands. The offset target is likely to be achievable outside the Cumberland subregion if necessary

VALUES THAT ARE POORLY REPRESENTED IN EXISTING RESERVES

Representativeness is a key goal of conservation planning. Representativeness refers to the extent to which reserves include a representative sample of the range of biodiversity values within a given area. Representativeness can be measured using surrogates such as habitat types (Margules & Pressey, 2000).

In Australia, the Comprehensive, Adequate and Representative (CAR) criteria is often considered when applying conservation targets (DECCW, 2010a). The CAR criteria include a representativeness target of 15 per cent of the pre-1750 distribution of each forest ecosystem included in conservation areas.

The Recovery Plan for the Cumberland Plain (DECCW, 2011) set representative targets for threatened ecological communities (TECs) of 15 per cent of remaining area of each TEC. This is equivalent to at least 5 per cent of the pre-1750 distribution of these TECs. These targets acknowledged that the subregion is a highly fragmented landscape and many of the existing vegetation types have been cleared to below 15 per cent of their pre-1750 extent.

This analysis used PCTs within the Plan Area to assess the representativeness of the SCAs.

Table 41-17 identifies:

- Total amount of each PCT in the Plan Area (PCTs impacted by the development are highlighted in blue)

- Amount/per cent of total amount in the Plan Area already represented in existing reserves (this includes reserves under the NP&W Act, BioBank sites and Biodiversity Stewardship Agreement sites)
- Amount/per cent of total amount in the Plan Area within SCAs
- Extent to which the SCAs contribute to existing levels of representation in the Plan Area

The table indicates that the SCAs have the potential to make a substantial contribution to existing levels of representation of PCTs in the Plan Area, including many PCTs that are currently under-represented in existing reserves.

The SCAs include all but 7 of the 39 PCTs (with an area greater than 1 ha) in the Plan Area. If these PCTs were secured for conservation, the SCAs would:

- Contribute to total representation within protected lands in the Plan Area of greater than 15 per cent for all but 5 PCTs
- Increase representation in protected lands in the Plan Area by greater than 50 per cent for 25 PCTs
- Increase representation in protected lands by greater than 75 per cent for the majority of PCTs (18 of 29) that have current levels of representation in existing reserves of less than 15 per cent
- Increase representation in protected lands by an average of 61 per cent for PCTs impacted by the development

For 12 PCTs, there are currently no areas protected in existing reserves. The SCAs include areas of 10 of these 12 PCTs and would therefore contribute to increasing representation by 83 per cent for these PCTs.

It is important to note that protection of land within SCAs will focus on PCTs impacted by the development under the Plan that have offset targets. However, in meeting these offset targets, it is likely that many PCTs not impacted by the development will also be included in conservation lands secured in the SCAs.

Table 41-17: Extent to which draft Plan contributes to protection of representative sample of PCTs in Cumberland subregion (impacted PCTs highlighted in blue)

PCT	Total amount in Plan Area (ha)	Amount in existing reserves* in Plan Area (ha)	Per cent in existing reserves* (%)	Amount in SCAs (ha)	Per cent in SCAs (%)	Per cent in SCAs or existing reserves* (%)	Per cent contribution of SCAs to existing levels of representation (%)
724	2049.3	286.1	14.0	106.2	5.2	19.1	27.1
725	1085.6	422.2	38.9	91.4	8.4	47.3	17.8
774	11.4	2.5	21.9	0.0	0.0	21.9	0.0
781	429.2	52.7	12.3	62.5	14.6	26.8	54.3
830	1362.1	130.8	9.6	708.2	52.0	61.6	84.4
835	6951.5	459.9	6.6	1017.7	14.6	21.3	68.9
849	11767.1	1024.7	8.7	1611.8	13.7	22.4	61.1
850	8821.7	747.1	8.5	3661.1	41.5	50.0	83.1
877	571.5	67.2	11.8	210.0	36.7	48.5	75.8
883	3727.4	526.1	14.1	409.4	11.0	25.1	43.8
920	6.4	0.0	0.0	1.8	27.9	27.9	100.0
941	101.6	21.7	21.4	0.0	0.0	21.4	0.0
958	165.2	39.7	24.0	57.7	34.9	58.9	59.2
1067	560.7	138.5	24.7	63.1	11.3	36.0	31.3
1081	2784.1	361.4	13.0	1232.3	44.3	57.2	77.3
1083	1.4	0.0	0.0	0.9	62.9	62.9	100.0
1086	43.8	31.3	71.5	24.2	55.3	126.8	43.6
1105	138.6	0.0	0.0	0.0	0.0	0.0	0.0
1126	1.5	0.0	0.0	1.0	66.4	66.4	100.0
1181	4509.5	434.6	9.6	2508.6	55.6	65.3	85.2
1234	41.2	0.0	0.0	8.1	19.7	19.7	100.0
1236	5.2	0.0	0.0	5.6	108.5	108.5	100.0

PCT	Total amount in Plan Area (ha)	Amount in existing reserves* in Plan Area (ha)	Per cent in existing reserves* (%)	Amount in SCAs (ha)	Per cent in SCAs (%)	Per cent in SCAs or existing reserves* (%)	Per cent contribution of SCAs to existing levels of representation (%)
1237	2.7	0.0	0.0	0.0	0.0	0.0	0.0
1253	248.0	85.3	34.4	0.0	0.0	34.4	0.0
1281	453.3	28.8	6.4	41.3	9.1	15.5	58.9
1284	11.0	1.3	11.9	0.0	0.0	11.9	0.0
1292	225.8	30.9	13.7	84.4	37.4	51.1	73.2
1319	17.3	17.3	100.0	0.0	0.0	100.0	0.0
1395	12475.8	852.8	6.8	4930.5	39.5	46.4	85.3
1637	62.0	42.5	68.5	23.2	37.5	106.0	35.4
1787	146.4	0.0	0.0	73.3	50.1	50.1	100.0
1789	534.1	0.0	0.0	466.7	87.4	87.4	100.0
1790	1250.0	8.0	0.6	869.9	69.6	70.2	99.1
1800	426.5	17.9	4.2	15.0	3.5	7.7	45.6
1808	6.7	0.0	0.0	2.3	34.2	34.2	100.0
1816	2.4	0.2	7.3	5.2	216.5	223.7	96.8
1826	56.4	0.0	0.0	5.8	10.3	10.3	100.0
1841	35.2	0.0	0.0	22.8	64.8	64.8	100.0
1900	43.2	23.4	54.3	42.1	97.4	151.7	64.2

*This includes reserves under the NP&W Act, BioBank sites and Biodiversity Stewardship Agreement sites

HIGH PRIORITIES FOR CONSERVATION

The NSW Government has developed several plans to identify priority areas for conservation or areas that are sensitive to biodiversity impacts in the Cumberland subregion. Two recent initiatives are:

- BIOMap core and corridors
- Biodiversity values map

BIOMap core/corridors

BIOMap identifies Priority Investment Areas (PIAs) where the protection and management of native vegetation is likely to maximise benefits to biodiversity within the Cumberland subregion. The PIAs comprise:

- Core areas: large areas of native vegetation and habitat where management will be of greatest benefit to the conservation of biodiversity values. These areas represent the habitat in the subregion most likely to support species persistence and interactions between species and landscape scale ecological processes
- Regional biodiversity corridors: linear areas that link core areas and play a crucial role in maintaining connections between species populations that would otherwise be isolated and at greater risk of local extinction

Table **41-18** and Table **41-19** show the amount of BIOMap core areas and corridors within the SCAs.

The tables indicate that the SCAs contain substantial amounts of BIOMap core and corridors – approximately 32 per cent of the total BIOMap core areas and 28 per cent of the total BIOMap corridors in the Cumberland subregion.

Table 41-18: BIOMap core areas within SCAs

Total area of BIOMap core in subregion (ha)	Area of BIOMap core in SCAs (ha)	Per cent of SCAs that is BIOMap core (%)	Per cent of total BIOMap core in subregion in SCAs (%)
24,196.8	7,819.8	28	32

Table 41-19: BIOMap corridors within SCAs

Total area of BIOMap corridors in subregion (ha)	Area of BIOMap corridors in SCAs (ha)	Per cent of SCAs that is BIOMap corridors (%)	Per cent of total BIOMap corridors in subregion in SCAs (%)
17,927.5	5,041.6	18	28

Biodiversity values map

The biodiversity values map identifies land with high biodiversity value that is particularly sensitive to impacts from development and clearing. The map forms part of the Biodiversity Offsets Scheme Threshold which is one of the triggers for determining whether the Biodiversity Offset Scheme under the BC Act applies to a clearing or development proposal.

Table 41-20 shows the amount of biodiversity values map areas within the SCAs.

The table indicates that the SCAs contain substantial amounts of biodiversity values map areas – approximately 27 per cent of the total biodiversity values map area in the Cumberland subregion.

Table 41-20: Biodiversity values map areas within SCAs

Total area of biodiversity values map in subregion (ha)	Area of biodiversity values map in SCAs (ha)	Per cent of SCAs that is within the biodiversity values map (%)	Per cent of total biodiversity values map in subregion within SCAs (%)
40,672.1	11,043.0	39	27

41.6.3 CONCLUSION

The analysis suggests that the commitments generally prioritise the protection of important biodiversity values as the SCAs within which the land-based commitments are intended to be delivered:

- Contain each impacted Commonwealth and NSW listed TEC
- Contain potential habitat for the majority of Commonwealth and NSW listed species
- Significantly contribute to increasing representation of PCTs in protected lands in the Cumberland subregion
- Include substantial areas of land identified by the NSW Government as priorities for conservation

Furthermore, it is likely that offset sites for the majority of species with specific offsets under the Plan are currently available (or are soon to be available) on Biobank or Stewardship sites and/or are represented within the SCAs. The data indicates that sourcing offsets for these species should be achievable under the Plan.

41.7 THEME 4: DO THE COMMITMENTS IMPROVE VALUES AND FUNCTION IN THE LONG TERM?

41.7.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 4) provide that commitments should ensure biodiversity values and ecological function are improved in the long term and set out a range of matters that commitments should be designed to protect, including:

- The size, shape and location of habitat in the landscape
- Habitat connectivity, such as corridors and riparian areas
- Management of key threatening processes and landscape scale threats
- Areas likely to provide significant potential for restoration

The analysis of Theme 4 involved determining the extent to which the SCAs contain each of these categories of matters. This included analysing:

- The size, shape and location of habitat in the landscape using GIS and by determining the extent to which large patches make up the total amount of native vegetation contained within the SCAs
- Habitat connectivity using GIS on the basis of BioMap core and corridors and other connected habitat elements
- Management of threats and restoration by discussing the commitments relating to these matters and drawing on the results of the trend analysis (see Supporting Document D)

41.7.2 ANALYSIS

SIZE AND LOCATION OF HABITAT PATCHES

Maximising the likelihood of viability or persistence of biodiversity values is a key goal of conservation planning (Margules & Pressey, 2000) and a key objective of the Cumberland Plain Recovery Plan (DECCW, 2011).

There are well established relationships between the size of a patch of native vegetation and the size and persistence of populations, with large patches generally supporting more persistent populations than smaller patches (Margules & Pressey, 2000). There are also relationships between the size of a patch and species richness, species dispersal, genetic diversity, persistence of large vertebrates, maintenance of near-natural disturbance regimes, and other important ecological functions (Hodgson, Thomas et al., 2009; Lindenmayer, Hobbs et al., 2008).

For this analysis, large patches are considered to be > 50 ha, and moderate patches are considered to be > 20 ha. This was based on findings by Parkes et al (2003) and recommendations of the Comprehensive, Representative and Adequate Advisory Group which suggest that in the Australian context, 50 hectares should be considered a minimum 'core' area of vegetation to prevent declines in biodiversity over time (Parkes, Newell, & Cheal, 2003; CARSAG, 2004).

The SCAs were designed to capture habitat patches in strategic locations in the landscape to maximise likely benefits to biodiversity values (see Chapter 8). This includes habitat patches adjacent to existing reserves or other large patches, or patches connecting or contiguous with other patches of habitat.

Table 41-21 shows the number of large and moderate patches in the SCAs and the extent to which large and moderate patches make up the total amount of native vegetation contained within the SCAs.

Table 41-22 shows the extent to which the SCAs contain the large and moderate patches that occur within the Plan Area.

The tables show that:

- Approximately 87 per cent of the total area of native vegetation in the SCAs comprises patches > 50 ha
- The SCAs contain about 35 per cent of the total area of patches > 50 ha in the Plan Area

Table 41-21: Extent to which large patches make up the total amount of native vegetation contained within the SCAs

	Total area of patches in SCAs (ha) > 50 ha or > 20 ha*	Per cent of total area of native vegetation in SCAs comprising patches > 50 ha or > 20 ha (%)*	Total number of patches in SCAs > 50 ha or > 20 ha*
Patches > 50 ha	16,000	87%	36
Patches > 20 ha	16,564	90%	70

*Note these figures may include smaller patches that are linked by contiguous areas of native vegetation, such as riparian corridors

Table 41-22: Extent to which the SCAs contain the largest patches within the Plan Area

	Total area of native vegetation patches in Plan Area (ha)	Per cent of total area of patches in Plan Area wholly or partially within SCAs (%)
Patches > 50 ha	45,947	35
Patches > 20 ha	49,372	34

HABITAT CONNECTIVITY

Habitat connectivity was a key factor influencing the location of the SCAs (see Chapter 8). In determining the SCAs, priority was given to including areas in the Cumberland subregion that were adjacent to and connecting other patches of habitat, including existing reserves, and that could form broad habitat corridors across the landscape.

The SCAs were also located to provide connectivity outside the Cumberland subregion. Figure 8-2 in Chapter 8 shows that the SCAs provide connectivity to existing reserves in the Blue Mountains to the west of the subregion, and to existing reserves and protected water catchments to the south-east and south-west of the subregion.

As part of the commitment to secure a minimum of 5,475 hectares of native vegetation in the Cumberland subregion, the Plan commits to securing priority habitat corridors within the subregion to support connectivity for ecological communities and species (Commitment 12). It is intended these priority habitat corridors will be secured within SCAs.

Actions to support the delivery of this habitat connectivity commitment include:

- Undertake ground-truthing within SCAs to confirm potential habitat corridors
- Secure priority habitat corridors and Koala movement corridors in accordance with the Conservation Lands Implementation Strategy under the Plan
- Protect avoided Koala habitat through environment (E2) conservation zoning in potential east-west Koala movement corridors between the Georges River and the Nepean River
- Through restoration, ensure at least one north-south corridor (the Georges River Koala Reserve) and one east-west corridor are each at least 390m wide, for Koala viability and movement
- Facilitate Koala movement for at least one east-west corridor by constructing a Koala crossing at Appin Road

The extent to which the SCAs contain areas important for habitat connectivity was analysed on the basis of BioMap core and corridors and other important connected habitat elements. These areas represent the most important area of habitat connectivity in the Cumberland subregion.

Section 41.6 shows that the SCAs contain substantial amounts of BIOMap core area and corridors, approximately 32 per cent of the total BIOMap core areas and 28 per cent of the total BIOMap corridors in the Cumberland subregion, and are therefore likely to make a substantial contribution to supporting habitat connectivity across the subregion.

It is also important to note that the urban capable lands under the Plan have avoided substantial areas of BIOMap core areas and corridors and other areas of connectivity, such as local corridors (see Chapter 24).

The parts of these areas within the nominated areas that are not included within SCAs, and that have been avoided for biodiversity or other purposes (riparian corridors, steep land) will be protected under the Plan by applying environment (E2) conservation zoning (see Chapter 8). Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land[2].

Key areas of habitat connectivity within the nominated areas that will be avoided are shown in Table 41-23.

Table 41-23: Key areas of habitat connectivity avoided in each nominated area and protected through environment zoning

Habitat connectivity type	Area in nominated areas (not including excluded lands)	Percentage avoided (not including excluded lands)
BIOMap regional corridor and core area	3,151 ha	89%
Connected vegetation	1,716 ha	52%
Isolated vegetation	14 ha	2%
Local corridor	217 ha	73%

LANDSCAPE THREATS

The Plan recognises that the effective management of landscape scale threats is critical to the success of the conservation program under the Plan and in managing the impacts of climate change on biodiversity (see Section 41.12). The Plan includes a range of commitments to reduce threats to conservation lands secured within SCAs, including:

- Weed and pest control programs to manage weeds and pests in conservation lands (Commitment 16 and 17)
- Support new or existing programs to control key diseases affecting species and TECs in the Cumberland subregion (Commitment 19)
- Fire management to support the maintenance of biodiversity values in conservation lands (Commitment 18)

Actions under these commitments generally include to:

- Establish working groups to advise on threat management
- Develop more detailed implementation strategies in consultation with working groups and other key stakeholders, including delivery partners, to set out:
    - Priorities for management of the threat
    - Guidance on management approaches
    - Any research needs
    - Delivery arrangements, including the provision of funding under the Plan

The Plan identifies a range of delivery partners to support implementation of these commitments and actions.

[2] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10% to allow for potential future development of essential infrastructure in non-certified land

Trend analysis

The recognition under the Plan of the importance of managing landscape scape threats is supported by the results of the trend analysis (see Box 1 and Supporting Document D). The trend analysis examined the potential impacts of development and offsetting under various scenarios on PCT 849 in the Cumberland subregion.

Box 1: Trend analysis

Trend analysis for PCT 849

As part of the EPBC Act strategic assessment process for the nominated areas and transport corridors, a trend analysis looking at the extent and condition of PCT 849 over the life of the Plan was undertaken by RMIT University (Gordon & Peterson, 2019). The trend analysis examined the potential impacts of development and offsetting under various scenarios on PCT 849 in the Cumberland subregion. It considered a summed score across the landscape for the PCT of extent and ecological condition (the latter being based on an approximation of the BAM vegetation integrity score).

The project involved two major components:

- A formal expert elicitation to gather quantitative knowledge regarding how the condition of PCT 849 will change over time under:
  - High or low intensity management
  - The case where the PCT is exposed to typical ongoing private land activities
- Quantitative modelling to simulate the urban development within the designated nominated areas and compensation via managing areas as biodiversity offsets in a strategically defined offset region and the ecological response of the PCT. The modelling included eight scenarios exploring different options for implementing biodiversity offsets which varied:
  - The timing of when offsets are implemented
  - The total area of offsets implemented
  - The type of management implemented for the offsets (low or high intensity)

The analysis found that:

- Existing landscape scale threats (e.g. weed invasion, grazing, rubbish dumping, disturbance from recreational activities) across the Cumberland subregion are significant and will result in an approximate 5.8 per cent decline in the extent and condition of the PCT over the life of the Plan unless additional areas are managed
- The proposed impacts of development under the Plan will lead to approximately the same magnitude of losses (~5.8 per cent) to the PCT that will result due to existing landscape threats
- High intensity management and early offsetting will provide the greatest benefits to the outcomes of the PCT over the life of the Plan
- Securing approximately 1,600 ha of offsets for the PCT:
  - Will compensate for the impacts of development where earlier offsetting and higher intensity management is preferential by improving the extent and condition of the PCT over the life of the Plan
  - Has the potential to also contribute significantly to addressing the declines across the subregion due to existing landscape scale threats

The commitments under the Plan to manage landscape scale threats reflect a broad and holistic approach to conservation and aim to address the current level of existing landscape scale threats across the Cumberland subregion.

RESTORATION

The Plan includes a commitment to undertake ecological restoration of priority areas secured for conservation within the Cumberland subregion. The Plan intends to undertake up to 1,370 hectares of ecological restoration on conservation lands targeting the following TECs:

- Cooks River Castlereagh Ironbark Forest

- Cumberland Plain Woodland
- River-flat Eucalypt Forest
- Shale Gravel Transition Forest
- Swamp Oak Forest

The Plan includes a range of actions to ensure restoration is effective, including:

- Developing a Restoration Implementation Strategy in consultation with key stakeholders and delivery partners, to:
  - Set out how the Plan will meet its restoration target
  - Identify the restoration potential of land within priority sites
  - Provide guidance on restoration expectations at priority sites
- Entering into written agreements with delivery partners, and engaging specialist providers if necessary, to implement the restoration strategy

The recognition under the Plan of the importance of restoration is consistent with the Cumberland Plain Recovery Plan (DECCW, 2011), which highlights the importance of restoration in the context of the substantial degradation that has occurred in the Cumberland subregion due to agricultural and urban land uses.

Trend analysis

The emphasis on restoration under the Plan is also supported by the results of the trend analysis (see Box 1 and Supporting Document D). The expert elicitation process (involving experts on the management of Cumberland Plain Woodland) undertaken for the trend analysis indicates that high intensity management on conservation lands provides significant potential for providing restoration gains for PCT 849, even when starting from a low initial condition.

It is important to note that the trend analysis found that low intensity management has limited capacity to provide restoration gains for PCT 849 over time, especially when starting from a low initial condition.

41.7.3 CONCLUSION

The analysis suggests that the commitments broadly ensure biodiversity values and ecological function are improved in the long term as the SCAs within which the land-based commitments are intended to be delivered:

- Include many large patches > 50 ha that comprise over 87 per cent of the total native vegetation in the SCAs and contain 35 per cent of the total area of patches > 50 ha in the Plan Area
- SCAs contain substantial amounts of BIOMap core and corridors

Importantly the Plan has also committed to managing key landscape threats, including weeds, pest animals and fire, and restoring substantial areas of land in the SCAs as part of the conservation program.

41.8 THEME 5: ARE THE COMMITMENTS ADDITIONAL TO EXISTING REQUIREMENTS?

41.8.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 5) requires that commitments are additional to existing conservation obligations. Existing conservation obligations are actions that are legally required to be carried out on land. Consistent with BC Regulation clause 5.1, existing obligations include actions required to be carried out:

- Because of the reservation of land under the NP&W Act
- Under existing conservation agreements or offset arrangements
- Under a condition of approval or consent under the EP&A Act

The 'draft guidelines for planning authorities' (EES, 2019) also state that existing conservation obligations include those under plans of management for 'community' land, and voluntary obligations are not considered to be existing conservation obligations

The Plan intends to secure all conservation land within SCAs through either:

- Creation of reserves through acquisition of land
- Establishment of Biodiversity Stewardship Agreements (BSAs) with landholders

The Plan ensures that commitments are additional to existing conservation obligations through:

- Accounting for existing conservation obligations in the process to identify SCAs
- Securing land in SCAs in accordance with the rules and processes under the BC Act and BAM, which account for existing conservation obligations

The analysis of Theme 5 involved explaining these processes.

41.8.2 ANALYSIS

STRATEGIC CONSERVATION AREAS

The SCAs were identified through a Conservation Priorities Method (see Chapter 8). The method combines detailed spatial information about biodiversity values with an analysis of constraints and opportunities to identify an optimal mix of potential conservation sites to offset the impacts of the development on biodiversity values.

The method to identify SCAs excluded land that was unlikely to be suitable as an offset, including because the land was already subject to existing conservation obligations or controls. This included the following land:

- Land reserved under the NP&W Act
- Existing BioBank and Biodiversity Stewardship Agreement sites
- Existing offsets for other development projects

The method ensures that land clearly already subject to existing conservation obligations is not identified within SCAs.

PROCESS TO SECURE BIODIVERSITY STEWARDSHIP AGREEMENTS AND RESERVES

All BSAs under the Plan will be established in accordance with the requirements of the BC Act and BAM. The BC Act and BAM have rules and processes in place to ensure that the credits generated from establishing BSAs take into account existing conservation obligations. These include:

- Criteria under the BC Regulation (clause 5.1) that prevents several categories of land subject to existing conservation obligations from being eligible as a site for a BSA, including offset sites
- A process under the BAM (section 13.11) that ensures credits can only be created by management actions on a BSA site that are additional to existing conservation obligations. This includes a set of rules that reduce the credits generated according to either the tenure of the land (including land classed as 'community land' under the *Local Government Act 1993)* or the type of management action already required under existing obligations

This same rules and processes will be applied to land secured as reserves under the Plan, as the Plan intends that BSAs will be established prior to the acquisition of land by the Office of Strategic Lands. The land will then be transferred (along with the BSA, covenants on title and ongoing annual management payments) to a suitable long-term public land management authority such as National Parks and Wildlife Authority or Council.

ACCOUNTING FOR OFFSET TARGETS

The Plan includes an action to establish an accounting process to track progress in meeting offset targets. Offset targets will be tracked in terms of hectares of land secured, as well as credits where appropriate.

As part of the accounting process, a method will be established to reduce the number of hectares that are counted towards an offset target where existing conservation obligations apply to a site. This method will be developed to be consistent with the rule set in the BAM (section 13.11) for credits.

41.8.3 CONCLUSION

The Plan ensures that commitments are additional to existing conservation obligations consistent with the 'draft guidelines for planning authorities' (EES, 2019) (Principle 5) through:

- Accounting for existing conservation obligations in the process to identify SCAs
- Securing land in SCAs in accordance with the rules and processes under the BC Act and BAM, which account for existing conservation obligations
- Establishing an accounting process to track progress in meeting offset targets, including a method to reduce the number of hectares that are counted towards an offset target where existing conservation obligations apply to a site

41.9 THEME 6: DO DEVELOPMENT CONTROLS PROPOSED AS COMMITMENTS CONSERVE THE ENVIRONMENT?

41.9.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 7) requires that commitments involving the use of development controls conserve or enhance the natural environment. Consideration of this principle is guided by the following:

- Land use zoning is implemented following the biodiversity certification application
- Land use zone objectives are consistent with conservation/enhancement of the natural environment
- Permissible uses are consistent with conservation/enhancement of the natural environment
- There are specific local provisions put in place that set out the development controls that will apply to protect native vegetation and any other habitat for native species on the land
- Minimum lot sizes and/or options for lot averaging and lot clustering aim to preserve the integrity of native vegetation and any other habitat for native species on the land
- Management actions are proposed to enhance the natural environment
- Security of biodiversity values is improved (i.e. development controls are new or represent a significant upgrade)

41.9.2 ANALYSIS

The Department is proposing a new State Environmental Planning Policy (SEPP) for strategic conservation planning to implement the Plan's strategic conservation planning requirements. The proposed SEPP will include:

- Environmental conservation (E2) zoning that will be applied to areas that are identified in the Plan as non-certified because they are avoided for biodiversity purposes, or other purposes (riparian corridors, steep land). Note that avoided land will have environment (E2) conservation zoning applied except for land owned by LALCs or under claim by LALCs. LALC owned land and land under claim represents 90 ha of the 4,795 ha of avoided land[3]
- Planning controls for the SCAs to minimise impacts from development on areas of high biodiversity value, improve the management of biodiversity and help protect TECs and species in these areas. Note that planning controls will be applied across the SCAs except for land owned by LALCs or under claim by LALCs. Deerubbin owned land has been excluded from the SCAs at their request. Other LALC owned land and land under claim represents 1,700 ha of the 28,300 ha of the SCAs
- Consistency clause for urban development to ensure consistency between the urban capable land identified in precinct plans and areas of urban capable land identified by the Plan, to contain urban development to the urban capable lands and ensure avoided lands remain outside the development areas
- Acquisition clauses that allow the relevant acquisition authority to secure lands suitable for public reserves, such as national parks and council reserves

In addition to these planning controls, the Department also proposes to introduce a Ministerial Direction under section 9.1 of the EP&A Act. The direction will apply to avoided land and the SCAs as mapped in the proposed SEPP. It will restrict the ability to rezone avoided land, increase development or intensify land uses in the SCAs, and require a

[3] The total area of avoided land at the start of the Plan is 4,795 hectares. The avoidance target of 4,315 hectares has reduced this figure by 10% to allow for potential future development of essential infrastructure in non-certified land

relevant planning authority to ensure any planning proposals consider the land use objectives that apply to avoided land and, for the SCAs, the matters for consideration in the planning controls that apply to the area.

Note that, as for the other planning controls, this control will be applied across the SCAs except for land owned by LALCs or under claim by LALCs. Deerubbin owned land has been excluded from the SCAs at their request. Other LALC owned land and land under claim represents 1,700 ha of the 28,300 ha of the SCAs

It is considered the SEPP and other measures will improve the security of biodiversity values in avoided lands and the SCAs, and represent a significant upgrade to existing levels of protection in these areas, as they will:

- Include zoning objectives and permissible uses consistent with conservation (for avoided lands)
- Reduce the risk of rezoning avoided land or increasing development or intensifying land uses in the SCAs, which reduces the likelihood of potential impacts from future planning proposals within these areas
- Ensure planning authorities take into account the land use objectives that apply to avoided land or, if the development proposal is for the SCAs, the matters in the planning controls that apply to the area, when considering development and other planning proposals for avoided lands or SCAs
- Facilitate the acquisition of high biodiversity value land within the SCAs under the conservation program. The tenure of land across the Plan Area is mostly freehold, meaning land will need to be acquired from landowners over time. The proposed SEPP supports this important process over the life of the Plan

41.9.3 CONCLUSION

The proposed SEPP and associated zoning and planning controls, as well as other measures, are considered to provide substantial protection to avoided lands and the SCAs, consistent with the matters to be considered under the 'draft guidelines for planning authorities' (EES, 2019) (Principle 7). These measures represent a significant upgrade to existing levels of protection in avoided lands and the SCAs. These areas are the key locations of high biodiversity value identified to achieve the Plan's conservation outcomes, and the SEPP therefore increases certainty that the commitments and actions under the Plan relevant to the conservation program will be successfully delivered.

41.10 THEME 7: ARE PROPOSED NEW NATIONAL PARKS CONSISTENT WITH THE CAR RESERVE FRAMEWORK?

41.10.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 7) requires that any proposed new national parks are consistent with the CAR reserve system scientific framework (Commonwealth of Australia, 2010).

Specifically, the national parks must be:

- Comprehensive: the national parks must include regional-scale ecosystems impacted by the biodiversity certification in each subregion or bioregion
- Adequate: the national parks must include sufficient levels of each ecosystem to provide ecological viability and maintain the integrity of populations, species and communities
- Representative: the national parks must include the variability of habitat within ecosystems

The Department has identified initial locations for land that will be potentially reserved under the NP&W Act within the SCAs. This includes three new reserves proposed to be established within the first five years of the Plan's implementation to deliver upfront strategic offsets (see section 41.11).

These reserve locations are not final and are likely to be refined.

The analysis of Theme 7 involved analysing data on the initial locations of land that will be potentially reserved under the NP&W Act within the SCAs on the basis of PCTs (those impacted by the development), as follows:

- Comprehensiveness: the extent to which the potential reserve locations contain each impacted PCT
- Adequate: the extent to which the potential reserve locations contain large patches of native vegetation more likely to be viable in the long-term and more likely to support persistence of species and communities
- Representative: the extent to which the potential reserve locations contribute to the existing levels of protection of each impacted PCT in the Cumberland subregion

It is important to note that the reserve locations are not final and are likely to be refined. The final location of reserves will be determined during implementation of the Plan based on consultation with key stakeholders and guided by the Conservation Lands Implementation Strategy (see Chapter 8).

41.10.2 ANALYSIS

COMPREHENSIVE

Table 41-24 shows the extent to which the potential reserve locations within SCAs contain each impacted PCT.

The table shows that 8 of the 9 impacted PCTs are included in the potential reserve locations, with one of these PCTs (PCT 830) available in restoration lands only.

For the PCT not included in the potential reserve locations (PCT 1800) the lack of available mapping for this PCT is likely to be driving this result.

Table 41-24: Extent to which potential reserves component of SCAs contains each impacted PCT

Impacted PCTs	Area of PCT available in potential reserves (ha)	Restoration potential in potential reserves (ha)
724	10.0	3.7
725	50.7	15.1
781	51.1	0.3
830	0.0	11.4
835	84.7	339.0
849	384.5	556.6
850	164.7	277.4
1395	1949.0	567.8
1800	0.0	0.0
Total	**2,694.7**	**1,771.3**

ADEQUATE

Table 41-25 shows the number of large and moderate patches in the potential reserves and the extent to which large and moderate patches make up the total amount of native vegetation contained within the SCAs.

Table 41-26 shows the extent to which the SCAs contain the large and moderate patches that occur within the Plan Area.

The tables show that:

- Approximately 95 per cent of the total area of native vegetation in the potential reserve locations comprises patches > 50 ha
- The potential reserve locations contain about 14 per cent of the total area of patches > 50 ha in the Plan Area

Table 41-25: Extent to which large patches make up the total amount of native vegetation contained within the potential reserves component of SCAs

	Total area of patches in SCAs (ha) > 50 ha or > 20 ha*	Per cent of total area of native vegetation in SCAs comprising patches > 50 ha or > 20 ha (%)*	Total number of patches in SCAs > 50 ha or > 20 ha*
Patches > 50 ha	6,371.4	95%	36
Patches > 20 ha	6,425.6	96%	70

*Note these figures may include smaller patches that are linked by contiguous areas of native vegetation, such as riparian corridors

Table 41-26: Extent to which the potential reserves component of SCAs contain the largest patches within the Plan Area

	Total area of native vegetation patches in Plan Area (ha)	Per cent of total area of patches in Plan Area wholly or partially within SCAs (%)
Patches > 50 ha	45,947	13.9
Patches > 20 ha	49,372	13.0

Representative

Table 41-27 identifies:

- Total amount of each impacted PCT in the Plan Area
- Amount/per cent of total amount in the Plan Area already represented in existing reserves (this includes reserves under the NP&W Act, BioBank sites and Biodiversity Stewardship Agreement sites)
- Amount/per cent of total amount in the Plan Area within potential reserve locations
- Extent to which the potential reserve locations contribute to existing levels of representation in the Plan Area

The table indicates that the potential reserve locations contribute greater than 10 per cent to existing levels of representation for the majority (6 of the 9) of PCTs, including contributing about 70 per cent to existing levels of protection of the critically endangered TEC Shale Sandstone Transition Forest (PCT 1395).

Table 41-27: Contribution of potential reserve locations to existing levels of representation of impacted PCTs

PCT	Total amount in Plan Area (ha)	Amount in existing reserves* in Plan Area (ha)	Per cent in existing reserves* (%)	Amount in potential reserve locations (ha)	Per cent in potential reserve locations (%)	Per cent in potential reserve locations or existing reserves* (%)	Per cent contribution of potential reserve locations to existing levels of representation (%)
724	2,049.3	286.1	14.0	10	0.5	14.4	3.4
725	1,085.6	422.2	38.9	50.7	4.7	43.6	10.7
781	429.2	52.7	12.3	51.1	11.9	24.2	49.2
830	1,362.1	130.8	9.6	0	0.0	9.6	0.0
835	6,951.5	459.9	6.6	84.7	1.2	7.8	15.6
849	11,767.1	1,024.70	8.7	384.5	3.3	12.0	27.3
850	8,821.5	747.1	8.5	164.7	1.9	10.3	18.1
1395	12,475.8	852.8	6.8	1,949.0	15.6	22.5	69.6
1800	426.5	17.9	4.2	0	0.0	4.2	0.0

*This includes reserves under the NP&W Act, BioBank sites and Biodiversity Stewardship Agreement sites

41.10.3 CONCLUSION

The analysis suggests that the potential reserves are broadly consistent with the CAR reserve system scientific framework (after Commonwealth of Australia, 2010) as the reserves:

- Include the vast majority of PCTs impacted by the development (are comprehensive)
- Comprise patches > 50 ha for the vast majority of native vegetation in the reserves (are likely to be adequate)

- Contribute greater than 10 per cent to existing levels of representation for the majority of PCTs (are representative)

It is important to note that further consideration of the CAR reserve system scientific framework will be made in finalising the locations of the potential reserves during implementation of the Plan.

41.11 THEME 8: WILL THE PLAN BE EFFECTIVELY IMPLEMENTED AND WILL OUTCOMES BE CERTAIN?

41.11.1 CONTEXT AND METHOD

The 'draft guidelines for planning authorities' (EES, 2019) (Principle 9) and the ToR (Sections 4.6(2), 5.3 (2), 6.1(4), 6.2, and 7.1) require analysis of the extent to which the commitments are likely to be implemented effectively to achieve the outcomes.

Effective implementation is particularly important with strategic assessments because of the size and complexity of the programs, the long time frames over which they are implemented, the number of stakeholders and the diversity of their interests, the amount of money the programs cost, and the complexity of the legal frameworks they operate within.

Lessons learnt from other strategic assessments around Australia suggest that effective implementation requires:

- Clear and feasible outcomes that the Plan will deliver
- Clarity about the delivery framework and mechanisms to implement the Plan
- Appropriate flexibility within the Plan to ensure it remains relevant over time
- Clear governance arrangements, including certain funding
- Comprehensive processes to monitor and report on implementation, and adapt implementation as needed

The analysis of Theme 8 involved addressing each of these key factors in relation to the following questions:

- Why is this important for effective implementation?
- What is required to achieve this?
- Is the Plan consistent with what is required?

41.11.2 ANALYSIS

CLEAR AND FEASIBLE OUTCOMES

Why is this important for effective implementation?

Clear and achievable outcomes are critical for effective implementation to allow delivery partners to understand what they need to achieve, allow regulators and the public to understand what is intended to be delivered, and enable the Plan to be evaluated to determine if it is operating well, and ultimately if it has been a success.

What is required to achieve this?

To achieve this, the Plan needs to:

- Frame outcomes within a program logic
- Ensure outcomes are clear, measurable and achievable

Is the Plan consistent with what is required?

Frame outcomes within a program logic

The outcomes under the Plan have been framed within a program logic that underpins the Plan.

The program logic describes broadly how the Plan will be implemented and the relationships between outcomes and commitments and actions ('or 'outputs'), and how the commitments and actions are expected to lead to the outcomes. Key elements of the program logic are:

- Overall vision and objective of the Plan
- Outcomes – Environmental, social and economic outcomes of the Plan
- Commitments – How the outcomes are going to be delivered
- Actions – What will be done to deliver the commitments

By framing the outcomes within a program logic, the Plan provides a clear picture of why and how it is intended to be delivered and a chain of reasoning between achieving the vision and taking actions. The increasing level of detail from vision to actions provides a suitable way of articulating what success looks like (i.e. the vision/objectives and outcomes that the Plan will deliver) as well as the way that will be achieved (i.e. the commitments and actions).

The vision and objective of the Plan have three elements to them:

- Environmental – conservation of biodiversity to support ecological function in the subregion
- Economic – facilitating urban development to support growth
- Social – improving liveability

The outcomes are considered to be consistent with the program logic, as they:

- Cover the three elements of the vision and objective
- Articulate what is needed to achieve the vision and objective
- Articulate the results of delivering the commitments

Importantly, the outcomes clearly reflect the level of performance or intended impact or value resulting from the delivery of commitment and actions. Appropriately, the outcomes are clearly distinct from the commitments, which reflect what is delivered as a result of the implementation of the actions.

Ensure outcomes are clear, measurable and achievable

The key environmental outcomes of the Plan are that:

- Extent and condition of native vegetation increases and improves within areas of the Cumberland subregion most likely to support long-term viability and ecological connectivity
- TECs persist and their condition improves within areas of the Cumberland subregion most likely to support long-term viability
- Populations of targeted threatened species persist and the condition of suitable habitat improves within areas of the Cumberland subregion most likely to support long-term viability
- Condition of riparian corridors within the nominated areas improves

It is considered that these outcomes reflect best practice as they are:

- Specific in relation to scope – in the context of the commitments under the Plan, the area over which the outcome is intended to be achieved and the contribution of the Plan in achieving that outcome is clearly defined
- Measurable and able to be reported against – changes in extent and condition of native vegetation and persistence of species can be measured and reported against under the MER framework for the Plan
- Achievable – in the context of the commitments under the Plan, the outcomes are considered to be achievable

Flexibility within the Plan to ensure it remains relevant

Why is this important for effective implementation?

Given the spatial and temporal scope of the Plan, it is important that it retains sufficient flexibility to ensure that implementation can adapt over time to deliver the outcomes. This may be necessary for a range of reasons, including:

- Development priorities change necessitating minor changes to development areas
- New knowledge on biodiversity values identifies new conservation opportunities
- Ecological processes change over time (e.g. due to climate change) that require alternative conservation approaches
- Changes to technology mean there are better ways to achieve the outcomes than envisaged now

What is required to achieve this?

To achieve this, the Plan needs to:

- Build processes into the Plan that enable changes to development locations in appropriate circumstances
- Include mechanisms under the Plan for changing how outcomes are delivered where appropriate
- Ensure flexibility around how the conservation program is delivered

How well does the Plan address this requirement?

Build processes into the Plan that enable changes to development locations

The Plan includes an appropriate level of flexibility around development. In particular, the Plan provides for flexibility in relation to projects where planning has not yet begun or that are only at concept stage, including:

- Essential infrastructure to support the nominated areas, such as water and electricity utilities, which is in various stages of development and may need to be located outside urban capable lands
- Detailed design and location of the transport projects, which are also in various stages of development

The Plan includes commitments and a set of guidelines for essential infrastructure projects that allow for both flexibility in relation to future strategic planning and detailed design while also ensuring the projects avoid and minimise, mitigate and (where appropriate) offset the impacts of development consistent with the outcomes of the Plan.

The Plan also establishes governance arrangements to ensure the Department and regulators are provided oversight over these arrangements to ensure these projects proceed consistent with the requirements of the Plan (see below).

Mechanisms for changing how outcomes are delivered

The outcomes and commitments under the Plan are fixed and cannot be changed over time. This is appropriate as it ensures the Plan provides as much planning, development and conservation certainty as possible.

The actions that will be implemented under the Plan to deliver the commitments are able to be changed over time. This allows an appropriate level of flexibility to change implementation approaches based on monitoring and evaluation of the effectiveness of these actions through the MER framework and adaptive management approach (see below).

It is considered this ability to change actions in based on an evaluation process and in response to changes in circumstances is essential to the successful delivery of the outcomes and commitments under the Plan.

Flexibility around how the conservation program is delivered

The Plan acknowledges that in some cases it may be challenging to meet some of the offset targets in the Plan. Rather than committing to reduced offset targets, the Plan allows for flexibility in reaching those targets through a set of conservation principles and ‘conservation lands selection steps’.

The principles are broad and prioritise the protection of the best remaining large patches of vegetation, areas that provide ecological connectivity and landscape function, species adaptation needs under climate change, as well as the restoration of habitat corridors and areas that provide buffers to intact native vegetation.

The conservation lands selection steps will be used to identify and secure reserves or BSAs under the conservation program. The details of the steps are set out in Sub-Plan A. The selection steps:

- Set out priorities for securing offset targets in terms of locations within and outside the Cumberland subregion and the biodiversity values being targeted (TECs versus species)
- Identify the circumstances, including time periods, where offset targets can be substituted for alternative offsets for other biodiversity values or conservation measures in cases where those targets cannot be secured

The Biodiversity Conservation Trust will be required to follow these steps when implementing the BSA component of the conservation program, and the Department will be required to follow these steps when developing reserve proposals. In summary, the selection steps prioritise:

1. Securing offsets from priority areas within the SCAs, including the following preferences: (in order):

  - Targeted TECs that are most impacted under the Plan
  - Targeted TECs that have the highest percentage cleared status (as identified in BioNet)
  - Targeted TECs or species where there is a shortfall between impacts and the securing of offsets
  - Species offset locations or areas of potential foraging habitat
  - Areas that provide additional conservation benefits (e.g. habitat connectivity, riparian corridors, etc)
2. Securing offsets from elsewhere within the SCAs following the same priorities above

In securing BSAs under the conservation program, the following additional selection steps apply:

3. Secure target TECs outside the SCAs but within the Cumberland subregion or adjacent subregions, or as a last option, anywhere else they occur in NSW, following the same priorities above
4. Secure species offset locations or areas of potential foraging habitat in accordance with Box 4 of Sub-Plan A
5. Secure alternate native vegetation in accordance with Box 4 of Sub-Plan A

Box 4 of Sub-Plan A specifies separate priorities for TECs and species and sets out the circumstances, including time periods, where offset targets can be substituted for alternative offsets for other biodiversity values, or alternative conservation measures, in cases where those targets cannot be secured.

The rules in Box 4 specify, for example, that where offsets for a target TEC cannot be secured within or outside the Cumberland subregion after taking appropriate steps (including securing of credits), preference should be to secure alternative PCTs of the same Class first, then of the same Formation, to those of the target TEC.

The selection steps to guide the selection of conservation lands are considered to appropriately balance the need to provide certainty for achieving conservation outcomes in the Cumberland subregion while retaining enough flexibility to ensure successful delivery of the conservation program. In particular, the steps:

- Have been developed consistent with the offset rules under the BC Regulation 2016
- Prioritise securing of offsets within the SCAs, which represent the areas in the Cumberland subregion that are considered most likely to be viable in the long-term and to maximise ecological function and connectivity
- Prioritise securing the most impacted TECs under the Plan first
- Ensure TECs and species are given higher priority where progress in securing offsets is not keeping pace with impacts of the development on those matters (through an offset reconciliation accounting process – see below)
- Cap the amount of offsets that can be secured outside the Cumberland subregion through BSAs under the conservation program to 20 per cent of the total TEC offset target under the Plan
- Specify clear timeframes over the life of the Plan after which species offset targets can be achieved outside the Cumberland subregion, with greater flexibility provided for higher conservation status species to minimise the time between the impact of the Plan and conservation benefit achieved by the Plan for these matters

CLARITY ABOUT THE DELIVERY FRAMEWORK

Why is this necessary to ensure effective implementation?

The Plan is a high level framework for delivering urban and transport development consistent with regulatory requirements for biodiversity outcomes. This framework needs to be given effect through delivery mechanisms that turn the high level requirements of the Plan into specifics so that delivery partners and developers know exactly what they need to do at a site or project level to meet the requirements of the Plan.

What is required to achieve this?

To achieve this, the Plan needs to:

- Clearly set out how the Plan is intended to be delivered
- Ensure the delivery framework is legally robust
- Ensure delivery partners act consistently with the Plan
- Enable the NSW Government to take action to ensure compliance

Is the Plan consistent with what is required?

Set out how the Plan is intended to be delivered

The Plan sets out a clear delivery framework for implementation. The primary delivery framework for the Plan is the existing NSW planning system. The Department is proposing a new State Environmental Planning Policy (SEPP) as the key statutory mechanism to implement strategic conservation planning and to provide certainty that the Plan's commitments and actions to protect, enhance, maintain and restore biodiversity in Western Sydney will be met

The key parts of the planning system that will be used to implement the Plan are described in Chapter 9, and include:

- Strategic plans, such as LUIIPs
- Precinct plans
- Neighbourhood plans
- DCPs
- Development applications
- Environment (E2) conservation zoning
- Planning overlays
- Ministerial Directions

Ensure the delivery framework is legally robust

The Plan ensures the delivery framework is legally robust through:

- Utilising the NSW planning system as the primary delivery framework for the Plan
- Developing a SEPP to support delivery of the Plan

A SEPP is a statutory planning instrument made under the EP&A Act and will ensure development within the nominated areas is consistent with State and Commonwealth approvals for biodiversity. The SEPP will give statutory effect to relevant commitments and actions in the Plan and will:

- Facilitate appropriate development on certified lands in the nominated areas
- Identify and protect areas of high biodiversity value in the nominated areas
- Identify areas across the Plan Area with high biodiversity value that can support the ecological function of the Cumberland subregion and areas with important connectivity or ecological restoration potential
- Minimise impacts from future development on biodiversity values in areas of high biodiversity value
- Support the acquisition of priority areas of high biodiversity value in the Cumberland subregion as conservation lands in perpetuity
- Minimise impacts to biodiversity values on land secured for conservation from adjoining land uses

The SEPP will include a provision that requires Precinct Plans (made as part of the planning framework for nominated areas) and their corresponding land use zones are consistent with the biodiversity approvals under the Plan. The objective of this clause is to ensure that urban development in the nominated areas occurs on the certified land identified under the Plan, to protect land avoided for its high value biodiversity.

Ensure delivery partners act consistently with the Plan

The Plan will ensure delivery partners act consistently with the Plan by establishing service level agreements or memorandums of understanding as part of the process of engaging delivery partners. These will set out:

- Roles and responsibilities
- Processes for delivery
- Funding arrangements
- Stakeholder consultation arrangements
- Any monitoring and reporting requirements

The Department has commenced consultation and collaboration with delivery partners in relation to the Plan.

Enable the NSW Government to take action to ensure compliance

The Plan includes a commitment to implement a surveillance and compliance program to ensure compliance with the Plan and conditions of approval, and includes several actions to deliver this commitment, including:

- Establishing a compliance working group comprising the Department and other key stakeholders
- Preparing a compliance strategy under guidance of the working group

The compliance strategy will address the key elements of an effective compliance program, including:

- Identifying relevant compliance mechanisms used to ensure compliance
- Setting out compliance monitoring/auditing priorities and processes
- Developing a clear decision-making for taking compliance action
- Setting out procedures and protocols for taking compliance action
- Identifying roles and responsibilities for compliance, including monitoring and taking action

CLEAR GOVERNANCE ARRANGEMENTS AND CERTAIN FUNDING

Why is this necessary to ensure effective implementation?

Governance is a broad term and there are many definitions. Governance can be thought of as the systems and structures for implementing the Plan to ensure compliance, transparency and accountability. Robust governance arrangements are necessary to ensure the Plan is delivered efficiently and effectively, and complies with any conditions of approval.

What is required to achieve this?

To achieve this, the Plan needs to:

- Establish an organisational structure and define roles and responsibilities
- Establish assurance mechanisms for delivery of the conservation program
- Ensure funding certainty

Is the Plan consistent with what is required?

The Plan establishes an implementation and assurance framework to ensure the efficient and effective delivery of the Plan. The framework covers governance arrangements, including roles and responsibilities of key delivery partners, assurance mechanisms for delivery of the conservation program and offsets, and funding arrangements.

The Plan and sub-plans are high level documents providing an overarching framework and assurance processes for implementing the Plan. It is appropriate for further details about how key elements of the Plan will be implemented to be developed during early implementation of the Plan. This allows proper consideration of more complex issues, seeking of expert advice through working groups, and comprehensive engagement with key stakeholders. The Plan includes actions to prepare more detailed implementation strategies for all key elements of the Plan, including:

- Conservation program – the Conservation Lands Implementation Strategy
- Restoration – the Restoration Implementation Strategy
- Programs for managing landscape threats – the Weed Control Implementation Strategy, the Pest Animal Control Implementation Strategy, and Fire Management Strategy
- Community engagement and research programs – the Education and Engagement Implementation Strategy, Aboriginal Engagement Implementation Strategy, and Research Program Implementation Strategy
- Compliance program – the Compliance Strategy

These implementation strategies will set out further details about how each of these key elements of the Plan will be implemented, including criteria for decision-making, priorities for action, policy guidance for decision-making and implementation, procedures and protocols, and governance arrangements.

Establish an organisational structure and define roles and responsibilities

The Plan establishes a clear organisational structure for implementation of the Plan and broadly sets out roles and responsibilities for each part of the structure, including delivery partners. The structure includes all relevant organisational levels needed to effectively implement the Plan, including:

- Oversight bodies
- Co-ordinating bodies
- Delivery partners
- Agency partners
- Technical working groups
- Stakeholder groups

The Plan clearly identifies the Department as the responsible agency for delivering the Plan and meeting regulatory requirements as the Party to the strategic biodiversity certification (under s8.9 BC Act) and Approval Holder (under s146B EPBC Act). The Department's role under the Plan includes:

- Meeting statutory requirements (as a Party and approval holder)
- Centrally coordinating the Plan
- Coordinating delivery partners, including setting implementation and reporting requirements
- Preparing regular Plan progress reports for publication
- Identifying breaches and notifying the appropriate regulatory authority

The Plan also establishes a Steering Committee as a key oversight body to:

- Provide strategic direction and make key decisions in relation to implementation
- Ensure commitments and outcomes are monitored and reported on

The Steering Committee includes executive level representatives from the Department, approval/regulators including DAWE and EES, and partner agencies, including Transport for NSW. Working groups will be established where appropriate to advise the Steering Committee on specific issues, including Koala and weed and pest management.

Roles and responsibilities of each body within the organisation structure will be defined in detail during early implementation of the Plan. The Department has commenced consultation with key delivery partners and will finalise and agree roles and responsibilities through service level agreements or memorandums of understanding.

Establish assurance mechanisms for delivery of the conservation program

The Plan includes several processes to ensure offsets are secured in accordance with the Plan and in a timely manner consistent with the staging and impacts of the development. These are:

- A reconciliation accounting process to reconcile offsets secured through the Plan with development impacts
- Adaptive management steps to align the securing of offsets with development

The Plan includes an accounting process to track the impacts of the development on biodiversity values as clearing progresses and progress in securing the offset targets proceeds. If progress in securing offsets is not keeping pace with the impacts, the Plan sets out an adaptive management response that will triggered at a specific point to rectify the balance.

Offset targets will be tracked in terms of hectares of land secured, as well as credits where appropriate. This will be done by undertaking assessments using the BAM at each BSA and reserve to confirm the biodiversity values present, the credits generated at the site, and the contribution the site makes to the hectare targets (Commitment 8, action 7).

The impacts of the urban and industrial development will be tracked using housing data from the Department's existing Sydney Housing Monitor and the Greenfield Housing Monitor. The impacts of the transport development will be tracked by Transport for NSW as the transport projects are constructed, and will be reported regularly to the Department (Commitment 3, action 4 and Commitment 4, action 2). The Department will adjust the predicted impacts and offset requirements associated with the transport corridors through the reconciliation accounting process, and publish adjustments through the Plan's annual updates and five yearly reviews (see Part 2). This process ensures changes to impacts and offset requirements under the Plan because of the future avoidance and minimisation processes needed for the transport corridors is transparent and properly accounted for.

The offset liability of the Plan at any given point in time is determined using a ratio of 3.5:1 applied to the total area (ha) of native vegetation cleared in urban capable land. This ratio was determined based on the method for determining offset targets (see Part 2), which applied a higher ratio to impacted native vegetation of higher condition or threat status to determine the amount of offset target for each protected matter. The offset liability ratio is an average ratio to be applied across all the impacts of development in the urban capable land and would determine the liability in terms total amount of native vegetation (ha) to be offset, rather than a specific amount of impacted TEC or species. This is considered to be a practical and feasible approach to determining the offset liability at any given point in time, and consistent with the flexibility built into the 'conservation lands selection steps' (see above).

If progress in securing offsets is not keeping pace with the impacts of the development, the Plan specifies that:

- No action will generally be taken in the first 5 years of implementation to address any imbalance
- If the offsets secured are less than 80 per cent of the offset liability after Year 5, the executive implementation committee will consider a response. This will include, in order of priority:
  - Voluntary property acquisition
  - Compulsory property acquisition
  - Land use planning responses to development

The Office of Strategic Lands will prioritise voluntary acquisition of properties through several approaches, including market purchase, passive voluntary acquisition, or active and targeted voluntary acquisition . The Department will consider the use of compulsory acquisition only after voluntary options are not successful. The Department would consult with the community and key stakeholders before compulsory acquisition was undertaken.

The Plan specifies that land use planning responses may include:

- Pause rezoning of remaining precincts in the nominated areas, until sufficient offsets are secured
- If rezoning of all nominated areas has occurred, place a moratorium on development assessments being determined within the nominated areas via an amendment to the EP&A Regulation (2000).

These planning responses would be considered as a final option after at least 2 years of attempting to address the imbalance between offsets and impacts (i.e. not before Year 8). The planning response will remain in place until the amount of offsets secured are greater than 80 per cent of the offset liability at that point in time.

Ensure funding certainty

The NSW Government will establish a conservation fund to implement the Plan. Funding will be secured using a public-private funding model. The model involves upfront investment from the government and substantive cost-recovery through the biodiversity component of a Special Infrastructure Contribution (SIC) levy imposed on housing development in the nominated areas.

By using an existing process to collect the levy, the SIC, the Plan ensures clarity regarding:

- Legal robustness of the levy
- How the levy is collected
- When and over what land the levy is payable
- Whether the levy can be reviewed or challenged by a developer
- Compliance mechanisms to ensure the levy is paid

In addition to using a SIC, the Plan includes an additional level of accountability and transparency in relation to funding by establishing a Trust to administer funds on behalf of the Department. Furthermore, the Plan includes an action to prepare a funding framework in consultation with the Trust to set out how funding decisions will be made and administered.

Consistent with best practice, the funding arrangements under the Plan:

- Were supported by a robust process to estimate costs
- Include indexing developer contributions to ensure purchasing power is maintained over time
- Include a transparent and independent evaluation program to ensure conservation outcomes are delivered

It is important to consider the need for some upfront government contributions to ensure funding is available early during implementation. Funding tied solely to a levy on development creates the following risks:

- Delays at the start of implementation before adequate funds from a levy become available
- Delays later during implementation due to downturns in development
- Priority biodiversity values are lost or degraded prior to being secured under the conservation program

As demonstrated by the trend analysis (see Box 1 and Supporting Document D), the existing level of landscape threats in the Cumberland subregion is significant. This creates a substantial risk that biodiversity values degrade before land is secured, which may reduce the effectiveness or increase the costs of the conservation program.

This risk is addressed to a large extent under the Plan through the NSW Government committing to fund the first five years of implementation of the Plan, and prioritising the establishment of three new reserves to deliver upfront strategic offsets to protect TECs and species habitat. These are:

- The Georges River Koala Reserve – This is the most important north–south Koala movement corridor along the Georges River between Appin and Kentlyn, and contains around 1,500 hectares of native vegetation, including approximately 375 hectares of Shale Sandstone Transition Forest and 60 hectares of Cumberland Plain Woodland
- The Gulguer Reserve Investigation Area – This investigation area covers about 1,800 hectares and is located in the Warragamba area. A reserve in this area will support the east-west connection between Burragorang State Conservation Area and Gulguer Nature Reserve. TECs contained the potential reserve include approximately 600 hectares of Shale Sandstone Transition Forest and 200 hectares of Cumberland Plain Woodland
- The Confluence Reserve Investigation Area – This investigation area lies in the Hawkesbury LGA in the north of the Plan Area, to the east of Londonderry and covers about 600 hectares. It has been identified as a potential area for conservation and ecological restoration efforts due to its proximity to several existing nature reserves

These reserve locations are not final and are likely to be refined. Other areas within the SCAs have also been identified for further investigation as future reserves to provide greater landscape connectivity, such as the Bargo area.

COMPREHENSIVE MONITORING AND REPORTING ON IMPLEMENTATION, WITH ADAPTIVE RESPONSES AS NEEDED

Why is this necessary for effective implementation?

Monitoring, evaluation, reporting and improvement through adaptive management (MERI) is essential for ensuring implementation of the Plan is effective, transparent and accountable. MERI enables key stakeholder, such as regulators and the public, to understand:

- How efficiently and effectively the Plan is being implemented
- Whether the Plan's outcomes are being achieved
- Adaptive improvements in implementation to better achieve the outcomes

What is required to achieve this?

To achieve this, the Plan needs to include:

- A clear commitment to MERI
- A MERI framework underpinned by a program logic
- Clarity on scope and timing of monitoring, reporting and evaluations
- Evaluation of outcomes not just 'outputs'
- Clarity on when and how adaptive management will be implemented
- A plan for implementing the MERI framework supported by funding

Is the Plan consistent with what is required?

A clear commitment to MERI/adaptive management

The Plan includes a commitment to implement a monitoring, evaluation and reporting program consistent with an overall MERI framework described in Sub-Plan A (Commitment 27). This commitment is supported by several actions to ensure the MERI framework is implemented effectively. The MERI framework provides for:

- Monitoring of the delivery of actions and commitments and achievement of outcomes
- Evaluation of the Plan at annual and 5-yearly intervals to inform adaptive management responses
- Public reporting on progress in delivering the Plan

A MERI framework underpinned by a program logic

The MERI framework has been developed on the basis of the program logic underpinning the Plan (see Chapter 5). The program logic describes broadly how the Plan will be implemented and how the commitments and actions are expected to lead to the Plan's outcomes. Developing the MERI framework on the basis of the program logic helps to:

- Clearly articulate assumptions underpinning the Plan (e.g. that action X leads to the delivery of commitment Y, which leads to the achievement of outcome Z)
- Determine robust Key Evaluation Questions (for evaluations) and Key Performance Indicators (for monitoring)
- Inform evaluations and adaptive improvements to implementation of the Plan

Clarity on scope and timing of monitoring, reporting and evaluations

Sub-Plan A sets out the scope and timing of monitoring, reporting and evaluations (see also Chapter 9).

Monitoring will be undertaken regularly throughout implementation of the Plan to inform the evaluations and will include monitoring of commitments and actions as well as outcomes, including monitoring and assessment of changes to biodiversity values at specific locations to determine whether the commitments and actions are effective.

Evaluations will be undertaken on an annual and 5-yearly basis over the life of the Plan and not just at the end of implementation. This is important for effective MERI so there is scope for adaptive management of the Plan, if necessary, to ensure commitments and outcomes are met. The evaluations will aim to:

- Determine the effectiveness of commitments and actions to deliver outcomes
- Reconsider assumptions made as part of the program logic
- Determine the influence of external factors outside the control of the Plan
- Inform any necessary adaptive management decisions to the implementation of the Plan

Reporting will include:

- An annual update on the delivery of the commitments and actions, including program revenue and expenditure
- A fire-yearly independent review on the status of the Plan, its delivery and interim outcomes, based on evaluations

Evaluation of outcomes not just 'outputs'

The purpose of an evaluation is to determine how well the Plan is being delivered and to provide a trigger point and basis for adaptive management of the Plan. An evaluation should include analysis of the achievement of outcomes, as well as the delivery of commitments and actions, because outcomes are what key stakeholders, including regulators and the public, are most interested in understanding. Evaluating outcomes also enables:

- Assumptions underpinning the program logic to be tested
- Effectiveness of the delivery of commitments and actions to be evaluated

An evaluation should also go beyond merely determining whether commitments or actions are being delivered or outcomes are being achieved, and should ask:

- If outcomes are not being delivered, why?

- How efficiently and effectively are commitments and actions being delivered?

Consistent with best practice, the Plan includes two types of evaluations:

- Evaluation of program implementation (or delivery of commitments and actions)
- Evaluation of program impact (or effectiveness and efficiency of the achievement of outcomes)

The Plan will undertake these evaluations on the basis of Key Evaluation Questions. A set of draft evaluation questions have been prepared for each evaluation type (Sub-Plan A, Appendix F).

Clarity on when and how adaptive management will be implemented

Adaptive management is critical for effective implementation given the Plan is inherently subject to uncertainty and assumptions. Key elements of good adaptive management are:

- Clearly defining outcomes
- Undertaking regular data collection/monitoring to track progress
- Completing regular evaluations to investigate cause and effect, efficiency and effectiveness, and test assumptions
- Establishing programs of research to test and improve management interventions

The Plan includes each of these key elements to enable effective adaptive management (see above).

Adaptive management under the Plan will use data from monitoring and the findings of program evaluations to determine whether actions need to be revised to more effectively achieve the commitments and outcomes.

Where an evaluation indicates a commitment or outcome is not being effectively and efficiently delivered or achieved, the Plan specifies that this will trigger a detailed review of implementation. This will be carried out by the relevant delivery agency for that particular project or program, in partnership with the Department.

The Plan specifies that adaptive responses may be triggered where:

- Offset targets are not being met
- External factors arise that affect the assumptions, logic or delivery of the Plan

The adaptive management steps to be taken where offset targets are not being met are described above.

A plan for implementing the MERI framework supported by funding

The Plan includes an action under Commitment 26 to finalise the evaluation program in consultation with key stakeholders, including:

- Establishing governance arrangements for the evaluation program
- Developing a monitoring and data collection method
- Finalising evaluation questions including scope and frequency
- Finalising the reconciliation accounting process (see above)
- Developing templates for reporting quarterly to the executive implementation steering committee and annual updates over the life of the Plan. Identify key performance indicators for biodiversity conservation

This action will provide clarity about how the MERI program will be delivered, including important matters such as what Key Performance Indicators will be used for monitoring, how monitoring will be undertaken data collected, and the frequency and locations (where appropriate) of monitoring for each indicator.

The Plan includes a commitment to establish funding for implementation (see above). Details of how much funding will be set aside to implement the monitoring, evaluation and reporting program will clarified in consultation with the Trust administering the funds under the Plan during early implementation of the Plan.

41.11.3 CONCLUSION

The Plan includes the key elements that are considered to be important for effective delivery and to achieve its intended outcomes. In particular, the Plan provides:

- Clear and feasible outcomes
- Clarity about the delivery framework and mechanisms to implement the Plan
- Appropriate flexibility to ensure it remains relevant over time
- Clear governance arrangements, including certain funding
- Comprehensive processes to monitor and report on implementation, and adapt implementation as needed

It is important to note that the Plan and subplans are high level documents providing an overarching framework and assurance processes for implementing the Plan, and that successful implementation relies on considerable further work being done during the early stages of implementation to sort out details. This is appropriate because it allows detailed consideration of complex issues, seeking of expert advice, and comprehensive engagement with stakeholders.

The Plan provides a clear framework for this future implementation work by identifying a set of actions that will be undertaken to deliver each commitment within a program logic framework.

41.12 THEME 9: DOES THE PLAN FACILITATE ADAPTATION TO CLIMATE CHANGE?

41.12.1 CONTEXT AND METHOD

The ToR (Section 4.6(5) and 5.3(1)) requires analysis of the extent to which the Plan considers, and the commitments under the Plan facilitate, adaptation of biodiversity to climate change.

The extent and nature of the impacts of climate change on specific biodiversity values is difficult to predict. There is a lack of information about how specific matters are likely to respond to climate change, and there is debate and uncertainty over how to best facilitate adaptation. Given this, the evaluation was undertaken in two main ways:

- A qualitative evaluation using a set of broad principles derived from the scientific literature on how to best manage the impacts and facilitate adaptation of biodiversity to climate change
- A quantitative evaluation using a recent study by Macquarie University that modelled changes to future habitat suitability on the Cumberland Plain for some Commonwealth listed species under several climate change scenarios

The qualitative evaluation was done to complement the quantitative evaluation because quantitative data is not available for all Commonwealth listed TECs and species and there are limitations associated with this data.

MACQUARIE UNIVERSITY STUDY

Scope of the study

The quantitative evaluation was based on a study by Macquarie University (Macquarie University, 2019) that modelled how climate change will affect the suitability of habitat for 92 Cumberland subregion species, including 23 Commonwealth listed Category 1 matters, under several different climate change scenarios. The study:

- Assessed the change in extent and location (losses and gains) of currently suitable habitat for each species under future climate changes. This helps to:
  - Understand how the availability of suitable habitat for a species may change in the future
  - Identify the species particularly vulnerable to climate change in terms of loss of habitat
- Determined the extent to which currently suitable habitat will remain suitable under future climate changes for each species. These areas represent climate refugia for those species
- Identified localities that are likely to remain suitable for multiple species under future climate changes. These areas represent climate refugia likely to be most robust to climate change for multiple species

Species Distribution Models (SDMs) were used to predict habitat suitability for species. The SDMs were developed specifically for the Macquarie University Study and are different to the SDMs used in the species impact assessments in this Assessment Report. The SDMs were developed on the basis of seven climate and environmental variables relating primarily to temperature and precipitation. For some species, additional environmental variables were used relating to soils, weathering and topography.

Changes to suitable habitat are discussed in the study in terms of total and local suitable habitat:

- Local suitable habitat is the area of suitable habitat within an IBRA subregion that contains records for the species. This reflects an assumption that the ability for a species to disperse into areas of future suitable habitat is limited to within IBRA subregions that are already populated by the species
- Total suitable habitat is the total area of suitable habitat for a species (ignoring current records). This reflects an assumption that the ability for species to disperse into areas of future suitable habitat is unlimited

Climate scenarios modelled

The study was based on four NARCliM climate scenarios that were modelled on an assumed emissions scenario (SRES A2) (see Table 41-28). The project modelled climate scenarios over three time periods:

- Baseline climate (1990–2009)
- Near-future (2020–2039)
- Distant future (2060–2079)

Table 41-28: Climate scenarios projected by four Global Climate Models

Scenario	Global Climate Model	Summary of future climate
Warmer/Wetter	MIROC3.2(medres)	Warmer and wetter than present, particularly in north eastern NSW, although alpine regions are projected to become drier
Hotter/Little Change	ECHAM5/MPI-OM	Has the greatest increase in temperature of the four scenarios. Precipitation trend varies across the state (slightly wetter in the north eastern and coastal regions, slightly drier elsewhere)
Hotter/Wetter	CCCMA CGCM3.1(T47)	Warmer than MIROC, and wetter across most of the state, although areas in the northwest and southeast of the state may be slightly drier
Warmer/Drier	CSIRO-Mk3.0	Warmer than present, and the driest of the four models

Key limitations of the study

The study is subject to several limitations. A key limitation is that the SDMs were not informed by the current extent of native vegetation and habitat in the Cumberland subregion. This means they may predict that suitable habitat occurs in areas that no longer contain native vegetation or habitat because of land clearing or urban development.

The study is useful in providing a broad indication of the adequacy of the Plan in facilitating adaptation to climate change. However, the results, particularly in relation to predicting areas in the Cumberland subregion likely to remain suitable for species under future climate changes, must be considered in the context of actual on-ground circumstances.

41.12.2 ANALYSIS

QUALITATIVE ANALYSIS

This section outlines a general set of key principles drawn from the scientific literature on how to best facilitate adaptation of biodiversity to climate change and analyses the Plan against these principles to help evaluate the extent to which the Plan is likely to facilitate adaptation of biodiversity to climate change.

Principles for managing biodiversity under climate change

The goal of adaptation can be defined as reducing the risk of adverse impacts by enhancing the 'resilience' or 'resistance' of ecosystems to change. Resilience strategies attempt to enhance a systems ability to recover from change, while resistance strategies attempt to enhance a systems ability to resist change (Heller & Zavaleta, 2009).

Scientists and practitioners have proposed a wide range of principles or strategies to manage the impacts of climate change on biodiversity (Heller & Zavaleta, 2009). A set of commonly recommended key principles can be derived from the literature. These principles are:

- Ensure representativeness and replication
- Protect the largest and most viable patches
- Maintain and improve habitat connectivity
- Reduce the impacts of other threats
- Manage uncertainty through adaptive management

Most of these principles are consistent with general conservation planning principles, and scientists often argue that many conservation planning principles remain robust under a changing climate (e.g. see Hodgson, Thomas, Wintle and Moilanen, 2009). Despite this, in identifying this set of key principles, it is recognised that:

- There is considerable uncertainty about the how climate change will impact biodiversity and the best ways to facilitate adaptation of biodiversity to climate change
- Measures to facilitate adaptation of biodiversity to climate change are likely to be regional and species-specific
- There may not be scientific consensus on all of these key principles and the relative importance of each
- There is much uncertainty about how each of the key principles should be applied in practice

Ensure representativeness and replication

Representativeness and replication are well established principles of conservation planning. Representation refers to the need to protect the full range of biodiversity (e.g. vegetation types). Replication refers to the need to protect multiple examples of each unit of biodiversity to order to spread risk (Margules & Pressey, 2000).

These two principles will continue to be important in facilitating adaptation of biodiversity to climate change (Dunlop & Brown, 2008; Heller & Zavaleta, 2009). Dunlop and Brown argue:

> *By sampling a diversity of communities…[we] are also sampling the underlying geographic diversity of the landscape…Thus, a set of areas that samples a high diversity of communities now will probably also capture a high diversity of communities under future climates, even if the composition of the communities is different in the future*

The extent to which the SCAs include a representative sample of each PCT in the Plan Area (including PCTs impacted by the development), and contribute to total representativeness within protected lands in the Plan Area, is assessed in Section 41.6 (see Table 41-17). The analysis indicates that the SCAs:

- Include all but 2 of the 32 PCTs in the Plan Area
- Contribute to total representation within protected lands in the Plan Area of greater than 15 per cent for all but 3 PCTs
- Have the potential to make a substantial contribution to existing levels of representation of PCTs in the Plan Area, including to many PCTs that are currently under-represented in existing reserves

Protect the largest and most viable patches

Another well-established principle of conservation planning is to focus conservation efforts on protecting and restoring large patches. There are well established relationships between the size of a patch of native vegetation and the size and persistence of populations, species richness, species dispersal, genetic diversity, persistence of large vertebrates, maintenance of near-natural disturbance regimes, and other important ecological functions (Hodgson, Thomas, Wintle and Moilanen, 2009; Lindenmayer et al., 2008; Margules & Pressey, 2000).

Scientists argue this principle will continue to be important in facilitating adaptation of biodiversity to climate change. Because habitat loss remains the key threat to biodiversity and relationships between patch size and biodiversity value is well-established, protecting areas of high quality native vegetation and habitats should remain the primary focus of conservation efforts under climate change (Heller & Zavaleta, 2009; Hodgson, Thomas et al., 2009).

The extent to which the SCAs include large (> 50 ha) and moderate (> 20 ha) patches is assessed in Section 41.7 (see Table 41-21 and Table 41-22). The analysis indicates that the SCAs protect substantial areas of large patches, as:

- Approximately 87 per cent of the total area of native vegetation in the SCAs comprises patches > 50 ha
- The SCAs contain about 35 per cent of the total area of patches > 50 ha in the Plan Area

Habitat connectivity

Maintaining and improving habitat connectivity is often considered the most important strategy to manage the impacts of climate change on biodiversity (Dunlop & Brown, 2008; Heller & Zavaleta, 2009). Despite this, there is much uncertainty about the importance of habitat connectivity in managing the impacts of climate change. Some scientists argue that other, more certain strategies, such as protecting the largest patches of high quality native vegetation, should be prioritised over habitat connectivity (Hodgson, Thomas et al., 2009):

> *As uncertainties about connectivity tend to be high, and increases in habitat quantity and quality coincidentally improve connectivity, we conclude one should generally provide higher weight in decision-making to actions that increase area and quality [of habitat] Theoretically, we know that populations will sometimes benefit more from a small, well-connected piece of habitat than a larger, more isolated one, but the relative uncertainties and the probability of worse-than-expected outcomes [from improving habitat connectivity] should also affect our decision making…*

The extent to which the SCAs include the most important areas of habitat connectivity in the Cumberland subregion (BioMap core areas and BioMap corridors – see Section 41.7) is assessed in Section 41.6 and Section 41.7. The analysis indicates that the SCAs protect substantial areas of BioMap core areas and corridors, including:

- Approximately 32 per cent of the total BIOMap core areas in the subregion
- Approximately 28 per cent of the total BIOMap corridors in the subregion

The SCAs are therefore likely to make a substantial contribution to supporting habitat connectivity across the subregion.

It is also important to note that habitat connectivity was a key factor influencing the location of the SCAs (see Chapter 8). Priority was given to including areas that were adjacent to and connecting other patches of habitat, including existing reserves, and that could form broad habitat corridors across the landscape.

The SCAs were also located to provide connectivity outside the Cumberland subregion, including to existing reserves in the Blue Mountains to the west of the subregion, and existing reserves and protected water catchments to the south-east and south-west (see Chapter 8). This potentially enables more mobile species to shift to higher elevations (e.g. the Blue Mountains) or south to cooler climates in response to climate change. Large-scale corridors that span climatic gradients such as provided by the SCAs can enhance the capacity of species to shift to more favourable areas, allowing species to respond to shifting climates' (Adaptation Research Network Terrestrial Biodiversity, 2017).

Reduce the impacts of other threats

Some scientists argue that given the uncertainty about the impacts of climate change on biodiversity and how best to facilitate adaptation, focusing on reducing key existing threats to biodiversity provides a robust strategy to address climate change. For example, Steffen et al (Steffen, Burbidge et al., 2009) state:

> *A central strategy is giving ecosystems the best possible chance to adapt by enhancing their resilience. Approaches to building resilience include managing appropriate connectivity of fragmented ecosystems…* [and] *implementing more effective control of invasive species, and developing appropriate fire and other disturbance management regimes*

The Plan recognises that the effective management of landscape scale threats is critical to the success of the conservation program under the Plan and in managing the impacts of climate change on biodiversity. The Plan includes a range of commitments to reduce threats to conservation lands secured within SCAs. These are discussed in Section 41.7.

Address uncertainty through adaptive management

Adaptive management is an iterative process that seeks to improve management over time by testing hypotheses and learning from the results, and then incorporating lessons learnt into future management actions.

Many scientists argue that given the uncertainty about the impacts of climate change on biodiversity and how best to facilitate adaptation, management within an adaptive framework will be critical to facilitating adaption.

The Plan will be implemented adaptively to ensure the commitments and actions are delivered and the outcomes are achieved efficiently and effectively. Adaptive management will be triggered on the basis of the findings of the evaluations undertaken as part of the monitoring, evaluation and reporting program under the Plan.

The approach to adaptive management under the Plan is described in Chapter 9 and evaluated in Section 41.11.

QUANTITATIVE ANALYSIS

The quantitative analysis, based on the Macquarie University study (Macquarie University, 2019), was used to identify the Commonwealth listed species most vulnerable to climate change, as well as determine the extent to which the SCAs contain suitable habitat for these species and refugia for multiple species under future climate changes.

Species most vulnerable to climate change

The Macquarie University study modelled the change in the area of 'currently occupied' suitable habitat across the Cumberland subregion and NSW under the different climate scenarios. 'Occupied habitat' means the proportion of the climatically suitable habitat that is also found within a subregion for which there are records.

Table 41-29 shows the results of the study for the 23 Commonwealth listed Category 1 species. The table shows the area of 'occupied' suitable habitat remaining at 2030 and 2070 that is predicted to remain suitable under all climate scenarios (i.e. there is consensus across all climate scenarios that the area remains suitable).

The table also indicates that climate change may have substantial impacts on suitable habitat for the vast majority of Commonwealth listed Category 1 species. Of the 23 Category 1 species modelled:

- The majority are predicted to have no suitable habitat remaining in the Cumberland subregion at 2070
- The vast majority are predicted to be subject to substantial declines of greater than 50 per cent in suitable habitat within NSW by 2030 and by 2070

The species likely to be most vulnerable to climate change were defined for this assessment as species with less than 100 km^2 of 'occupied' suitable habitat remaining at 2030 across NSW. These species are highlighted in blue and are:

- *Eucalyptus benthamii*
- *Leucopogon exolasius*
- *Micromyrtus minutiflora*
- *Persoonia bargoensis*
- *Persoonia nutans*
- *Pomaderris brunnea*
- *Pultenaea parviflora*

Table 41-30 identifies the risk of impacts of the Plan on these seven species and the commitments under the Plan relevant to each species, drawing on the assessments in this Assessment Report (see Chapter 29).

The table shows that the risk of impacts of the Plan on these species is generally considered to be very low or low.

The Plan includes commitments to secure offset locations for *Personnia nutans* and *Pultenaea parviflora* and substantial areas of potential habitat for each of these seven species through meeting offset targets for Plant Community Types (PCTs) – see Section 41.5) in conservation lands within the SCAs.

Given the low risk of impacts to most of these species, the specific offsets being provided for the two higher risk species, and the consistency of the SCAs with adaptation principles (see above), it is considered that the commitments are adequate to facilitate adaptation to climate change for these species.

Table 41-29: Predicted impacts of climate change on currently 'occupied' habitat at 2030 and 2070 under all climate scenarios

		Habitat in Cumberland subregion		Habitat within NSW				
Species	**Status**	**Current habitat (km²)**	**Predicted habitat at 2070 (km²)**	**Current habitat (km²)**	**Predicted habitat at 2030 (km²)**	**Predicted % habitat remaining at 2030**	**Predicted habitat at 2070 (km²)**	**Predicted % habitat remaining at 2070**
Acacia bynoeana	EN	17.9	9.6	10,379	5,916	57%	3,529	34%
Acacia pubescens	V	16.8	1.8	3,828	842	22%	421	11%
Anthochaera phrygia	CE	21.0	0.0	198,185	126,838	64%	120,893	61%
Botaurus poiciloptilus	EN	14.9	0.0	217,443	36,965	17%	32,616	15%
Commersonia prostrata	EN	10.1	0.0	5,858	351	6%	176	3%
Dasyurus maculatus	V	8.8	0.0	135,878	74,733	55%	40,763	30%
Eucalyptus benthamii	V	7.7	0.0	1,244	0	0%	0	0%
Genoplesium baueri	EN	0.9	0.8	2,217	1,751	79%	1,751	79%
Heleioporus australiacus	V	4.4	0.1	22,399	5,152	23%	3,584	16%
Lathamus discolor	EN	0.7	0.0	39,770	15,510	39%	12,329	31%
Leucopogon exolasius	V	5.5	0.0	1,972	0	0%	0	0%
Litoria aurea	EN	20.3	0.0	21,568	2,157	10%	647	3%
Melaleuca deanei	V	8.3	1.1	6,793	2,174	32%	1,087	16%

		Habitat in Cumberland subregion		Habitat within NSW				
Species	**Status**	**Current habitat (km²)**	**Predicted habitat at 2070 (km²)**	**Current habitat (km²)**	**Predicted habitat at 2030 (km²)**	**Predicted % habitat remaining at 2030**	**Predicted habitat at 2070 (km²)**	**Predicted % habitat remaining at 2070**
Melaleuca deanei	V	8.3	1.1	6,793	2,174	32%	1,087	16%
Micromyrtus minutiflora	EN	3.4	0.0	349	0	0%	0	0%
Persoonia bargoensis	EN	2.4	0.0	342	0	0%	0	0%
Persoonia glaucescens	EN	1.1	0.0	1,214	304	25%	0	0%
Persoonia hirsuta	EN	19.7	0.1	8,659	1,126	13%	433	5%
Persoonia nutans	EN	8.0	0.0	844	0	0%	0	0%
Pimelea curviflora var. *curviflora*	V	6.5	0.6	3,376	675	20%	473	14%
Pimelea spicata	EN	19.2	0.0	2,012	262	13%	40	2%
Pomaderris brunnea	EN	19.8	0.0	6,943	0	0%	0	0%
Pteropus poliocephalus	V	26.9	24.7	59,602	46,490	78%	46,490	78%
Pultenaea parviflora	EN	7.0	0.0	728	80	11%	0	0%

Table 41-30: Impacts of Plan and relevant commitments for species predicted to be most vulnerable to climate change

Species	Risk of impacts	Relevant commitments under the Plan	Amount of potential habitat in SCAs (ha)
Eucalyptus benthamii	Low risk	No specific offset target	1,495 ha
Leucopogon exolasius	No risk	No specific offset target	132 ha
Micromyrtus minutiflora	Very low risk	No specific offset target	3,818 ha
Persoonia bargoensis	Low risk	No specific offset target	5,174 ha
Persoonia nutans	Medium risk	2 offset locations	1,617 ha
Pomaderris brunnea	Low risk	No specific offset target	7,606 ha
Pultenaea parviflora	High risk	2 offset locations	1,371 ha

Suitable habitat for species in Cumberland subregion

Table 41-31 shows the predicted area of 'occupied' suitable habitat within SCAs at 2070 under all climate scenarios for the 23 Commonwealth listed Category 1 species. The species likely to be most vulnerable to climate change (as defined above) are highlighted in blue in the table. The table shows that:

- The majority of species are predicted to not have any suitable habitat remaining in Cumberland subregion at 2070
- The SCAs are predicted to contain suitable habitat for five of the 23 Commonwealth listed Category 1 matters at 2070
- The SCAs do not contain any suitable habitat for the species most vulnerable to climate change (highlighted in blue). However, none of these species are predicted to have any suitable habitat remaining in the subregion at 2070

Table 41-31: Predicted area of 'occupied' suitable habitat within SCAs at 2070 under all climate scenarios

Species	Status	Predicted habitat at 2070 in Cumberland subregion (ha)	Predicted habitat at 2070 in SCAs (ha)
Acacia bynoeana	EN	96,300	2,400
Acacia pubescens	V	18,000	200
Anthochaera phrygia	CE	0	0
Botaurus poiciloptilus	EN	100	0
Commersonia prostrata	EN	0	0
Dasyurus maculatus	V	0	0
Eucalyptus benthamii	V	0	0
Genoplesium baueri	EN	8,100	0
Heleioporus australiacus	V	800	0
Lathamus discolor	EN	0	0
Leucopogon exolasius	V	0	0
Litoria aurea	EN	300	0
Melaleuca deanei	V	10,600	1,900

Species	Status	Predicted habitat at 2070 in Cumberland subregion (ha)	Predicted habitat at 2070 in SCAs (ha)
Melaleuca deanei	V	10,600	1,900
Micromyrtus minutiflora	EN	0	0
Persoonia bargoensis	EN	0	0
Persoonia glaucescens	EN	0	0
Persoonia hirsuta	EN	700	300
Persoonia nutans	EN	0	0
Pimelea curviflora var. *curviflora*	V	5,700	0
Pimelea spicata	EN	0	0
Pomaderris brunnea	EN	0	0
Pteropus poliocephalus	V	246,600	19,200
Pultenaea parviflora	EN	0	0

Refugia for multiple species in Strategic Conservation Areas

The study identified the localities in the Cumberland subregion that are likely to continue to have suitable climates for multiple threatened species under all climate scenarios. These are called 'high value' refugia and are particularly valuable for conservation as they represent the areas that are most likely to be robust to climate change.

High value refugia were identified in the study by combining maps for each species of 'occupied' suitable habitat that remains suitable under all climate scenarios, and calculating the number of species for which each map cell was suitable.

Table 41-32 show the extent to which the SCAs contain potentially suitable habitat for multiple species (of the 92 species modelled in the study) under all climate scenarios ('high value refugia'). The figures shown in the table are not additive (e.g. row 1 means that there is a total of 4,300 ha of habitat in the SCAs that is suitable for all 9 species).

The table shows:

- Some localities in the Cumberland subregion retain potentially suitable habitat (a total 100 ha) under all climate scenarios for up to a maximum of 22 of the 92 modelled species
- The SCAs include localities that retain considerable areas of potentially suitable habitat (a total of 4,300 ha) under all climate scenarios for multiple species (a maximum of 9 species)

Table 41-32: Extent to which SCAs contain habitat for multiple species under all climate scenarios

Number of species	Area of habitat in Cumberland subregion suitable for that number of species (ha)	Area of habitat in SCAs suitable for that number of species (ha)	Percentage of total habitat in Cumberland subregion included in SCAs (%)
9	34,800	4,300	12%
15	18,300	700	4%
22	100	0	0%

41.12.3 CONCLUSION

The extent and nature of the impacts of climate change on specific biodiversity values is difficult to predict. There is a lack of information about how specific matters are likely to respond to climate change, and there is debate and uncertainty over how to best facilitate adaptation of biodiversity to climate change.

- Protect the largest and most viable patches
- Maintain and improve habitat connectivity
- Reduce the impacts of other threats
- Manage uncertainty through adaptive management

The quantitative analysis, which was based on the Macquarie University study, suggests that climate change will significantly impact the availability of suitable habitat in the Cumberland subregion for the vast majority of the 92 modelled Commonwealth-listed species.

The risk of impacts of the Plan on the seven species identified as being most vulnerable to climate change is generally considered to be low. In the context of this risk, and given the consistency of the SCAs with adaptation principles, it is considered that the commitments under the Plan are adequate to facilitate adaptation to climate change for these species.

While the SCAs are predicted to only contain suitable habitat for five of the 23 Commonwealth listed Category 1 matters at 2070, the majority of species are predicted to not have any suitable habitat remaining in Cumberland subregion.

It is important to note that the Macquarie University study is subject to several key limitations. This means the results must be considered in the context of actual on-ground circumstances, including whether areas predicted to retain suitable habitat under future climate changes have not been cleared and still contain habitat.

41.13 CONCLUSION

It is considered that the Plan will deliver substantial conservation outcomes for the Cumberland subregion and adequately addresses the likely impacts of the urban, industrial, infrastructure, agribusiness and transport development on biodiversity values and other protected matters under the BC Act and EPBC Act.

The Plan is broadly consistent with the 'draft guidelines for planning authorities' (EES, 2019) and the requirements in the Commonwealth Terms of Reference relating to evaluating the commitments. In particular, the Plan:

- Is broadly consistent with the principles of ESD
- Has achieved substantial avoidance outcomes for biodiversity values, including avoiding 95 per cent of all high (intact) condition) native vegetation, and has adequately avoided SAII entities
- Includes commitments that:
    - Adequately address the biodiversity values being impacted
    - Address the most important biodiversity values, particularly the most threatened matters
    - Are considered likely to improve values and ecological function in the long-term
    - Are additional to existing requirements
    - Involve development controls that conserve the environment
    - Involve new reserves generally consistent with the CAR reserve framework
    - Are likely to be effectively implemented and ensure outcomes are certain
    - Are consistent with key principles for facilitating adaptation of biodiversity to climate change

In concluding that the Plan adequately addresses the impacts of the development, it is important to note that the Plan's commitments are not driven solely by meeting the biodiversity credit requirements of the BAM, which is a key part of the definition of 'no net loss' under the BAM. This is consistent with the BC Act. For strategic biodiversity certifications such as the Plan, the Act does not require the value of commitments be calculated in terms of credits. This recognises that strategic biodiversity certification provides significant opportunities to maximise benefits to biodiversity and address landscape scale conservation challenges that are not provided by site-by-site assessment processes.

The key commitments under the Plan have been developed in recognition of these potential benefits, including:

- Focusing the conservation program, including offsets, on the areas of the landscape considered most likely to be viable in the long-term and maximise ecological function and connectivity across the landscape
- Addressing ecological function and landscape-scale ecological processes through improving habitat connectivity and undertaking ecological restoration in priority parts of the landscape
- Implementing programs to manage threats at a landscape scale that can benefit multiple species and TECs

- Focusing the conservation program, including offsets, on the areas of the landscape considered most likely to be viable in the long-term and maximise ecological function and connectivity across the landscape
- Addressing ecological function and landscape-scale ecological processes through improving habitat connectivity and undertaking ecological restoration in priority parts of the landscape
- Implementing programs to manage threats at a landscape scale that can benefit multiple species and TECs
- Consolidating offsets into larger patches that are likely to be more viable in the long term

Furthermore, modelling work undertaken as part of the Assessment Report that looked at trends in native vegetation extent and condition in the subregion (see Supporting Document D) demonstrated that the existing level of landscape threats is significant and is likely to lead to substantial declines in native vegetation over time unless action is taken. The Plan's commitments will help to address this ongoing decline by ensuring large areas in the landscape are secured and managed in perpetuity and through programs to manage landscape threats.

A key implication of the modelling work for the Plan is that offsets should be established as early as possible to help reverse the trend of decline. This is addressed to a large extent under the Plan through the NSW Government committing to fund the first five years of implementation of the Plan and prioritising the establishment of three new reserves (the Georges River Koala Reserve, the Gulguer Reserve Investigation Area, and the Confluence Reserve Investigation Area) to deliver early strategic offsets to protect TECs and species habitat.

Part 7 References

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OPENLINES
Environmental consulting

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

PART 8: SUPPORTING DOCUMENTS

PREPARED FOR THE NSW GOVERNMENT DEPARTMENT OF PLANNING, INDUSTRY AND ENVIRONMENT

Part 8 – Contents

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document A – EPBC agreement and ToR

THE HON MELISSA PRICE MP
MINISTER FOR THE ENVIRONMENT

MS18-001422

The Hon Anthony Roberts MP
NSW Minister for Planning
52 Martin Place
SYDNEY NSW 2000

12 NOV 2018

Dear Minister Roberts

Thank you for your letter of 18 October 2018, providing the statutory Agreement to undertake a strategic assessment under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999* for Western Sydney, signed by yourself and Minister Upton.

I am writing to inform you that I have counter-signed the Agreement and have enclosed a copy for your records. I understand that you and Minister Upton will now invite public comments on the draft Terms of Reference for the assessment.

I look forward to the assessment proceeding, and to working with you to ensure good environmental outcomes from this important commitment under the Western Sydney City Deal.

Yours sincerely

MELISSA PRICE

CC: Minister for Cities, Urban Infrastructure and Population, the Hon Alan Tudge MP

ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (Cth)

Part 10 Strategic Assessment

Section 146 agreement

Strategic Assessment of the impacts of actions taken under
the *Cumberland Plain Conservation Plan*
on matters protected by Part 3 of the EPBC Act

between

THE COMMONWEALTH MINISTER FOR THE ENVIRONMENT

and

THE STATE OF NEW SOUTH WALES

Table of Contents

1. Parties

1.1 The parties to this agreement are:

the Commonwealth Minister for the Environment

and

The State of New South Wales, represented by the Minister for Planning and the Minister for the Environment.

2. Definitions

2.1 Unless the context indicates otherwise in this agreement, the definitions, meanings and terms in the EPBC Act apply to this agreement including its attachments.

2.2 In this agreement:

agreement means this strategic assessment agreement entered into between the **parties** on the date the last party executes this agreement, and includes any attachments.

attachment means an attachment to this agreement.

Commonwealth Environment Department means the Commonwealth Department with responsibility for administering the EPBC Act from time to time.

Commonwealth Minister means the Commonwealth Minister with responsibility for administering the EPBC Act, and includes a delegate of the Minister.

DPE means the New South Wales Department of Planning and Environment.

EPBC Act means the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Impact means an impact as defined under section 527E of the EPBC Act and includes impacts from an event or circumstance as a result of implementation of the Plan on areas outside the strategic assessment area.

Impacts to which this agreement relates means the impacts of actions under the Plan on any matter protected by a provision of Part 3 of the EPBC Act.

OEH means the New South Wales Office of Environment and Heritage.

Parties means the parties to this agreement as set out at clause 1.

Plan means the *Cumberland Plain Conservation Plan* which will be prepared pursuant to clauses 4 and 6 of this agreement and which constitutes a 'policy, plan or program' pursuant to section 146 of the EPBC Act. The actual name of the Plan may change prior to submission for endorsement under the EPBC Act.

Protected matter means a matter protected under Part 3 of the EPBC Act.

State means the State of New South Wales.

Strategic assessment area means the indicative area of the Cumberland Plain as shown in the map at **Attachment 1**. The final strategic assessment area will be agreed between the State and Commonwealth.

Strategic Assessment Report means the report describing and assessing the impacts of actions under the Plan on protected matters, as contemplated by section 146(2)(a) of the EPBC Act, and prepared under clauses 5 and 6 of this agreement.

Supplementary Report means a report which includes:

a) a summary of all the public comments received; and

b) sets out how comments have been addressed through modification/s to the Plan or Strategic Assessment Report, if any, following public exhibition of the draft Strategic Assessment Report and draft Plan.

Terms of Reference means the terms of reference for the Strategic Assessment Report prepared under clause 5 of this agreement.

In this agreement references to the singular include the plural.

3. Context and scope

3.1 Under the Western Sydney City Deal, the Commonwealth, the State of NSW and a number of local councils have committed to working together to improve the lives of the people of Western Sydney through better transport, improved housing supply and affordability, better access to jobs and improved environmental outcomes.

3.2 The Parties acknowledge that the Cumberland Plain of Western Sydney has important environmental values that must be considered alongside the economic and social benefits of development of the region, and that a landscape approach to planning may benefit the environment.

3.3 The Parties agree to reduce duplication and streamline regulatory processes through alignment of a strategic assessment under Part 10 of the EPBC Act with an application for biodiversity certification under the NSW *Biodiversity Conservation Act 2016*. This may include conducting parallel public consultation periods and producing consolidated assessment documentation that satisfies regulatory processes of both jurisdictions.

3.4 The Parties agree to undertake a strategic assessment of the impacts of actions under the *Cumberland Plain Conservation Plan* (the Plan), currently being prepared by the State of NSW, on all matters protected under Part 3 of the EPBC Act.

3.5 The Plan will aim to provide for development over approximately 38 years within the boundary of the strategic assessment area. The Plan may include consideration of residential, commercial and industrial developments, and supporting infrastructure including major transport corridors for future roads.

3.6 The Parties agree to share information and work collaboratively throughout the strategic assessment.

4. Development of the Plan

4.1 The Parties agree that the State will develop a Plan that will seek to maximise conservation of protected matters that occur within, or adjacent to, the agreed strategic assessment area through a landscape approach to environmental conservation.

4.2 The Plan will include, but is not limited to, the identification of areas for development and commitments and outcomes for conservation of protected matters in the agreed strategic assessment area.

4.3 The Plan will include an implementation framework that describes how the commitments for conservation of protected matters set out in the Plan will be achieved. This implementation framework will address the following:

a) how outcomes and commitments for protected matters will be documented, delivered and adequately resourced throughout the life of the Plan; and

b) a framework for adaptive management, review of the effectiveness of the implementation in meeting the objectives for protected matters over time, and provision of a 5 yearly assurance report.

4.4 The Plan may include additional content relating to other responsibilities of the State.

4.5 The Plan will clearly identify and address protected matters separately from other State matters and ensure that, to the extent consistent with applicable NSW laws, the 'avoid, mitigate and offset' hierarchy of principles has been applied.

4.6 The State agrees to consult with interested stakeholders on the development of the draft Plan.

5. Terms of Reference for the Strategic Assessment Report

5.1 Pursuant to section 146(1B)(b) of the EPBC Act, the Parties agree to the preparation of Terms of Reference for a Strategic Assessment Report on the impacts of actions under the Plan on protected matters.

5.2 The State must make available for public comment, by notice, the draft Terms of Reference for the Strategic Assessment Report. The State must ensure that, at a minimum, the notice:

a) is posted on the DPE or OEH website;

b) is published in a national newspaper and a state daily newspaper circulating in NSW;

c) mentions:

i. that the draft Terms of Reference are available for public comment;

ii. the provision of the EPBC Act that requires the draft Terms of Reference for the Strategic Assessment Report to be published (i.e. section 146(1B)(b)(ii));

iii. where and how copies may be obtained in an electronic and hard copy form without charge or at a reasonable cost;

iv. contact details for obtaining further information, including reasonable access for persons with special needs; and

d) invites public comment on the draft Terms of Reference for the Strategic Assessment Report for a period of at least 28 calendar days that is specified by the Commonwealth Minister and set out in the notice.

5.3 The Commonwealth Environment Department will make the notice and draft Terms of Reference available electronically on the Commonwealth Environment Department's website.

5.4 The Parties may directly notify any party they think may have an interest in the draft Terms of Reference of the notice in clause 5.2.

5.5 Following consideration by the State of the public comments on the draft Terms of Reference and the making of any revisions by the State, the State will submit to the Commonwealth Minister:

a) any revised draft Terms of Reference; and

b) a copy of all public comments relating to the draft Terms of Reference; and

c) a document summarising whether and how the public comments have been taken into account in the revised draft Terms of Reference.

5.6 If the Commonwealth Minister is satisfied that the revised draft Terms of Reference will provide for a strategic assessment report that adequately addresses the impacts to which this agreement relates, the Commonwealth Minister will notify the Parties that the Terms of Reference can be finalised.

5.7 On receipt from the Commonwealth Minister of a notification under clause 5.6, the Parties must finalise the Terms of Reference.

6. Publication of the Plan and Strategic Assessment Report

6.1 Once the Terms of Reference for the Strategic Assessment Report have been finalised in accordance with clause 5.7, the State must prepare a draft Strategic Assessment Report in accordance with this agreement and the finalised Terms of Reference.

6.2 The State will provide the draft Plan and draft Strategic Assessment Report to the Commonwealth Environment Department for comment prior to both documents being released for public comment under clauses 6.4 - 6.6.

6.3 The Commonwealth Environment Department will assist the State toward ensuring that the draft Strategic Assessment Report adequately addresses the impacts to which this agreement relates by providing comments on the draft Plan in a timely manner.

6.4 Following the completion of the process set out in clauses 6.2 - 6.3 of this agreement, the State must, by notice, make the draft Strategic Assessment Report and draft Plan available for public comment. The State must ensure that, at a minimum, a notice:

a) is posted on the DPE or OEH website;

b) is published in a national newspaper and a state daily newspaper circulating in NSW

c) mentions:

i. that the draft Plan and draft Strategic Assessment Report are available for public comment;

ii. where and how copies may be obtained in an electronic and hard copy form without charge or at a reasonable cost;

iii. contact details for obtaining further information, including reasonable access for persons with special needs;

iv. the address to which public comments should be provided; and

d) invites public comment for a period of at least 28 calendar days that is specified by the Minister in the notice.

6.5 The Parties may separately notify any person, of the notice under clause 6.4 and of the availability of the draft Plan and draft Strategic Assessment Report.

6.6 The Commonwealth Environment Department will make the draft Plan and draft Strategic Assessment Report available electronically on its website.

6.7 Following consideration of any public comments received, the State will prepare, and then submit to the Commonwealth Environment Department for further comment:

a) a copy of all public comments;

b) a revised draft Strategic Assessment Report that takes account of the public comments received (if any);

c) a revised draft Plan that takes account of the public comments received (if any); and

d) a Supplementary Report.

6.8 The Minister is to direct the Commonwealth Environment Department to assist the State in ensuring that the revised draft Strategic Assessment Report adequately addresses the impacts to which this agreement relates by providing comments in a timely manner. The comments provided by the Commonwealth Environment Department may include recommended modifications to the draft Strategic Assessment Report, the draft Plan or both.

6.9 Following consideration of the Commonwealth Environment Department's comments, the State must finalise the revised draft Strategic Assessment Report and the revised draft Plan.

6.10 The State must then submit the following documents to the Commonwealth Minister:

a) the Strategic Assessment Report; and

b) the Plan; and

c) the Supplementary report.

7. Consideration of the Strategic Assessment Report and the Plan

7.1 Following receipt of the Strategic Assessment Report and the Plan in accordance with clause 6 of this agreement, the Commonwealth Minister may make recommendations to the State about the Plan (including recommendations for modification of the Plan).

7.2 The Commonwealth Minister may request any additional information he or she considers necessary in order to consider whether the Strategic Assessment Report adequately addresses the impacts to which this agreement relates.

7.3 If the Commonwealth Minister makes recommendations about the Plan, the State may:

a) seek clarification from the Commonwealth Minister on the recommendations;

b) modify the Plan to give effect to the Commonwealth Minister's recommendations; or

c) modify the Plan in a manner that has the same effect as the modifications recommended by the Commonwealth Minister.

7.4 If the State modifies the Plan in response to the Commonwealth Minister's recommendations, the State must submit to the Commonwealth Minister for consideration:

a) the modified Plan; and

b) a summary of how the Minister's recommendations were given effect.

7.5 Following receipt of the modified Plan, the Commonwealth Minister may request any additional information he or she considers necessary in order to consider whether the impacts of actions under the Plan on protected matters have been adequately addressed.

8. Endorsement of the Plan

8.1 The Commonwealth Minister may endorse the Plan if satisfied that:

a) the Strategic Assessment Report adequately addresses the impacts to which this agreement relates (that is, impacts of actions under the Plan on protected matters); and

b) either the recommended modifications to the Plan, or modifications having the same effect, have been made.

8.2 In determining whether or not to endorse the Plan, the Commonwealth Minister may consider the extent to which the commitments for the protection and management of protected matters are enforceable and achievable over the life of the Plan.

8.3 In determining whether he or she is satisfied that the Strategic Assessment Report adequately addresses the impacts to which the agreement relates, the Commonwealth Minister must have regard to the extent to which the Plan meets the objectives of the EPBC Act, including how the Plan:

i. protects the environment, especially those aspects of the environment that are protected matters under Part 3 of the EPBC Act;

ii. promotes ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;

iii. promotes the conservation of biodiversity;

iv. provides for the protection and conservation of heritage;

v. promotes a cooperative approach to the protection and management of the environment; and

vi. assists in the co-operative implementation of Australia's international environmental responsibilities.

8.4 If the Plan is endorsed by the Commonwealth Minister, the State must make the Strategic Assessment Report, Plan and (if relevant) Supplementary Report, publicly available electronically through an official website for the life of the Plan.

8.5 The Parties acknowledge that the endorsement of the Plan itself does not constitute any approval for the taking of actions under Part 10 of the EPBC Act.

9. Approval of actions

9.1 If the Commonwealth Minister endorses the Plan, the Commonwealth Minister may then approve the taking of an action, or class of actions, in accordance with the Plan. The effect of this approval decision is that any actions or class of actions approved under section 146B would not need further approval by the Minister under the EPBC Act if taken in accordance with approval and any conditions attached to the approval decision.

9.2 The Parties agree that an approval holder (or holders) will be named for any approval of actions, or classes of actions, granted under section 146B of the EPBC Act.

10. Environmental information management

10.1 The Parties agree to work cooperatively and share information, to the fullest extent practical, so as to avoid duplication of work in undertaking the strategic assessment pursuant to this agreement, subject to meeting requirements under the EPBC Act. To deliver upon this objective the Parties commit to the following open access requirements:

a) Information is accessible and reusable by the community, business, government and other stakeholders.

b) Information is published under an Open Licence (preferably Creative Commons Attribution licence), and available in the public domain.

c) Information is published and described in a way that maximises discovery and reuse, preferably online, and in open formats.

d) Information is published at the highest resolution and accuracy available.

e) Information is released electronically at no cost to users or, if other formats are required, at minimal cost.

f) The Parties agree to restrict information access only where necessary to adequately manage sensitive or confidential information.

10.2 The Parties agree to develop and maintain a Data Management Plan to record the key pieces of data and information generated to support the decision for this strategic assessment.

10.3 Parties will endeavour to jointly explore new approaches and internationally recognised standards to inform the strategic assessment to achieve best practice environment impact assessment and effective and transparent monitoring and reporting.

11. Governance arrangements and dispute resolution

11.1 The Parties agree to use best endeavours to establish agreed timelines within one month of the signature of this agreement for deliverables and arrangements to ensure adequate communications to progress the strategic assessment. This may include preparation of joint or individual project plans. The Parties agree to use reasonable efforts to resolve by negotiation any problem that arises between them in the course of carrying out this agreement (dispute).

11.2 A party will not terminate this agreement as a result of a dispute until the following process has been exhausted:

a) If there is a dispute between the Parties concerning this agreement, either party may give written notice of the Dispute to the other party which will state that it is a notice under this clause and will specify the details of the dispute concerned.

b) Management representatives of each of the Parties will endeavour in good faith to agree upon a resolution of the dispute.

c) Should management representatives fail to reach a resolution within 14 business days of receipt of a notice of dispute (or another timeframe agreed in writing between the Parties), the dispute will be taken to senior executive service (SES) or equivalent representatives of each of the Parties.

d) SES representatives will endeavour in good faith to agree upon a resolution of the dispute.

e) Should the SES representatives fail to resolve the dispute within 10 business days (or other time frame agreed in writing between the Parties), the dispute will be taken to the:

i. relevant Deputy Secretary of the Commonwealth Environment Department, and

ii. relevant Deputy Secretary, DPE; and

iii. Chief Executive, OEH,

who will endeavour to reach agreement regarding the dispute.

12. Variation

12.1 The Parties may vary this agreement by written agreement only to the extent that the varied agreement is consistent with the provisions of the EPBC Act.

12.2 Any variation to this agreement shall be published on the DPE or OEH website.

13. Termination

13.1 This agreement may be terminated at any time by written notice from either Party, except where the termination relates to a Dispute and the procedure at clause 11 has not been followed.

14. General

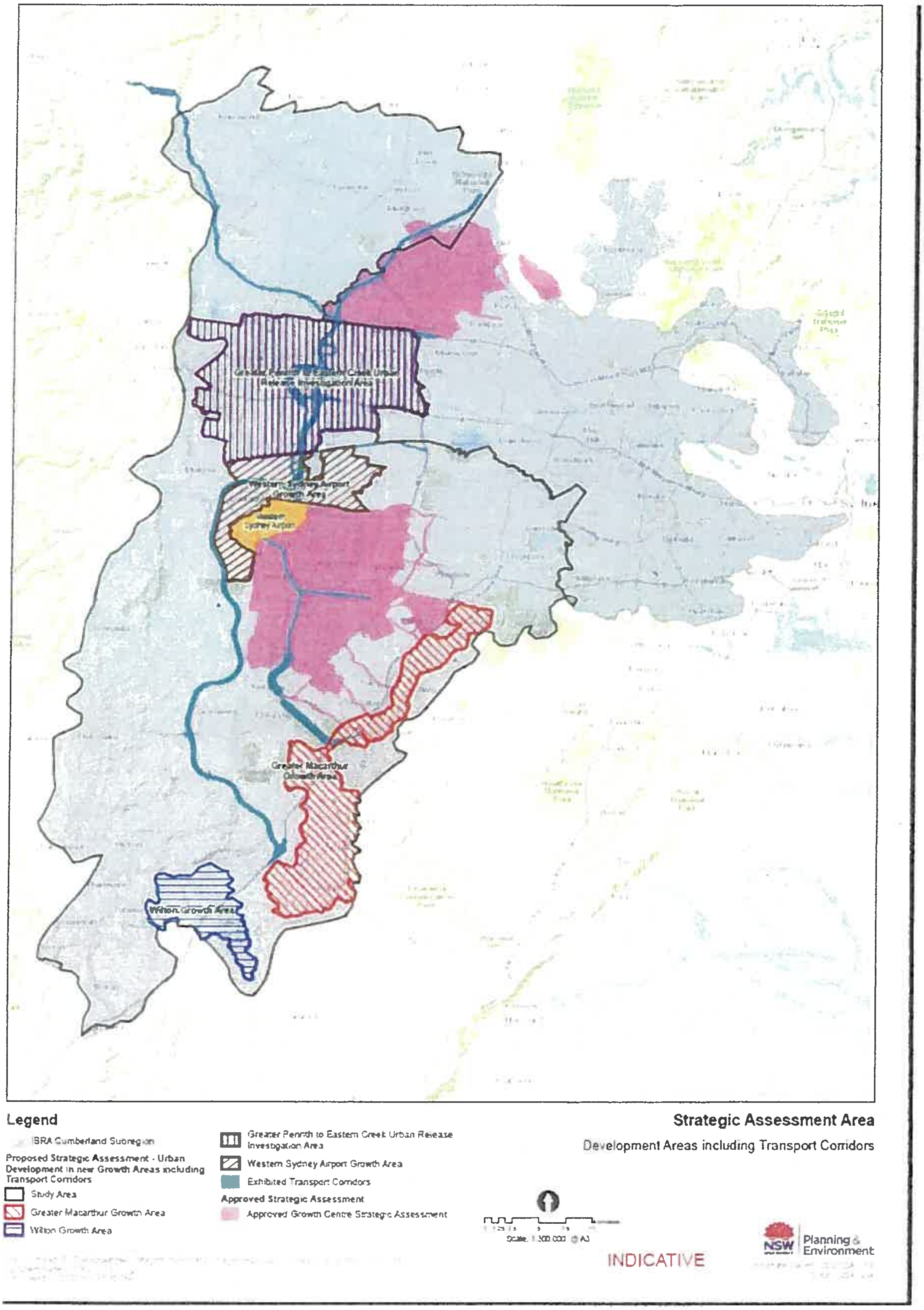
14.1 Any notice given by a party under this agreement must be in writing and hand delivered or sent by pre-paid post or email to the appropriate representative at the specified address. The appropriate representative for each Party is:

i. relevant Deputy Secretary, DPE (Deputy Secretary, Policy and Communications, GPO Box 39, Sydney NSW 2001) and Chief Executive, OEH (PO Box A290, Sydney South 2000), and

ii. Assistant Secretary of the Branch managing the strategic assessment within the Australian Government Department of the Environment and Energy (Assistant Secretary, Assessments and Waste, Environment Standards Division, GPO Box 787 Canberra ACT 2601).

14.2 Notwithstanding any other provision of this agreement, the Parties may disclose information about this agreement, including personal information, where required or permitted to be disclosed by law.

ATTACHMENT 1: INDICATIVE MAP OF STRATEGIC ASSESSMENT AREA



SIGNED for and on behalf of the
COMMONWEALTH OF AUSTRALIA
represented by

The Hon Melissa Price MP

Minister for the Environment

Signature

12/11/18
Date

SIGNED for and on behalf of the
STATE OF NEW SOUTH WALES
represented by

The Hon. Anthony John Roberts MP

Minister for Planning

Signature

18/10/xviii
Date

The Hon. Gabrielle Cecelia Upton MP

Minister for the Environment

Signature

16.10.18
Date

Draft Terms of Reference for the Strategic Impact Assessment Report for the Cumberland Plain Conservation Plan

1. PURPOSE OF THE STRATEGIC IMPACT ASSESSMENT REPORT

   1.1. The purpose of the Report is to assess the impacts of actions taken under the Cumberland Plain Conservation Plan (Plan) on all matters protected by Part 3 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) ('protected matters').

2. DESCRIPTION OF THE PLAN BEING ASSESSED

   2.1. The Report must describe the Plan:

      1. The Report must provide a summary outlining its overall purpose, key elements, spatial extent, and timeframes, including how long the Plan will be in effect.
      2. The Report must provide details about the key elements, including:
         a. The conservation commitments and outcomes to be delivered for protected matters.
         b. The actions likely to be taken under the Plan over the short, medium and long term.
         c. The legal and administrative frameworks to implement the Plan and the persons and authorities responsible for implementation, including:
            i. How the Plan has been developed and its legal standing under New South Wales law.
            ii. The relationship of the Plan to other relevant policies, plans, guidelines, commitments, regulations and legislation including existing approvals under Commonwealth legislation for the Western Sydney Airport and the Western Sydney Growth Centres.
            iii. Management, approval and funding arrangements for implementing the Plan.
      3. The Report must describe the need and justification for the Plan including the environmental, social and economic drivers for its development.
      4. The Report must describe the decision-making framework used in considering alternatives and developing conservation outcomes of the Plan. It should identify where alternative options that have been evaluated to reach the final Plan have been published.
      5. The Report must describe how the principles of ecologically sustainable development (ESD) (as set out in section 3A of the EPBC Act) are considered and promoted in the development of the Plan.

3. DESCRIPTION OF THE PROTECTED MATTERS IMPACTED BY THE PLAN

   3.1. The Report must describe the nature of the environment within the strategic assessment area, and other areas outside the strategic assessment area that may be impacted by actions taken under the Plan. This must include (at a minimum):

      1. A description of historical and current land use.
      2. The extent and quality of native vegetation present including detailed mapping of ecological communities and habitat for threatened species listed under the EPBC Act.
      3. The nature of the environment, including ecosystem processes and threatening processes.
      4. A description of the landscape context for key environmental matters, including connectivity, habitat fragmentation and ecological processes.
      5. A spatial map of areas that are already protected for environmental purposes, including Bio-banking and Biodiversity Stewardship sites.

3.2. The Report must identify and describe each protected matter that may be impacted directly, indirectly and cumulatively by actions taken under the Plan, including (at a minimum):

1. Key sites, and where relevant, key habitats for protected matters.
2. Important populations of protected matters, including the consideration of the importance of both small and large areas of habitat, and their position within the landscape.
3. Areas likely to be important for maintaining ecological processes (for example, habitat connectivity) for protected matters.
4. Condition of protected matters, including where relevant, seasonal and annual variability, and their likelihood to alter over time.
5. Key threatening processes.

4. ASSESSMENT OF THE IMPACTS OF THE PLAN ON PROTECTED MATTERS

4.1. The Report must describe and assess the likely impacts of actions taken under the Plan on all protected matters.

4.2. The Report must describe the method used to understand likely impacts on all protected matters of actions taken under the Plan. The level of the assessment will be proportionate to the level of likely risk to each protected matter. The method must:

1. Be appropriate for assessment at a strategic scale.
2. Rely on the best available information.
3. Discuss uncertainty, including reference to the technical data and information relied upon.

The Report must identify the data used in the assessment, any limitations it may have, where (or if) the data is available and where it can be accessed, including publicly accessed.

4.3. Describe and assess separately the likely impacts (if any) of actions taken under the Plan on the environment on Commonwealth land (as defined in section 528 of the EPBC Act).

4.4. The Report may also consider protected matters that are potentially eligible for listing as a result of inclusion in a final priority assessment listing held by the Commonwealth, or a recommendation to the Commonwealth Minister for listing by the Threatened Species Scientific Committee prior to the Report being submitted.

4.5. The Report must include an analysis of the likely adverse impacts of actions of the Plan on protected matters. This must include (at a minimum) consideration of:

1. Information on the following :
   a. Number and size of populations/important populations.
   b. Extent (in hectares) of suitable habitat.
   c. Extent (in hectares) and condition of protected matters.
   d. Landscape connectivity and ecological processes.
   e. Heritage listing and values.
2. How impacts on protected matters will be avoided through land use planning and other measures, and what mitigation measures will be implemented to reduce impacts, including a description of the mitigation measures and how unavoidable impacts will be offset.
3. Potential indirect and cumulative impacts.

4.6. The Report must include an analysis of the conservation benefits (beneficial impacts) of the Plan, including:

1. How protected matters will be conserved, protected and managed within the Strategic Assessment Area and other areas related to the Plan.
2. The adequacy of the conservation measures under the Plan in protecting and managing protected matters, including the effectiveness of implementation and funding arrangements and who will be responsible for delivering on commitments.
3. How proposed conservation measures involving environmental offsets meet the principles of the *Environment Protection and Biodiversity Conservation Act, Environmental Offsets Policy, 2012.*

4. How landscape connectivity has been maintained and improved, which may include opportunities for strategic restoration of key corridors and areas adjacent to sites with high biodiversity values.
5. How adaptation to reasonable climate change scenarios has been considered.

4.7. The Report must consider the extent to which the impacts on protected matters of actions taken under the Plan meet legislative obligations under the EPBC Act, including but not limited to:

1. Consistency with Australia's international obligations, including the Ramsar Convention.
2. Consistency with recovery plans (section 146K of the EPBC Act).
3. Regard to objectives, conservation actions and other relevant information in conservation advices (section 146K of the EPBC Act).
4. Consistency with World Heritage management plans (sections 316 and 321 of the EPBC Act) and National Heritage place management plans (sections 324S and 324X of the EPBC Act).

The Report may also consider other Commonwealth policy guidelines on protected matters.

4.8. The Report must include justification for key methods used in the assessment, including summaries of independent peer review processes and where the review/s are available to the public.

5. EVALUATION OF THE OVERALL OUTCOMES OF THE PLAN

5.1. The Report must evaluate the overall commitments and outcomes for protected matters taking into account likely impacts on protected matters from actions taken under the Plan.

5.2. The evaluation must include:

1. The extent to which protected matters are represented in areas to be protected or managed under the Plan or in existing protected areas in the IBRA bioregion/subregion.
2. The extent to which the areas to be protected or managed under the Plan or existing protected areas in the IBRA bioregion/subregion will ensure the long-term viability of each protected matter.
3. Whether there will be serious and irreversible impacts on any protected matter.
4. An assessment of how the Plan meets the endorsement criteria set out in the Agreement at clause 8.

5.3. The evaluation may also include consideration of:

1. The extent to which the conservation measures under the Plan facilitate adaptation of biodiversity to climate change and address any significant vulnerabilities of protected matters under reasonable climate change scenarios.
2. The likely effectiveness of the conservation measures under the Plan in protecting and managing protected matters and any risks and uncertainties.

6. ADDRESSING UNCERTAINTY AND ADAPTIVE MANAGEMENT

6.1. The Report must identify key uncertainties and risks associated with implementing the Plan, responses to these and proposed adaptations to changing circumstances. Key uncertainties may include:

1. Knowledge gaps in scientific understanding and responding to new knowledge.
2. Assumptions made in assessing potential impacts and benefits.
3. How changes to State and Commonwealth legislation, policies, plans and advice is to be accounted for in the management of the areas impacted by the Plan.
4. Effectiveness or capacity to ensure the Plan is implemented.

6.2. The Report must describe and assess the adequacy of the procedures proposed in the Plan to ensure an adaptive approach to implementation of the Plan. This must include:

1. How the results of monitoring will be used to understand the effectiveness of conservation outcomes for protected matters and improve implementation.
2. How new information relating to protected matters and biodiversity, including legislative changes, may be assessed and accounted for in implementation of the Plan.

7. MONITORING AND REPORTING AND AUDITING

7.1. The Report must describe and assess the adequacy of the monitoring programs, regular review, public reporting and independent auditing processes proposed in the Plan to:

1. Ensure conservation commitments and outcomes for protected matters contained in the Plan are delivered.
2. Enable implementation of the Plan to adapt where monitoring demonstrates delivery of the conservation actions are not leading to the predicted conservation outcomes.
3. Enable implementation of the Plan to adapt to changed circumstances, where there are risks to protected matters.

7.2. The Report must identify and analyse the likely circumstances and procedures that may result in the review or modification of implementation plans proposed to deliver on commitments and outcomes for each protected matter as described in the Plan, or abandonment of the Plan.

8. INFORMATION SOURCES

8.1. The Report must identify the sources of information and data relied upon including the reliability and currency of the data.

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Environmental consulting

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document B – Peer review report

Excellence in your environment

Western Sydney Strategic Assessment
Independent Peer Review

Prepared for Department of Planning and Environment | 25 March 2019

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Document control

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1. Introduction

Niche Environment and Heritage Pty Ltd (Niche) have been commissioned by NSW Department of Planning and Environment (DPE) to undertake an independent peer review of the Western Sydney Strategic Assessment. Specifically Niche were engaged to address Section 4.8 of the EPBC Terms of Reference, which requires that:

> *The Report must include justification for key methods used in the assessment, including summaries of independent peer review processes and where the review/s are available to the public.*

1.1 Background

The NSW Government has identified four Growth Areas and approximately 200 kilometres of Transport Corridors to support planned future growth in Western Sydney over the next 38 years (see

Figure 1). These initiatives are identified under a number of strategies including:

- A Metropolis of Three Cities - The Greater Sydney Region Plan (Greater Sydney Commission, 2017b)
- Future Transport 2056 (Transport NSW, 2017)
- Western Sydney City Deal (2018).

The four Growth Areas are:

- Wilton Growth Area
- Greater Macarthur Growth Area
- Western Sydney Aerotropolis Growth Area
- Greater Penrith to Eastern Creek Urban Release Investigation Area.

The NSW Department of Planning and Environment (DPE) is pursuing the relevant State and Commonwealth statutory environmental approvals required for development of the Growth Areas and Transport Corridors. As part of this approval process, DPE is preparing the Draft Cumberland Plain Conservation Plan (the Plan). The Plan will outline both the program of development works proposed for authorisation under relevant legislation, and commit to environmental measures that will contribute to the maintenance or return of ecological function on the Cumberland Plain in response to the proposed development.

The Plan is being drafted to meet State and Commonwealth statutory requirements for assessment of impacts on threatened species and ecological communities. DPE will seek approval for the Plan under the:

- Biodiversity certification provisions (Part 8) of the NSW *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment provisions (Part 10) of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

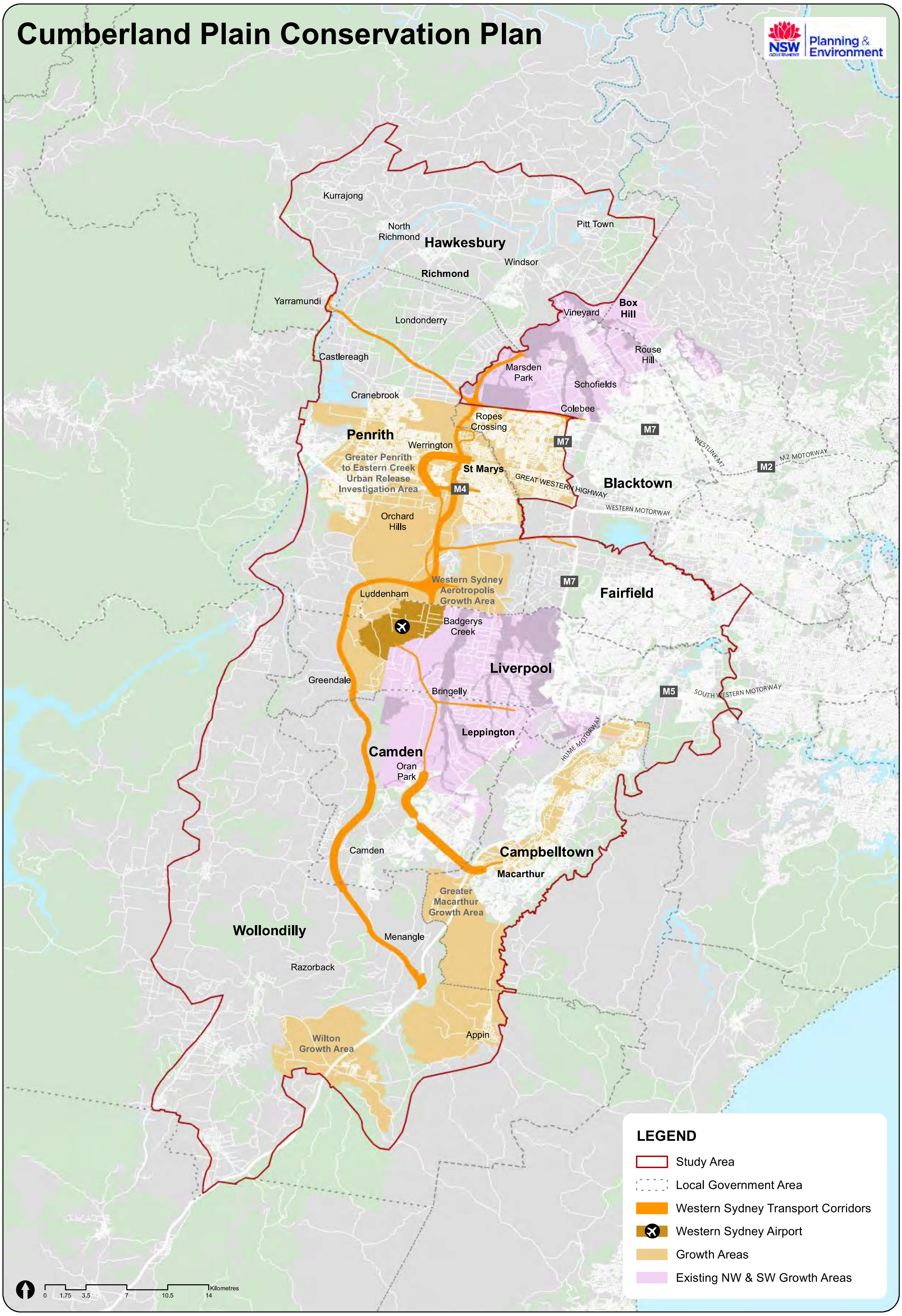

Figure 1. Map of the strategic assessment area

1.2 Scope of impact assessment within the Draft Cumberland Plain Conservation Plan

The scope of impact assessment within the Plan under the BC Act and EPBC Act is different (see Table 1). This relates to both:

- The components of the proposed development that is being assessed for approval
- The impact assessment requirements under each piece of legislation.

Table 1. Impact assessment requirements of the BC Act and the EPBC Act

Legislation	Impact assessment requirement	Comments
BC Act	Address provisions of the legislation and regulations under the relevant approval pathway within the Act.	The Plan is being assessed as a strategic application for biodiversity certification under Part 8 of the BC Act. The relevant regulatory provisions need to be met.
	Use of the Biodiversity Assessment Methodology (BAM)	The BAM is the detailed impact assessment method that is required under the BC Act
	Consider the guidelines for planning authorities for proposing conservation measures in strategic applications for biodiversity certification (Draft Version 7)	The Guidelines "*provide guiding principles for demonstrating that the conservation measures proposed for a strategic application for biodiversity certification adequately address impacts on biodiversity values under section 8.7 of the BC Act*" The Guidelines need to be addressed
EPBC Act	Address and meet relevant provisions of the legislation and regulations	The Plan is undergoing strategic assessment under Part 10 of the EPBC Act.
	Address the terms of Reference for the Strategic Impact Assessment Report for the Cumberland Plain Conservation Plan	The Terms of Reference specify the requirements for the Strategic Assessment Report
	Consider relevant statutory documents in the impact assessment process.	The EPBC Act requires that certain statutory documents be considered in the impact assessment process. For example, these include recovery plans, threat abatement plans, and conservation advices
	Consider EPBC Act policies and guidelines	The Australian Government has published a range of EPBC Act policies and guidelines which need to be considered in the impact assessment process

The assessment approach under Part 10 of the EPBC Act is different for the Transport Corridors that occur outside the Growth Areas compared with the other proposed development components. Table 2 shows the assessment approach for the proposed development components under Part 10 of the EPBC Act.

Table 2. Assessment approaches under Part 10 of the EPBC Act

Proposed development component	Assessment approach
Four growth areas	Detailed assessment of impacts on Commonwealth protected matters on the basis of the BAM and in accordance with the Terms of Reference
Sydney Metro Stage 1	
Transport Corridors within the growth areas	
Transport Corridors outside the growth areas	High level, risk-based assessment of protected matters and likely effectiveness of proposed avoidance, mitigation and offset measures to meet an improve or maintain scenario

1.2.1 EPBC Act Terms of Reference

The Terms of Reference for the Strategic Impact Assessment Report (SIAR) are part of the Strategic Assessment Agreement between the NSW and Australian Governments. They set out the information requirements that the impact assessment component of the Plan needs to address for matters protected under the EPBC Act.

The Terms of Reference broadly require the impact assessment to:

- Describe the Plan being assessed (clause 2)
- Describe the protected matters impacted by the Plan (clause 3)
- Assess the impacts of the Plan on protected matters (clause 4)
- Evaluate the overall outcomes of the Plan (clause 5)
- Address how uncertainty and adaptive management are considered in the Plan (clause 6)
- Describe the monitoring, reporting and auditing that will be implemented under the Plan (clause 7)
- Identify the information sources used to inform the impact assessment report (clause 8).

Clause 4.2 of the Terms of Reference outlines how the Plan should describe the methods used in the assessment:

"*The Report must describe the method used to understand likely impacts on all protected matters of actions taken under the Plan. The level of the assessment will be proportionate to the level of likely risk to each protected matter. The method must:*

1. *Be appropriate for assessment at a strategic scale*
2. *Rely on the best available information*
3. *Discuss uncertainty, including reference to the technical data and information relied upon*

The Report must identify the data used in the assessment, any limitations it may have, where (or if) the data is available and where it can be accessed, including publicly accessed."

The SIAR is designed to meet all of the Terms of Reference.

1.2.2 Key steps in the impact assessment

Despite the differences between the BC Act and EPBC Act processes, there are three common and key steps in the impact assessment:

- Step 1 – understand the environment
- Step 2 – understand impacts (and identify avoidance and mitigation measures)
- Step 3 – evaluate the outcome of the plan to adequately mitigate for any impacts and assess the benefits to the environment from the conservation measures.

1.3 Scope of the peer review

1.3.1 Peer review requirement

The peer review relates only to the strategic assessment under the EPBC Act. Section 4.8 of the EPBC Terms of Reference requires:

> *The Report must include justification for key methods used in the assessment, including summaries of independent peer review processes and where the review/s are available to the public.*

It is agreed that the term 'key methods' refers to technical methods for describing the protected matters impacted by the plan, such as methods used to collect data on protected matters and map or model the known or predicted occurrence of protected matters. The methods to be reviewed in this report include the assumptions underpinning all analyses and modelling, and the decisions about what datasets to include or exclude in the mapping and/or modelling processes.

We have been advised by DPE that the term 'key methods' does not include approaches to understand the likely impacts on protected matters of actions taken under the Plan, such as the approach to assessing direct impacts, indirect impacts, or cumulative impacts, or demonstrating how adaptation to climate change has been considered.

While the peer review is only required for the EPBC Act process, the results of the review will be of interest to the NSW Office of Environment and Heritage as part of the BC Act strategic biodiversity certification.

1.3.2 Methods for review

The following methods have been reviewed:

- The approach to determining the relevant Commonwealth matters for assessment ("the categorisation approach")
- The methodology for mapping EPBC Act-listed TECs, including any assumptions about correlations/ alignment between NSW Plant Community Types and EPBC Act TECs
- The knowledge-based method applied to mapping Category 1 EPBC listed threatened species
- The appropriateness and representativeness of the variables and datasets used for mapping habitat for 19 EPBC listed species using species distribution modelling
- The methods for identifying important populations of listed flora and fauna across the strategic assessment area for each species, and the application of the method for each species
- The evaluation method for determining the viability of the Southern Sydney koala population
- The Conservation Priorities Method, which is being used to identify priorities for offsetting.

1.4 Approach to the peer review

Niche was provided with details of the methods used to identify the range of protected matters prior to attending a workshop facilitated by Open Lines, which aimed to provide further information and opportunity for consultation with personnel involved. The workshop was held at DPE's Sydney office (Pitt Street) on 18th February 2019 and included detailed presentations by the lead author of each method:

- Tom Holden (Open Lines) – Chair and overview of EPBC impact assessment

- James Shepard (Biosis) - EPBC TEC mapping
- Rebecca Dwyer (Biosis) – Knowledge based mapping for EPBC Category 1 species
- Callan Wharfe (Biosis) - EPBC population mapping
- Peter Hemphill (Open Lines) - EPBC categorisation approach and Koala evaluation method
- Ascelin Gordon (RMIT) - Species distribution modelling
- Darren James (DAJ Environmental) and Ophelie Tinel (DPE) - Conservation priorities method

Dr Rhidian Harrington and Evelyn Craigie of Niche Environment and Heritage attended the workshop in their capacity as peer reviewers. CVs for Rhidian and Evelyn are provided in Annex 1.

Open Lines provided a detailed summary of the methods of each element in an agenda for the workshop but, apart from the *Western Sydney Strategic Plan – Species distribution Modelling* report (RMIT) and a section of the *Conservation Priorities Method for the Cumberland Plain Conservation Plan* report (DPE), no other reports were provided to the peer reviewers.

The workshop provided an opportunity to clarify any sections of the method that were unclear. Further information was provided following the workshop including updates to the method descriptions and GIS data. Where further information or clarification was required to inform the review, this was obtained directly from the creators/authors of the method.

2. Determining the relevant Commonwealth matters for assessment

2.1 Overview of method

Relevant Commonwealth matters for assessment within the Plan were determined by applying the 'categorisation method'. This involved identifying all matters with potential to be affected by the proposal within a 10 kilometre buffer around the boundary of the strategic assessment area, using the Protected Matters Search Tool, NSW Bionet, Atlas of Living Australia and the Commonwealth's Finalised Priority Assessment List (FPAL). Each matter identified on the list was then assigned to Category 1 (to undergo detailed assessment), or Category 2 (no further assessment).

If a threatened species or community met any of the following criteria, it was assigned to Category 1:

- The BAM process for the Growth Areas identified the species may be impacted
- The species was subject to a commitment in the Sydney Growth Centres Strategic Assessment Program Report
- A known important population occurs in the strategic assessment area
- The strategic assessment area contains >5% of all known records in NSW of a species since 1990 according to the Atlas of NSW Wildlife dataset
- The strategic assessment area comprises >5% or more of the mapped distribution of the species according to DoEE's current distribution mapping
- It is an FPAL species, and available information suggests it occurs in the strategic assessment area.

If a migratory species met any of the following criteria, it was assigned to Category 1:

- The strategic assessment area supports important habitat or an ecologically significant proportion of modelled habitat for a species
- The strategic assessment area contains >5% of all known records in NSW of a species since 1990 on the Atlas of NSW Wildlife.

The results of the threatened and migratory species categorisation were reviewed by two senior ecologists familiar with the area to confirm its accuracy.

All Ramsar Wetlands downstream of the study area and all world and national heritage and Commonwealth land in the study area were assigned to Category 1.

2.2 Data collection and categorisation

The approach is considered appropriate for determining matters for assessment at a strategic scale as it:

- Uses a precautionary approach, with the initial step aiming to capture all matters that may be of relevance within the strategic assessment area and within 10 kilometres of its boundary
- Uses appropriate criteria to categorise the matters for further assessment
- Aligns with standard methods used in ecological assessment for identification of matters for assessment
- Includes analysis and cross-checking that is independent of the source data and method outputs.

2.3 Details of the approach

2.3.1 Data collection/manipulation

The methods used to identify potential Threatened Ecological Communities (TECs) is considered appropriate as an initial filter as it captures all Plant Community Types in the strategic assessment area that may be TECs.

2.3.2 Assumptions

The categorisation method includes information from sources that are not specific to the area, e.g. EPBC Act recovery plans and conservation advice. In some cases, these sources may not include information relevant to the assessment area. This should be identified as a limitation, however, it is noted that area specific information was also used and results were reviewed by ecologists familiar with the area of investigation.

2.3.3 Datasets

The method uses the ecological databases that are commonly used in ecological assessment, supplemented by the results of recent studies undertaken in the Growth Areas and review by ecologists familiar with the area. This is considered to be appropriate as it:

- Incorporates the most up to date databases that are available at the required scale
- Is conservative and unlikely to exclude matters that require further assessment.

2.4 Components that require improvement

The reviewed methods are considered appropriate for the strategic assessment and no components requiring improvement have been identified. However, any limitations associated with the information sources should be identified within the strategic assessment, including whether they incorporate up to date information and the scale at which they are relevant.

3. Mapping for EPBC Act TECs

3.1 Overview of method

This section summarises the methods used to prepare the general vegetation map and the EPBC Act TEC map. The methods used to prepare the general vegetation map is not the subject of this review, however, as it underlies the EPBC Act TEC mapping, a brief summary is provided.

3.1.1 General vegetation mapping

Due to the different requirements for the BAM and the EPBC Terms of Reference, two methods were used to prepare the general vegetation map as follows:

- Within the Growth Areas, vegetation mapping commenced with a desktop study and subsequent updates based on data collected in the field in accordance with the BAM
- Within the Cumberland sub-region (outside the Growth Areas) vegetation mapping was based on the vegetation maps prepared by OEH:
    - *Remnant Vegetation of the Western Cumberland Subregion: 2013 update* (OEH 2013)
    - *The Native Vegetation of the Sydney Metropolitan Area: Version 3.0* (OEH 2016).

The desktop study included analysis of:

- Recent Nearmap imagery at 15 centimetre resolution
- NSW Landuse polygons from DPI
- NSW soils datasets at 1:100,000 from the OEH data portal
- NSW geology datasets at 1:250,000 from the DPE data portal
- Processing multispectral aerial imagery at 60 centimetre resolution into NDVI imagery
- Amalgamating previous native vegetation mapping undertaken by Biosis and others across the Growth Areas
- Combining two existing OEH maps of native vegetation within the Cumberland sub-region (OEH, 2013, 2016b) into a single layer and clipping the layer to the Growth Area boundaries
- Creating a Canopy Height Model using 1 metre LiDAR data from various projects contained within Biosis' GIS database (data ranged from six years to nine years old)
- Processing the Canopy Height Model into amalgamated canopy polygons for vegetation over 1 metre in height.

The draft maps were then updated based on the results of field survey (in the Growth Areas only), which included rapid assessment ground-truthing and plots in accordance with the BAM.

It is considered the datasets, methods for data collection and assumptions associated with the general vegetation mapping are appropriate and provide the most suitable base for mapping of EPBC Act TECs.

3.1.2 EPBC Act TEC mapping

All TECs with the potential to occur in the strategic assessment area were identified based on the Protected Matters Search Tool and Plant Community Types (PCTs) identified during the general vegetation mapping.

The method used to map EPBC Act TECs within the Growth Areas is summarised as follows:

1. Identify PCTs that correlate with an EPBC Act TEC and thereby identify specific areas that may comprise an EPBC Act TEC
2. For each potential area of EPBC Act TEC, apply criteria related to:
    a. distribution and patch size class
    b. projected foliage cover (where relevant to the TEC threshold criteria)
    c. elevation (where relevant)

3. Map vegetation polygons that meet the above criteria as candidate TEC polygons
4. Apply condition class criteria to candidate polygons within which BAM plots have been undertaken, and assign the polygon as the TEC, or remove it as the TEC
5. Apply condition class criteria to candidate polygons within the Growth Areas but external to the development footprint, i.e. areas within the Growth Area were BAM plots were not undertaken, and assign a potential category to the polygon (high, moderate and low potential and not TEC)
6. The methods and outputs were reviewed by the DoEE.

The method used to map EPBC Act TECs external to the Growth Areas is summarised as follows:

1. Identify PCTs that correlate with an EPBC Act TEC and thereby identify specific areas that may comprise an EPBC Act TEC
2. Apply distribution and patch size criteria and remove polygons that did not meet the criteria
3. Apply condition class criteria, based on condition classes associated with the two source maps (OEH 2013 and OEH 2016)
4. Analyse draft maps to remove areas with discrepancies such as cleared land and assign a potential category to the polygon (high, moderate and low potential and not TEC).

3.2 General Approach

3.2.1 Data collection/manipulation

The general approach is considered appropriate for assessment of EPBC Act TECs at a strategic scale as it:

- Incorporates all TECs that have potential to occur in the strategic assessment area, including one TEC that is proposed for listing
- Is repeatable across the entire strategic assessment area
- Has established rule sets that incorporate all relevant attributes for each TEC, as described in the DoEE's Species Profile and Threats Database (SPRAT) and discussion with DoEE
- Relies on the best available information, including the most recent iterations of all input data
- Allows for updates to be incorporated
- Is adjusted to account for the different levels of accuracy in vegetation mapping available across the strategic assessment area
- Includes analysis and cross-checking that is independent of the source data, model outputs and other input information.

3.2.2 Assumptions

The method incorporates numerous assumptions, largely associated with the data used in the GIS model. This is necessary in the absence of field collected data and has been adequately discussed and justified for each point where an assumption is made. Where it was possible to reduce the level of uncertainty involved, for example through a cross check of results by GIS and ecology practitioners, this has been undertaken and explained.

It is considered that further details of all datasets used in the project are required. Information such as whether the data is based on a desktop study or field verification, and methods used to capture the data.

3.2.3 Datasets

The method has incorporated the best available information as it:

- Incorporates the results of extensive recent field survey where possible
- Incorporates the most up to date datasets that are available at the required scale
- Has updated the data where possible
- Has considered a wide range of data and its suitability to the assessment.

3.3 Details of the approach

3.3.1 Data collection/manipulation

The methods used to identify potential TECs is considered appropriate as an initial filter as it captures all PCTs in the strategic assessment area that may be TECs.

TEC mapping in the Growth Areas

Further filtering by patch size, canopy cover, native vegetation patch size, soil and elevation (in areas for which field data is available) is appropriate as it incorporates the factors that determine whether vegetation meets the criteria to be a TEC (as described in SPRAT) and for which data is available and can be accurately interrogated. The GIS interrogation of the data, coupled with independent review by an ecologist, is considered appropriate and would achieve as much accuracy as possible without field verification.

For patches where BAM data is not available, the method does not identify areas of TEC but rather, categorises the candidate TEC polygons according to their potential to be a TEC (High, Moderate, Low and Not TEC). This is appropriate as it accounts for greater uncertainty in the model and is likely to overestimate the areas of potential TEC, rather than underestimate. This conservative approach is appropriate for a strategic level assessment where comprehensive field surveys have not been conducted.

TEC mapping – Cumberland Plain

The reduced filtering undertaken for TECs in the Greater Cumberland Plain (patch size and condition only) is appropriate as it accounts for the increased reliance on data that has not been validated in the field.

This method also categorises the candidate TEC polygons according to their potential to be a TEC (High, Moderate, Low and Not TEC). This is appropriate as it accounts for the reliance on data that has not been validated in the field and is also likely to provide a conservative estimate of the TECs in the area. This is appropriate for a strategic level assessment where comprehensive field surveys have not been conducted.

3.3.2 Assumptions

The assumptions associated with the method are clearly stated and considered appropriate. They comprise factors that can reasonably be assumed based on known data, such as presence of hollows and species composition. The assumptions are also inclusive, i.e. the required features for a polygon to be a TEC are assumed to be present (for polygons that remain after the filtering process), rather than absent, thereby resulting in an approach that is likely to provide a conservative estimate of the TECs in the area. This is appropriate for a strategic level assessment.

3.4 Components that require improvement

The method is considered appropriate for the strategic assessment and components requiring improvement have not been identified. However, further details associated with the input data should be included to provide the reader a more complete understanding of the limitations of the method. This includes details of the extent and dates of field validation undertaken for the source mapping.

4. Mapping of EPBC species

Section 3.2 of the Terms of Reference requires the SIAR to describe for the strategic assessment area the protected matters that may be impacted directly, indirectly and cumulatively by actions taken under the Plan. Habitat for Commonwealth listed Category 1 species was mapped within the Cumberland sub-region using either:

- Species Distribution Modelling (SDM) where species data is adequate, or
- Assumed presence using a knowledge-based method (KBM)

In some cases, a map was prepared for a Commonwealth listed Category 1 species within the Growth Areas in accordance with the BAM because the Commonwealth species is also a NSW listed candidate species credit species. Under the BAM, candidate species credit species were mapped within the Growth Areas using:

- An expert report in accordance with section 6.5.2 of the BAM, or
- Assumed presence using a knowledge-based method (KBM)

Where a map was prepared for a Commonwealth listed Category 1 species within the Growth Areas in accordance with the BAM, that Growth Areas map was integrated into the Cumberland sub-region map and formed the basis of the assessment of impacts on that species within the Growth Areas.

4.1 Species Distribution Modelling

Species Distribution Modelling (SDM) was undertaken for Commonwealth listed Category 1 species within the Cumberland subregion where adequate species records were available to develop a model. SDMs were developed for 19 Commonwealth listed Category 1 species (6 fauna species and 13 flora species). The assessment will use SDMs for 15 of those species.

SDMs are statistical models used to estimate the relationship between species records at sites and the environmental and/or spatial characteristics of those sites. Once this relationship has been estimated, the statistical model can be used to predict other locations in the landscape where the species is likely to occur.

The models were developed using the software 'Maxent'.

Data required for the modelling included:

- Species records obtained from BioNet. During a review of the records, various errors were identified. Ecologists were engaged to review the records and exclude those with errors.
- Twenty-one environmental predictors that were used to establish the relationships between species records at sites and the environmental and/or spatial characteristics of those sites. These included:
  - Native vegetation (PCTs)
  - Soil type
  - Mean annual temperature
  - Mean annual radiation
  - Number of days per year with minimum temperature less than 2 degrees
  - Latitude
  - Distance to streams
  - Topographic position.

An approach was developed to account for the different levels of bias likely to be present in the species records. This resulted in the development of three maps for each species with different assumptions regarding bias in the records, depicting the likelihood of occurrence for each species. These three maps were then combined to produce a single Species Distribution Model for each species with three classes of occurrence for each species:

- Unlikely to occur – none of the three models predicted the species to occur
- Potential to occur – at least one of the three models predicted the species to occur
- Likely to occur – all three of the models predicted the species to occur.

It is considered that the datasets and their interrogation, which was used to feed into the SDM, are the most appropriate and suitable of methods available at this spatial scale for predicting species distribution. The covariates (environmental predictor layers) used in the modelling were reviewed for each species and are considered to be appropriate.

4.1.1 Details of approach

Data collection/manipulation

The general approach is considered appropriate for modelling species distribution at a strategic scale as:

- The way in which the BioNet species record data was interrogated by an ecologist and filtered based on a 100 metre accuracy criteria would have adequately excluded records that were spatially inaccurate
- The environmental predictors used for each species were appropriate and used appropriate data and the best data available
- Biases in data (i.e. BioNet data is not random) is accounted for as best is possible by using three different models with different assumptions regarding bias
- Interpretation of the model's outputs (i.e. "unlikely to occur", "potential to occur" and "likely to occur") provide a very conservative approach which is likely to overestimate species occurrence
- Includes analysis and cross-checking that is independent of the source data, model outputs and other input information.

The exclusion of Koala records from within the 10 kilometre buffer region due to a large number of records in the buffer region skewing the model to predict reduced occupancy within the Cumberland Subregion appears appropriate. As is exclusion of records not within native vegetation due to them representing dispersing males.

The report rightly notes that the predicted distribution for the Green and Golden Bell Frog should be approached with caution. The fact that the model excluded areas without vegetation means that small waterbodies within the Subregion would not be captured, even if frogs had been recorded there.

Assumptions

The method appears to incorporate numerous assumptions, and although some of these are referred to throughout the report, it is considered that further details are required. It is recommended that a separate section of the report list all assumptions and discuss their implications to the modelling.

Datasets

The method has incorporated the best available information as it:

- Incorporates the most up to date datasets that are available at the required scale, although it is recognised that vegetation and soil data contained errors that could not be rectified and that vegetation data did not extend across the whole buffer area
- Has interrogated the data and excluded it when inaccurate
- Has considered a wide range of data and its suitability to the assessment.

4.1.2 Summary

In general, the approach used for generating the species distribution models would over-predict the habitat for a species. Errors in data (particularly vegetation and soil) may have resulted in associations with these variables that were artefacts, thus over-predicting species distribution. However, the use of "likely to occur" and "potential to occur" regions limits the likelihood of over-prediction in this regard.

Other factors that may have resulted in over-prediction include the highly fragmented and modified habitat within the Subregion, which means patches of habitat that contain the appropriate predictors for a species may be too isolated or degraded for that species to occur.

Although over-predicting a species distribution is acceptable from a precautionary approach care must be taken that this approach is not transposed to offset sites, as it will predict false occurrence. It is noted though that all offset sites would be surveyed prior to being secured. Consideration must also be made of the offsetting requirements from over-predicting species distribution as this will have significant cost implications, and could result in offsets being provided unnecessarily. Over-prediction may also prevent development in areas of limited conservation value.

Despite the potential issues with data error and over-prediction of species distribution, the interrogation of the data, coupled with independent review by an ecologist, is considered appropriate and would achieve as much accuracy as possible without field verification.

4.1.3 Components that require improvement

The approach is considered appropriate for the strategic assessment and components requiring improvement have not been identified. However, further details associated with the assumptions of the model should be included to provide the reader a more complete understanding of the factors affecting the outcomes of the model.

The *Western Sydney Strategic Plan – Species Distribution Modelling* report has numerous typographical errors, but these have not been detailed in this report.

4.2 Knowledge-based mapping method

Where adequate species records were not available, Commonwealth listed Category 1 species within the Cumberland subregion were mapped on the basis of assumed presence using a knowledge-based method. The method is the same method applied to NSW-listed candidate species credit species within the Growth Areas. It was based on the following steps:

STEP 1: IDENTIFICATION OF POTENTIAL HABITAT

Potential habitat for each species was identified and mapped using the Western Sydney Strategic Assessment Vegetation Mapping undertaken by Biosis for the project. Each species polygon was initially mapped using the relevant PCT and condition class identified in BioNET.

The potential habitat was then refined using scientific literature, including the following spatial and non-spatial data resources:

- Atlas of NSW Wildlife (BioNet)
- Commonwealth SPRAT database
- OEH Threatened Biodiversity Data Collection
- Cumberland Plain Recovery Plan (OEH 2011)
- Other recovery plans/conservation advices
- NSW Threatened Species Profiles Database
- BirdLife Australia shorebird data
- Hydrological modelling derived from LiDAR data
- Topographic information, including height and slope, obtained from LiDAR data
- The altitude above sea level and slope
- Soils data digital atlas of Australian soils

STEP 2: UNDERTAKE FIELD SURVEYS

Letters were sent by DPE to all landholders within the development footprints of the Growth Areas to request access. Due to a limited response, Biosis also undertook door knocking to request access for targeted surveys.

Targeted surveys for threatened flora and fauna were undertaken within the 'development footprint' where access was provided by landholders. Due to time restrictions of the project, it should be noted that targeted fauna surveys were not undertaken in accordance with the relevant survey guidelines, and were only used to identify potential habitat for relevant species.

STEP 3: INTEGRATE RESULTS FROM TARGETED SURVEYS

The results from the targeted surveys were incorporated in two ways:

- Any areas where a species was not recorded (and where surveys were considered sufficient) were removed from the potential habitat polygons
- Any areas where a species was recorded were integrated into the mapping.

STEP 4: ASSUMED PRESENCE IN POTENTIAL HABITAT

Given the limitations in access and survey, species were assumed to be present in all areas of potential habitat.

4.2.1 Details of approach

Data collection/manipulation

The general approach is considered appropriate for mapping of EPBC Act species habitat at a strategic scale as it:

- Interrogated species record data using an expert ecologist and removed any inaccurate records

- Used appropriate data and the best data available, including updated Western Sydney Strategic Assessment Vegetation Mapping undertaken by Biosis for the project
- Assumed presence of a species if potential habitat was present and survey of the habitat patch was insufficient to determine presence
- Used an appropriate approach for determining candidate species that would be impacted
- Used appropriate assumptions and criteria for determining potential habitat
- Includes analysis and cross-checking that is independent of the source data and other input information
- Used a conservative approach so that despite insufficient survey effort compared with the government guidelines species habitat would be over-estimated.

More details and justification are required on the exclusion of habitat based on patch size, particularly for species where a patch size of 1,000 hectares was used (i.e. Spotted-tailed Quoll, Satin Flycatcher, Oriental Cuckoo, Horsfield's Cuckoo, Spectacled Monarch and Rufous Fantail). It is considered that use of such a large patch size, particularly for highly mobile species such as birds, will exclude areas of potential habitat that could be utilised by these species.

More details and justification is required with respect to the exclusion of records for some species that are earlier than the lifespan of the species. For example, records for the Regent Honeyeater were restricted to those post 2008 to account for the 10 year lifespan of the species. It is considered that the exclusion of these records, particularly for highly mobile species, will exclude areas of potential habitat that could be utilised by those species.

Assumptions

The assumptions associated with the method are clearly stated and considered appropriate for a strategic level assessment, except for the issues discussed above in the *Data collection* section.

It’s important these assumptions are presented in the report.

Datasets

The method has incorporated the best available information as it:

- Incorporates the most up to date datasets that are available at the required scale, including updated vegetation mapping
- Has interrogated the data and excluded it when inaccurate
- Has considered a wide range of data and information relevant to the species habitat requirements, and its suitability to the assessment.

4.2.2 Summary

In general, the approach used for the knowledge based method would over-predict the habitat for a species. However, it is considered that some data refining approaches, such as exclusion of habitat based on patch size and the exclusion of records older than the lifespan of the species, may result in suitable habitat being excluded for some species.

Although over-predicting a species distribution is acceptable from a precautionary approach care must be taken that this approach is not transposed to offset sites, as it will predict false occurrence. It is noted though that all offset sites would be surveyed prior to being secured. Consideration must also be made of the offsetting requirements from over-predicting species distribution as this will have significant cost implications, and could result in offsets being provided unnecessarily. Over-prediction may also prevent development in areas of limited conservation value. However, it is noted that detailed surveys would be completed prior to areas being developed.

Despite the potential issues with data error and over-prediction of species distribution, the interrogation of the data, coupled with independent review by an ecologist, is considered appropriate and would achieve as much accuracy as possible without significantly more effort with respect to field verification.

4.2.3 Components that require improvement

The approach is generally considered appropriate for the strategic assessment. However, the exclusion of habitat based on patch size needs to be explained and justified in detail and, where it might result in suitable habitat being excluded for some species, an alternative approach used.

4.3 Important populations

The term 'important populations' refers to a concept applied under the EPBC Act to inform the assessment of impacts of actions, such as urban development, on matters of national environmental significance. Important populations are defined in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) (DoE, 2013) as:

> *Any population of a vulnerable species which meets the definition of an important population in the Commonwealth's Significant Impact Guidelines (Policy Statement 1.1) as follows:*
>
> *'A population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:*
>
> - *key source populations either for breeding or dispersal*
> - *populations that are necessary for maintaining genetic diversity, and/or*
> - *populations that are near the limit of the species range'*.

For the purposes of the SIAR, important populations are also defined as including any population of an endangered or critically endangered species. Under the EPBC Act, all populations of an endangered or critically endangered species are considered to be important for the survival and recovery of the species.

The following steps were undertaken to identify and map important populations for critically endangered, endangered and vulnerable Commonwealth listed Category 1 matters:

- Step 1: Development of criteria for defining important populations for vulnerable Commonwealth listed Category 1 matters. The criteria and rationale for each criteria is provided in Table 3
- Step 2: For each species, BioNet records were analysed to define biological populations of the species. This analysis was undertaken by ecologists at Biosis with knowledge and expertise in the ecology of each species. Where gene flow between two records is considered likely, the records were assigned to the one population. The ecologists took the following factors into account in determining whether gene flow is likely between records:
    - Distance between individual flora records
    - The presence of features or barriers that might limit demographic or genetic exchange
    - Pollinator type and seed dispersal mechanism (where known)

    - The continuity of patches of vegetation.
- Step 3: For critically endangered and endangered Category 1 matters:
    - Describe and map each population (including identifying population sizes).
- Step 4: For vulnerable Category 1 species:
    - Collate the required data on each species as per the data sources in Table 3
    - Apply the criteria in Table 3 to each species, using GIS analysis where necessary
    - Describe and map each population (including identifying population sizes).

Table 3. Criteria for identifying and mapping important populations of vulnerable Commonwealth listed Category 1 species

	Criteria	Rationale	Data sources
1	Any population of a species identified as potential Serious and Irreversible Impacts (SAII) entity under the NSW BC Act	SAII entities have been identified under the NSW BC Act and meet one or more of the following principles: • Species in rapid rate of decline • Very small population size • Very limited geographic distribution • Unlikely to respond to management and therefore irreplaceable • Populations of SAII entities therefore make a significant contribution to the conservation of the species.	• Threatened Biodiversity Data Collection
2	A population identified or inferred in a Commonwealth conservation advice, recovery plan, final determination, or other relevant policy document as being important	Consistent with the EPBC Act Policy Statement 1.1 (DoE, 2013).	• Recovery plans • Conservation advices • Final determinations
3	A population that is a site-managed species or iconic species targeted for conservation under the NSW Saving our Species program	Species targeted by the Saving our Species program have been prioritised for conservation effort under a program that aims to maximise the chance of securing the greatest number of species in the wild. Therefore populations targeted under the NSW Saving our Species program could comply with the following EPBC important population criteria: • Key source populations either for breeding or dispersal • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range'.	• Save our Species program conservation projects database
4	A population associated with a commitment made under the Sydney growth	These populations have been previously identified for conservation, have had significant resources attributed to their conservation and are subject to existing commitments under the Sydney growth centres	• Sydney Growth Centres Strategic Assessment: Program Report (DOP, 2010)

	centres conservation program	conservation program and should therefore be considered important.	• NSW *Threatened Species Conservation Act 1995* Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006
5	Any population of a species that contains more than 20% of the total population (total number of mature individuals in the species) or 20% of the Area of Occupancy (AOO)* of that species	Significant contribution to the conservation of the species. Loss of any population that contains 20% or more of the total population or Area of Occupancy is justification for change in status from Vulnerable to Endangered under IUCN and EPBC Act criteria (IUCN 2012).	• BioNet, site specific surveys
6	Any population of a species where the species has less than 10 known subpopulations	These are species that have very few populations. All known populations therefore make a significant contribution to the conservation of the species. Loss of any population of such a species would be significant.	• BioNet, site specific surveys
7	Any population of a species that is a large population in the context of the ecology of that species, in the opinion of expert ecologists	Large populations are important from a genetic perspective. They typically will have sufficient genetic diversity, increased evolutionary potential, reduced inbreeding effects and increased probability of long term viability and persistence.	• BioNet, site specific surveys
8	Any population of a species within a conservation reserve (regardless of the number of plants or size, etc)	These populations are important because they are more likely to be effectively managed and have a greater chance of persistence due to their occurrence in a conservation reserve, and therefore make a significant contribution to the conservation and recovery of the species. Conservation reserve refers to those that meet IUCN protected area categories I-IV.	• BioNet, site specific surveys • National parks estate data • BioBank site data
9	Any population of a species that is important for maintaining the Extent of Occurrence (EOO)^ of that species	Maintaining the full range of a species has a greater chance of retaining the variation within the species (a primary aim of biodiversity conservation). Populations at the extent of occurrence or that are outliers to the more general distribution are likely to contain genetic difference or capacity to persist in different environmental conditions that will provide the species ability to cope and respond to changes in the environment, such as climate change.	• BioNet, site specific surveys • Commonwealth database profiles/distribution mapping

*AOO is defined as the area within a species 'extent of occurrence' which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats.

^Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy.

4.3.1 Details of approach

Data collection/manipulation

The general approach is considered appropriate for determining important populations at a strategic scale as it:

- Interrogated species record data using an expert ecologist and removed any inaccurate records
- Used appropriate data and the best data available
- The criteria used for identifying and mapping important populations was appropriate and comprehensive
- Used appropriate assumptions for determining populations of individual species
- Includes analysis and cross-checking that is independent of the source data and other input information
- Used a conservative approach so that despite quality of data methods for determining populations were unlikely to be overlooked.

More details and justification is required with respect to the exclusion of populations for some species that are earlier than the lifespan of the species. For example, records for the Regent Honeyeater were restricted to those post 2008 to account for the 10 year lifespan of the species. It is considered that the exclusion of these records may exclude records that could contribute towards a population of that species not being considered. However, it is noted that only three species were not considered to have important populations within the Subregion.

Assumptions

The assumptions associated with the method are clearly stated and considered appropriate for a strategic level assessment, except for the issues discussed above in the *Data collection* section.

It's important these assumptions are presented in the report.

Datasets

The method has incorporated the best available information as it:

- Incorporates the most up to date datasets that are available at the required scale
- Has interrogated the data and excluded it when inaccurate
- Individual records have been interrogated by an expert ecologist.

4.3.2 Summary

In general, the approach used for determining important populations is adequate and conservative. However, it is considered that some data refining approaches, such as the exclusion of records older than the lifespan of the species, may exclude records that could contribute towards a population of that species not being considered.

4.3.3 Components that require improvement

The approach is generally considered appropriate for the strategic assessment. However, for the species that have been determined not to have important populations within the subregion AND have had records excluded based on the lifespan of the species, a detailed discussion of the implications of the approach needs to be provided.

5. Southern Sydney Koala population viability evaluation method

5.1 Background and context

There are a significant number of koalas within and adjacent to the southern portion of the strategic assessment area.

These koalas are thought to be in recovery, with research indicating clear increases in the area of habitat occupied by koalas in the locality over recent years. The koalas in the area are subject to a range of existing threats, in particular increasing road kill along Appin and Picton Roads. They will also be subject to direct impacts as a result of development within the Greater Macarthur and Wilton Growth Areas (noting that significant avoidance of impacts has occurred), and potential indirect impacts associated with proximity to new urban areas and roads.

However, the Cumberland Plain Conservation Plan (the Plan) also provides a significant opportunity to:

- Protect and manage large areas of habitat for the population
- Restore and improve key habitat corridors
- Manage and reduce threats
- Improve the information base for the population to assist in ongoing adaptive management

5.1.1 Terminology

The koalas within and adjacent to the southern portion of the strategic assessment area are currently being referred to as the "Southern Sydney koala population".

However, it is noted that koalas within this locality may in fact comprise two ecologically and genetically distinct koala populations (the Southern Tablelands koala population, and the Campbelltown koala population).

It is known that the Campbelltown koala population is important as it is free from Chlamydia. Conversely, the Southern Tablelands population is known to contain virulent strains of Chlamydia.

It is thought that these two koala populations may have originally been separated due to low population numbers, yet as populations expand, they may now be increasingly exposed to contact with each other.

The locations of the boundaries between each population are difficult to determine and further research is required as part of this assessment to identify them. It is noted that the true locations of the boundaries between the populations may be unknown and therefore there is a potential that the assessment approach may need to account for uncertainty in this regard.

Therefore, the terminology "Southern Sydney koala population" may be subject to change in the future, depending upon further consideration of whether the assessment area encompasses one or two koala populations, the likely location of the boundaries between the koala populations (if known), or whether the boundaries of the koala populations are unknown.

The Plan defines a [draft] outcome for the Southern Sydney koala population that it aims to deliver. It is:

> *"Key areas of habitat for iconic and distinctive threatened species such as koala are protected and managed".*

5.1.2 Regulatory context

Koalas are listed as vulnerable under both the EPBC and BC Acts. The key instruments considered for the assessment included:

- Approved Conservation Advice for *Phascolarctos cinereus* (DSEWPC, 2012)
- EPBC Act referral guidelines for the vulnerable koala (Department of the Environment, 2014)
- Recovery plan for the koala (*Phascolarctos cinereus*) (DECC, 2008)
- State Environmental Planning Policy No 44 – Koala Habitat Protection
- Securing the koala in the wild in NSW for 100 years: Saving Our Species Iconic Koala Project 2017-2021 (OEH, 2017)
- NSW Koala Strategy (OEH, 2018)
- Conserving koalas in Wollondilly and Campbelltown LGAs (OEH, 2018).

5.2 Overview of approach

This section summarises the approach to the evaluation methods for determining the viability of the Southern Sydney koala population.

Open Lines is preparing a detailed impact assessment for the Southern Sydney koala population. This is based on addressing the terms of reference for the EPBC strategic assessment through:

- Understanding the background to koalas and the regulatory context for the assessment
- Understanding the baseline information for the species within the strategic assessment area
- Analysing the efforts to avoid and minimise impacts
- Analysing the direct and indirect impacts to koalas as a result of development under the Plan
- Assessing the proposed mitigation and management measures within the Plan
- Assessing the proposed conservation measures within the Plan
- Assessing potential cumulative impacts on koalas within the strategic assessment area
- Carrying out a detailed evaluation of the outcome for the species against the statutory and policy requirements. This will be done using the method that is the subject of this peer review (described below)

Open Lines are working with Associate Professor Mathew Crowther who is providing expert advice on the assessment.

5.2.1 Information sources

In addition to the documents listed above, the information sources in Table 4 were considered.

Table 4: Information sources for the impact assessment

Source	Description
Literature on the ecology of the population	The ecological characteristics of the koala population in the locality have been intensively studied over the last few decades. Research efforts have included government research (conducted by the Saving Our Species program administered by OEH), numerous academic publications and a PhD thesis.

	From this body of research, information specifically about the Southern Sydney koala population is available regarding: • Koala home range sizes and densities (OEH, 2018a; Ward, 2002) • Potential population size (Biolink, 2016; OEH, 2018a; Ward, 2002) • Population trends (Biolink, 2016, 2018b) • Preferred feed tree species (OEH, 2018a; Phillips & Callaghan, 2000; Sluiter, Close, & Ward, 2002; Ward, 2002) • Habitat connectivity requirements (Biolink, 2018a) • Population genetics (Kjeldsen et al., 2018; Lee, Zenger, Close, Jones, & Phalen, 2010) • Key threats (Phillips, 2016) This targeted literature is complemented by a broader body of research relating to koala populations and ecological characteristics across the range of the species. The available literature and resources provide a solid foundation with which to understand the key characteristics and conservation needs of the Southern Sydney koalas.
Species records	Koala records within and adjacent to the study area have been accessed from the NSW BioNet Atlas database. The BioNet Atlas contains species records within the study area which were obtained during recent research conducted by the Saving Our Species program, and therefore is considered a resource containing contemporary knowledge of koala distributions within the area. BioNet records have been used in research to assess population trends (Biolink, 2016, 2018b) and identify koala roadkill locations and hotspots (OEH, 2018a). BioNet records have also been used to conduct Species Distribution Model mapping as part of the current assessment process.
Cumberland Plain wide species distribution model	A Species Distribution Model (SDM) has been prepared to predict the occurrence of koala habitat within the Cumberland subregion. The SDM supports environmental impact analysis within the Growth Areas, such as through providing information about the relative importance of habitat within each Growth Area, and providing indicative information about the availability of habitat for offsetting.
Habitat and corridor mapping	Comprehensive mapping of koala habitat within the study area has been undertaken, first by OEH within the Greater Macarthur and Wilton GA, with the methodology then replicated by Biosis for the whole of the Cumberland subregion. This habitat mapping is based upon: • Mapping Plant Community Types (PCTs) to a fine resolution across the study area, and using coarser resolution data across the wider subregion • Classifying each PCT as either 'high', 'medium' or 'low' quality habitat for koalas, and from this identifying 'principal' and 'supporting' koala habitat • Identifying movement corridors, and categorising corridors into 'primary', 'secondary' and 'tertiary' corridors • Identifying important koala habitat based on species polygons Habitat mapping provides insight into the relative importance of vegetation areas for supporting koalas, and enables avoidance, mitigation and conservation measures to be appropriately targeted to ensure the best possible outcomes for koalas within the locality.
Mapping of habitat critical to the survival of the species	Mapping of habitat critical to the survival of the species is currently being undertaken in accordance with the *EPBC Act referral guidelines for the vulnerable koala* (Department of the Environment, 2014). The mapping process is based on scoring

	criteria and considers the following key parameters in determining the value of koala habitat: • Koala occurrence • Vegetation composition • Habitat connectivity • Existing threats • The value of the potentially impacted koalas to the recovery of the wider koala community Each attribute is assigned a score based on whether or not certain parameters are met for each of the above attributes. If an area of habitat equals or exceeds a score of 5, then the habitat considered to be habitat critical to the survival of the species. The purpose of this mapping is to identify the presence of habitat which is of significant conservation value to koalas, such that appropriate avoidance, mitigation and conservation measures may be taken during environmental assessment.
Habitat connectivity analysis around Greater Macarthur and Wilton	Biolink Ecological Consultants were engaged by OEH to conduct an analysis of habitat connectivity across the Wilton Growth Area and the southern portion of the Greater Macarthur Growth Area. The purpose of the assessment was to assess the current habitat connectivity of the area, and then model the projected changes in habitat connectivity following development within the Growth Areas and upgrading of Appin Road. The results of this assessment provide insight into relative the accessibility of different patches of koala habitat within the Growth Areas, and enables assessment of the potential fragmentation impacts of different development scenarios.

It is considered that the datasets and literature considered as part of the assessment are appropriate and comprehensive, and provide the most suitable base for meeting the objectives. Although only in draft form, the Campbelltown City Council Comprehensive Koala Plan of Management should be considered.

5.2.2 Key gaps

Open Lines identify two key knowledge gaps which remain for koalas within the assessment area, which may impact upon the environmental assessment methodologies used to determine the viability of the Southern Sydney koala population, and whether the outcome in the Plan has been met. These gaps are as follows:

Demographic statistics for the koalas within the study area

Key demographic information (such as the birth rates, mortality rates, and mortality causes) are currently not available for the Southern Sydney koala population. This lack of information is considered to impede the capacity to immediately conduct an accurate Population Viability Analysis (PVA) model, which is a well-recognised methodology to assess a population’s viability.

Open Lines consider it may be possible for a PVA to be conducted in the future, once further background work has been undertaken to consolidate all available information for the koalas within the study area, and then further survey work is undertaken to obtain information which is otherwise not available.

Boundaries of koala populations within the study area

Open Line identify that further work is required as part of the assessment process to ensure that the best available knowledge has been accessed, to identify the locations (and porosities) of boundaries between the Campbelltown and Southern Tablelands koala populations.

It is noted that the Campbelltown koala population is currently free of Chlamydia, whereas the Southern Tablelands population is known to contain virulent strains of Chlamydia.

It is noted that potential proximity and subsequent connectivity between the Campbelltown and Southern Tablelands koala populations is of conservation concern, and that it has the real potential to significantly impact upon the projected the viability of the Campbelltown koala population.

5.2.3 The evaluation method for review

The evaluation method is based on posing a series of evaluation questions:

1. Will the Plan deliver the desired outcome of the Plan and ensure viability of koalas?
2. How does the Plan address the OEH principles?
3. How does the Plan consider the EPBC Act referral guidelines?
4. Has the Plan had regard for the Conservation Advice?

Question 1: Will the Plan deliver the desired outcome of the Plan and ensure viability of koalas?

The current draft koala outcome in the Plan is:

> *Key areas of habitat for iconic and distinctive threatened species such as koala are protected and managed.*

In addition to analysing this outcome, Open Lines considered it important to look at the current and future viability of the Southern Sydney Population. Predicting the performance of the Plan against this framework has its challenges. In particular, the assessment relies upon a clear and measurable definition of viability.

Viability has been defined as the ability of the koala population to persist and avoid extinction. There are a number of key factors which have been identified as influencing a population's viability:

- Extent and quality of habitat
- Landscape connectivity
- Level of threat
- Genetic variation
- Population size and demographics
- Stochastic events.

Population Viability Analysis was not used as much of the input data was not available and it was considered that the model's predictions might be inaccurate and result in inappropriate conservation actions. Further it was considered that if the Koala population responded in ways not predicted this would undermine scientific and public confidence in the process.

Instead population viability will be analysed through considering the factors which influence a population's viability, and through assessing whether any of these factors will be negatively affected in a significant manner such that the viability of the population could be undermined.

To this end, the following approach is proposed by Open Lines to analyse whether the Plan will achieve the desired outcome. It is based on considering each of the factors that drive viability and includes:

- Step 1 avoidance of impacts: Calculate the avoidance of impacts to koala habitat as a result of planning decisions in the Greater Macarthur and Wilton Growth Areas through:
  - Calculating available habitat in each Growth Area broken down by primary, secondary and tertiary corridors
  - Calculating avoidance of habitat for biodiversity reasons
  - Calculating avoidance of habitat for other reasons (e.g. topography).
- Step 2 extent and quality of habitat: Calculate the net change in the extent of quality of habitat as a result of development, restoration and offsetting through:
  - Calculating the total current extent of habitat broken down by primary, secondary and tertiary corridors
  - Calculating the future extent of habitat once the Plan has been implemented. This will include areas to be restored.
- Step 3 landscape connectivity: Analyse changes to landscape connectivity through:
  - Reviewing the findings of the GIS-based GAPCLoSR undertaken by Biolink
  - Analysing the projected changes to primary corridors.
- Step 4 level of threat: Analyse changes to the level of threat to the population through:
  - Roadkill:
    - Assessing current roadkill records
    - Assessing projected decline of roadkill events with proposed wildlife fencing and/or crossing structures
    - Assessing changes in koala movement patterns as a result of proposed wildlife fencing
  - Dogs:
    - Assessing the likely increase in dog density and associated dog predation of koalas under projected development scenarios
  - Disease:
    - Assessing the likely current and projected connectivity between the Campbelltown (disease free) and Southern Tablelands (diseased) koala populations, under current conditions ('do nothing' approach) and under projected development scenarios.

- Step 5 genetic variation: consider possible changes to the genetic variation of the population through:
    - Assessing current available literature regarding the genetic diversity of the local koala populations
    - Assessing the likelihood of koala populations or sub-populations becoming genetically isolated as a result of the proposed development
    - Assessing the severity of the risk posed by low genetic diversity to koala population viability, noting that some of the most heavily populated and expanding koala populations within Australia are populations with very low genetic diversity.
- Step 6 population carrying capacity: analyse possible changes to the carrying capacity of the population through:
    - Habitat loss (either through land clearing, or through isolation of otherwise viable habitat patches)
    - Alteration of habitat quality through long-term environmental changes such as climate change.

Given the lack of data available to feed in to the PVA it is agreed that using PVA at this time may provide inadequate or false outputs and that it should not be used. It is considered the proposed approach to assessing Koala viability through measuring changes to the extent and quality of Koala habitat, connectivity, threats, genetic variation and carrying capacity is appropriate and the best possible approach, in light of the absence of suitable data for PVA. It is agreed that the use of carrying capacity rather than Koala numbers is a better approach as it takes into consideration habitat loss and alteration, whereas measuring Koala numbers would be time consuming expensive and potentially of low accuracy, and may not reflect true carrying capacity due to delayed changes to populations from changed habitat.

Question 2: How does the Plan address the OEH principles?

The following outlines the evaluation approach for determining how well the Plan addresses the principles outlined by OEH.

- Principle 1: Avoid new residential development within core koala habitat and primary corridors:
    - As per Step 1 for Question 1
- Principle 2: Separate residential development and koala populations to minimise ongoing threats from domestic dogs and vehicles:
    - Assessing the suite of management measures which are proposed to separate residential developments from koala populations in terms of:
        - Which measure/s will be implemented
        - Where each measure will be implemented

        - Whether there are any areas or gaps in which no measures are implemented at the interface of koala-urban habitat, and whether the localised lack of mitigation measures represents a significant threat to koalas
        - Whether there are sufficient provisions for long-term monitoring and maintenance for each measure
        - Whether the proposed measures to be implemented are supported by appropriate scientific data to indicate their effectiveness in achieving their desired outcomes

- Principle 3: Identify critical revegetation zones that will augment and strengthen core habitat and corridors:
    - Assessing the location/s of proposed rehabilitation and/or revegetation areas with regards to the locations of important habitat
    - Assessing whether proposed revegetation areas contribute to strengthening important habitat, and/or widening/filling in gaps within existing corridors
    - Assessing whether revegetation targets key priority areas identified by OEH, which are as follows:
        - "The highest priority in the Wilton GA is in the south- east section, where core koala habitat surrounds and almost fully encloses cleared land at the start of the primary corridor along Allen's Creek (Allen's corridor)."
        - "the length of the eastern side of the [Greater Macarthur] GA, to the east of Appin Road, directly adjacent to the Georges River corridor… Other areas include areas to the east of the Ousedale-Mallaty corridor to complete a corridor connection (on both ends) for a secondary corridor currently connected to a primary corridor at one end."
    - Where revegetation is located outside of areas highlighted as priority revegetation areas by OEH, the associated justification of the environmental benefits of the proposed revegetation is to be examined.

- Principle 4: Identify koala road kill hotspots requiring road kill mitigation fencing and/or underpasses to allow safe passage of koalas:
    - Assessing the locations of road kill hotspots which have been identified by OEH with regards to proposed locations of wildlife fencing and/or crossing structures. An assessment will be made as to whether the locations of the proposed fencing/crossing structures are likely to:
        - Reduce roadkill at roadkill hotspots
        - Result in changes in species movements across transport infrastructure through the wider locality
    - Assessing whether adequate provisions have been made for long-term maintenance and monitoring of fencing and/or crossing structures

- In the event of other and/or additional measures being proposed, available literature and/or expert advice will be assessed to consider the likely effectiveness of proposed measures in achieving desired outcomes.

It is considered that if the Plan addresses the principles as outlined it would result in the viability of the southern Sydney Koala population(s) would be maintained. With respect to Principle 3 and 4, revegetation and mitigation measures outside the Growth Areas could still benefit the southern Sydney Koala population(s), including inside the Growth Areas, and should be considered and discussed in the evaluation.

Question 3: How does the Plan consider the EPBC Act referral guidelines?

The evaluation will consider if and how the Plan has had regard for the objectives of the guidelines:

- Promote avoidance and mitigation of impacts on the koala
- Promote a clear, consistent and transparent approach for making decision on whether an action is likely to result in a significant impact on the koala
- Promote streamlined decision-making and approval processes
- Promote the recovery of the koala.

Additional considerations posed by the guidelines will also be evaluated:

- Potential impacts to habitat critical to the survival of the species
- Implementation of mitigation and management measures to protect the species.

It is considered the evaluation would adequately consider the EPBC Act referral guidelines.

Question 4: Has the Plan had regard for the Conservation Advice?

The koala Conservation Advice is a brief and broad document which is intended to provide generalised advice to both management/approval bodies and proponents with regards to conservation information and requirements for koalas in Queensland, New South Wales and the Australian Capital Territory.

The Advice acknowledges that the ecological characteristics and conservation requirements of Koala populations vary significantly across the range of localities covered by the Advice. Therefore, the Advice states that in many cases, local and regional research and Koala management plans may provide far more detail and may be more applicable at local and regional scales.

The evaluation will consider if and how the Plan has had regard for the Conservation Advice. This includes analysis of how the Plan relates to:

- Identified threats
- Research priorities
- Priority management actions.

It is considered the evaluation would adequately have regard for the Conservation Advice.

5.3 Summary

It is considered that with the data available that the evaluation method is appropriate for a landscape-scale assessment and would adequately assess the viability of the southern Koala population. It is agreed that due to poor data availability using PVA at this time may provide inadequate or false outputs and that it should not be used. The evaluation method's consideration of landscape issues such as connectivity and landscape-scale threats such as roads and disease means it is appropriate and the best possible approach, in light of the absence of suitable data for PVA.

The evaluation method addresses the terms of reference and has regard for conservation advice and EPBC Koala guidelines.

The peer review by Associate Professor Mathew Crowther and input from relevant government authorities such as the Commonwealth Department of Environment and Energy and NSW Office of Environment and Heritage have provided a robust audit mechanism.

5.4 Components that require improvement

The evaluation method is considered appropriate for a strategic assessment and components requiring improvement have not been identified. Although it is a complex method with many influencing and interactive factors, which will be difficult to interpret and synthesis, it is still considered more appropriate than a PVA and or a simpler method.

Use of a PVA in the future should be considered, but only if the current method is determined to be deficient or producing outputs that don't meet realities, and if sufficient data can be collected or becomes available. The effort required to collect data adequate for PVA over such a large area is significant, and will be extremely expensive, so should not be considered lightly.

6. Conservation priorities method

6.1 Overview of method

The Conservation Priorities Method aims to determine and prioritise conservation methods for the Cumberland Plain study area. To offset the impacts associated with development of the Growth Areas and transport corridors, it identifies areas suitable for conservation through establishment of Biodiversity Stewardship Sites or National Park Reserves. The method combines spatial data with an analysis of constraints and opportunities. Constraints with respect to establishment of offset sites include land where conservation measures are already required and urban/industrial zoned land. Opportunities include large areas of vegetation in good condition, and proximity to protected/important land such as national parks or riparian areas.

Offset requirements were determined by applying a ratio matrix that applies an offset ratio to all impacted entities based on their conservation status and condition. In accordance with the matrix, the offset ratio increases as conservation significance increases (i.e. from not listed through to critically endangered under the EPBC Act and/or BC Act) and as the condition of vegetation improves.

6.2 Legislative requirements

The project will comprise a strategic application, allowing greater flexibility in application of the offsetting requirements of the BC Act and EPBC Act. Nonetheless, the method aims to address the offsetting requirements of the BC Act and the offsetting principles stated in the OEH Draft Guidelines and EPBC Act Environmental Offsets Policy.

It is considered the method adequately addresses the above requirements and principles as it targets the vegetation and species that will be impacted by the development, aims to improve or maintain biodiversity values, emphasises important biodiversity areas such as national parks and aims to establish in-perpetuity protection for the offset areas.

6.3 Data sources and manipulation

The datasets used in the method are considered appropriate as they can be consistently applied across the study area and comprise the most up-to-date information regarding biodiversity values, development and land use.

The categorisation of constraints and opportunities is appropriate and successfully prioritises potential offset sites across the study area. The method favours privately owned land, which is likely to involve difficulties with landowner involvement and cooperation at this scale. However, the method prioritises offset sites, thereby providing alternative options if difficulties are encountered.

7. Conclusion

Niche were commissioned by DPE to undertake an independent peer review of the Western Sydney Strategic Assessment to meet the EPBC Terms of Reference. The review was based on a workshop held at DPE's Sydney office on 18th February 2019 where the authors of each method provided detailed presentations and an agenda for the workshop that summarised the details of each method of the assessment.

This peer review has summarised the methods for each component of the assessment and then provided comments on the adequacy of the data and method used, and whether there can be improvements. In general it is considered the datasets, methods for data collection and assumptions associated with the methods are appropriate for a strategic assessment and most components do not require improvement. However, in general, details associated with the input data and assumptions should be included to provide the reader a more complete understanding of the limitations of each method.

The methods used are generally conservative and unlikely to under-represent the presence or distribution of any threatened ecological community or species. In fact, the methods used in most methods are likely to over-predict distribution and it is important these approaches are not transposed to the offset component of the assessment as they may predict false presence in future offset lands. However, it is noted that all offset sites would be surveyed prior to establishment. Some species records are excluded from consideration based on patch size and this approach may exclude areas of potential habitat that could be utilised by some of these species.

Despite some potential issues with data error and an overly conservative approach, the interrogation of the data, coupled with independent review by suitably qualified ecologists, is considered appropriate for a strategic assessment and would achieve as much accuracy as possible without significantly more effort with respect to field verification.

Annex 1 – Curriculum Vitae

CV

Rhidian Harrington

BSc (Hons), MSc, PhD

Director and Ecologist

niche
Environment and Heritage

"My goal is to develop the best environmental consultancy in Australia: an organisation that staff are proud to be a part of and that clients partner with to achieve sustainable and efficient project outcomes."

- Founding director of Niche Environment and Heritage
- Over 25 years' experience as an ecologist and project manager
- Design, implementation and delivery of large complex ecological projects
- Extensive experience with road and mining projects, and offsetting
- Biodiversity Assessment Method (BAM) - Accredited Assessor under the NSW *Biodiversity Conservation Act 2016*
- Vice President, Environmental Institute of Australia and New Zealand (EIANZ)

Career overview

Rhidian is a professional ecologist and project manager with over 25 years' experience working across a diverse range of industry sectors and environments. Rhidian has been the senior scientist and project manager on many major projects, including environmental assessments, management plans and mitigation design, particularly for linear infrastructure and large mining developments.

Rhidian has experience in flora and fauna survey, federal and state offsetting schemes and project management for environmental approvals projects. Rhidian has conducted ecological work throughout Australia (NSW, VIC, QLD, SA and the NT) as well as overseas in southern Africa and Pakistan. He is experienced in the application of state and federal legislation which relates to the conservation of threatened species and communities, and related planning instruments. Rhidian has acted as an expert witness in the NSW Land and Environment Court. Rhidian is an Accredited BAM Assessor under the NSW BC Act.

Employment history

2009–present	Director and Ecologist, Niche Environment and Heritage
2003-2009	Manager/Senior Ecologist, Biosis
2002-2003	Project Officer, Black-eared Miner Recovery Team, La Trobe University
2002–2002	Scientific Writer, Institute for Land and Food Resources, Melbourne Uni
2000–2001	Zoologist/Project Manager, Melbourne Enterprises International Ltd
1998–2002	Research Assistant/Demonstrator, University of Melbourne
1995-1996	Research Assistant, Botswana National Parks
1997-1998	Lecturer/Demonstrator, University of the Witwatersrand, South Africa
1992-1992	Research Assistant, Australian Centre for Tropical and Freshwater Research (ACTFR), James Cook University

Skills

- Project management
- Ecology assessments for major projects
- Ecological survey and monitoring
- BioBanking and BAM assessments
- Offsetting strategies and BDAR's
- Stewardship Site Assessments
- Biodiversity offset brokerage
- Impact minimisation (mitigation)
- Expert witness and peer review
- Government agency consultation and advocacy
- Strategic planning and advice
- Regulatory compliance
- Quality assurance

Flagship projects

Key offsetting projects that Rhidian has project managed

Brimbin New Town; Biodiversity Certification Assessment, 2013-2014

Hunter Valley Operations (Rio Tinto); Upper Hunter Strategic Assessment, 2013-2015

Mobile: 0488 224 999 **Email**: rharrington@niche-eh.com

Wambo Coal Mine; Upper Hunter Strategic Assessment, 2013-2015
Boggabri Coal Mine; Independent audit of EBPC Act offsets, 2013
Transport for NSW; review of offsetting guide and calculator; 2015-2016
O'Donnelltown'; Biodiversity Stewardship site assessment; 2018
Edgeworth (NSW) residential development; offset strategy; 2016-2017
Austen Quarry Stage 2 Extension; BioBanking assessment and offset strategy; 2016-2017
'Piney Range'; BioBank site assessment; 2016-2017
Mt Thorley Warkworth Mine; biodiversity areas; bird assemblage monitoring; 2016
Warkworth Mine; offsets vegetation and habitat monitoring; 2014, 2015 and 2016
Chinese Theme Park; BioBanking assessment; 2014-2015
Oxley Hwy to Kempsey Pacific Hwy Upgrade; Biodiversity Offset Management Plan, 2014-15
Hunter Expressway; BioBanking assessment; 2013
West Wallsend residential development; SIS and offset strategy, 2012-2013
Caroona Coal Project; Fauna, aquatic ecology and offsetting assessment, 2013-2015
Hunter Valley Operations; Ecological assessment and offset strategy, 2012-2013
Warkworth Mine; Biodiversity offset strategy, 2013
Warkworth Mine; Local offsets vegetation and habitat monitoring program, 2014-2015
Warkworth Sands Woodland Restoration Plan, 2013
Vickery Coal Mine; SSD ecological assessment and offset strategy, 2011-2014
Tarrawonga Coal Mine; BioBanking Assessment, 2010-2011

Other offsetting projects Rhidian has been involved in

'Glenhaven'; BioBank site assessment; 2016
'Blackjack Mountain'; BioBank site assessment; 2014-2015
Tahmoor South Coal Mine; Ecological assessment and offset strategy, 2013-2014
Balranald Mineral Sands Project; Ecological assessment and offset strategy, 2013-2014
Marys Mount Quarry; Ecology assessment, Koala PoM and BioBanking assessment, 2013-14

Major road projects that Rhidian has project managed

Outer Suburban Arterial Roads Program; Technical Due Diligence Advisor – Ecology, 2017
Toowoomba Second Range Crossing; Technical Due Diligence Advisor – Ecology, 2014-2015
East West Link; Technical Due Diligence Advisor - Ecology, 2013-2014
Hunter Expressway; Project Ecologist, 2004-2009
Pacific Highway Upgrade: Tintenbar to Ewingsdale; Environmental Assessment, 2004-2009
Pacific Highway Upgrade: Woodburn to Ballina; Environmental Assessment, 2006-2008
Oxley Highway Upgrade: Species Impact Statement, 2004-2006
Pacific Highway Upgrade: Moorland to Herons Creek; Environmental Assessment, 2004-2006
Pacific Highway Upgrade: F3 to Raymond Terrace; Environmental Assessment, 2004-2006
Pacific Highway Upgrade: Ballina Bypass modification; Environmental Assessment, 2007-2008
Central Coast Highway Upgrade: Carlton to Matcham Road; EA, 2008-2009
Central Coast Highway Upgrade: Matcham Road to Ocean View Drive; EA, 2008-2009
Central Coast Highway Upgrade: Woy Woy Road Intersection at Kariong; EA, 2009
Princes Highway Upgrade: Tomerong Bypass; Environmental Assessment, 2011
Terrigal Drive Upgrade (two separate projects); Environmental Assessment, 2011
Picton Road Upgrade: Reverse Curves Stage 2; Environmental Assessment, 2012
Princess Highway Upgrade: Nowra Bypass; threatened species assessments, 2012
Pacific Highway Upgrade: Wyong Town Centre Study; Environmental Assessment, 2012
Shortland to Sandgate; Threatened species surveys and assessments, 2013
Federal Environment Department Linear Infrastructure Mitigation panel, 2007

CV

Evelyn Craigie

BSc (Zoology), MEM

Senior Ecologist

"I aim to find innovative solutions that maximise environmental benefits and progress sustainable development."

- Accredited BAM Assessor under the *Biodiversity Conservation Act 2016*
- 14 years' experience in the private and public sectors, including both State and local government
- Experienced in application of environmental and planning legislation and negotiating solutions to ecological issues
- Experience in flora and fauna field survey
- Member of Ecological Consultants Association of NSW

Career overview

Evelyn's career experience includes 10 years in ecological consulting and four years in the public sector. Evelyn's recent experience in development assessment at State and local government has given her a comprehensive working knowledge of environmental and planning legislation and valuable insight into the complexities of environmental planning, the development process and experience in stakeholder liaison.

Evelyn's experience in ecological consulting includes project management, planning and carrying out of field survey. Evelyn has prepared numerous high quality reports that are clearly written and comprehensible to all readers including clients, government agencies, site workers and the general public.

Employment history

2018 –present	Senior Ecologist, Niche Environment and Heritage.
2015 – 2018	Ecologist, Central Coast Council
2014 – 2016	Planning Officer, NSW Department of Planning and Environment
2011 – 2014	Senior Ecologist, Environmental Resources Management Pty Ltd
2004 – 2011	Ecologist, AECOM

Skills

- Comprehensive understanding of environment and planning legislation
- Flora and fauna survey
- Biobanking Assessment Methodology
- Stakeholder liaison and negotiation
- Project management
- Clear written communication

Flagship projects

Prepare Biobank Agreements on behalf of NSW Office of Environment and Heritage (OEH) (2018)

Evelyn has reviewed four applications to establish Biobank Sites and prepared the associated Biobank Agreements on behalf of OEH. This included a comprehensive review of all submitted documents to ensure compliance with the Biobanking Assessment Methodology, liaison with the applicant and OEH and preparation of the Biobank Agreement.

Reports in accordance with Biodiversity Assessment Method (2018)

Evelyn has undertaken survey and reporting in accordance with the Biodiversity Assessment Methodology (BAM) for Part 4 development applications, including development projects and stewardship site projects. Field survey included quadrats in accordance with the BAM and targeted threatened flora survey. Evelyn managed the process through to submission to local government and provided advice to the client with respect to meeting offset obligations.

Mobile: 0488 224 810 **Email**: ecraigie@niche-eh.com

Review of Biodiversity Reports on behalf of Bayside Council (2018)

Evelyn reviewed the biodiversity reports for a Planning Proposal on behalf of Bayside Council. Evelyn was able to draw on her previous State and Local government experience to ensure all biodiversity aspects of the proposal were adequately addressed.

Review of Flora and Fauna Assessments for Planning Proposals, Part 4 Development Applications and State Significant Development (2014 – 2018)

Evelyn assessed numerous ecological reports In her previous roles as a development assessment officer at the Department of Planning and Environment and Central Coast Council. Projects ranged from single dwellings to residential and industrial subdivisions and re-zonings. These roles provided Evelyn with a comprehensive working knowledge of planning and environmental legislation and experience in guiding projects through the complexities of the development application process.

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Environmental management and approvals
Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting
Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)

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OPENLINES
Environmental consulting

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document C – Expert reports

Supporting document C – Contents

Expert report – *Acacia bynoeana*

Expert report for *Acacia bynoeana* (Bynoe's Wattle), Dr Steven Douglas, February 2019

Expert Report For

Acacia bynoeana

(Bynoe's Wattle)

Strategic Assessment for the
Cumberland Plain Conservation Plan

Greater Macarthur, Greater Penrith to Eastern Creek,
Wilton, and Western Sydney Aerotropolis Growth Areas

Prepared for NSW Department of Planning & Environment, February 2019

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Table of Contents

Acacia bynoeana on the edge of a roadside cutting. © S. Douglas

1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Acacia bynoeana*, insufficient survey extent; constraints on the effectiveness of survey; and unreliability of detection due to aspects of the species' ecology are the primary reasons for preparing an Expert Report.

The purpose of this Report is to provide an assessment of the current status and conservation requirements of *Acacia bynoeana* within the four priority Growth Areas of Greater Macarthur (GMGA); Wilton (WGA); Greater Penrith to Eastern Creek (GPECGA); and Western Sydney Aerotropolis (WSAGA)to determine whether:

a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within Growth Areas and development footprints as part of the biocertification process.

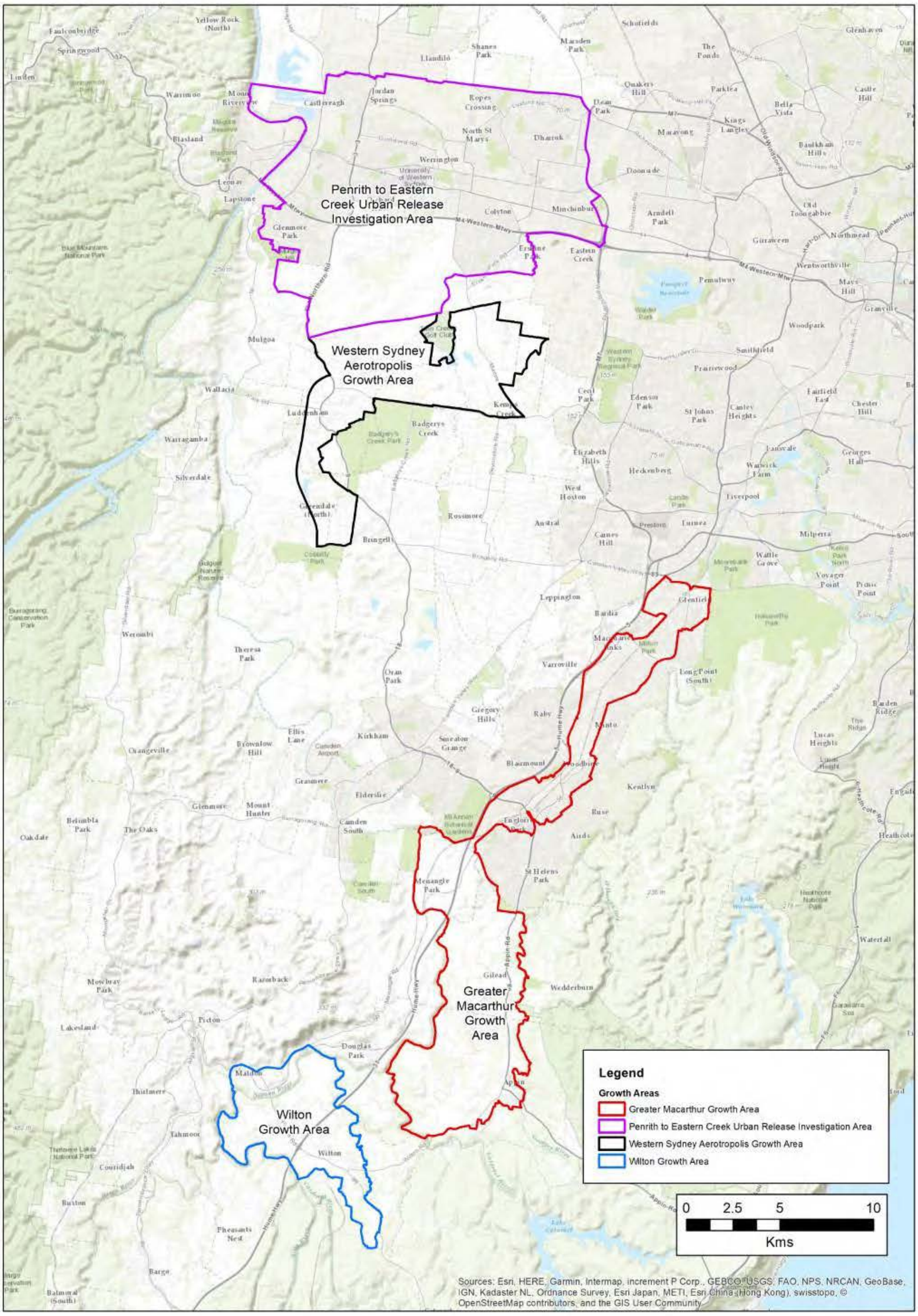
1.2 Project context

The NSW Government is identifying areas for future urban land use and associated infrastructure in western Sydney. The four priority Growth Areas are all located in the Cumberland Subregion under the Interim Biogeographic Regionalisation for Australia (IBRA) (SEWPaC, 2012).

As part of the planning for these areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify land use outcomes. A strategic assessment of this Plan is underway, and this Expert Report will assist in determining the extent and quantum of impacts of the proposed urban growth on *Acacia bynoeana*.

Acacia bynoeana (Bynoe's Wattle), Putty Road © S. Douglas

1.3 Study area



Map 1. Growth Areas subject to this Expert Report

Greater Penrith & Eastern Creek Growth Area (GPECGA)

A large portion of this Growth Area is already urbanised, with several areas of industrial land use. Significant rural and peri-urban areas remain in the central north, the centre, and the southwest. Large areas of remnant vegetation are present in the far north (former Australian Defence Industries site, now in part Wianamatta Regional Park), and the Orchard Hills Defence facility. Mining of alluvium for sand and soil continues in the far northwest of the area in the Penrith Lakes locality.

The area has been extensively cleared because of its relatively arable terrain, based mainly on shale and alluvium. Some of the remaining vegetation is associated with the much less arable to infertile Castlereagh Woodlands and its older, leached and mineralised alluvium and shale-derived soils. Strips of remnant vegetation are present along some of the larger watercourses such as Eastern and South Creeks. Significant parts of the study area are or were flood-prone, and this has influenced the retention of vegetation in some affected areas.

Western Sydney Aerotropolis Growth Area (WSAGA)

This Growth Area adjoins the Greater Penrith to Eastern Creek area, extending south to the locality of Greendale, west of Bringelly. It is currently largely rural, with villages at Luddenham and Kemps Creek. Most rural areas are pastoral, but there are significant areas of more intensive rural use, including poultry and egg production, a large dairy and associated fodder cropping, and some market gardens and enclosed fruit and vegetable production. Quarrying occurs at the localities of Badgerys Creek and Kemps Creek.

This Growth Area is extensively cleared but retains native vegetation in areas where rural uses were constrained by steeper terrain, flooding along streams, or unsuitable soils.

Greater Macarthur Growth Area (GMGA)

The GMGA occurs in southwestern Sydney on predominantly shale soils that have been heavily cleared for agriculture and urban or industrial use. The northernmost section has long-established urban and commercial / industrial land use, while the southern section is largely rural (pastoral, minor cropping), with some villages and primarily subsurface mining (e.g. coal and coal seam gas). It extends from urban Glenfield in the north, to the rural village of Appin in the south.

In the southernmost section, geological uplift and erosion have exposed infertile sandstone terrain along gullies and valleys. Much of that terrain remains naturally vegetated because it is unsuited to agriculture, however it occupies only a small percentage of the total area of this heavily-cleared region. Between the infertile sandstone valleys and the relatively arable shale plateau and hills is a geological and ecological transition zone. Whilst much of the vegetation of the shale terrain has been cleared, a greater area of vegetation remains on the transition zone, primarily in the south. Both the shale and transition zones support Critically Endangered ecological communities that are potential habitat for some threatened plant and animal species.

Wilton Growth Area (WGA)

The Wilton Growth Area is the most southerly of the four Western Sydney Growth Areas dealt with in this Report. It extends from the village of Douglas Park in the north, to the village of Wilton in the south. It is primarily rural (pastoral) area with some more intensive agriculture, significant but mostly underground mining (primarily coal), and some long-established villages. The Hume Motorway dissects this Growth Area.

The pattern of clearing and vegetation retention is broadly similar to that of Greater Macarthur, with the majority of remnant vegetation associated with infertile but biodiverse sandstone gullies and the Nepean River gorge, and with associated transition into the heavily cleared shale landscapes.

1.4 Justification for the use of an Expert Report

An Expert Report for *Acacia bynoeana* is required as part of the threatened biota assessment for the Cumberland Plain Conservation Plan because:

1) Survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH, 2016) for field traverses due to limitations on land access, particularly in the GMGA;
2) Survey quality was constrained by drought conditions. Whilst this species is perennial, under sufficiently severe drought and associated total grazing pressure (livestock, if relevant; native species; feral species), it can be suppressed such that it only remains apparent (but likely undetectable) as rootstock and as seed bank. Drought was a major limitation on survey effectiveness in this instance. A known location of the species was visited by fellow botanist, Robert Miller, but could not be detected, even though the habitat was still in place. This suggests that the surveys for this species will have under-detected it because of drought and associated increased grazing / browsing pressures;
3) Survey effectiveness was further constrained by parts of the study area having been long-unburnt. This can create an unnaturally dense shrub layer that limits access and that also creates conditions likely to suppress the species such that it may retreat to the seedbank until favourable conditions return (post-fire or equivalent disturbance).

Surveys associated with biocertification of the study areas and earlier projects in those areas have been insufficient to reliably determine the presence and extent of the species. An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region, but also in the ACT, Central Coast, southern NSW (coast, tablelands and slopes), throughout Victoria and into eastern South Australia. I have primarily been self-employed, with a mix of government, private, and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for OEH (Native Vegetation Information Science). A summary of my credentials as required under the BAM is provided below as Table 1. I was approved by OEH as a species expert for *Acacia bynoeana* under s.6.5 of the BAM in November 2018

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Acacia bynoeana*

BAM section	BAM requirement	Details
s.6.5.2.8 (g)	Name of expert	Dr Steven Douglas
s.6.5.2.3 (a)	Expert's qualifications	Bachelor of Science (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. Master of Environmental Planning, Graduate School of Environment, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006. BAM Accredited Ecologist, 2018.
s.6.5.2.3 (b)	History of experience in ecological research and survey method for the relevant entity	Review of BioNet and incorporated NSW Herbarium database records of *A. bynoeana* (DPE, 2018). Provision of expert witness evidence in relation to *Acacia bynoeana* (QUBE proposal, Moorebank; included assessment of adequacy of biobanking arrangements) L&EC 2017/81889 (2017-18). Discovery and documentation of new population of *Acacia bynoeana* in Penrose State Forest, including management advice to Forestry Corporation and monitoring (2015-on-going). Rediscovery and documentation of 'lost' 1960s 'Bundanoon' records of *Acacia bynoeana* in Morton National Park (2012-13). Acknowledged by OEH for contribution to the 2009 Draft Recovery Plan for *A. bynoeana*. Consultant to OEH in its review of the current, 2014 Draft Recovery Plan for *A. bynoeana*. On-going advice to OEH to maintain currency of this Plan. Preparation of species management profile for Hornsby and later Gosford LGA Threatened Biota Management Plans (1999 and 2001). Surveys, documentation and recommendations for threatened species including *Acacia bynoeana* as part of the Landcom ESD report (Total Environment Centre, 1999). Successfully nominated species for upgrade from Vulnerable to Endangered under Threatened Species Conservation Act 1995 (1998). Numerous historic surveys in northwest and western Sydney including Hills Shire, Hornsby Shire, Blue Mountains City, Hawkesbury and Penrith LGAs (1994-2000) as evidenced by BioNet and NSW Herbarium records.

s.6.5.2.3 (c)	Resumé detailing projects pertaining to the survey of the relevant entity	See Appendix 1. Relevant surveys and works listed above. Penrose SF population survey used OEH-compliant transects. Minor survey of potential habitat at locality of Kemps Creek for DPE Expert Report. Meandering transect used.
s. 6.5.2.3 (d)	Employer's name and period of employment (if relevant)	Self-employed ecological consultant, 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map, South Coast Regional vegetation map, Review of mapping issues for TECs).
s.6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant entity	Profiles prepared for this species in threatened biota management plans for Hornsby and Gosford Councils. Successful nomination to NSW Scientific Committee to upgrade species' conservation status. Consulted by DECCW on this and other threatened flora species of the region as part of a data review for the purposes of the Biobanking Tool (2006). Consulted by OEH in PAS2 and SOS reviews of this species. Current member of SOS project panel. Engaged by Forestry Corp to advise on management of this species in Penrose SF. Approved as a BAM species expert for *Acacia bynoeana* by OEH in November 2018.

2. Species information

2.1 Description

"Bynoe's Wattle is a semi-prostrate shrub to a metre high. The (adult) phyllodes ('leaves') are shiny, stiff and narrow, 1.5 - 5 cm long and 1 - 3 mm wide…" (OEH, 2017 online species profile). "Decumbent shrub to 0.3 (-0.5) m tall" (Cowan, 2001 in Flora of Australia on-line). "Decumbent shrub to 0.5 m high" (Kodela, 2012 in PlantNET on-line).

The species is best described as having a range of growth forms from prostrate to decumbent to erect, depending on habitat and disturbance history. The tallest plants occur in the lower Hunter / Lake Macquarie regions and can reach 1 metre high; the lowest-growing plants occur primarily on shallow and infertile soils derived from Hawkesbury, Narrabeen, or rarely, Nowra Sandstones and associated laterite, broadly south and west of Lake Macquarie and range from ground-hugging (<5 cm high) to ~20 cm high; and plants of 10 - 30 cm high occur on Paleogene-Neogene alluvium and associated laterite in the Castlereagh Woodlands (roughly in the centre of the species' distribution).

Driscoll (2006 in OEH, 2014) recognised what he considered to be a form of the species in Yengo National Park that was different to the many plants he'd seen in the north and north-east of the species' range. He stated that the Yengo plants have "a much shorter leaf length, sessile peduncles, and fewer flowers and anthers." I am cited in OEH (2014) as suggesting that Driscoll's comments about the Yengo plants are actually typical of the 'southern' populations (i.e. those south of the Lake Macquarie / Hunter area). Driscoll's work was largely in the far north of the species' range, and it is the northern occurrences that are atypical of the species as a whole, though there may be a cline of traits between the Central Coast and the Hunter district. The physical differences between the northernmost populations, and the more typical, much lower-growing plants that occur across most of the species' range is such that the recognition of two subtaxa has been suggested (Douglas, pers. obs. in OEH, 2014). Were a northern subspecies to be recognised, it would have a far smaller range than the typical form of the species, but it is apparently more abundant and potentially more fecund within that area of habitat than would be the typical form across the same sized area. Further research is required to clarify the taxonomic distinctions and any changes in conservation status that this might generate.

Acacia bynoeana in bud – handheld GPS unit for scale. Regenerating in slashed APZ, Penrose State Forest (© Forestry Corporation)

2.2 Ecology

"The single flower heads, on short hairy stems, appear anytime from September to March. Its seedpods are mature from September to January" (OEH, 2017).

Acacia species are generally self-incompatible, and the pollinators are likely to be small native bees and wasps (Bernhardt, 1987 cited in OEH, 2014).

Seed dispersal is most likely by ants seeking to collect the aril. Seeds are taken into the ant nest, and later discarded in a wide area around the nest (Whitney, 2002 and OEH, 2014). Seeds are likely to remain viable over many years in the absence of germination cues, with the species likely to develop a persistent, soil-stored seed bank, as is typical for most Acacias (NPWS, 2002, cited in OEH, 2014).

Driscoll (2006) states that the species is largely clonal and spreads vegetatively by underground stems. Consideration of stem thickness suggests that the plants are relatively long lived. The species is known to resprout following some forms of disturbance, including fire. It can survive in highly modified habitats such as slashed Asset Protection Zones, and road/trail verges.

Driscoll notes that most plants appear to be resprouts or other clonal growth, and that seedlings are rare. However, determining whether a plant is a seedling or a resprout can require some amount of excavation of the root and stem, which may be fatal. Most of Driscoll's assessments relate to populations in the northern part of the species' range, and they may not be representative of the species overall.

I have observed definitive seedlings of this species at Penrose (see below) on a disused fire trail. A BioNet record (Turner, 2005, Tadmore Rd, Cranebrook) also notes "one individual still with juvenile leaves at base, not seen on previous site visit so possibly recent recruit…". A search for the word 'juvenile' in BioNet records for this species within the Cumberland Subregion plus a 100 km buffer found only Turner's reference, though most records simply don't record details about the age of observed plants.

Plants are not always apparent and appear periodically, perhaps in response to local disturbance (Benson & McDougall 1996). The species is "cryptic, clonal and difficult to detect, particularly when not in flower" (OEH, 2014). It is described as "rather inconspicuus" by Fairley (2004).

Acacia bynoeana seedling showing juvenile (lobed) and adult (linear) leaves.
(© Forestry Corporation).

2.3 Distribution and abundance

A range of publications, including on-line resources, provide different distributions for this species, largely as a result of there being significant changes to its known range over time. Some describe it as occurring 'near Wollongong' but this is a result of database errors, as the only legitimate records in that region are not at all near the city and are a considerable distance inland to the north and west within the Woronora Plateau. Many outdated sources list the northern limit as Morriset (Lake Macquarie region), and the southern limit as the Mittagong area (Southern Highlands, Central Tablelands). Neither remain accurate, with the species now accepted to occur substantially further north and south of those areas, as well as further west.

Current knowledge is that *Acacia bynoeana* is found from the Hunter District (North Rothbury) in the north, to the Southern Tablelands (near Goulburn) and South Coast hinterland (Colymea / Parma Ck), and west to just beyond the Blue Mountains (Bogee in the Captertee Valley, and Lithgow areas).

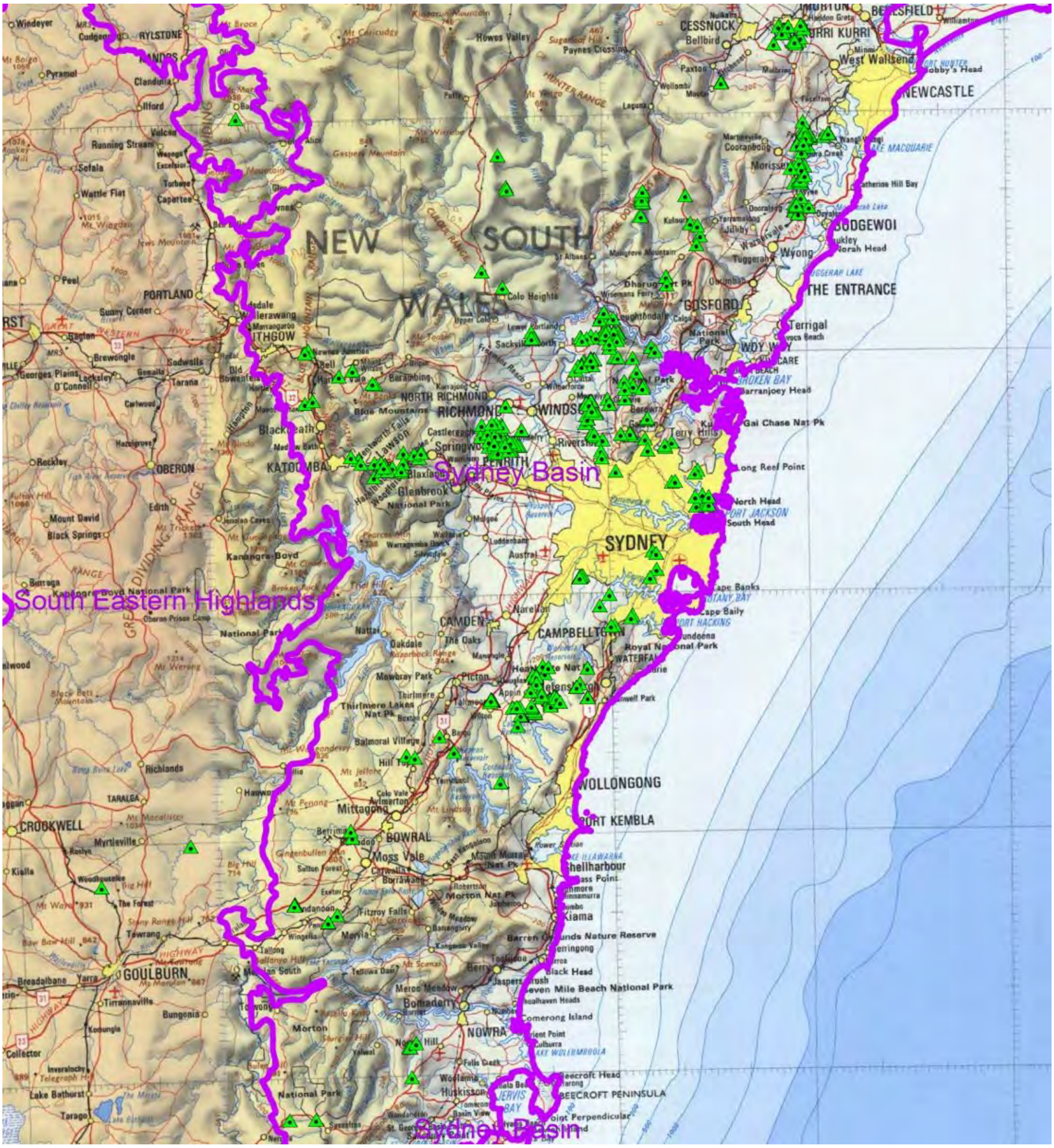
Based on cleaned BioNet data, this species is largely endemic to the Sydney Basin Bioregion, with the exception of three outliers: a record in Tarlo River National Park (part of an incomplete species list for that Park, with no co-ordinates available for this record, so potentially unreliable); a record north of Goulburn (in a vegetation sampling plot with accurate co-ordinates), both of which are within the South Eastern Highlands Bioregion; and another in the Capertee Valley (modern Herbarium specimen with sufficiently accurate co-ordinates), just within the South Western Slopes Bioregion[1].

Map 2 was generated from BioNet data and gives a generally accurate indication of the species' known range, but not the extent of potential habitat. Large areas of NPWS estate and Water NSW catchment lands have not been subject to the same level of survey effort as areas where pressure for land clearing is high or where activities such as underground mining have funded surveys in relation to surface works and subsidence concerns. The map shows an absence of records of the species between the urban areas of the Blue Mountains, and the Southern Highlands, despite there being extensive areas of potential habitat present. Similarly, there are very few records north from the Blue Mountains villages through Wollemi National Park, but again, the area contains significant areas of potential habitat.

As of 2006, the species was known from about 113 extant locations across 21 LGAs (Driscoll, 2006). The number of locations will have increased since that time, though known and unknown destruction of plants and perhaps populations is also likely in that time. The total *estimated* population size in 2006 was 1400 to potentially >6000, though counts were only made at 18 populations, and data indicates that 84 populations only support 1 plant. Two populations were known to support >400 individuals (another was known at that time but not to Driscoll), but 91% of all populations are estimated to support <100 individuals (Driscoll, 2006). Driscoll believes that most population data is very deficient, and that most sightings do not entail a sufficiently thorough census. I concur, as many records lack any population data. In one example provided by Driscoll and Bell, a population estimate of 9 changed to a count of >300 after systematic survey (with some allowance for clonality) (OEH, 2014). OEH has not published a more recent estimate of the number and size of populations, and the 2014 draft Recovery Plan had not proceeded to a final version at this time.

It is important to note that most population 'counts' are estimates because the species is partially clonal, so it is often not feasible to determine the number of actual individuals without genetic testing or potentially destructive sampling.

[1] The boundaries of Bioregions and subregions are often mapped very coarsely and can be misleading in some regards. In this instance, Steenbeeke (OEH / DPE, pers. comm.) states that the Capertee Valley primarily comprises Permo-Triassic deposits of the Sydney Geological Basin and should be included in the Sydney Basin Bioregion, not in the South Western Slopes Bioregion. He notes that the location of the *A. bynoeana* record in that area is on Permian Shoalhaven Group geology.



Map 2. Cleaned BioNet data (extracted 18/10/18)

The above map was generated from BioNet data and gives a generally accurate indication of the species' known range, but not the extent of potential habitat. Large areas of NPWS estate and Water NSW catchment lands have not been subject to the same level of survey effort as areas where pressure for land clearing is high or where activities such as mining have funded surveys. The map shows an absence of records of the species between the lower Blue Mountains and the Southern Highlands, despite there being extensive areas of potential habitat present. A recent record by Orme (not shown) from Joadja has begun to fill that gap. Similarly, there are very few records north from the Blue Mountains villages through to those north of Colo Heights and near St. Albans. Again, that area contains significant areas of potential habitat.

2.3.1 Reservation status

The NSW Scientific Committee (1999) states, "Most of the known sites (of *A. bynoeana*) are not reserved, although populations are known from several reserves including Marramarra National Park, Castlereagh Nature Reserve, Lake Macquarie SRA[2], Blue Mountains National Park". This information was updated by Driscoll (2006) who states that the species is known from 12 NPWS reserves (see Table 2). Five of these are State Conservation Areas that do not prohibit subsurface or surface mining, so do not provide the security that a National Park (NP) or Nature Reserve (NR) designation can.

At least one population (or part thereof) is reserved in a Biobanking offset site (Moorebank). However, that site was burnt in a very intense fire event in April 2017 during severe drought, and at this stage, the status of the *A. bynoeana* population there has not been documented. Part of the area had been burnt only 2-3 years prior to the arson event, which could result in extinction of this species in the affected area, depending on how fire affected the seedbank and how much, if any, successful recruitment occurs post-fire.

Steenbeeke (DPE, pers. comm.) suggests the species may be within the Westcliff Colliery 'managed offset'. Information about other reserved populations in Biobanking offset / stewardship sites was not available due to confidentiality constraints.

Table 2. Modified from Driscoll (2006) by DEE (2008) and for this report. *Best estimate.

Reserve	Records	Individuals*	Populations
Bargo SCA	1	2	1
Berowra Valley RP (now NP)	4	8	3
Blue Mountains NP	8	16	8
Castlereagh NR	4	8	1
Colymea SCA	1	2	1
Jilliby SCA	1	5	1
Ku-ring-gai Chase NP	4	8	4
Lake Macquarie SCA	1	1600	1
Maroota Ridge SCA	4	8	1
Marramarra NP	9	18	1
Wollemi NP	1	2	1
Yengo NP	10	94	1

[2] SRA = State Recreation Area. These were later replaced with the State Conservation Area designation, which has different planning and management parameters but is still a relatively low level of reservation.

Table 3. Additional NPWS reserves containing BioNet records of the species as of November 2018

Reserve	Records	Notes
Agnes Banks NR	1	No recent records despite intensive survey for associated species
Bargo River SCA	1	At edge of reserve
Dharawal NP	51	Detailed survey on and near firetrails and utility corridors. Number of populations much less than number of records
Dharawal SCA	2	One in reserve, one on roadside – may or may not be inside reserve
Morton NP	4	Two sets of two records, distant from each other
Parma Creek NR	1	Credible
Parr SCA	2	One site
Popran NP	1	Credible
Tarlo River NP	1	Dubious record in an incomplete species list for the reserve
Upper Nepean SCA	1	Credible
Werakata NP	3	One site, triplicated. Dubious, possible spatial error.
Wianamatta NR	7	One to three sites – some records with low spatial accuracy

In some instances, the number of records per reserve cited by Driscoll has since increased e.g. Colymea SCA (now 3 records not 1).

In its Final Determination to upgrade the species from Vulnerable to Endangered, the NSW Scientific Committee states, "Recent vegetation surveys in Royal National Park have not located the species. The species was also known from one site within Ku-ring-gai Chase National Park, but several subsequent searches of the site have failed to find any plants". BioNet data currently shows a duplicated, old record on the edge of Royal NP near Loftus, and 4 records in Ku-ring-gai NP. It is this record from Royal NP that has not been rediscovered. A review of cleaned BioNet data for the species in Ku-ring-gai Chase NP revealed 4 records: one by Auld in 1985 (the record referred to by the Scientific Committee); two by Foley in 1998, one of which is an apparent rediscovery of Auld's record, and the other at a nearby by separate site; and one by Foley in 2001 from a different population. Consequently, the statement in relation to the Ku-ring-gai Chase NP population by the Scientific Committee is now redundant. However, there are no records of the species at any of those sites since 2001, but this may be solely an artefact of no survey effort.

"Large populations are present in the Cessnock area of the Hunter Valley, but none of these are currently present in conservation reserves" (Bell & Driscoll, 2002). BioNet data indicates that these populations are near Ellalong and Kurri Kurri, and that one triplicated record may be within Werakata National Park, but they do not provide sufficient detail to verify this.

The species is also now known in considerable numbers (>100 apparent plants, but potentially far fewer individuals) within two sites in Penrose State Forest. Both are outside zones subject to plantation forestry, and the largest is wholly within a bushfire Asset Protection Zone. Whilst the APZ will be maintained to protect plantations, it is now managed with the conservation of *A. bynoeana* in mind, meaning that slashing is less frequent than has been the case; not as low to the ground (parts of the site are now bare due to historically intensive and low slashing); and timed to avoid flowering and seed production. Manual methods of vegetation suppression are also used between slashing events, and these target tree saplings and large shrubs. This practice likely favours *A. bynoeana* by reducing competition and shading through the maintenance of a derived low heathland in what would have been heathy to scrubby forest or woodland.

Additional populations may be reserved as a result of the pending declaration of several new Flora Reserves (deemed Koala Reserves, to be managed by NPWS) within State Forests. However, none were evident based on current BioNet data and Forestry Corporation tenure. Again, this may be a result of low or no survey effort. The species is likely to occur in at least two of the forthcoming Flora Reserves: Meryla and Jellore, both of which are in the Southern Highlands. It may also be present in the forthcoming Comleroy Flora Reserve northwest of Sydney.

The species is now known to occur in many more NPWS reserves than when it was gazetted as Endangered in 1999, or as reported in Driscoll's work of 2006, and by OEH (2014). However, the true size and viability of all such populations is largely unknown. There are also more records of the species, and some more information about apparent population sizes. However, the species remains inadequately conserved across much of its range, and most records either have no population data, or relate to a single plant.

2.4 Habitat

2.4.1 Geology and soil

Acacia bynoeana occurs primarily in heathland, scrub, woodlands and forests on Triassic and Permian primarily sandstone-derived soils (including but not limited to members of the Hawkesbury, Narrabeen & Shoalhaven Groups); the Wianamatta Shale / Hawkesbury Sandstone transition and often-associated Mittagong Formation; and on Paleogene-Neogene alluvium deposits of the Cumberland Plain and environs (*sensu* Martyn, 2018). Some occurrences are known from Quaternary and Cainozoic geologies (Driscoll, 2006), but these are a very small proportion across the species' range. The three geographically outlying records are apparently associated with older geologies that form the basement of the Sydney geological basin. Most occurrences are from sandstone plateaux, with the exception of those from parts of the Lake Macquarie and Hunter area, and those from the Castlereagh Forests and Woodlands of Western Sydney.

Associated Soil Landscapes include but are not limited to: Berkshire Park (Paleogene-Neogene alluvium); Faulconbridge, Bundeena, Gymea, Lambert, Somersby, Oxford Falls, Penrose, Penrose A, Soapy Flat, Nattai Tablelands (Hawkesbury Group); Lucas Heights, Hilltop (Mittagong Formation); Warragamba, Gorokan, Awaba (Narrabeen Group); Durran Durra (Ordovician Metasediments); Canobla Gap (Megalong Conglomerate and Berry Siltstone); Doyalson (Munmorah Conglomerate); Heddon Greta (Permian Branxton Formation). Other Soil Landscapes may be relevant towards the limits of the species' distribution but occur in areas without Soil Landscape maps or where the available data appears incorrect.

Altitude of known habitat ranges from 0-1000 m, though Driscoll (2006) believes that the species may be found at higher elevation subject to survey effort.

2.4.2. Associated vegetation communities and NSW TECs

The species "Seems to prefer open, sometimes slightly disturbed sites such as trail margins, edges of roadside spoil mounds and in recently burnt patches. Associated overstorey species include Red Bloodwood, Scribbly Gum, Parramatta Red Gum, Saw Banksia and Narrow-leaved Apple" (OEH, 2017). The listed overstorey species are only a subset of those that are relevant across the species' range, and are not representative, nor do they occur at all locations where the species is present.

OEH (2014) and the OEH Threatened Biodiversity Data Collection list the following Keith Vegetation Classes as being associated with *A. bynoeana*:

- Sydney Coastal Dry Sclerophyll Forests;
- Sydney Coastal Heaths;
- Sydney Hinterland Dry Sclerophyll Forests; and
- Sydney Sand Flats Dry Sclerophyll Forests.

The Threatened Biodiversity Data Collection indicates that *Acacia bynoeana* is potentially associated with 52 Plant Community Types (PCTs) across its range. Some of these are also associated with State and Commonwealth-listed Threatened Ecological Communities (TECs). Within the Growth Areas, relevant communities and NSW-listed TECs, excluding apparent errors, are shown in Table 4. The associated PCTs are treated by OEH as *potential* habitat, and the species may not actually occur in all of those communities.

Associations between a species and Vegetation Classes and PCTs in the Threatened Biodiversity Data Collection were determined by the species' Accountable Officer within OEH some years ago, and staff were required to take a relatively inclusive approach in accordance with the precautionary principle (Steenbeeke, pers. comm.). This may mean that for some species, Vegetation Classes and PCTs have been associated with them even though there is little or no empirical evidence to support that, but where the officer believed that these attributes credibly represent *potential* habitat. Given the limitations of vegetation mapping and that in most cases, survey effort for threatened species is incomplete across their range, such an approach is understandable.

It appears that in some cases, the associations with Vegetation Class and PCTs in the Threatened Biodiversity Data Collection may have been amended after the assignments described above, and that some more recent associations may be influenced by spatial errors in species' records and/or errors in or limitations of vegetation maps. The apparent association between *Acacia bynoeana* and PCT 1292 is apparent evidence of this, as this unit is a riparian scrub that is unsuitable habitat for this plant. Similarly, the association with PCT 849 is very likely unsound, as the species is not accepted to occur on Wianamatta Shale.

An assessment of the association between *A. bynoeana* and PCTs was undertaken to better understand the potential habitat for this species in terms of plant communities. The assessment is constrained by limitations of BioNet data and available vegetation maps. The assessment of the species' relationship with PCTs in and near the Cumberland Subregion used OEH vegetation maps that were publicly available at the time and did not use the updated vegetation maps produced within the Growth Areas. The information is used to generate 'species polygons' (maps of potential habitat) as required under the BAM. Whilst DPE required habitat associations to be graded i.e. strong to weak association with particular PCTs, only ungraded PCT association data was used to generate the 'species polygons'.

Some records of the species were seen to not be spatially associated with a PCT. This may be because:

- the record occurs in a site now cleared of native vegetation or too degraded to be captured by mapping;
- because the record is too spatially uncertain, so has been assigned generic co-ordinates, usually in a named town or suburb, and such settled areas often lack remnant native vegetation; and/or
- the record plots just outside an area of mapped vegetation because it is on a road verge, and even most GPS records are only accurate to 5m, meaning it could plot on the road, not on the vegetated verge.

To overcome this latter problem, those records were assigned a 10 m buffer so that they would associate with the nearest mapped vegetation polygon up to 10 m from the plotted location.

A further consideration is that survey effort for the species is not evenly distributed across the area subject to analysis. Some sites of potential habitat have had very little or no effort, often due to tenure constraints, yet others have had every apparent plant recorded (mostly in reserves or as part of ecological impact assessments). This creates very substantial biases in the data, which can create misleading weightings of association between the species and particular PCTs. Furthermore, most records do not include population data, such that a record might be for one plant or many. In short, this analysis is best used only for presence/absence i.e. whether the species has been recorded at a point that is mapped as a particular PCT, or not. Analysis beyond that is very constrained by deficiencies and biases in the datasets, especially in BioNet data.

The analysis of association with PCT in Table 4 below deals only with records in the Cumberland Subregion plus a 10 km buffer. Records that associate with a PCT when a 10 m buffer is used are included in the counts of sightings below and are not shown separately. Two analyses were undertaken: All records in the target area without regard to spatial Accuracy score; and only records in that area with Accuracy score of 100 m or better. The latter analysis is considered more reliable, but both sets of figures are provided. Sightings with Accuracy <=100 m are shown in square brackets **[ ]** and in bold text. Where available, the combined count of individuals associated with the records is provided in parentheses { }. Those counts relate only to records with Accuracy <=100 m. Where a record doesn't contain population data, it is assumed to relate to a single plant.

Only PCTs mapped in the Growth Areas are dealt with below. For PCTs outside the Growth Areas and within the 10 km buffer, only Coastal Sandstone Ridgetop Woodland (1777) is significantly associated with *Acacia bynoeana* (80 [71] {112} Very High).

Some PCTs can appear to have a greater or lesser association than is known or likely to be the case. This is evident for this species in that an uncritical review of the raw data would generate an association with this species and PCT 849, a form of Cumberland Plain Woodland that is not considered habitat for this species in any of the literature. The very few records that appear to be associated with that vegetation were more likely in Shale Gravel Transition Forest or Shale Sandstone Transition Forest, both of which can have a broad and indistinct ecotone with Cumberland Plain Woodland such that mapping of the boundary can be very difficult, even at quite a fine map scale.

Similarly, the raw data for PCT 1181 indicates a potentially Low to Moderate relevance as potential habitat, but this is likely to be influenced by spatial errors in the species' records and/or spatial and other limitations of the vegetation maps. At least some of the records associated with this sandstone-based PCT are more likely associated with PCT 1081, which may not have been accurately mapped. The association with 1181 is subsequently rated as Low probability/relevance as habitat.

Inclusion of PCTs 724, 725 and their derived shrubland state (808) as Very Low probability habitat in Table 4 would not ordinarily be supported by the methodology adopted here because there are no spatially credible records of the species from PCT 724 and only two from PCT 725. However, given the limitations of both survey data for the species (incomplete across its range, variable dependent on tenure/access, variable over time, variable in spatial accuracy, variable in quality, etc.) and of vegetation maps, inclusion of PCT 725 as potential habitat is in accordance with the precautionary principle and is made based on advice from Steenbeeke (DPE, pers. comm., relying on his field observations and his interpretation of habitat-related text associated with some records of the species). Steenbeeke also believes that 724 should be included as potential habitat, but I have not adopted that recommendation because there is insufficient evidence to support this, and I consider it unlikely to support the species, or at most, to be extremely low value habitat.

TABLE 4. Species records relative to mapped PCTs

PCT	PCT Name	Associated TECs (NSW BC Act)	% Cleared (VIS)	Sightings & Population	Relative association	Adjusted relative association#
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Shale Gravel Transition Forest (E)	75	1 **[0]** {0}	Probably nil	Nil
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Cooks River/Castlereagh Ironbark Forest (E)	95	4 **[2]** {4}	Very Low	Very Low
808	Derived shrubland on Tertiary Gravels of the Cumberland Plain	Shale Gravel Transition Forest (E) Cooks River Castlereagh Ironbark Forest (E)	75-95 inferred from 724/725	Not mapped	Very Low (inferred)	Very Low
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CE)	93	7 **[2]** {2}	Very Low	Nil
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland (V) Castlereagh Swamp Woodland (E)	50	54 **[48]** {157}	High	High
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Not a TEC but some areas may be within Shale Sandstone Transition Forest (CE)	40	70 **[62]** {114}	Very High	Very high
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney	Not a TEC	20	17 **[10]** {71}	Low	Low
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (CE)	80	37 **[36]** {153}	High	Moderate

Description of PCTs associated with *Acacia bynoeana*

PCT 725

This community is not mapped in the WGA and GMGA, as the requisite geology is apparently not present. However, it may have been present to a minor extent in the far north of the GMGA because the presence of a very small area of 883 (below) indicates that there was at least one unmapped occurrence of Paleogene-Neogene alluvium.

This PCT is present to a very limited degree near the localities of Kemps and Badgerys Creeks in the WSAGA, and in the far central north of the GPECGA. It is restricted to Paleogene-Neogene alluvium/laterised shale, and this substrate is naturally rare and localised in those areas. Most occurrences in the GPECGA are within or near the currently gazetted and proposed portions of Wianamatta Regional Park, with only small patches occurring further east. It is part of the Cooks River/Castlereagh Ironbark Forest TEC.

PCT 883

This community is absent from the WGA, as the requisite geology is not present. It has been mapped only in the northern section of the GMGA as four small polygons in a section of infrequently-mown urban parkland adjoining a sporting facility. Whilst much of what little remnant vegetation remains, these polygons appear to be correctly ascribed to this community. However, aerial and ground-based photo interpretation indicates that much of the habitat within those polygons is likely to be too compromised to support this species, largely due to the nature of disturbance history and the severity of weed invasion (particularly African Love Grass). Engagement with Campbelltown Council as the land manager resulted in Council setting aside some areas from mowing. This increases the prospect for regeneration of *A. bynoeana*, but application of fire to stimulate regeneration is also likely to be necessary, especially in long-unburnt and long-unmown areas. The habitat value of the four polygons of 883 appears variable, but the ecology of *A. bynoeana* is such that it can persist in significantly compromised sites, such that these remnants are treated as potential habitat for the species.

PCT 883 has been mapped by OEH as two patches near the locality of Kemps Creek, only one of which is in the WSAGA, the other being just south of Elizabeth Drive. Fieldwork determined that the patch previously mapped within the WSAGA was incorrectly assigned and is better placed in one or two alternative PCTs (724/725). Based on the analysis shown in Table W, these two PCTs are very poorly associated with *A. bynoeana*, which may at least partially explain the absence of records of this species from this locality despite several surveys being undertaken there in association with recent land clearing applications.

OEH mapping shows four small patches of 883 in the central north of the GPECGA, three of which are within Wianamatta Regional Park. A few patches are mapped nearby at Llandilo on the northern border of the GPECGA. There could be additional very small patches within the GA that have not been correctly mapped due to the coarse resolution of soil and geology maps. The revision of OEH's map by Biosis has reduced this PCT's extent in the GPECGA to a single linear patch in the eastern portion of Wianamatta Regional Park. This PCT is extensive north from Cranebrook and is present within Castlereagh and Windsor Downs Nature Reserves. It is the most extensive community within what remains of the threatened Castlereagh Forests & Woodlands, partly because its soils are relatively infertile. It is a Vulnerable ecological community.

PCT 1081

This community is a form of 'shale sandstone transition forest' that was previously within the scope of the now circumscribed Shale Sandstone Transition Forest (SSTF) TEC. It has been independently assessed as a prospective threatened community, that whilst significantly reserved, is suffering on-going losses around Sydney, largely due to urban and peri-urban land use. It is a very significant habitat for *A. bynoeana* and several other threatened plant species.

This PCT is absent from GPECGA and WSAGA due to the lack of suitable geology. It is present as a very minor component of the northern GMGA (one site and three polygons) and as moderate component of the WGA. It is likely to have been naturally uncommon to rare in those areas and has probably not been heavily cleared there. It is not readily mapped with high reliability because of the broad ecotone with PCT 1395. Consequently, a precautionary approach is particularly necessary when dealing with areas mapped as PCT 1081, as some may be better classified as 1395 and therefore a Critically Endangered Ecological Community. It is also highly likely that 1081 is present but unmapped in areas that show 1395 immediately adjoining 1181, as the transition zone between the associated geologies is rarely as simple as most maps indicate.

PCT 1181

This community is mapped within the WGA and GMGA, but is generally outside the proposed areas of urbanisation, being associated with sandstone soils in gullies, valleys and steeper slopes. It is usually excluded from the proposed urban footprint because of its association with protected habitat along watercourses, and because of bushfire risk and steep, often rocky terrain. This PCT is not strongly associated with *A. bynoeana* habitat, and the association that is evident in the Bingara Gorge records may be an artefact of the vegetation mapping and of map scale. Most of those records are within vegetation mapped as 1395, with a small proportion close to or just over the boundary with 1181.

This PCT is not present in the GPECGA or the WSAGA due to the absence of associated geology.

PCT 1395

This community is the principal PCT of SSTF TEC and has a relatively moderately strong association with *A. bynoeana*. This community occurs on flat to gently sloping terrain, usually bordering cleared or highly modified rural land. This PCT is absent from the GPECGA and the WSAGA due to the lack of associated geology.

Even where proposed urbanisation does not involve clearing of SSTF, it can be increasingly threatened by urban encroachment in the form of bushfire hazard reduction works, recreational pressures, urban pollution e.g. nutrient-laden runoff, increased weed invasion from inappropriate landscaping/gardening, and increased predation of fauna by domestic pets.

2.4.3 Associated Commonwealth TECs

The Approved Conservation Advice for this species (DEE, 2013) contains significant errors that were brought to that agency's attention in 2016 but remain in its on-line publication as of November 2018. These include *incorrectly* associating *A. bynoeana* with the following nationally listed threatened ecological communities: Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion, White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, Western Sydney Dry Rainforest and Moist Woodland on Shale, and Blue Gum High Forest in the Sydney Basin.

The Advice correctly associates the species with Shale Sandstone Transition Forest (this is essentially the same entity as the NSW TEC of the same name), and to a minor degree, the species can be found near but not in Temperate Highland Peat Swamps on Sandstone. The latter does not occur in the Growth Areas. Other nationally listed threatened ecological communities are also relevant but remain absent from the now-outdated text provided by DEE (2013). These are Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion; and at least on the basis of statistics, Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest. These are composite entities that each combine at least two NSW TECs. The species is strongly associated with Castlereagh Scribbly Gum Woodland but less so with Agnes Banks Woodlands.

2.4.4 Habitat condition

Degraded and significantly modified areas of the above-described PCTs can still be habitat for this species due to its ability to persist as woody rootstock and in the soil seed bank. Such modified sites may have reduced or no canopy and/or midstorey, and/or reduced understorey and some weed invasion. It is known to occur in highly modified sites such as slashed bushfire Asset Protection Zones, and road and trail verges, and in former small-scale quarries. Some forms of disturbance, even relatively severe forms that would be considered clearing of vegetation, appear to be beneficial to this species, within limits. This situation is recognised for numerous threatened plant species in and beyond the Sydney Basin Bioregion. It is believed to be related to the fact that modern fire regimes are likely to be significantly different to those prior to 1788, and that some native animal species that had a role in seed dispersal and understorey modification are now extinct, locally or entirely.

The condition of potential habitat for this species is not, in itself, a reliable indicator of the species' presence, and accordingly, **all condition states are considered in determining suitable habitat** i.e. intact, thinned, scattered, derived shrubland and, to a lesser degree, derived grassland.

3. Description of the study area

3.1 Landscape context and land use history

All of the Growth Areas have been significantly cleared for earlier activities, primarily timber production associated with opening areas for agriculture and pastoralism, minor areas of surface resource mining, and to varying degrees, for urban and commercial/industrial use. They are proposed to accommodate phased increases in urban land use, primarily within existing cleared or highly modified lands. Increased urban use is planned as a response to population growth.

3.1.1. Greater Macarthur Growth Area (GMGA)

The GMGA extends from Glenfield in the north to Appin in the south. It is largely within the Campbelltown LGA with the southernmost section within the Wollondilly LGA. The northern half comprises an urban renewal corridor centred on the Sydney to Main Southern railway line. It encompasses the existing industrial and residential suburbs of Glenfield, Macquarie Fields, Minto, Leumeah and Campbelltown. The GMGA is associated with extensively cleared, gently undulating shale terrain typical of the Cumberland Plain, and contrasts the sandstone gorges of the Woronora Plateaus across the Georges River to the east. The northern portion of the GMGA is already substantially urbanised, with remnant vegetation largely restricted to creek-lines or small patches associated with designated open space. Vegetated creek-lines include Bunbury Curran Creek, Bow Bowing Creek, Leumeah Creek, Fishers Ghost Creek and Spring Creek.

The more extensive southern half of the GMGA, south of Rosemeadow, comprises proposed urban land releases at Menangle Park, Mount Gilead and Appin. Menangle Park and Mount Gilead are subject to separate planning processes, so are not within the scope of this biocertification. In the north-west, Mount Sugarloaf (213 m AHD) forms the southern end of a hilly ridge on the Luddenham Soil Landscape above the Menangle floodplain that extends north to Denham Court, then to Cecil Hills and Prospect Hill. Some native vegetation persists, although it is often invaded by African Olive. The floodplain is dissected by Menangle Creek and its tributaries, including Nepean Creek, Woodhouse Creek and Leafs Gully.

The southern GMGA is primarily semi-rural and agricultural land, with creek corridors and some larger patches of remnant vegetation located between the Nepean and Georges Rivers. Geologically, the area comprises gently undulating hills on Wianamatta Shale intergrading via a shale sandstone transitional zone (can include the Mittagong Formation) with steeper and infertile terrain on Hawkesbury Sandstone along the rivers. Transitional and sandstone geologies are sometimes exposed along the smaller creek lines.

3.1.2. Wilton Growth Area (WGA)

The WGA is a relatively smaller area that occurs to the south of the GMGA, extending from the vicinity of Douglas Park in the north, Maldon in the north-west, and beyond Wilton in the southeast. The boundaries closely follow the Nepean River in the north and west, a tributary Allens Creek in the east, and the Cordeaux River in the south. Away from the Nepean River and gullies, a higher, gently undulating zone has been largely cleared for agriculture. The Woronora Plateau forms the southern boundary and includes the northernmost section of the large Upper Nepean State Conservation Area, with unreserved but closed areas of the Water NSW Special Area (Sydney water supply catchment) extending to the east and southeast. The Hume Motorway dissects the WGA roughly north to south, and Picton Road traverses it roughly northwest to southeast.

The WGA includes both shale, shale sandstone transition and sandstone environments. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The flatter shale terrain has soils of the Blacktown Soil Landscape, which is derived from Ashfield Shale (a member of the Wianamatta Group), and typically supported the now Critically Endangered Cumberland Plain Woodlands. Much of this area is cleared or modified for agriculture and hobby farms. It comprises native/exotic grassland with smaller areas of Derived Native Grasslands in relatively better condition. Areas above the gullies feature soils of the Lucas Heights Soil Landscape derived from the Mittagong Formation (a transitional bed between the Wianamatta and Hawkesbury Groups). These support variable shale sandstone transition woodlands and forest, some of which are also Critically Endangered. In the steeper gullies, the Hawkesbury Soil Landscape dominates, and supports Hawkesbury Sandstone Gully Forest types with Ridgetop Woodlands on some of the upper slopes.

3.1.3. Greater Penrith to Eastern Creek Growth Area (GPECGA)

The GPECGA is a relatively large area that extends from Rooty Hill, Minchinbury and Hassell Grove in the east, across the Cumberland Plain to the Hawkesbury-Nepean River in the northwest, then south through Jamisontown, Glenmore Park, to the intersection between The Northern Road and the Warragamba Water Supply Pipelines in the far south-west.

The predominant geology is Wianamatta Shale on flat to gently undulating terrain that has been extensively cleared for agriculture, and later for housing and industrial use, with some remnant vegetation on current and former Defence holdings. The shale soils support(ed) Cumberland Plain Woodlands. Overlying the extensive shale deposits are small areas of weathered Paleogene-Neogene alluvium e.g. Shalvey and Willmot, that are much more common to the north. These support(ed) the Castlereagh Forests & Woodlands complex of vegetation types, which is strongly associated with several threatened plant species. More common are broadly linear deposits of Quaternary alluvium along watercourses such as South Creek and Eastern Creek, and on the flood terraces of the Hawkesbury-Nepean River. Other lithologies occur but are very rare and of very small extent.

Very little of the GPECGA is reserved in NPWS estate. Wianamatta Regional Park (which emphasises recreational uses) encloses small areas of former Defence land in the far north. Adjacent to the southwestern boundary is the small Mulgoa Nature Reserve (emphasises biodiversity values). Two Biobanking sites adjacent to the Nature Reserve have increased the area under conservation.

3.1.4. Western Sydney Aerotropolis Growth Area (WSAGA)

The WSAGA abuts the GPECGA's southernmost border near the locality of Sovereign (east of Mulgoa), then extends south past Greendale, northeast to the locality of Badgerys Creek, east to Kemps Creek, and northward to the vicinity of Mount Vernon, excluding Twin Creeks Golf Course and associated settlement.

The lithology and soils are broadly similar to that of the GPECGA, being effectively just an extension of that area to the south to incorporate the developing Badgerys Creek Airport and environs. The area is even more severely cleared of native vegetation, except along some streams and on rare occurrences of steeper terrain. It contains no NPWS reserves, with the nearest being the small Kemps Creek Nature Reserve, outside the Area to the southeast. Gulguer Nature Reserve and Bents Basin State Conservation Area occur to the southwest of Greendale.

3.2 Geology and remnant vegetation

All of the Growth Areas are within the Cumberland Subregion. The dominant lithology across all of the Growth Areas is Wianamatta Shale (Ashfield and Bringelly Shales), with much smaller areas of Paleogene-Neogene alluvium occurring largely outside these boundaries, and much larger areas of Quaternary alluvium associated with floodplains of the many watercourses.

The terrain varies from almost flat through to steeply hilly areas associated with minor volcanism and more often, in association with shale ranges. In the far south, the more elevated shale landscapes have been eroded down to the underlying Hawkesbury Sandstone in a series of gullies and gorges. A transition zone between the shale and the sandstone is discernible in some areas.

On the dominant shale geology, the associated Critically Endangered Cumberland Plain Woodlands are still present in all of the four Growth Areas but have been disproportionately cleared for rural and later urban and allied uses. Much of what remains of this ecological community occurs as paddock trees and areas of remnant native ground-layer vegetation in pastoral and other contexts, with the exception of some substantial, though fragmented and isolated remnants. Remnant vegetation in these relatively fertile and arable landscapes is often in poor condition. In the most heavily cleared areas, it can be restricted to strips along watercourses. Some forms are dominated by *Casuarina* species. Weeds are common and sometimes severe in the moister situations. Weeds often extend into higher and drier terrain, especially in the form of African Olive and African Love Grass, both of which can occur on a landscape scale.

Small areas of the biodiverse Castlereagh Forests & Woodlands persist in all but the Wilton Growth Area on often-laterised Paleogene-Neogene alluvium. These variable woodlands and open forests support a particularly high number of threatened plant species, and because their soils are less suitable for agriculture and grazing, are better conserved than the Cumberland Plain Woodlands. Nonetheless, they are all listed as threatened ecological communities.

In the two southern Growth Areas, vegetation of the shale sandstone transition zone is relatively common and tends to remain in less arable areas adjoining the largely cleared former Cumberland Plain Woodlands. It is often found fringing the largely uncleared sandstone-based terrain, and ranges from highly intact to significantly modified and degraded, largely due to grazing and weed invasion. The associated Shale Sandstone Transition Forest is recognised as Critically Endangered due to extensive clearing across its substantial range, and because of the severity of other threats. Very little is present in formal conservation areas.

In the two southern Growth Areas, diverse, sandstone-based vegetation persists in association with most of the many incised watercourses. This vegetation is broadly the same as what occurs in extensive conservation estate around urban Sydney, but some communities adjoining current or former Shale Sandstone Transition Forest are not well-conserved and are threatened by further clearing and degradation.

3.2.1 Plant Community Types

The following section lists the Plant Community Types mapped in each Growth Area with brief notes about their distribution in those Areas. The list is not restricted to PCTs associated with *A. bynoeana*.

3.2.1.1 Greater Macarthur Growth Area (GMGA)

The predominant ecological communities in the GMGA are or were Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), all of which are Threatened Ecological Communities. All have been extensively cleared and degraded, primarily by agriculture and weed invasion, but also by urban and allied uses. There are no NPWS reserves in this Growth Area. However, the very small Leacock, Edmondson and William Howe Regional Parks occur just outside the border and are managed primarily for recreation rather than conservation. Dharawal State Conservation Area and National Park border the southern portion of the Growth Area to the east.

A summary of the mapped ecological communities is found in Table 5. The maps are based on OEH products that have been updated by Biosis for DPE.

Table 5. Summary of all ecological communities within the Greater Macarthur Growth Area

PCT	PCT Name	Distribution & notes
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Small patch at Menangle Sugarloaf on SE slopes.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Along creek lines in shale areas in northern and central parts of GMGA.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Small patches on shale soils throughout GMGA but mostly in northern and central parts.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches on shale soils throughout GMGA, more common in southern parts on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	4 polygons, Macquarie Fields, most of which have long been historically mown (Milton Park Softball Complex). They are now subject to regeneration.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	One small occurrence mapped around the margins of bushland associated with Smiths Creek at Leumeah.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Nepean River north from Menangle Bridge.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Narrow zone along Nepean & Georges Rivers and tributary gullies and a small zone along Smiths Creek at Leumeah.
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Restricted to parts of the riparian zones of the more incised and larger watercourses. Very restricted extent in this Area.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Relatively small remnants extend from Glenfield into the far south where it is extensive on transitional soils mostly south from Rosemeadow. Can intergrade with 849 and 1081.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Only mapped to a very minor extent as highly linear remnants between Glenfield and Macquarie Fields (along the railway) and at Ingleburn (adjoining roads).

3.2.1.2 Wilton Growth Area (WGA)

The predominant ecological communities in the WGA are or were Cumberland Plain Woodland (CPW) and Shale Sandstone Transition Forest (SSTF) both of which are Threatened Ecological Communities. Sandstone-based communities occur in and surrounding the more incised watercourses. There are no NPWS reserves in this Growth Area, though Upper Nepean State Conservation Area occurs immediately to the south. There is a Biobanking site on the northern side of the river near Douglas Park (within the WGA), and three more such properties to the immediate north (including St Marys Towers) and those associated with coal mines (Steenbeeke, pers. comm.).

Table 6. Summary of all ecological communities within the Wilton Growth Area

PCT	PCT Name	Distribution & notes
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	On shale soils of higher, gently undulating terrain of northern and central areas. Small patches with scattered trees (farming properties) adjoining more extensive exotic and native grasslands.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	One patch in a derived grassland (treeless) condition in the west, and a much larger portion in the far north.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Limited to a few patches in the north between 1395 on plateau edges and 1181 in sandstone gullies.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Common on slopes and plateau edges above and around incised sandstone-based watercourses that surround most of the Area.
1292	Water Gum – Coachwood riparian scrub along sandstone streams	Restricted to a very narrow riparian strip along the Nepean River.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	The most extensive community on shale sandstone transition soils between 849/850 and sandstone communities along gullies. Variable floristics.

3.2.1.3 Greater Penrith to Eastern Creek Growth Area (GPECGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Shale Gravel Transition Forest and Castlereagh Forests & Woodlands. River-flat Eucalypt Forest was previously much more extensive along the Hawkesbury-Nepean River and adjoining primary floodplain, and it remains to varying degrees along many watercourses such as Eastern Creek, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. There is one NPWS reserve in this Growth Area: Wianamatta Regional Park, however it is already significantly fragmented and may be required to potentially accommodate a large transport corridor. The small Mulgoa Nature Reserve and associated Biobanking sites occur near the south-western border of this Growth Area. Yarramundi SCA occurs on the western boundary but across the Nepean River, and Wianamatta NR occurs near the NW corner.

Table 7. Summary of all ecological communities within the GPECGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Scattered as small remnants and one larger remnant in the central portion, but with greater extent in the central north, mainly in the western ungazetted portion of Wianamatta Regional Park.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	A few very small remnants present south of the M4, with larger remnants within and near the gazetted and ungazetted portions of Wianamatta Regional Park.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northwest, with some small remnants in the southwest, often associated with watercourses.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Present to a very minor extent on the southwestern edge adjoining Mulgoa Nature Reserve
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains through the south and central areas.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Common in and near Orchard Hills in the south, and former ADI lands in the central north, with some areas in the ungazetted portion of Wianamatta Regional Park. Other scattered remnants, particularly in the east.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches in the south west, primarily in pastoral settings and on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Restricted to one linear polygon in the eastern portion of Wianamatta Regional Park.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Hawkesbury-Nepean River, primarily near Penrith Lakes.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Present as mostly-linear remnants along South Creek and Eastern Creek and tributaries, with some scattered occurrences, including along the M4.

3.2.1.4 Western Sydney Aerotropolis Growth Area (WSAGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Castlereagh Forests & Woodlands near the localities of Kemps and Badgerys Creeks, and potentially in the vicinity of the water pipeline crossing of Luddenham Road. Riverflat Eucalypt Forest remains to varying degrees along most watercourses, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. Swamp Oak Forest occurs mainly along South Creek and some tributaries. There are currently no NPWS reserves in this Growth Area. The small Kemps Creek Nature Reserve occurs just outside the south-eastern corner and Gulguer Nature Reserve and Bents Basin State Conservation Area are near the south-western corner.

Table 8. Summary of all ecological communities within the WSAGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Restricted to the Kemps and Badgerys Creek area as three patches of remnants.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	As above: two patches with smaller remnants nearby and on slightly higher ground than 724.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northeast, with one remnant in the centre.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains but very little remains, and most occurrences are linear.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	The most common PCT in this Area, with remnants throughout on the dominant shale terrain.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Only very small patches in the far south.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain and Hunter valley	Present as mainly very linear remnants along most watercourses but largely absent from the southernmost portion.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principal source of threatened flora records in NSW is the OEH BioNet database, which includes most records held by the NSW Herbarium (specimen-based), as well as sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may not have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet are original – most are simply replicate records based on specimens held in other herbaria.

The preliminary assessment of threatened species records undertaken for the preparation of this Expert Report reiterated the merit of reviewing BioNet data and resolving a range of errors, rather than simply using data 'as held'. *Acacia bynoeana* records within BioNet were reviewed, and numerous corrections were made, though the majority of these relate to the assigned spatial accuracy scores and to clarifying or correcting location placements and descriptions. Not all records were able to be checked in that stage, and a second review for records in or near the Growth Areas was conducted to further improve data quality. The reviews eliminated a range of errors and allowed many records that were otherwise too spatially vague, to be refined such that they were suitable for habitat modelling and for general reference. Not all records were reviewed, and inaccuracies remain in the dataset, but records within the Cumberland Subregion are now far more accurate in terms of their identification of the species, their location, and their spatial accuracy score.

BioNet data should only be treated as indicative, not least because there has not been comprehensive survey of all of the Growth Areas or environs, and surveys have been variously constrained. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate.

Field survey undertaken by consultancy firms engaged by DPE (Biosis and Ecoplanning) did not add any records of this species. Fellow botanist, Robert Miller and I undertook very limited survey in the Kemps Creek locality. No new records of the species were generated.

4.1.1 Existing records by Growth Area

Acacia bynoeana records in Greater Macarthur Growth Area

There are no records of the species from the GMGA, but numerous records just outside its boundaries to the northeast (Moorebank), east (Wedderburn and Appin), and south (between Appin and Cataract).

Prior to the BioNet data cleansing process, a record of the species from 2006 plotted in Appin township, however that record was investigated and seen to have been collected from 'East of Appin'. It has since been moved to co-ordinates consistent with that location, east of the river, just outside the GMGA. There are over 50 records of the species in that wider area within 8km north, east and south of Appin.

Acacia bynoeana records in Wilton Growth Area

The species has been recorded in 2015 within the WGA (20 records in one population detected as part of survey for the Bingara Gorge urban development northeast of Wilton village). The nearest record outside the WGA is ~5km ESE and is part of a group of records south of Appin within the Water NSW water catchment area. Two records occur ~14 km SSW and SW of the Bingara Gorge population. One is within Upper Nepean SCA, the other plots west of Bargo on what is likely vacant Crown land.

Acacia bynoeana records in Greater Penrith to Eastern Creek Growth Area

There are no records of the species in the GPECGA, and the nearest occur between 1 and 2 km north of the northern GA boundary. Of these, the only records that are considered spatially reliable are those in the northern section of Wianamatta Nature Reserve near Cranebrook Road. Those to the east of the Nature Reserve (e.g. Rodd, 1967, RBG Collection, 'Llandilo' – plots in two arbitrary locations in rural areas (second record is Atlas duplicate); and Chamberlain & de Lacey, 1999 'Cherrywood in Llandilo') lack sufficient detail to determine where they were collected. The 'Cherrywood' reference likely relates to Cherrywood Oval or Cherrywood Bicentennial Park (apparently now Wianamatta NR), however the vegetation mapped by OEH near the oval or in much of the NR doesn't match that described by the Collectors. The 'Cherrywood' record has been moved to the edge of the NR, which is close to the Oval. A collection in the area by Hind in 1987 gives a road intersection reference that allows for adequate spatial accuracy. When reviewed, it plotted incorrectly but was able to be moved to match the location description, placing it ~2.6 km north of the GPECGA northern boundary.

If the species were present in the GPECGA, it would likely be found in remnant Castlereagh Forest & Woodland communities. These occur mainly north of the Growth Area through Llandilo, Londonderry to Windsor Downs, with some present just inside this Area at Ropes Crossing, Wilmot and Lethbridge Park (mostly within Wianamatta Regional Park).

Acacia bynoeana records in Western Sydney Aerotropolis Growth Area

There are no records of the species in the WSAGA, nor within several kilometres of its boundaries. This is unsurprising given the very limited area of historic and current potential habitat in this Area. Additionally, much of the potential habitat is apparently long-unburnt, which likely disfavours the detection of this species.

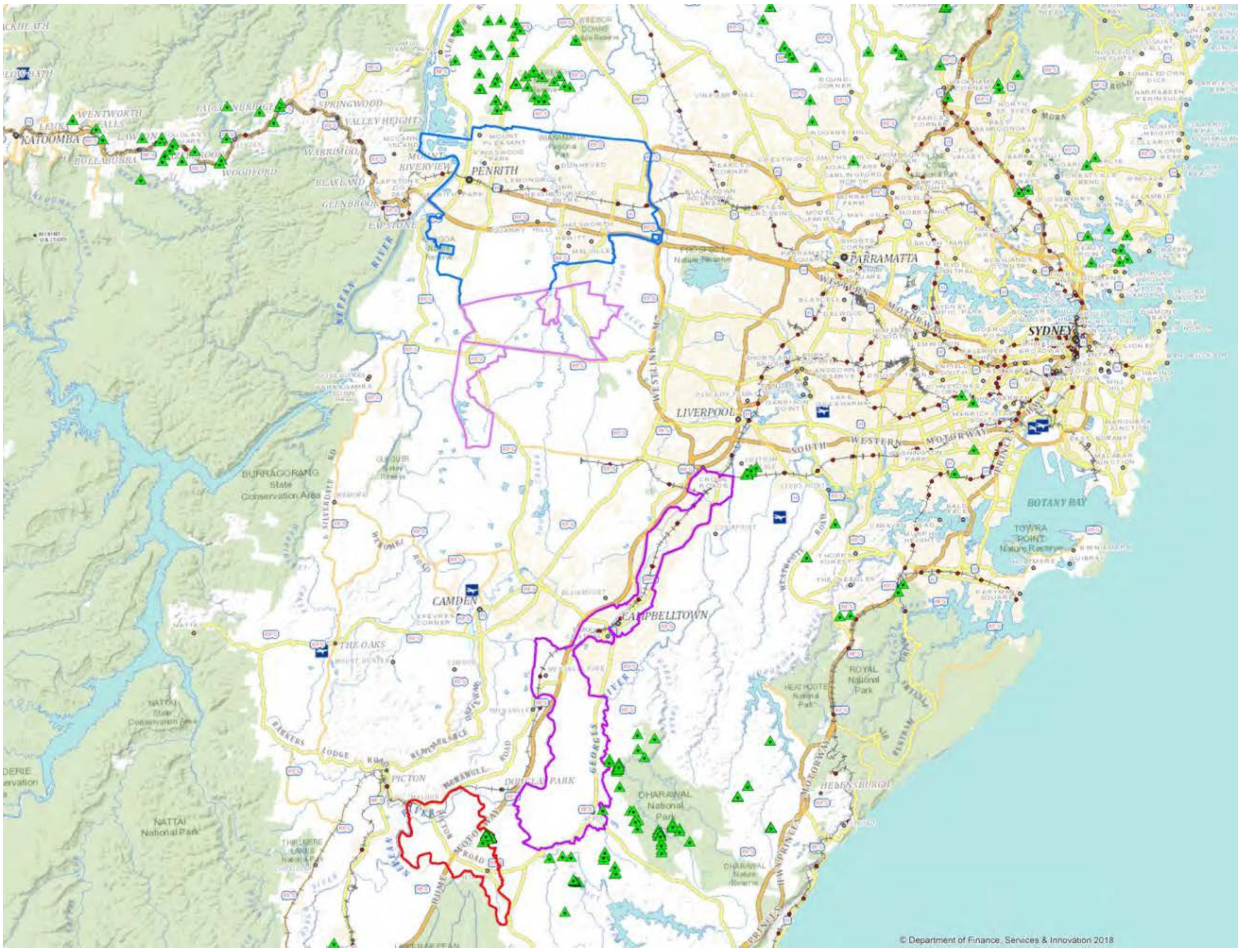
If the species is present in this Growth Area, it is likely to occur in remnant Castlereagh Forest & Woodland communities in the localities of Kemps Creek and Badgerys Creek. The only potential habitat in this Growth Area is ranked as having a Very Low association with *A. bynoeana*.

4.1.2 Prior surveys within each Growth Area

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods and findings across the study area.

The OEH Authorised Officer for *A. bynoeana* was contacted in this regard. He advised that he does not hold this information and he referred me to the manager of threatened biota matters in the Greater Sydney OEH office. No additional information was provided other than to note that a recent survey of State-owned land outside but near the GPECGA had contributed new threatened flora records to BioNet. No new records of *A. bynoeana* were apparent in that dataset.

I separately became aware of some earlier surveys of threatened flora that OEH had commissioned for areas of NPWS estate near the GPECGA. With approval from the NPWS, the lead ecologist who undertook those surveys provided information about his work, none of which entailed targeted searches for *A. bynoeana*, though incidental records were confirmed to have been lodged in BioNet.



Map 3. BioNet records (cleaned as of 26/11/18) relative to Growth Areas

NB each point may not designate a collection or observation at that location, as most very old records lacked any co-ordinates, or only supplied coarse co-ordinates, and may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

4.2 Summary of survey work undertaken for the biocertification assessment

4.2.1 Vegetation mapping

Vegetation mapping of the Cumberland Subregion was completed in stages by OEH in 2013 and 2016. These two vegetation layers have been used as the base to compile an updated vegetation community layer for each of the Growth Areas. This updated work has been completed by Biosis under contract to DPE. The mapping update includes checking plant community types and confirming the accuracy of boundaries to account for clearing or regrowth that may have occurred since the original mapping was completed. Field verification of the mapping was undertaken by Biosis and Ecoplanning, both of whom undertook vegetation surveys where access was permitted.

Vegetation in the Growth Areas was mapped and assessed based on five vegetation condition classes:

- Intact;
- Non-offsettable Grassland;
- Offsettable Grassland;
- Scattered Trees;
- Thinned.

4.2.2 Field survey effort

The information in section 4.2.2 has been provided by DPE but has been edited here to only deal with threatened flora where feasible. Further details are provided separately by DPE:

An initial 726 letters were sent to landholders within the Wilton and Greater Macarthur Growth Areas in late 2017 with a second letter following in March 2018. To increase the response rate, Biosis commenced targeted door-knocking in May 2018. From this, just under 20% of landholders within these Growth Areas allowed access to their property. However, this included access to large parcels of land owned by major developers, which allowed a reasonable amount of access, particularly for the Wilton Growth Area.

Floristic plot data collected:

- Wilton (86 plots across 6 PCTs)
- Greater Macarthur (82 plots across 9 PCTs)

Approximately 150 of the plots required to meet BAM requirements were obtained by supplementing Biometric plots from various recent assessments. This involved locating the previous plots and collecting additional data on stem classes, number of large trees, and litter cover to meet BAM requirements. The ecologists had no trouble locating the original survey sites and found that the additional data was quick and easy to collect (approximately 30 minutes per site).

The remaining plots in Wilton and Greater Macarthur, and all of the plots in Western Sydney Aerotropolis and Greater Penrith to Eastern Creek consisted of new plots surveyed for this project. All plots were sampled according to the methods prescribed by the BAM Manual (OEH 2017). This includes collecting information on species cover and abundance from 20 x 20 m or equivalent configuration plots within each vegetation zone.

A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Growth Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council.

Floristic plot data collected:

- Western Sydney Aerotropolis (53 plots across 6 PCTs)
- Greater Penrith to Eastern Creek (26 plots across 7 PCTs)

Targeted survey for threatened species

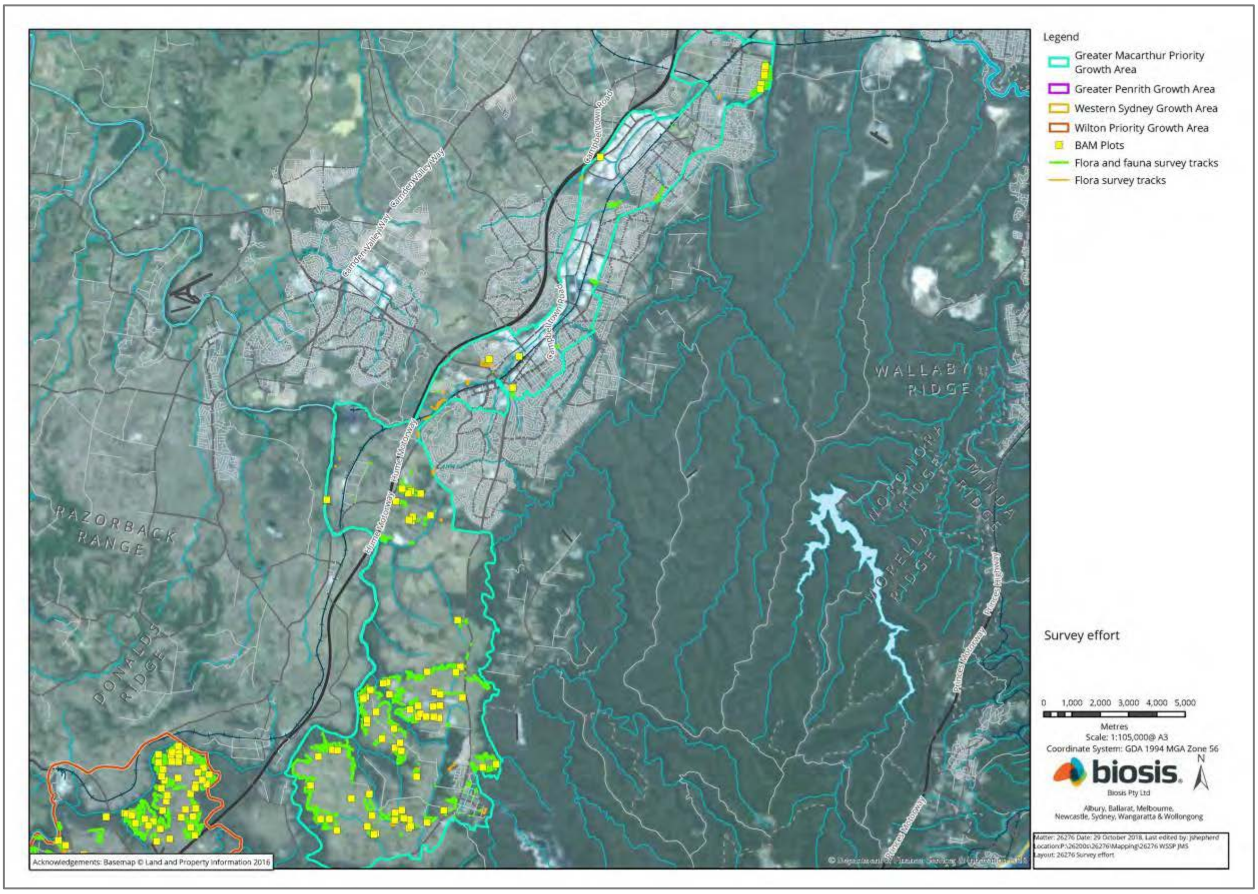
Targeted survey for threatened plant species has been conducted on lands where access has been granted. Vegetation transects and random meanders for threatened flora was conducted by Ecoplanning and Biosis in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey has included effort through each PCT and vegetation zone and has extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m).

Likely habitat for most threatened flora species comprised areas of lower disturbance. This includes areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora.

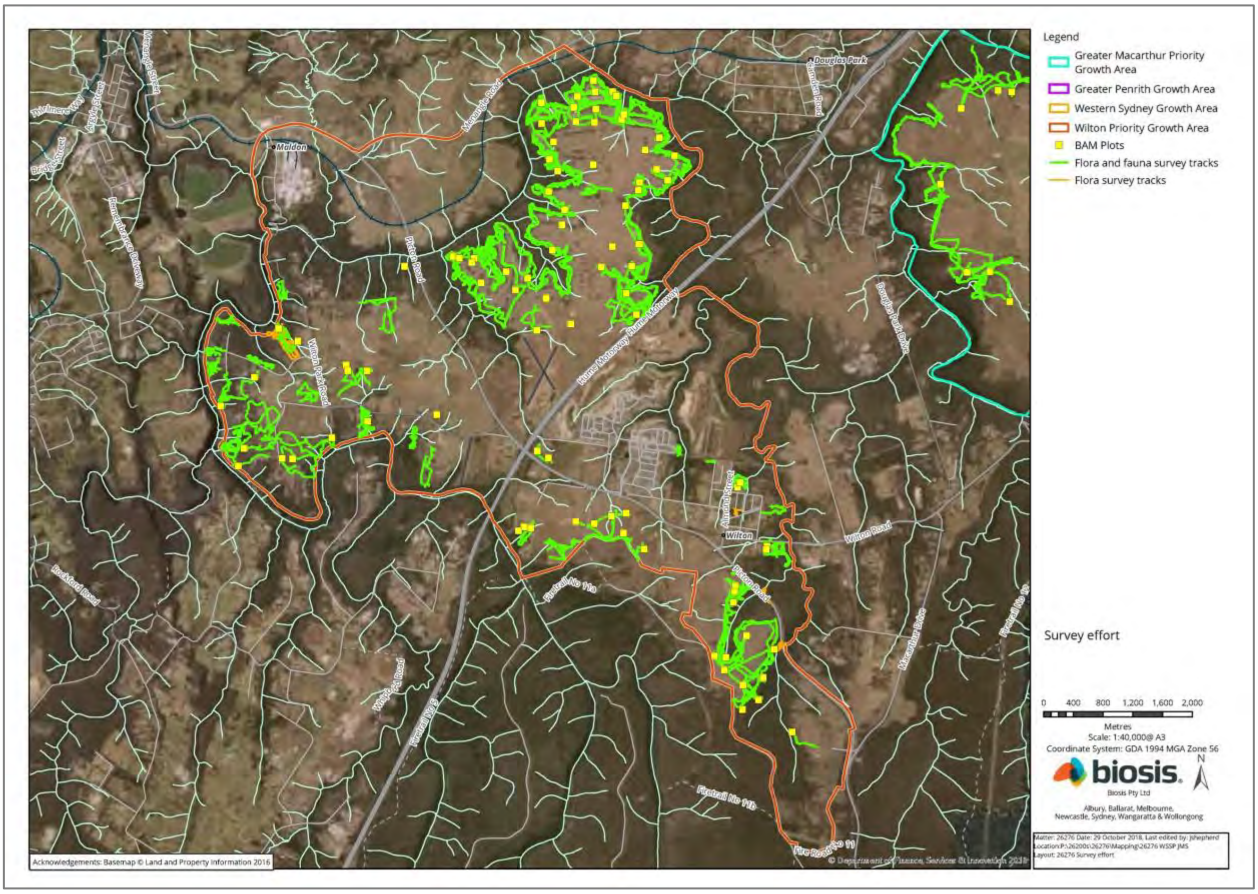
Table 9. Survey effort for threatened plant species *and* fauna habitat by PCT

PCT No.	Area of PCT in Growth Area (ha)	Area of PCT in urban zone (ha)	Field survey area (ha)	Percent of PCT surveyed within Growth Area (%)	Percent of PCT surveyed relative to urban zone (%)
724	191.3	57.0	12.1	6.3%	21.2%
725	167.4	51.4	6.9	4.1%	13.4%
781	68.9	5.6	0.9	1.4%	16.8%
830	21.6	0.8	1.7	7.8%	206.5%
835	1175.8	287.3	30.5	2.6%	10.6%
849	3078.3	637.6	125.0	4.1%	19.6%
850	522.9	294.3	36.1	6.9%	12.3%
883	7.4	0.0	0.5	6.8%	
1081	74.2	0.0	0.2	0.3%	
1105	138.6	0.0	0.0	0.0%	
1181	780.7	0.2	39.6	5.1%	19794.4%
1292	39.8	0.0	0.3	0.7%	
1395	3326.6	486.9	483.4	14.5%	99.3%
1800	232.6	20.2	7.3	3.1%	36.2%
TOTAL	**9826.1**	**1841.3**	**744.5**	**7.6%**	**40.4%**

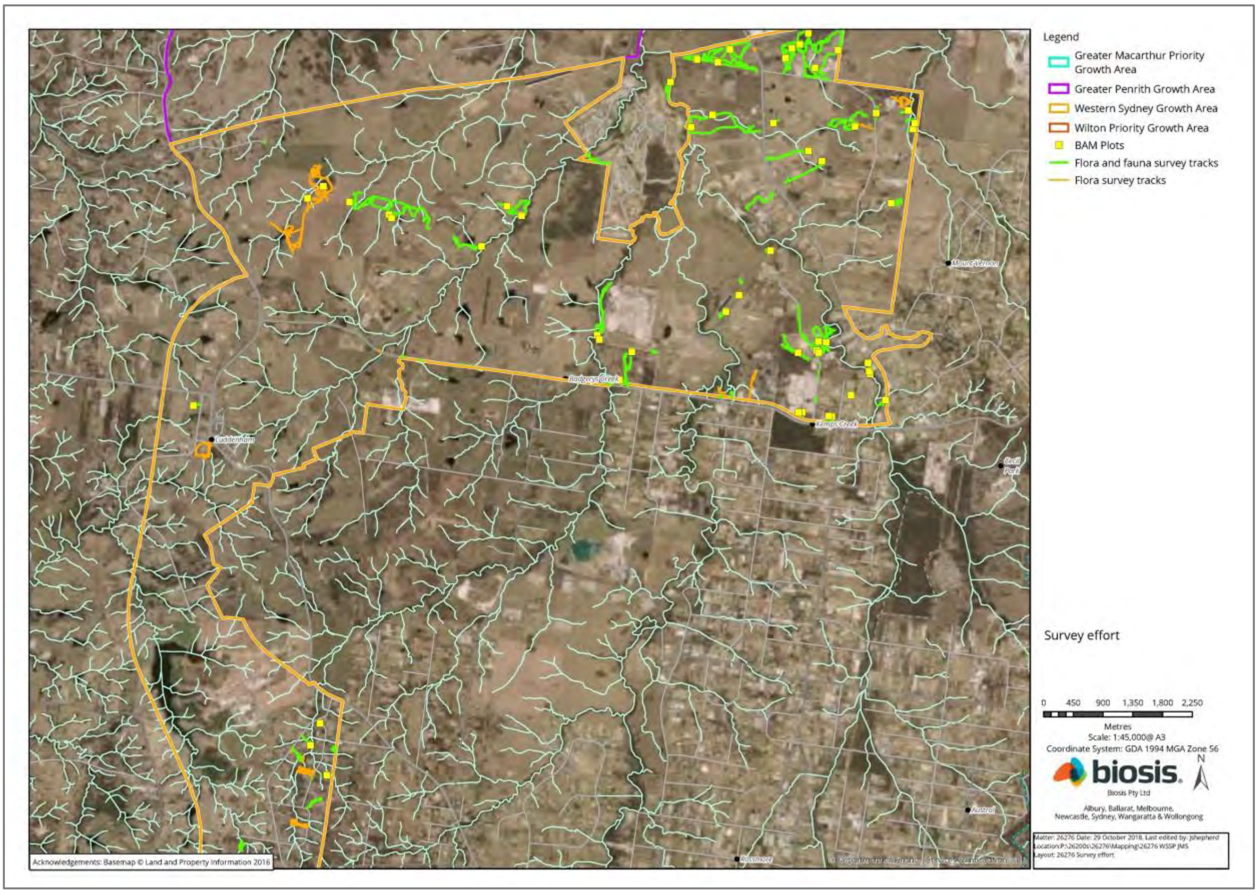
Field survey effort was not confined to the urban zone. Surveys occurred into nearby vegetation zoned for conservation. The urban zone has been revised over time and some areas where survey had already occurred were later removed. For these reasons, comparison of the survey area to the urban zone is indicative only. Survey effort has been calculated using a 20-metre buffer either side of GPS survey tracks. For the purposes of this analysis, the urban zone includes land zoned for future urban development plus transport corridors within the growth areas. It does not include any transport corridors outside the growth areas.



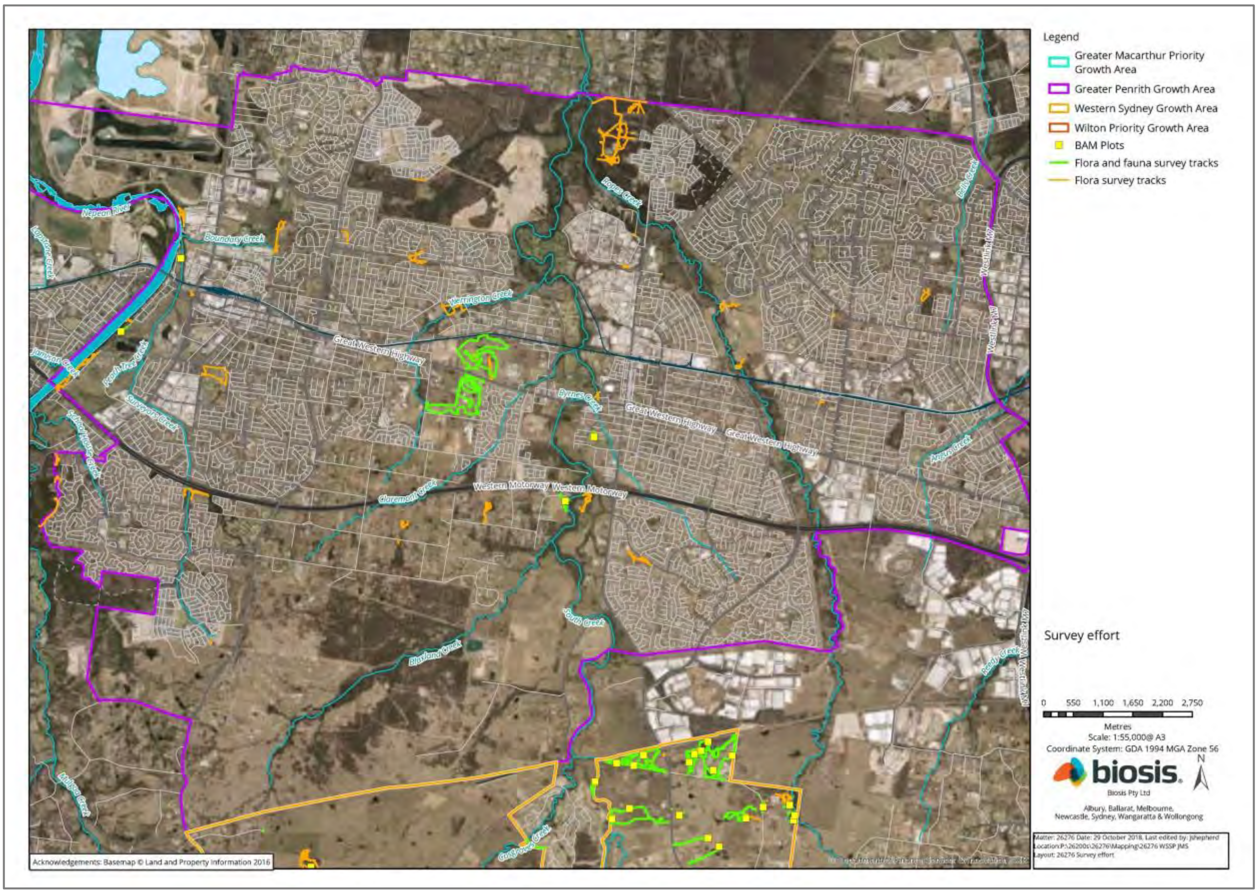
Map 4. GMGA survey effort (Biosis & Ecoplanning)



Map 5. WGA survey effort (Biosis and Ecoplanning)



Map 6. WSAGA survey effort (Biosis and Ecoplanning)



Map 7. GPECGA survey effort (Biosis and Ecoplanning)

4.2.3 Survey constraints –timing / site conditions

As noted earlier, severe drought affected all of the study areas for some or all of the survey period. The Wilton and Greater Macarthur GAs were only surveyed during drought, whereas the Greater Penrith & Eastern Creek and the Aerotropolis GAs were surveyed both during intense drought and the subsequently slightly wetter conditions that followed in the Spring of 2018. Whilst wetter, drought remained present, and fellow Expert, Robert Miller, reported that vegetation was evidently drought-affected across all of the Growth Areas into November.

Drought, combined with increased intensity and extent of total grazing pressure, meant that affected surveys are likely to have under-recorded the target species compared to normal conditions. Whilst drought alone is unlikely to cause *A. bynoeana* to die back to rootstock or die and only remain as seedbank, when combined with increased herbivory due to drought, this is a far more likely outcome.

Irrespective of drought, surveys for this species are constrained by consideration of fire ecology, in that this species can be suppressed and even rendered apparently extinct at a site if the area has not been burnt for many years. Prolonged absence of fire is a constraint in some of the surveyed areas. Conversely, the species could be undetectable or not readily distinguished and identified in areas burnt recently. Areas burnt too often may also see the species suppressed or even eliminated. This is a factor in some of the survey sites closer to urban areas where a mix of hazard reduction burning and arson occur.

4.2.4 Survey constraint – surveys undertaken by generalists / non-experts

A. bynoeana is regarded as a cryptic species (OEH, 2014) and even when adult, it can occur as a very small plant with dull-coloured leaves such that it is easily missed, even by expert observers. It is more likely to be present but not recorded when surveyed by personnel not very familiar with the species and its ecology, particularly in terms of micro-habitat features.

Even when the prescribed OEH survey methods are used, a combination of site-based constraints, the species' sometime-cryptic nature, and a lack of familiarity with this species creates a situation where the species may be present but was not recorded. This is supported in part by the observations of Driscoll (cited in OEH, 2014) who noted that irrespective of issues arising from clonality, the population size and local extent of this species is often under-estimated by observers for a range of explicable reasons. I am aware of a repeatedly surveyed site involving effort by different consultancy firms over at least 10 years, yet none managed to record all occurrences of this species.

4.3 Surveys completed specifically for this Report

I was provided with the opportunity to undertake limited surveys in the Wilton and Greater Macarthur Growth Areas but elected not to on the basis that severe drought undermined the value of any survey in determining if the species was absent from any area. This decision was later validated by feedback from fellow botanist, Robert Miller, in relation to his not being able to detect *A. bynoeana* under those conditions at a site where he had previously recorded it, even though the habitat was intact.

I undertook surveys of potential habitat for *A. bynoeana*, *A. pubescens* and *Persoonia nutans* in the localities of Kemps Creek and Badgerys Creek in early November 2018. There were no records of the species in those areas, and only relatively small and sometimes significantly altered areas of very low probability potential habitat remain within the Growth Area, and not all were accessible for a range of reasons. Some other threatened plant species with which *A. bynoeana* is sometimes known to occur are present in this area.

I was accompanied by Robert Miller during my brief survey, and whilst we detected other threatened plant species, we did not detect any new records of *A. bynoeana*. We concluded that potential habitat is present on the surveyed site and on adjoining, more heavily vegetated land to the south. Both areas are now excluded from the proposed urban footprint / biocertified land.

The map below shows the transects associated with a brief survey within the WSAGA (northern line largely within a s.88b conservation area) and outside the WSAGA (short southern line).

Map 8. GPS track logs (purple lines)

4.4 Assessment of species' presence

4.4.1 Greater Macarthur Growth Area

The species is not known to be present in this Growth Area but is considered likely to occur in the southern portion. It is unlikely to occur within the majority of the proposed urban footprint because that area was never suitable habitat or has been too heavily modified.

The northern half of the GMGA is not likely to support the species based on the extent of land clearing and/or the absence of suitable habitat parameters such as plant communities and soil types. Were the species found in the highly urbanised northern GMGA, it is likely that unless on public land able to be managed for conservation, any such occurrence may not be viable in terms of size, area of habitat, threats including fragmentation / isolation of habitat, and ability to maintain ecological processes.

In contrast, the southern half of the GMGA contains significant areas of potential habitat as determined by the presence of associated PCTs. This habitat mainly occurs around the upper slopes and ridges associated with gullies and valleys of incised watercourses, and some other remnants that appear to have escaped clearing and grazing due to their relative infertility or other constraints. Some potential habitat is present within and on some edges of the biocertification area (urban footprint). However, potential habitat within the proposed urban footprint is likely to be of lower condition and less viable due to historic and current land uses.

4.2.2 Wilton Growth Area

The species is known to be present in this Growth Area, though only on a site outside the proposed urban footprint, within a separately approved urban release area. A significant area of similar habitat occurs largely outside but occasionally on the margins of or adjoining the proposed urban footprint. However, surveys of some nearby sites supporting apparently suitable habitat by the same personnel who found the documented population did not detect any further occurrences. This may be a result of the areas having different disturbance histories, particularly in terms of grazing and fire. This situation does not preclude the species being present in those sites, as it may be restricted to the seed bank or to rootstock.

The species is unlikely to occur within the majority of the proposed urban footprint as it was never suitable habitat or has been too heavily modified. Potential habitat within the proposed urban footprint is likely to be of lower condition and less viable due to historic and current land uses.

4.2.3 Greater Penrith to Eastern Creek Growth Area

The species is not known to be present in this Growth Area, but a relatively small area of potential habitat is present within the proposed urban footprint, including within Wianamatta Regional Park, which appears to be proposed for further clearing and fragmentation to accommodate a large transport corridor. Areas of potential habitat are limited to the far central north of the Growth Area. On the Cumberland Plain, this species primarily occurs north of the GPECGA in the Castlereagh / Londonderry area.

4.2.4 Western Sydney Aerotropolis Growth Area

The species is not known to be present in this Growth Area, and most mappable areas of potential habitat are outside the proposed urban footprint. There is very little direct conflict between proposed urbanisation and potential habitat for the species in this area. The extent of potential habitat is limited to a few patches of remnant vegetation between the localities of Kemps Creek and Badgerys Creek. There are no nearby records. Most of the WSAGA was always unsuitable habitat for this species based on geology, soil and plant community associations.

4.5 Assessment of suitable habitat for *Acacia bynoeana*

4.5.1 Description and relative significance of potential habitat

As per the findings presented earlier in Table 4, combined with expert knowledge, the following vegetation communities are regarded as potential habitat for *A. bynoeana* where they occur across any of the Growth Areas. However, not all parts of these communities are likely to support the species. Wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat, as this species prefers drier, more open conditions. This limitation is addressed later through the specification of riparian exclusion buffers.

Table 9. PCTs known or likely to be habitat for *A. bynoeana*

PCT	PCT Name	Relative significance
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	**Very Low**
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	High
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Very High
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney	Low
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Moderate

The following sections describe the relative habitat value and local occurrences of each PCT mapped in each Growth Area.

<u>Greater Macarthur Growth Area</u>

The vegetation mapping provided for use in the project indicates that there is **1614.1 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs. However, significant portions of some components are of lesser habitat significance due to persistent disturbance, particularly intensive pastoralism (sewing of introduced pasture species, addition of fertiliser, commercial stocking rates), and are less likely to retain this species in any form. However, *Acacia* seeds can remain viable for ~100 years, so even in highly modified sites with persistent suppressive factors such as grazing, the species could regenerate from seed were those factors to cease or be adequately reduced in intensity and duration.

Table 10. Potential habitat in the GMGA

PCT	Distribution	Relative habitat value of local occurrences
883	Four very small polygons at Macquarie Fields	Very low at this site due to historical land use. The species may regenerate if issues of mowing, absence of fire, and intense weed invasion are remedied. Any resultant population would be isolated from core habitat and surrounded by unsympathetic land uses.
1081	Restricted to one remnant surrounding an incised watercourse in urban bushland.	Moderate to high but this community is of relatively limited extent in this GA
1181	Common only on the edges of and within sandstone gullies and gorges but very limited extent; from Gilead south, mainly on GA boundaries, with a small outlier at Leumeah	Low potentially extending to Moderate depending on sandstone influence – high sandstone and no shale influence is of lower habitat value. Not suitable habitat close to watercourses.
1395	Common in the far south from around Menangle Park through Gilead to Appin area; between cleared shale landscapes and the upper margins of sandstone gullies	Moderate to high depending on shale content – high shale content is of lower habitat value. Unlikely habitat when near watercourses

Wilton Growth Area

1380.8 ha of potential habitat is identified in the WGA, with several recent records within one population mapped as part of the Bingara Gorge housing project. Similar habitat extends along the upper slopes of many remnant vegetation areas associated with larger watercourses.

Table 11. Potential habitat in the WGA

PCT	Distribution	Relative habitat value of local occurrences
1081	Uncommon and restricted to three substantial patches above sandstone gorges, mainly on or near edges of WGA.	Moderate to high but this community is of relatively limited extent in this GA
1181	Common within sandstone gullies and gorges, mainly on or near WGA boundaries.	Low to moderate depending on sandstone influence – high sandstone and no shale influence is of lower habitat value. Not suitable habitat close to watercourses.
1395	Common in the far south from around Menangle Park through Gilead to Appin area; between cleared shale landscapes and the upper margins of sandstone gullies	Moderate to high depending on shale content – high shale content is of lower habitat value. Unlikely habitat when near watercourses

Greater Penrith to Eastern Creek Growth Area

There was always very limited scope for the species to occur in this Area, and much less so as a result of historic and on-going land clearing. However, **132.9 ha** of potential habitat is identified

Table 12. Potential habitat in the GPECGA

PCT	Distribution	Relative habitat value of local occurrences
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	This PCT occurs primarily in the far central north and is mostly within reserve. Very Low ranking but may be present depending on the disturbance history of the habitat.
883	Only in far north, and of very minor extent	High – strong association with this PCT but no records from this area at present, though proximate records are present to the north and northwest.

Western Sydney Aerotropolis Growth Area

Only a relatively small area of habitat existed in this Area, and even less remains due to historic and on-going land clearing. What little remains is known or likely to be associated with other threatened plant species. There are currently no records of *A. bynoeana* in this area. **39.8 h**a of potential habitat is identified.

Table 13. Potential habitat in the WSAGA

PCT	Distribution	Relative habitat value of local occurrences
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Very Low ranking but may be present depending on the disturbance history of the habitat. Restricted to Kemps Ck and Badgerys Ck localities as relatively small remnants – apparently long-unburnt.

4.5.2 Species habitat polygons

Species habitat polygons generated by this report relate to the extent of potential habitat and the area and percentage that is proposed to be cleared for urbanisation or transport corridors (Maps 9-11). These habitat polygons and associated calculations were generated to inform biodiversity offset requirements. The data presented in this section does not deal with species habitat outside proposed urban and allied zones as those areas are treated as conservation zones or are excluded from urban and associated transport zones for a range of reasons.

The species habitat polygons include all relevant condition classes of relevant PCTs as identified in this Report. In this case, all condition classes are included.

As part of the formulation of the species habitat polygons, graded riparian exclusion buffers were used in recognition that *A. bynoeana* does not occur in riparian vegetation. Buffers are relatively large for this species as it does not occur in riverflat/creekflat situations. The buffer distances increase with the mapped Strahler stream order as shown in Table 14. The accuracy of the buffers is limited by available data, including the mapped location of streams. The buffer is applied either side of the mapped stream centreline. Note that these riparian buffer distances are a different concept and serve a different purpose to those applied by DPE for the purposes of protecting streamside vegetation and watercourses in its planning within the Growth Areas.

Table 14. Buffer distance applied to stream orders

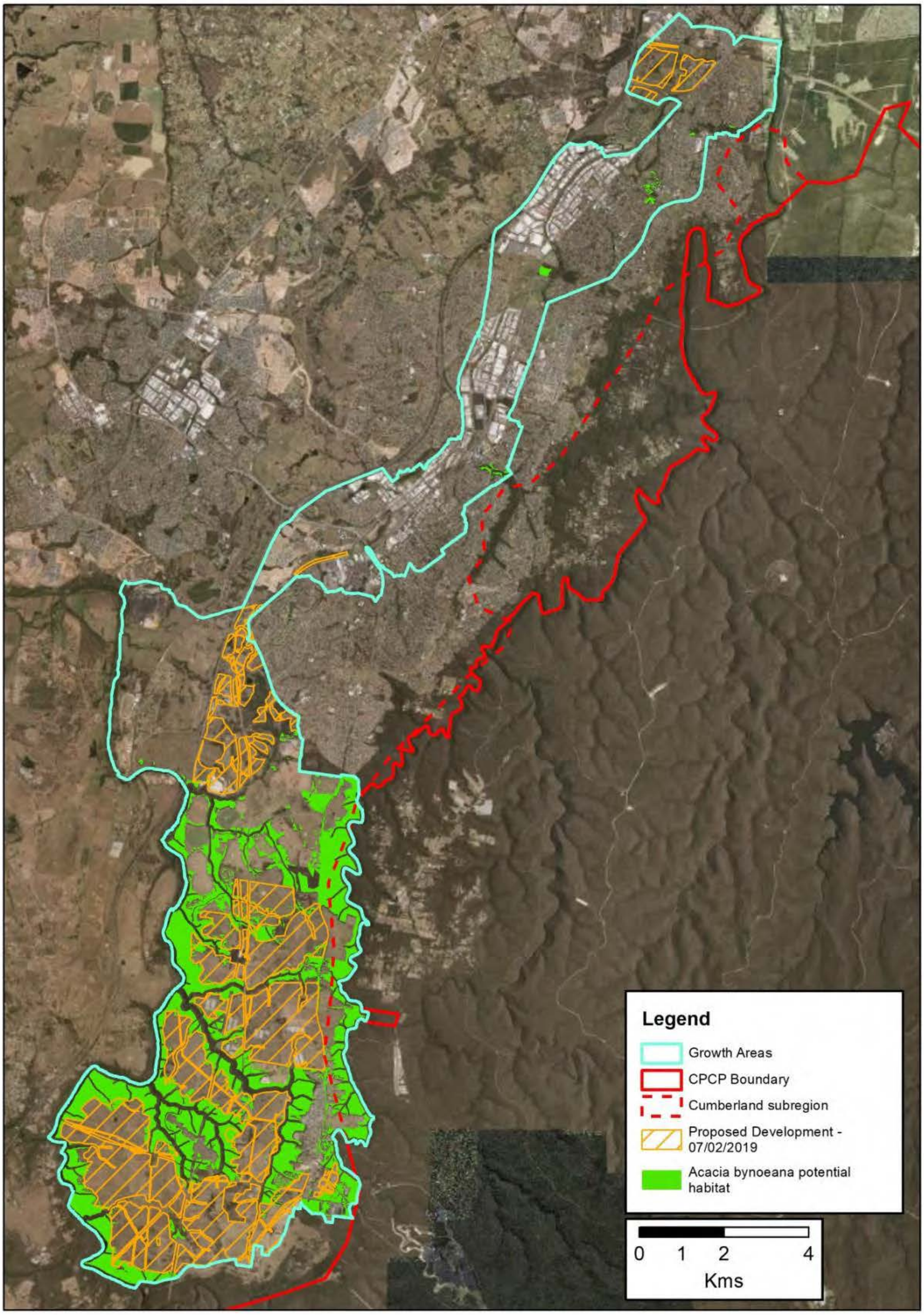
Stream order	Buffer distance (m)
1	20
2	30
3	40
4	60
5	70
6	80
7	90

Table 15. Potential habitat and proposed removal of potential habitat by Growth Area

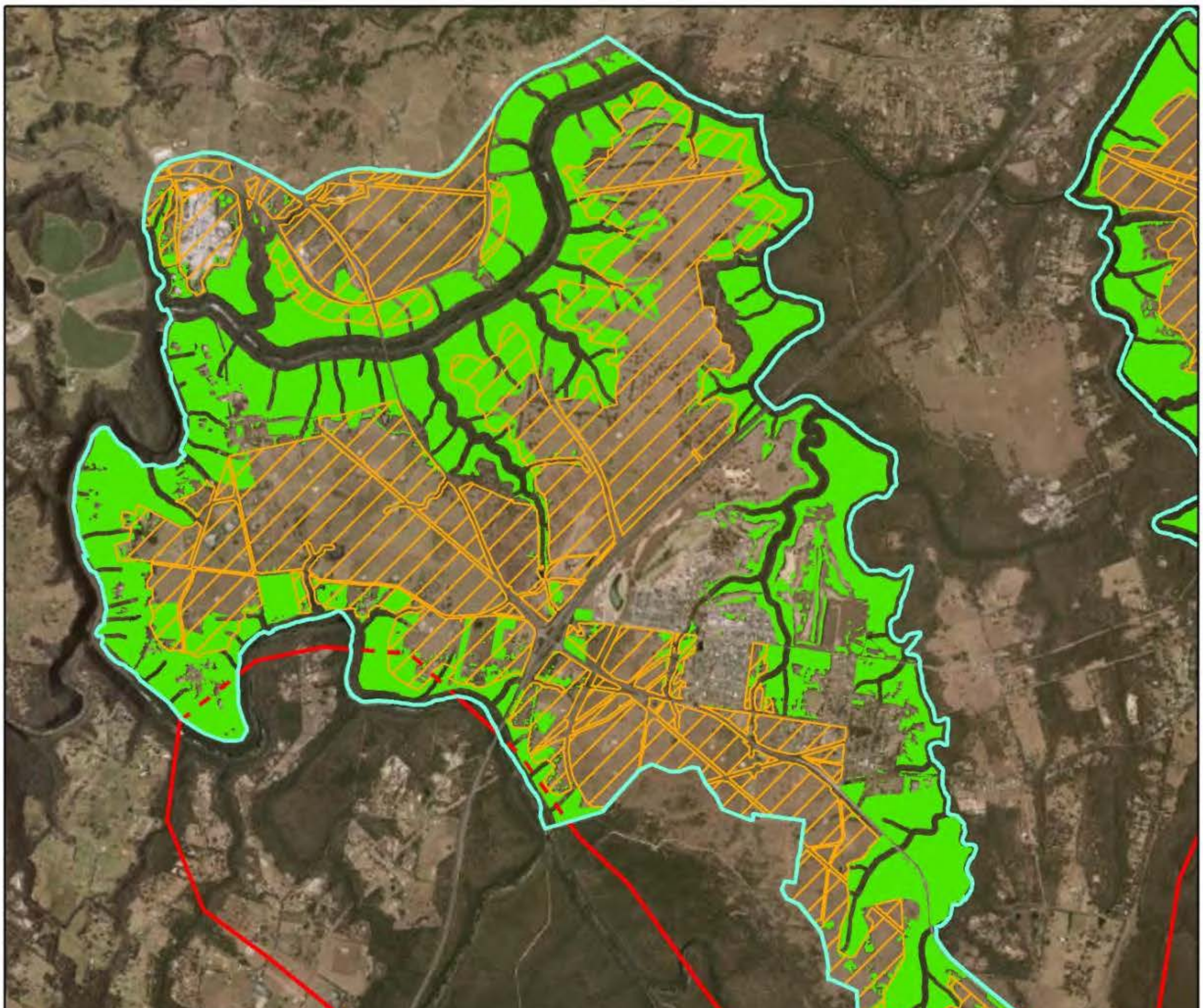
Growth Area	Area of potential habitat (ha)	Area of potential habitat removal (ha)	% area of potential habitat removal by GA
Greater Penrith to Eastern Creek	132.9	3.8	2.9
Western Sydney Aerotropolis	39.8	11.8	29.6
Greater Macarthur	1614.1	126.5	7.8
Wilton	1380.8	300.8	21.8
Transport corridors **(all GAs)**	-	20.7	0.7
TOTAL	**3167.6**	**463.7**	**14.6**

These figures are based on precautionarily modelled *potential* habitat, and do not necessarily equate with *actual* habitat, nor do they provide any information of potential population sizes or population viability. It is unlikely that a large percentage of the potential habitat identified in this Report would actually support *A. bynoeana* because this species is naturally rare and patchily distributed, even though it can sometimes be locally abundant in favourable conditions.

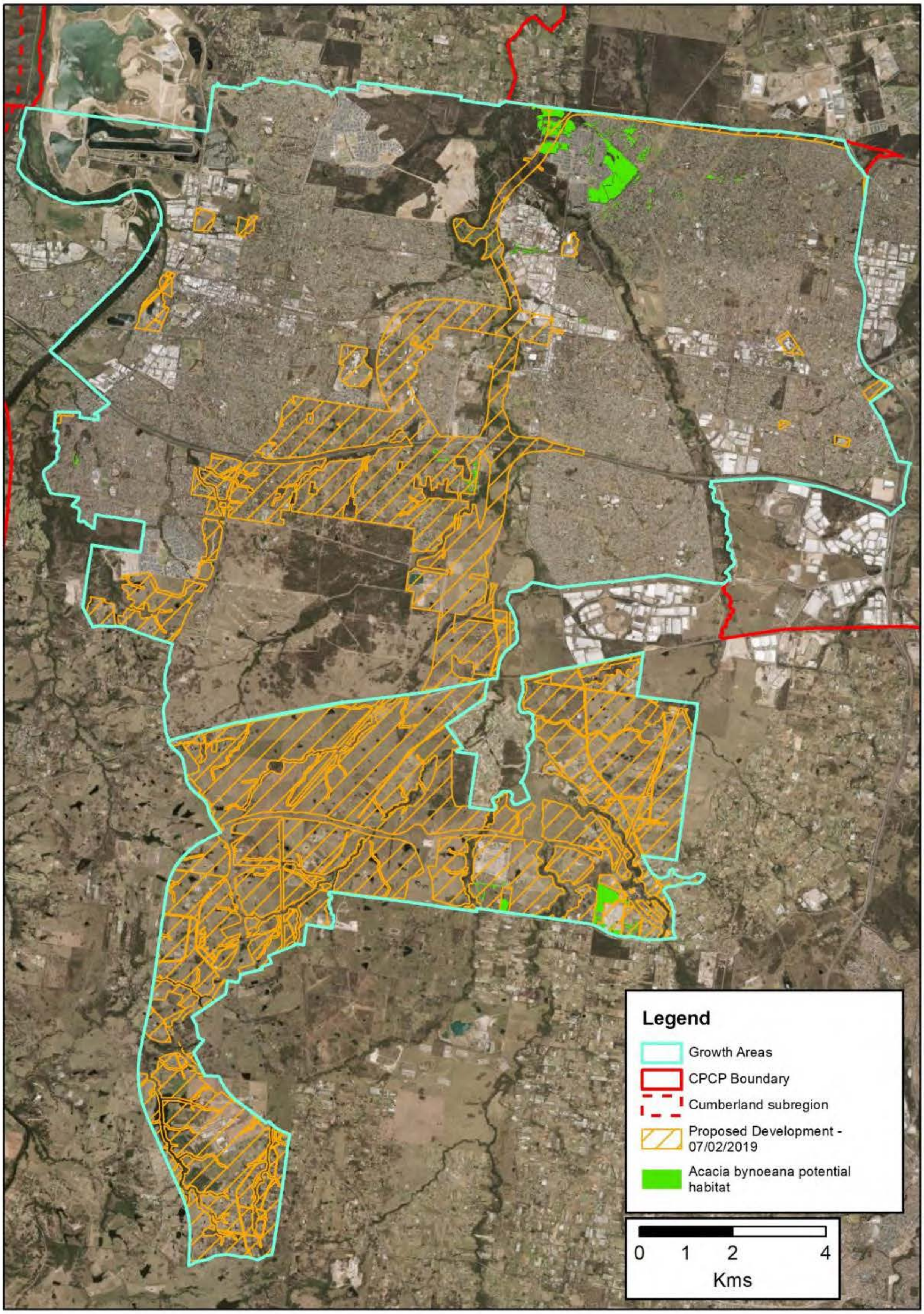
Map 9 Greater Macarthur - Potential habitat and proposed urban/transport habitat removal



Map 10 Wilton - Potential habitat and proposed urban/transport habitat removal



Map 11 Greater Penrith & Eastern Creek plus Western Sydney Aerotropolis
– potential habitat and proposed urban/transport habitat removal



5. Summary and conclusion

Within the four Growth Areas, *Acacia bynoeana* is currently only known from the Wilton GA. However, potential habitat for this species exists in all four Growth Areas, based on the species' known association with specified Plant Community Types, with other threatened plant species, and with abiotic factors. In the southern Growth Areas, it is most likely to occur in habitat associated with the shale sandstone transition, the Mittagong Formation, and upper Hawkesbury Group on plateaux margins and upper slopes. In the northern Growth Areas, it is likely to occur only in relatively small remnants of a particular subset of Paleogene-Neogene alluvium associated with the Castlereagh Forests & Woodlands.

Based on current information, the proposed urban footprint and associated transport corridors of all four Growth Areas would destroy 463.7 hectares of potential habitat for *A. bynoeana*. This equates to 14.6% of the area of potential habitat identified in those Growth Areas. Not all of the area proposed for removal is of equal value as potential habitat, and different PCTs and condition classes have different probabilities of supporting *A. bynoeana*. The actual extent of conflict between habitat for the species and proposed clearing for urbanisation is likely to be much smaller as the species is naturally rare and patchily distributed.

In the Greater Penrith to Eastern Creek Growth Area, the greatest direct conflict between proposed urbanisation and potential habitat for this species is a proposed transport corridor through the western (apparently ungazetted) portion of Wianamatta Regional Park. Most of this Growth Area is and always was unsuitable habitat for this species for geological reasons, and only relatively small areas remain in the central far north in and near the Regional Park.

In the Greater Macarthur, Western Sydney Aerotropolis, and Wilton Growth Areas, the majority of potential habitat for this species is outside the proposed urban footprint. However, because this species is relatively tolerant of some quite intense types of disturbance, and that it can persist for many decades in the soil seedbank, as well as surviving for some time as rootstock, it may occur in habitat that might otherwise be disregarded and even not mapped as native vegetation. It is likely that highly modified sites that might support the species in some form are of relatively low significance for it in the context of the much larger areas of more intact potential habitat that are excluded from proposed urbanisation. It is also feasible that disturbance associated with urbanisation, particularly the creation of bushfire Asset Protection Zones between bushland conservation areas and housing, could advantage this species, especially where the habitat has not burnt for many years. Thinning of the shrub layer by fire or mechanical means could favour the species, as may soil disturbance associated with fire trail construction. More frequent, moderate intensity burning of bushland that represents known or likely habitat for this species, may, within limits, also advantage it compared to low frequency and/or very cool burning.

The positioning of the bushland/urban interface and associated infrastructure such as APZs should have regard to this species' habitat and ecology, and appropriate buffers and other strategies are required to prevent direct and indirect harm to this species as a result of the urbanisation of adjoining lands. For example, potential habitat should not be compromised by the placement of housing nearby as this might prevent that habitat being managed for conservation, especially in terms of bushfire risk management. DPE has informed me that APZs would be accommodated within the proposed urban footprint, not in the adjoining non-biocertified bushland.

The absence of records from areas of potential habitat does not mean it could not be present because:

- not all areas have been surveyed historically or recently;
- all surveys have a range of limitations, and recent efforts were particularly constrained by drought;
- not all discoveries of threatened species are disclosed;
- large areas of potential habitat are highly likely to have fire regimes that do not favour this species, meaning it may currently occur in very low numbers or as seedbank, yet could appear in substantial numbers after an appropriate fire or equivalent disturbance; and
- this species can persist in cryptic forms such that even thorough coverage of a site cannot rule out its presence if otherwise suitable habitat is present.

These factors have been considered in the preparation of the species habitat polygons that will inform DPE in relation to biodiversity offset obligations.

6. Information used in the assessment

6.1 DPE or OEH resources

- BioNet data (internal access provided under license for use in this Expert Report and associated dataset cleaning for the purposes of species habitat modelling to meet EPBC Act requirements)
- Atlas of Living Australia on-line (partial use to check for records not in BioNet)
- EMU data (NSW Herbarium specimen database, provided by OEH)
- OEH on-line threatened species profile
- OEH Threatened Species Data Collection on-line
- OEH BioNet Vegetation Classification Database (previously known as VIS)
- EPBC Act Listing/Conservation Advice
- OEH PCT (vegetation) maps for Sydney Metropolitan and Cumberland Plain
- Field data from Biosis and Ecoplanning consultancies engaged by DPE
- GIS layers and maps provided by DPE and its contractors

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7. Acknowledgements

I acknowledge the contributions of DPE staff, particularly Dayle Green, Greg Steenbeeke and Christian Marando (GIS), and DPE contractor Darren James (GIS) in the preparation and refinement of this document and associated maps. My contractor, Rhys Grogan, also assisted with GIS output in the form of drafts of the 'species polygons'.

Consultant botanist, Robert Miller assisted with fieldwork at Kemps Creek, and provided information about field observations associated with searches for his target species and with opportunistic sitings of my target species.

OEH staff assisted with some aspects of data availability and with the processing of many amendments to BioNet records.

8. Statement of professional independence

Whilst I was engaged and funded by DPE to prepare this Expert Report, and draft reports and maps were reviewed by DPE staff, I was not coerced by DPE to amend my work in any manner that I did not otherwise agree with. I believe that I had appropriate professional independence in the preparation of this document and associated maps.

I also declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses with property in the Growth Areas, nor do I have other active clients with real estate or associated commercial interests in the Growth Areas.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for a large number of private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation.

I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields.

I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management.

I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections, and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps, and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy-making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Founding member of the Ecological Consultants Association of New South Wales (did not renew due to my relocating to Victoria and later to the ACT).
- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honey Bee.

Species / population	Work conducted
Acacia bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset.
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Recognised by OEH as a species expert (Nov 2018).
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA
Callistemon linearifolius	Fieldwork, research, successful nomination, advice to RMS and NPWS, PAS2 review
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going)
Callistemon purpurascens	Described new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going)
Calotis glandulosa	Fieldwork (new and extended populations, Kosci NP), CAM review
Calotis pubescens	Fieldwork (new population, Kosci NP), CAM review
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records

Species / population	Work conducted
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council and OEH, CAM reviews
E. aquatica	Fieldwork, advice to Council and Forestry Corporation
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel
E. kartzoffiana	Fieldwork, research, expert witness
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination and advice to NSWSC – listing pending
Gyrostemon thesioides	Successful nomination
Helichrysum calvertianum	Fieldwork, research, nomination, advice to NSWSC – listing pending
Hibbertia fumana	Research, minor fieldwork, expert witness
*H. incana (*syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review

Species / population	Work conducted
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Recognised by OEH as a species expert under BC Act (Nov 2018).
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset.
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable - listing pending
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Recognised by OEH as a species expert under BC Act (Nov 2018).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All of the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DEE re Cwlth listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DEE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DEE Recovery Plan update, advice to OEH
Elderslie Banksia Scrub Forest	Major review for DEE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DEE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping, advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping, advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping, and advice about revised listing, advice to DEE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent)
Robertson Basalt Tall Open-forest	Modelling and mapping, advice to NSW SC
Robertson Rainforest	Modelling and mapping
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters research. Formally published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping
Southern Highlands Shale (Forest &) Woodland	Major contributor to DEE listing, drafting of Listing and Conservation Advices, advice to OEH about revision of NSW listing, modelling and mapping. Contracted to prepare listing for upgrade to CE.
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel

Ecological community	Nature of engagement
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils and to OEH/SC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping, advice to OEH
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to DEE listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advices
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy,* 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Edited but not refereed publications

Douglas, S.M. 2014. "When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum". *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. "Black Gum: a threatened tree of upland New South Wales and Victoria." *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. "Species profile and monitoring of Dampiera fusca". *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. "Endangered plant discovered" (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. "Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong". News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. "Phoenix flora: a post-fire discovery in the ACT". *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. "Phoenix flora" (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. "Mysteries of the Megalong Valley: another rare plant for the Blue Mountains." *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. "Land of the living dead – tree decline in urban areas". *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. "Bushland weeds – more on native weeds". *Environment NSW*, December

Douglas, S.M. 2000. "Regional Parks". *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. "Community biodiversity surveys". *National Parks Journal,* 40(3)

Douglas, S.M. 1996. "Mapping our urban bushland". *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. "Healing the Hawkesbury: start with bushland protection". *National Parks Journal*. 38(4)

Public media coverage

2004, November 6. "Bright flowering spot after fire" - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran
- Supervisor for undergraduate dissertation, "Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve" (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation "Riparian Vegetation of upper Cattai Creek" (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**

- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**
- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report – *Acacia pubescens*

Expert report for *Acacia pubescens* (Downy Wattle), Dr Steven Douglas, February 2019

ECOLOGICAL SURVEYS & PLANNING

Expert Report For

Acacia pubescens

(Downy Wattle)

Strategic Assessment for the Cumberland Plain Conservation Plan

Greater Macarthur, Greater Penrith to Eastern Creek,
Wilton, and Western Sydney Aerotropolis Growth Areas

Prepared for NSW Department of Planning & Environment, February 2019

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Table of Contents

1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Acacia pubescens*, insufficient survey extent; constraints on the effectiveness of survey; and unreliability of detection due to aspects of the species' ecology are the primary reasons for preparing an Expert Report.

The purpose of this Report is to provide an assessment of the current status and conservation requirements of *Acacia pubescens* within the four priority growth areas of Greater Macarthur (GMGA); Wilton (WGA); Penrith to Eastern Creek (PECGA); and Western Sydney Aerotropolis (WSAGA)to determine whether:

a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within growth areas and development footprints as part of the biocertification process.

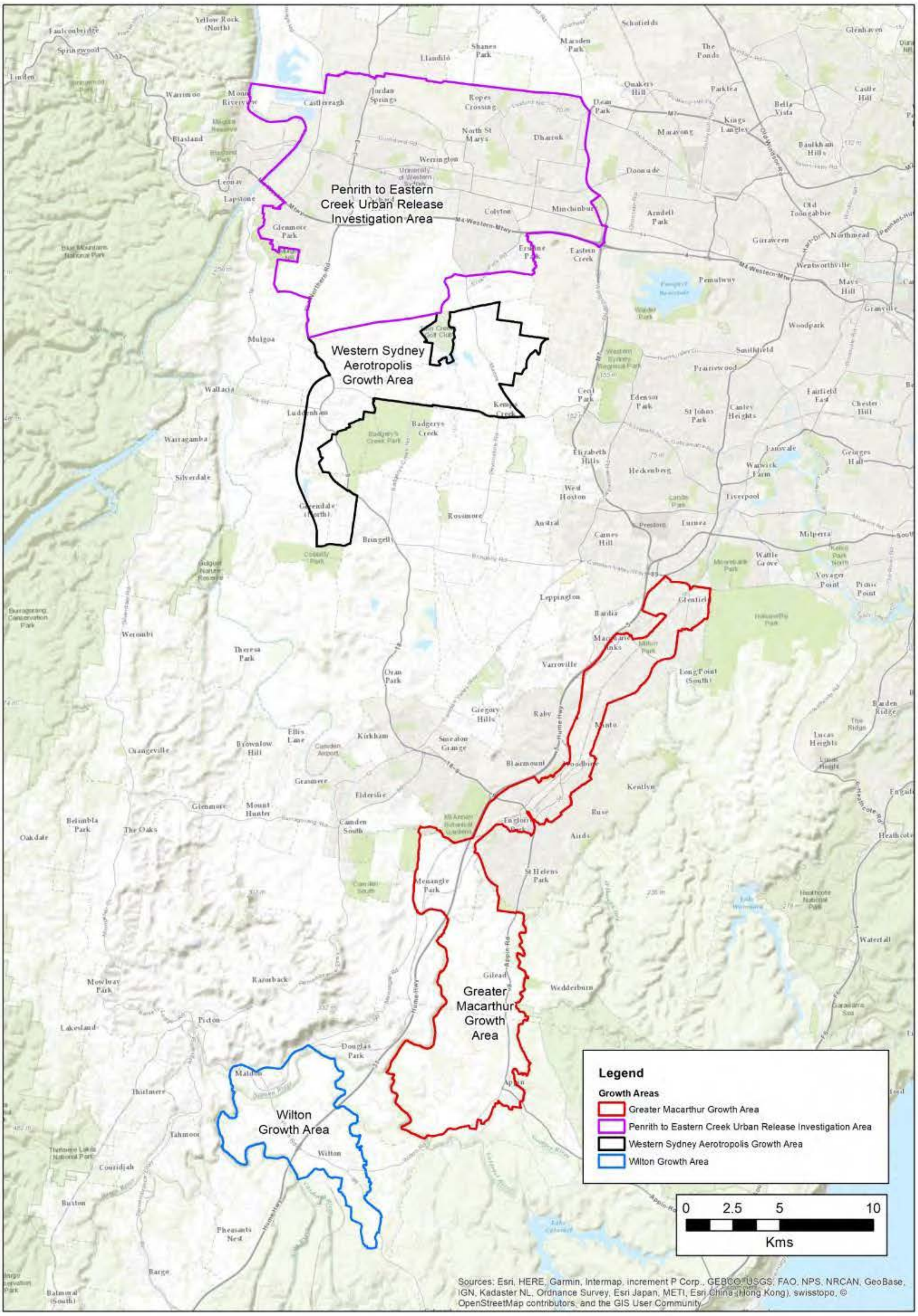
1.2 Project context

The NSW Government is identifying areas for future urban land use and associated infrastructure in western Sydney. The four priority growth areas are all located in the Cumberland Subregion under the Interim Biogeographic Regionalisation for Australia (IBRA) (SEWPaC, 2012).

As part of the planning for these areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify land use outcomes. A strategic assessment of this Plan is underway, and this Expert Report will assist in determining the extent and quantum of impacts of the proposed urban growth on *Acacia pubescens*.

Acacia pubescens, Aylmerton © S. Douglas

1.3 Study area



Map 1. Growth Areas subject to this Expert Report

Greater Penrith & Eastern Creek Growth Area (GPECGA)

A large portion of this Growth Area is already urbanised, with several areas of industrial land use. Significant rural and peri-urban areas remain in the central north, the centre, and the southwest. Large areas of remnant vegetation are present in the far north (former Australian Defence Industries site, now in part Wianamatta Regional Park), and the Orchard Hills Defence facility. Mining of alluvium for sand and soil continues in the far northwest of the area in the Penrith Lakes locality.

The area has been extensively cleared because of its relatively arable terrain, based mainly on shale and alluvium. Some of the remaining vegetation is associated with the much less arable to infertile Castlereagh Woodlands and its older, leached and mineralised alluvium and shale-derived soils. Strips of remnant vegetation are present along some of the larger watercourses such as Eastern and South Creeks. Significant parts of the study area are or were flood-prone, and this has influenced the retention of vegetation in some affected areas.

Western Sydney Aerotropolis Growth Area (WSAGA)

This Growth Area adjoins the Greater Penrith to Eastern Creek area, extending south to the locality of Greendale, west of Bringelly. It is currently largely rural, with villages at Luddenham and Kemps Creek. Most rural areas are pastoral, but there are significant areas of more intensive rural use, including poultry and egg production, a large dairy and associated fodder cropping, and some market gardens and enclosed fruit and vegetable production. Quarrying occurs at the localities of Badgerys Creek and Kemps Creek.

This Growth Area is extensively cleared but retains native vegetation in areas where rural uses were constrained by steeper terrain, flooding along streams, or unsuitable soils.

Greater Macarthur Growth Area (GMGA)

The GMGA occurs in southwestern Sydney on predominantly shale soils that have been heavily cleared for agriculture and urban or industrial use. The northernmost section has long-established urban and commercial / industrial land use, while the southern section is largely rural (pastoral, minor cropping), with some villages and primarily subsurface mining (e.g. coal and coal seam gas). It extends from urban Glenfield in the north, to the rural village of Appin in the south.

In the southernmost section, geological uplift and erosion have exposed infertile sandstone terrain along gullies and valleys. Much of that terrain remains naturally vegetated because it is unsuited to agriculture, however it occupies only a small percentage of the total area of this heavily-cleared region. Between the infertile sandstone valleys and the relatively arable shale plateau and hills is a geological and ecological transition zone. Whilst much of the vegetation of the shale terrain has been cleared, a greater area of vegetation remains on the transition zone, primarily in the south. Both the shale and transition zones support Critically Endangered ecological communities that are potential habitat for some threatened plant and animal species.

Wilton Growth Area (WGA)

The Wilton Growth Area is the most southerly of the four Western Sydney Growth Areas dealt with in this Report. It extends from the village of Douglas Park in the north, to the village of Wilton in the south. It is primarily rural (pastoral) area with some more intensive agriculture, significant but mostly underground mining (primarily coal), and some long-established villages. The Hume Motorway dissects this Growth Area.

The pattern of clearing and vegetation retention is broadly similar to that of Greater Macarthur, with the majority of remnant vegetation associated with infertile but biodiverse sandstone gullies and the Nepean River gorge, and with associated transition into the heavily cleared shale landscapes.

1.4 Justification for the use of an Expert Report

An Expert Report for *Acacia pubescens* is required as part of the threatened biota assessment for the Cumberland Plain Conservation Plan because:

1) Survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH, 2016) for field traverses due to limitations on land access, particularly in the GMGA;
2) Survey quality was constrained by drought conditions. Whilst this species is perennial, under sufficiently severe drought and associated total grazing pressure (livestock, if relevant; native species; feral species), it can be suppressed such that it only remains apparent (but likely undetectable) as rootstock and as seed bank. Drought was a major limitation on survey effectiveness in this instance. A known location of the threatened species, *Acacia bynoeana* was visited by fellow botanist, Robert Miller, but could not be detected, even though the habitat was still in place. This is believed to be a result of drought;
3) Survey effectiveness was further constrained by parts of the study area having been long-unburnt. This can create an unnaturally dense shrub layer that limits access.

Surveys associated with biocertification of the study areas and earlier projects in those areas have been insufficient to reliably determine the presence and extent of the species. An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region, but also in the ACT, Central Coast, southern NSW (coast, tablelands and slopes), throughout Victoria and eastern South Australia. I have primarily been self-employed with a mix of government, private, and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for OEH (Native Vegetation Information Science). A summary of my credentials as required under the BAM is provided below as Table 1. I was approved by OEH as a species expert for *Acacia pubescens* under s.6.5 of the BAM in November 2018.

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Acacia pubescens*

BAM section	BAM requirement	Details
s.6.5.2.8 (g)	Name of expert	Dr Steven Douglas
s.6.5.2.3 (a)	Expert's qualifications	Bachelor of Science (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. Master of Environmental Planning, Graduate School of Environment, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006. BAM Accredited Ecologist, 2018.
s.6.5.2.3 (b)	History of experience in ecological research and survey method for the relevant entity	Review of BioNet and incorporated NSW Herbarium database records of *A. pubescens* (DPE, 2018). Included reclassification of suspect outlying records, known plantings, hybrids, and significant refinement of data about the outlying Mountain Lagoon population (a single collection site, not several). Provision of expert witness evidence in relation to *Acacia pubescens* (QUBE proposal, Moorebank; included assessment of adequacy of biobanking arrangements) L&EC 2017/81889 (2017-18). Rediscovery, documentation and validation of disjunct Southern Highlands record of *Acacia pubescens* (2016-17). Advice to OEH and Wingecarribee Shire Council. Successfully nominated Wingecarribee Shire population of *A. pubescens* as Endangered under *Threatened Species Conservation Act* – later omitted due to changes caused by Biodiversity Conservation Act. Rediscovery and validation of disjunct southernmost population (South Nowra) (2016-17). Acknowledged by NPWS for contributions to and review of the Recovery Plan for *A. pubescens* (2003). Consulted by OEH in relation to illegal clearing of a known population, and appropriate remedial actions (2017). Consulted by NPWS in relation to proposed horse riding in known and likely habitat for this species (2018). Numerous historic surveys in northwest and western Sydney including Hills Shire, Hawkesbury Shire, Fairfield City, and Penrith LGAs (1994-2000) as evidenced by BioNet and NSW Herbarium records.
s.6.5.2.3 (c)	Resumé detailing projects pertaining to the survey of the relevant entity	See Appendix 1. Relevant surveys and works listed above. Minor incidental survey of potential habitat at locality of Kemps Creek for DPE Expert Report. Meandering transect used.
s. 6.5.2.3 (d)	Employer's name and period of employment (if relevant)	Self-employed ecological consultant, 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map, South Coast Regional vegetation map, Review of mapping issues for TECs).

s.6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant entity	Consulted by OEH in PAS2 reviews of this species. Engaged by DPE to review and refine/correct BioNet data for this species. Consulted by DECCW on this and other threatened flora species of the region as part of a data review for the purposes of the BioBanking Tool (2006). Requested by OEH to nominate as a contributor to forthcoming CAM / BAM Calculator review of this (and numerous other threatened flora) (2018/19). Approved as a BAM species expert for *Acacia pubescens* by OEH in November 2018.

2. Species information

2.1 Description

Acacia pubescens is "A spreading (to slightly weeping) shrub, 1 - 5 m high with brilliant yellow flowers, bipinnate leaves (divided twice pinnately) and conspicuously hairy branchlets" (OEH, 2017; Kodela, 2016; NPWS, 2003a; Benson & McDougall, 1996).

It "May be confused with *A. cardiophylla*, which has cordate pinnules. Hybridises with *A. baileyana*, *A. cardiophylla* and other species" (Kodela, 2016) including the nationally rare *A. jonesii* (NPWS, 2003a). All such hybrids are unnatural occurrences as the other species have been introduced into *A. pubescens'* range. This is a threat to the species' genetic integrity (NPWS, 2003a, b), though the extent of such occurrences are unknown. Natural hybrids with *A. irrorata*, *A. mearnsii* and other local species are feasible where they co-occur.

2.2 Ecology

A. pubescens "Flowers from August to October. Pollination of *Acacia* flowers is usually by insects and birds. The pods mature in October to December." (OEH, 2017). *Acacia* species are generally self-incompatible, and the pollinators are likely to be small native bees and wasps (Bernhardt, 1987).

Seed dispersal is most likely by ants seeking to collect the aril. Seeds are taken into the ant nest, and later discarded in a wide area around the nest (Whitney, 2002). Seeds are likely to remain viable over many years in the absence of germination cues, with the species likely to develop a persistent, soil-stored seed bank, as is typical for most *Acacias* (NPWS, 2003a, b).

A. pubescens can occur as copses or thickets due to its suckering habit, especially in areas where there has been disturbance such as slashing, attempted / earlier clearing or 'underscrubbing', roadworks, excavations or fire. Many remnant occurrences are linear and restricted to roadsides and fence lines.

"Recruitment is more commonly from vegetative reproduction than from seedlings. The percentage of pod production and seed fall for this species appears to be low. *Acacia* species generally have high seed dormancy... It is thought that the species needs a minimum fire free period of 5 - 7 years to allow an adequate seedbank to develop. Longevity is unknown, but clonal species [such as *A. pubescens*] have been known to survive for many decades" (OEH, 2017). Preliminary generic work by Moore *et al*. (1999) has shown that in most cases, the often-dense patches in which the species can occur, often with hundreds of stems, are one individual (NPWS, 2003). One clonal individual was seen to cover 1.2 ha (Moore *et al*., 1999).

Experiments that involved providing *A. pubescens* seed to captive emus provided preliminary evidence that seeds that survived digestion germinated earlier than those not ingested, but the experiment was truncated and did not produce a result in relation to germination frequency differences (P. Ridgeway, pers. comm., 2018).

Acacia pubescens © S. Douglas

2.3 Distribution and abundance

NPWS (2003a) describes the species as being restricted to clayey soils in the Sydney region, with most occurrences on the Cumberland Plain. Kodela (2016) lists the species' distribution as "Bilpin to Georges River and in the Oakdale area (Central Coast botanical division); southern limit outlier populations at Aylmerton (Central Tablelands) and Nowra area (South Coast); dubiously recorded at Woodford where it is possibly cultivated." OEH (2017) states the species' distribution is "Concentrated around the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon."

As the species has been in cultivation for some decades, care is required to ensure that database records are not plantings or associated naturalisations. Three records of the species (all are apparent replicates) at Woodford in the Blue Mountains are regarded by NPWS (2003a) as plantings. They occur in a former garden, not in bushland, and on geology not known to support the species. These were recoded as 'planted' during the BioNet data cleansing project that forms part of the DPE biocertification assessment.

A publicly available BioNet map of the species' distribution will generally be accurate at a coarse scale, but can include records that are unsound e.g. misidentified, data entry error, incorrectly located, and in this case, potentially planted. "Some organisations have planted *A. pubescens* on land under their control… Bankstown Council planted *A. pubescens* in at least five reserves (Mirambeena Reserve, Salt Pan Creek Reserve, Deepwater Park, Roberts Park and at The Crest of Bankstown). It is also believed that the RTA planted some plants along the M5 Motorway, which were taken from plants lost during its construction... There are also *ex situ* plantings of the species in Mount Annan Botanic Garden, the Australian National Botanic Gardens and the Burrendong Arboretum. The species is sold in some commercial and Council nurseries…" (NPWS, 2003a). Known plantings may be appear in general BioNet search results but should be clearly coded as such and will be shown with the annotation 'cv' (cultivated) in Herbarium records.

Two north-eastern outlying records of the species in the Central Coast region were also assessed. The northernmost has been corrected as it was apparently a data entry error. The other, east of Gosford is regarded as a planting or naturalisation from a planting (the identification is supported by a vouchered specimen, but the habitat is considered illegitimate – Narrabeen Sandstone in or at least near wet sclerophyll forest). NPWS (2003a) sensibly dismisses a reference to the species at the junction of Yalwal and Ettrema Creeks in Morton National Park as a likely misidentification of *A. irrorata*. That record no longer appears in BioNet.

The northern-western limit of the species at Mountain Lagoon (referred to by some as Bilpin) remains the same as described in NPWS (2003a, b). However, a review of BioNet data, particularly that from the Royal Botanic Gardens Sydney Database, revealed that there were numerous records spread across that area and beyond, yet there is only one actual location where the species occurs at that locality. Explanations for the spread of those records, most of them in unsuitable habitat for the species, include generalisation of records due to the use of coarse resolution co-ordinates, plus what appear to be data entry errors when co-ordinates were entered into one of the databases. A record from nearby 'Bilpin' is likely to also be from Mountain Lagoon, and a record from Scheyville that plotted incorrectly south of Bilpin has been corrected. The Mountain Lagoon population was confirmed by me in early December 2018.

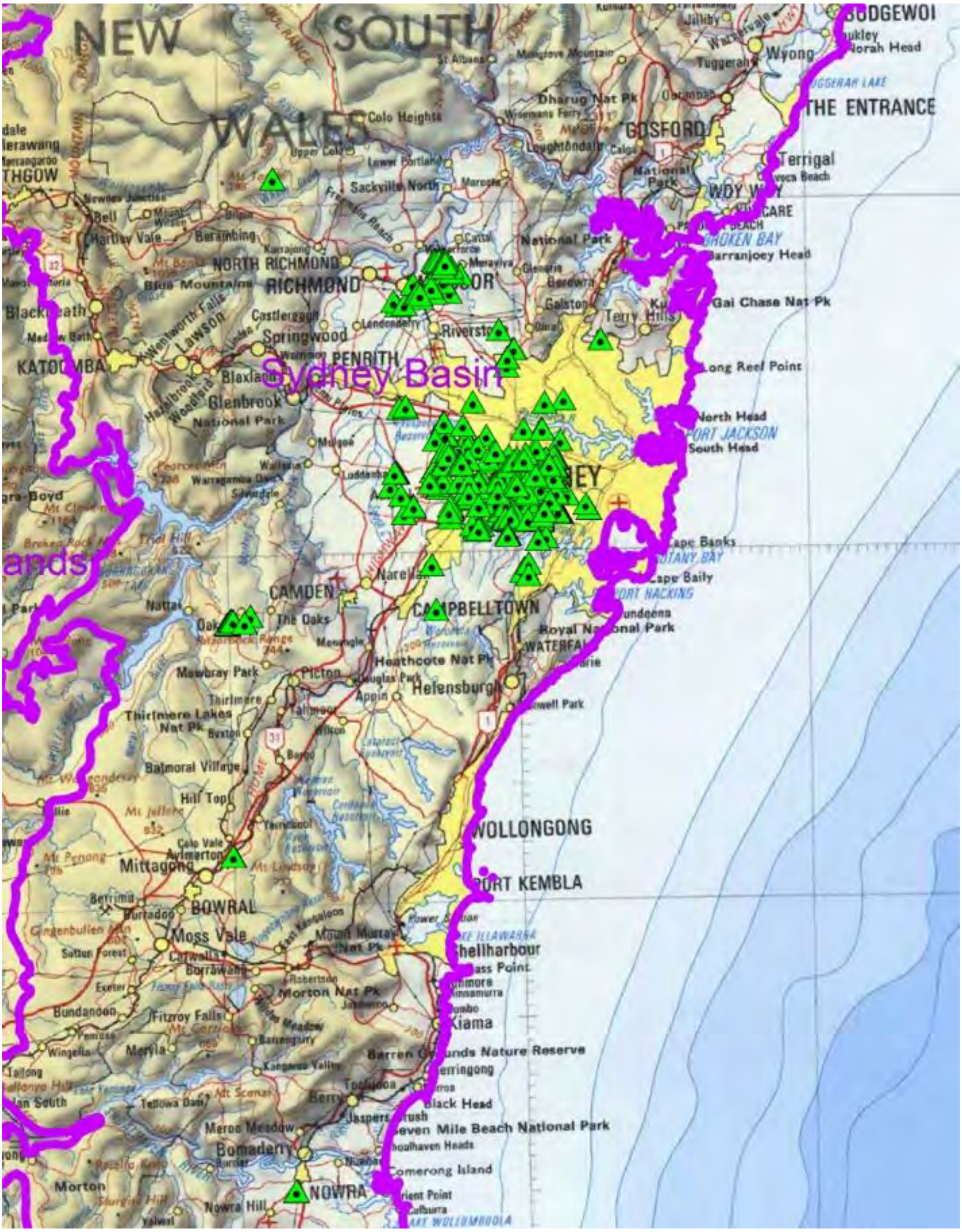
The south-western limit of the species is still the Macarthur district (The Oaks) in the form of several records within one scattered population. The easternmost record is at Bardwell Creek (1999). It was rediscovered, and its location was more accurately recorded in 2012. A '1770' collection from 'Port Jackson' plots on South Head but will likely be from much further inland, probably close to the Parramatta River where other collections have been made. South Head is not a legitimate eastern limit for the species and is inappropriate habitat. That record has since been moved to the nearest known population as part of the data cleansing process. A new north-eastern extant limit was documented in 2009 from North Turramurra and is accepted to be valid.

The now quite dated Recovery Plan for this species (NPWS, 2003a) reports, "*Acacia pubescens* has been recorded from 195 sites and is currently known from 151 of these. Although the species is known from a large number of sites, a high percentage of these (51%) consist of populations of fewer than 20 ramets (or 'clones'). Most of these populations are subject to numerous threats."

The range of Downy Wattle prior to European settlement is likely to have been similar to the current extent, however considerable losses from within this range have occurred. This is particularly evident within the Sydney region. It is likely that many more populations or subpopulations have been destroyed by the clearing of habitat, prior to their discovery. "Habitat loss is a major issue in Western Sydney. Over 90% of the original distribution of vegetation in the region has been cleared (NPWS, 1997). Eleven of the sites recorded on the Atlas for NSW Wildlife (as of 1998) no longer contain *A. pubescens*. Most of these sites have been lost to residential development. Many old records indicate that the species occurred in locations that have now been developed, such as Georges Hall, Belmore, Cabramatta, Chester Hill and Warwick Farm" (NPWS, 2003a). It is likely that approval has been granted by authorities to the destruction of some of the known populations since 2003, though previously undocumented populations are also likely to have been found, primarily towards the edges of its range where pressure for habitat removal and thus survey effort is likely to have been historically lesser.

Some translocation projects are known to have occurred. In the absence of an updated Recovery Plan or component information, it is not known how many populations are extant, and what the estimated total population size is. It is important to note that because the species is clonal, most population 'counts' are estimates because it is often very difficult to determine the number of individuals without genetic testing or potentially destructive sampling. NPWS (2003a) uses a separation distance of 300 m to arbitrarily define individuals.

Most of the Plant Community Types (PCTs) that are significantly associated with this species in the Growth Areas are Threatened Ecological Communities ranging from Critically Endangered to Vulnerable, with some having different status under NSW and Federal law. Some of the other PCTs that are known habitat for this species are also threatened by historic and on-going clearing and degradation, and by inadequate reservation.



Map 2. Cleaned BioNet data (extracted 26/11/18)

NB, each point may not designate a collection or observation at that location, as most very old records lacked any co-ordinates, or only supplied coarse co-ordinates, and may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

2.3.1 Reservation status

NPWS (2003a, b) state that "Only five of the 151 known sites (of the species) occur within conservation reserves (Scheyville National Park and Windsor Downs Nature Reserve)." As of 2018, there are currently only two records of the species in Windsor Downs Nature Reserve, and both are on the northern edge of the reserve, adjoining an established urban area. There are many more records from Scheyville National Park and on an adjoining Crown road reserve. Since 2003, Prospect Nature Reserve has been declared and incorporates three records of the *A. pubescens*. The species is also now known from Western Sydney Regional Park (4 records in the reserve, several just outside).

NPWS (2003a) note that some NSW Herbarium specimen records of the outlying population at Mountain Lagoon say that they were obtained in Wollemi National Park, but NPWS could only locate the species at one site on land then owned by the Department of Land and Water Conservation (DLWC) i.e. not in the National Park. Part of the problem in this instance is that historically, there have been numerous records of the species incorrectly plotted around the Mountain Lagoon locality and beyond. When reviewed as part of the BioNet data cleansing project funded by DPE, the large number of records from this locality were interpreted to have all been collected at the one readily detected roadside site – the one verified by NPWS in 2003 as part of the Recovery Plan. All BioNet records of the species (and NSW Herbarium records) have since been moved to that location which was checked by me and confirmed to be in what is now NPWS estate. The former DLWC portion appears to have been added to the National Park since 2003. Searches for this species at the locality of Mountain Lagoon on and near trails in NPWS estate resulted in no new occurrences being detected (Goosen, N. and Monahan, D. [NPWS] pers. comm. 2018).

A. pubescens also occurs in numerous Council reserves, though some of these are known to entail outright plantings (NPWS, 2003a) or augmentation plantings. BioNet data suggests that the greatest number of apparent plants on public land occur within Council reserves, though this may be at least in part a result of increased survey effort in those areas. NPWS (2003) also notes that a population at Rookwood Cemetery and another at Liverpool Showground are subject to protective management.

The species is present in a Biobanking offset site on former Defence Department land at Moorebank, and may be present in other such areas, but this information was not provided by OEH. Information about other reserved populations in Biobanking offset / stewardship sites was requested from the Biodiversity Conservation Trust that now administers such areas. DPE has since advised that it has been provided with that information but is unable to provide it to me due to confidentiality constraints.

2.4 Habitat

2.4.1 Geology and soil

Acacia pubescens occurs on Paleogene-Neogene and Quaternary alluviums; on Wianamatta Shale; at the interface between it and Hawkesbury Sandstone (including the Mittagong Formation); and in one atypical instance, on a clayey variant of Permian Nowra Sandstone. Occurrences associated with the Wianamatta Shale / Hawkesbury Sandstone interface tend to represent the limits of the species' distribution where the once-more extensive shale soils are eroding. The majority of occurrences are associated with Paleogene-Neogene alluvium (including Londonderry Clay, Rickabys Creek Gravels) and its interface with Wianamatta Shale. Associated soils can be gravelly, often with ironstone i.e. laterite (*sensu* Martyn, 2018). Soil Landscapes include but are not limited to Berkshire Park; Blacktown, Luddenham, Glenorie; Faulconbridge; Lucas Heights; South Creek, Birrong, Richmond; and Nowra.

"The topography of the habitat of the species is flat to gently undulating: a characteristic of the Cumberland Plain region. The sites of *A. pubescens* range in altitude from 0 to 650 metres a.s.l." (NPWS, 1998 cited in NPWS, 2003a). This information remains broadly correct. It appears that in 1998, NPWS already regarded the Southern Highlands outlier as legitimate (the specimen was collected by a NPWS staff member), as it is the only population to occur anywhere near as high as 650 m elevation (the altitude is ~550 m).

2.4.2 Associated vegetation communities and NSW TECs

The species "occurs in open woodland and forest, in a variety of plant communities including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel Transition Forest and Cumberland Plain Woodland" (OEH, 2017). All of these are Threatened Ecological Communities (TECs). According to the OEH Threatened Species Database, NPWS (2003a), and analysis undertaken for this Report, additional TECs that should be mentioned in the OEH profile include Shale/Sandstone Transition Forest, and Castlereagh Scribbly Gum Woodland. The strong correlation between this species and TECs is an indication of how threatened its habitat is. The species is also known from plant communities that are not currently TECs, but those associations are relatively weak. These are discussed later in this Report.

"Stands of *A. pubescens* have been recorded in open, disturbed areas, surrounded by exotic species. Although these areas are clearly not the natural habitat of *A. pubescens*, the species may survive in these situations for many years, due to its suckering nature and ability to tolerate some levels of disturbance. These areas are important as they provide information as to the original extent of the species and they may contain examples of genetic variability that have been lost elsewhere" (NPWS, 2003a). In a particularly acute example of the species' resilience, in 1999, the species was found surviving in tiny pockets of remnant habitat within a formal carpark at Fairfield Showground. Many such small and/or significantly modified habitats are not mapped as native vegetation.

The OEH Threatened Biodiversity Data Collection (July 2018) listed the following Keith vegetation classes as being associated with *A. pubescens*:

- Coastal Valley Grassy Woodlands;
- Cumberland Dry Sclerophyll Forests;
- Northern Hinterland Wet Sclerophyll Forests;
- Sydney Coastal Dry Sclerophyll Forests;
- Sydney Hinterland Dry Sclerophyll Forests;
- Sydney Sand Flats Dry Sclerophyll Forests; and
- 'Highly disturbed areas with no or limited native vegetation'.

Associations between a species and Vegetation Classes and Plant Community Types (PCTs) in the Threatened Species Data Collection were determined by the species' Accountable Officer within OEH some years ago, and staff were required to take a relatively inclusive approach in accordance with the precautionary principle (Steenbeeke, pers. comm.). This may mean that for some species, Vegetation Classes and PCTs have been associated with them even though there is little or no empirical evidence to support that, but where the officer believed that these attributes credibly represent *potential* habitat. Given the limitations of vegetation mapping and that in most cases, survey effort for threatened species is incomplete across their range, such an approach is understandable.

It appears that in some cases, the associations with Vegetation Class and PCTs in the Threatened Biodiversity Data Collection may have been amended after the assignments described above, and that some more recent associations may be influenced by spatial errors in species' records and/or errors in or limitations of vegetation maps. In this case, the link to Northern Hinterland WSF is unsound and most likely produced by an invalid northern outlying record of the species. OEH was advised of this and related issues in mid-July 2018. Some such errors have since been rectified through the BioNet data cleansing process undertaken as part of DPE's assessment of the effects of biocertification on threatened species.

An assessment of the association between *A. pubescens* and PCTs was undertaken to better understand the potential habitat for this species in terms of plant communities. The assessment is constrained by limitations of BioNet data and available vegetation maps. The assessment of the species' relationship with PCTs in and near the Cumberland Subregion used OEH vegetation maps that were publicly available at the time and did not use the updated vegetation maps produced within the Growth Areas by the biocertification process. The information is used to generate 'species polygons' (maps of potential habitat) as required under the BAM. Whilst DPE required habitat associations to be graded i.e. strong to weak association with particular PCTs, only ungraded PCT association data was used to generate the species polygons.

Some records of the species were seen to not be spatially associated with a PCT. This may be because:

- the record occurs in a site now cleared of native vegetation or too degraded to be captured by mapping;
- because the record is too spatially uncertain, so has been assigned generic co-ordinates, usually in a named town or suburb, and such settled areas often lack remnant native vegetation; and/or
- the record plots just outside an area of mapped vegetation because it is on a road verge, and even most GPS records are only accurate to 5m, meaning it could plot on the road, not on the vegetated verge.

To overcome this latter problem, those records were assigned a 10 m buffer so that they would associate with the nearest mapped vegetation polygon up to 10 m from the plotted location.

A further consideration is that survey effort for the species is not evenly distributed across the area subject to analysis. Some sites of potential habitat have had very little or no effort, often due to tenure constraints, yet others have had every apparent plant recorded (mostly in reserves or as part of ecological impact assessments). This creates very substantial biases in the data, which can create misleading weightings of association between the species and particular PCTs.

Most records do not include population data, meaning that a record might relate to one apparent plant or to many: a situation significantly compounded by the clonal nature of this species such that many apparent plants may be one individual. Furthermore, not all occurrences have been subject to intensive surveys that record all apparent individuals. This can cause a bias in the apparent strength of association between a PCT and the species. In short, this analysis is best used only for presence/absence i.e. whether the species has been recorded at a point that is mapped as a particular PCT, or not. Analysis beyond that is very constrained by deficiencies and biases in the datasets, especially in BioNet data.

The analysis of association with PCT in Table 2 deals only with records in the Cumberland Subregion plus a 10 km buffer. Records that associate with a PCT when a 10 m buffer is used are included in the counts of sightings below and are not shown separately. Two analyses were undertaken: All records in the target area without regard to spatial Accuracy score; and only records in that area with Accuracy score of 100 m or better. The latter analysis is considered more reliable, but both sets of figures are provided. Sightings with Accuracy <=100 m are shown in square brackets **[ ]** and in bold text. Where available, the combined count of individuals associated with the records is provided in parentheses { }. Those counts relate only to records with Accuracy <=100 m. Where a record doesn't contain population data, it is assumed to relate to a single plant.

Only PCTs mapped in the Growth Areas are dealt with in Table 2. This can mask associations between the species and PCTs that occur elsewhere. Because of the concentration of occurrences on the Cumberland Plain, this effect is largely limited to outlying and atypical populations beyond the Cumberland Subregion.

In the raw data, some PCTs can appear to have a greater or lesser association than is actually the case. PCTs 850 and 1181 have been excluded from Table 2 and are not regarded as potential habitat for the species on the basis of there being too few records mapped in those PCTs, and on known habitat parameters. The very few records that the raw data showed to be associated with those PCTs are likely a result of spatial errors in the records or spatial or other limitations of the vegetation maps. Additionally, there are 68 records of the species in Mangrove Forest, 4 in Coastal Lagoons, and 2 in Saltmarsh, yet the species does not occur in any of those communities. Consequently, all such occurrences are excluded from the analysis in Table 2, though some regard has been given to the PCTs in which those records most likely occur, and this has been used in the weightings afford to PCTs in the column 'Adjusted relative association'.

TABLE 2 – BioNet records of *A. pubescens* and counts of individuals relative to mapped PCTs

PCT	PCT Name	Associated TECs (NSW BC Act)	% Cleared (VIS)	Sightings & Population	Relative association	Adjusted relative association#
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Shale Gravel Transition Forest (E)	75	1887 **[1780]** {10278}	Very High	Very High
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Cooks River/Castlereagh Ironbark Forest (E)	95	2240 **[2405]** {2930}	Very High	Very High
808	Derived shrubland on Tertiary Gravels of the Cumberland Plain	Shale Gravel Transition Forest (E) Cooks River/Castlereagh Ironbark Forest (E)	75-95 inferred from 724/725	Not mapped	Very High (inferred)	Very High (inferred)
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	River-flat Eucalypt Forest of Coastal Floodplains (E)	93	93 **[78]** {77}	Low	Low
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CE)	93	579 **[521]** {10262}	High	Moderate
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland (V) Castlereagh Swamp Woodland (E)	50	33 **[33]** {2955}	Very Low	Very Low
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Not a TEC but some areas may be within Shale Sandstone Transition Forest (CE)	40	164 **[164]** {285}	Moderate	Low
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (CE)	80	5 **[3]** {155}	Very Low	Very Low

2.4.2 Associated Commonwealth TECs

The Commonwealth Department of Environment & Energy (DEE) Species Profile and Threats Database for *Acacia pubescens* (DEE, 2003) shows that an Approved Conservation Advice for this species was released in 2016 (TSSC, 2016). However, like the species' SPRAT webpage, this only reiterates content from the Recovery Plan and other NSW Government sources. The now quite dated (2003) Recovery Plan is relied upon to list the associated TECs, but only NSW-listed TECs are mentioned – not Commonwealth TECs. For this species, the NSW TECs with which the species is accepted to be associated are largely equivalent to or components of Commonwealth TECs. An exception is River-flat Eucalypt Forest of Coastal Floodplains, which does not have a Commonwealth equivalent.

2.4.3 Habitat condition

Degraded and significantly modified areas of the PCTs that are known or likely habitat for *A. pubescens* can still support it due to its ability to persist in the soil seed bank and as root suckers. Modified sites may have reduced or no canopy and/or midstorey, and/or reduced understorey and some weed invasion. Some may be dominated by shrubs in areas of regrowth after earlier clearing or 'under-scrubbing'.

This species is known to occur in highly modified sites such as slashed bushfire Asset Protection Zones, and road / trail and railway verges and corridors, and in former small-scale quarries or spoil dumps (NPWS, 2003a, 2003b; Kodela, 2016; Douglas, pers. obs.). Some forms of disturbance, even relatively severe forms that would be considered clearing of vegetation, appear to be beneficial to this species, within limits. This situation is recognised for numerous threatened plant species in and beyond the Sydney Basin Bioregion. It may be related to the fact that modern fire regimes are likely to be significantly different to those prior to 1788, and that some native animal species that had a role in seed dispersal and understorey modification are now extinct or regionally extinct.

The condition of potential habitat for this species is not a reliable indicator of the species' presence, and accordingly, **all vegetation condition states are considered in determining potential habitat,** i.e. intact, thinned, scattered, derived shrubland, and derived grassland. However, sites with long and intensive grazing history will be unlikely to retain the species.

3. Description of the study area

3.1 Landscape context and land use history

All of the Growth Areas have been significantly cleared for earlier activities, primarily timber production associated with opening areas for agriculture and pastoralism, minor areas of surface resource mining, and to varying degrees, for urban and commercial/industrial use. They are proposed to accommodate phased increases in urban land use, primarily within existing cleared or highly modified lands. Increased urban use is planned as a response to population growth.

3.1.1. Greater Macarthur Growth Area (GMGA)

The GMGA extends from Glenfield in the north to Appin in the south. It is largely within the Campbelltown LGA with the southernmost section within the Wollondilly LGA. The northern half comprises an urban renewal corridor centred on the Sydney to Southern Highlands railway line. It encompasses the existing industrial and residential suburbs of Glenfield, Macquarie Fields, Minto, Leumeah and Campbelltown. The GMGA is associated with extensively cleared, gently undulating shale terrain typical of the Cumberland Plain, and contrasts the sandstone gorges of the Woronora Plateau across the Georges River to the east. The northern portion of the GMGA is already substantially urbanised, with remnant vegetation largely restricted to creek-lines or small patches associated with designated open space. Vegetated creek-lines include Bunbury Curran Creek, Bow Bowing Creek, Leumeah Creek, Fishers Ghost Creek and Spring Creek.

The more extensive southern half of the GMGA, south of Rosemeadow, comprises proposed urban land releases at Menangle Park, Mount Gilead and Appin. Menangle Park and Mount Gilead are subject to separate planning processes, so are not within the scope of this biocertification. In the north-west, Mount Sugarloaf (213 m AHD) forms the southern end of a hilly ridge on the Luddenham Soil Landscape above the Menangle floodplain that extends north to Denham Court, then to Cecil Hills and Prospect Hill. Some native vegetation persists, although it is often invaded by African Olive. The floodplain is dissected by Menangle Creek and its tributaries, including Nepean Creek, Woodhouse Creek and Leafs Gully.

The southern GMGA is primarily semi-rural and agricultural land, with creek corridors and some larger patches of remnant vegetation located between the Nepean and Georges Rivers. Geologically, the area comprises gently undulating hills on Wianamatta Shale intergrading via a shale sandstone transitional zone (can include the Mittagong Formation) with steeper and infertile terrain on Hawkesbury Sandstone along the rivers. Transitional and sandstone geologies are sometimes exposed along the smaller creek lines.

3.1.2. Wilton Growth Area (WGA)

The WGA is a relatively smaller area that occurs to the south of the GMGA, extending from the vicinity of Douglas Park in the north, Maldon in the north-west, and beyond Wilton in the southeast. The boundaries closely follow the Nepean River in the north and west, a tributary Allens Creek in the east, and the Cordeaux River in the south. Away from the Nepean River and gullies, a higher, gently undulating zone has been largely cleared for agriculture. The Woronora Plateau forms the southern boundary and includes the northernmost section of the large Upper Nepean State Conservation Area, with unreserved but closed areas of the Water NSW Special Area (Sydney water supply catchment) extending to the east and southeast. The Hume Motorway dissects the WGA roughly north to south, and Picton Road traverses it roughly northwest to southeast.

The WGA includes both shale, shale sandstone transition and sandstone environments. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The flatter shale terrain has soils of the Blacktown Soil Landscape, which is derived from Ashfield Shale (a member of the Wianamatta Group), and typically supported the now Critically Endangered Cumberland Plain Woodlands. Much of this area is cleared or modified for agriculture and hobby farms. It comprises native/exotic grassland with smaller areas of Derived Native Grasslands in relatively better condition. Areas above the gullies feature soils of the Lucas Heights Soil Landscape derived from the Mittagong Formation (a transitional bed between the Wianamatta and Hawkesbury Groups). These support variable shale sandstone transition woodlands and forest, some of which are also Critically Endangered. In the steeper gullies, the Hawkesbury Soil Landscape dominates, and supports Hawkesbury Sandstone Gully Forest types with Ridgetop Woodlands on some of the upper slopes.

3.1.3. Greater Penrith to Eastern Creek Growth Area (GPECGA)

The GPECGA is a relatively large area that extends from Rooty Hill, Minchinbury and Hassell Grove in the east, across the Cumberland Plain to the Hawkesbury-Nepean River in the northwest, then south through Jamisontown, Glenmore Park, to the intersection between The Northern Road and the Warragamba Water Supply Pipelines in the far south-west.

The predominant geology is Wianamatta Shale on flat to gently undulating terrain that has been extensively cleared for agriculture, and later for housing and industrial use, with some remnant vegetation on current and former Defence holdings. The shale soils support(ed) Cumberland Plain Woodlands. Overlying the extensive shale deposits are small areas of weathered Paleogene-Neogene alluvium e.g. Shalvey and Willmot, that are much more common to the north. These support(ed) the Castlereagh Forests & Woodlands complex of vegetation types, which is strongly associated with several threatened plant species. More common are broadly linear deposits of Quaternary alluvium along watercourses such as South Creek and Eastern Creek, and on the flood terraces of the Hawkesbury-Nepean River. Other lithologies occur but are very rare and of very small extent.

Very little of the GPECGA is reserved in NPWS estate. Wianamatta Regional Park (which emphasises recreational uses) encloses small areas of former Defence land in the far north. Adjacent to the southwestern boundary is the small Mulgoa Nature Reserve (emphasises biodiversity values). Two Biobanking sites adjacent to the Nature Reserve have increased the area under conservation.

3.1.4. Western Sydney Aerotropolis Growth Area (WSAGA)

The WSAGA abuts the GPECGA's southernmost border near the locality of Sovereign (east of Mulgoa), then extends south past Greendale, northeast to the locality of Badgerys Creek, east to Kemps Creek, and northward to the vicinity of Mount Vernon, excluding Twin Creeks Golf Course and associated settlement.

The lithology and soils are broadly similar to that of the GPECGA, being effectively just an extension of that area to the south to incorporate the developing Badgerys Creek Airport and environs. The area is even more severely cleared of native vegetation, except along some streams and on rare occurrences of steeper terrain. It contains no NPWS reserves, with the nearest being the small Kemps Creek Nature Reserve, outside the Area to the southeast. Gulguer Nature Reserve and Bents Basin State Conservation Area occur to the southwest of Greendale.

3.2 Geology and remnant vegetation

All of the Growth Areas are within the Cumberland Subregion. The dominant lithology across all of the Growth Areas is Wianamatta Shale (Ashfield and Bringelly Shales), with much smaller areas of Paleogene-Neogene alluvium occurring largely outside these boundaries, and much larger areas of Quaternary alluvium associated with floodplains of the many watercourses (*sensu* Martyn, 2018).

The terrain varies from almost flat through to steeply hilly areas associated with minor volcanism and more often, in association with shale ranges. In the far south, the more elevated shale landscapes have been eroded down to the underlying Hawkesbury Sandstone in a series of gullies and gorges. A transition zone between the shale and the sandstone is discernible in some areas.

On the dominant shale geology, the associated Critically Endangered Cumberland Plain Woodlands are still present in all of the four Growth Areas but have been disproportionately cleared for rural and later urban and allied uses. Much of what remains of this ecological community occurs as paddock trees and areas of remnant native ground-layer vegetation in pastoral and other contexts, with the exception of some substantial, though fragmented and isolated remnants. Remnant vegetation in these relatively fertile and arable landscapes is often in poor condition. In the most heavily cleared areas, it can be restricted to strips along watercourses. Some forms are dominated by *Casuarina* species. Weeds are common and sometimes severe in the moister situations. Weeds often extend into higher and drier terrain, especially in the form of African Olive and African Love Grass, both of which can occur on a landscape scale.

Small areas of the biodiverse Castlereagh Forests & Woodlands persist in all but the Wilton Growth Area on often-laterised Paleogene-Neogene alluvium. These variable woodlands and open forests support a particularly high number of threatened plant species, and because their soils are less suitable for agriculture and grazing, are better conserved than the Cumberland Plain Woodlands. Nonetheless, they are all listed as threatened ecological communities.

In the two southern Growth Areas, vegetation of the shale sandstone transition zone is relatively common and tends to remain in less arable areas adjoining the largely cleared former Cumberland Plain Woodlands. It is often found fringing the largely uncleared sandstone-based terrain, and ranges from highly intact to significantly modified and degraded, largely due to grazing and weed invasion. The associated Shale Sandstone Transition Forest is recognised as Critically Endangered due to extensive clearing across its substantial range, and because of the severity of other threats. Very little is present in formal conservation areas.

In the two southern Growth Areas, diverse, sandstone-based vegetation persists in association with most of the many incised watercourses. This vegetation is broadly the same as what occurs in extensive conservation estate around urban Sydney, but some communities adjoining current or former Shale Sandstone Transition Forest are not well-conserved and are threatened by further clearing and degradation.

3.2.1 Plant Community Types

The following section lists the Plant Community Types mapped in each Growth Area with brief notes about their distribution in those Areas. The list is not restricted to PCTs associated with *A. pubescens*.

3.2.1.1 Greater Macarthur Growth Area (GMGA)

The predominant ecological communities in the GMGA are or were Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), all of which are Threatened Ecological Communities. All have been extensively cleared and degraded, primarily by agriculture and weed invasion, but also by urban and allied uses. There are no NPWS reserves in this Growth Area. However, the very small Leacock, Edmondson and William Howe Regional Parks occur just outside the border and are managed primarily for recreation rather than conservation. Dharawal State Conservation Area and National Park border the southern portion of the Growth Area to the east. A summary of the mapped ecological communities is found in Table 3. The maps used here are based on OEH products that have been updated by Biosis for DPE.

Table 3. Summary of all ecological communities within the Greater Macarthur Growth Area

PCT	PCT Name	Distribution & notes
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Small patch at Menangle Sugarloaf on SE slopes.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Along creek lines in shale areas in northern and central parts of GMGA.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Small patches on shale soils throughout GMGA but mostly in northern and central parts.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches on shale soils throughout GMGA, more common in southern parts on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	4 polygons, Macquarie Fields, most of which have long been historically mown (Milton Park Softball Complex). They are now subject to regeneration.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	One small occurrence mapped around the margins of bushland associated with Smiths Creek at Leumeah.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Nepean River north from Menangle Bridge.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Narrow zone along Nepean & Georges Rivers and tributary gullies and a small zone along Smiths Creek at Leumeah.
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Restricted to parts of the riparian zones of the more incised and larger watercourses. Very restricted extent in this Area.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Relatively small remnants extend south from Glenfield; extensive on transitional soils mostly south from Rosemeadow. Can intergrade with 849 and 1081.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Only mapped to a very minor extent as highly linear remnants between Glenfield and Macquarie Fields (along the railway) and at Ingleburn (adjoining roads).

3.2.1.2 Wilton Growth Area (WGA)

The predominant ecological communities in the WGA are or were Cumberland Plain Woodland (CPW) and Shale Sandstone Transition Forest (SSTF) both of which are Threatened Ecological Communities. Sandstone-based communities occur in and surrounding the more incised watercourses. There are no NPWS reserves in this Growth Area, though Upper Nepean State Conservation Area occurs immediately to the south. There is a Biobanking site on the northern side of the river near Douglas Park (within the WGA), and three more such properties to the immediate north (including St Marys Towers) and those associated with coal mines (Steenbeeke, pers. comm.).

Table 4. Summary of all ecological communities within the Wilton Growth Area

PCT	PCT Name	Distribution & notes
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	On shale soils of higher, gently undulating terrain of northern and central areas. Small patches with scattered trees (farming properties) adjoining more extensive exotic and native grasslands.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	One patch in a derived grassland (treeless) condition in the west, and a much larger portion in the far north.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Limited to a few patches in the north between 1395 on plateau edges and 1181 in sandstone gullies.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Common on slopes and plateau edges above and around incised sandstone-based watercourses that surround most of the Area.
1292	Water Gum – Coachwood riparian scrub along sandstone streams	Restricted to a very narrow riparian strip along the Nepean River.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	The most extensive community on shale sandstone transition soils between 849/850 and sandstone communities along gullies. Variable floristics.

3.2.1.3 Greater Penrith to Eastern Creek Growth Area (GPECGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Shale Gravel Transition Forest and Castlereagh Forests & Woodlands. River-flat Eucalypt Forest was previously much more extensive along the Hawkesbury-Nepean River and adjoining primary floodplain, and it remains to varying degrees along many watercourses such as Eastern Creek, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. There is one NPWS reserve in this Growth Area: Wianamatta Regional Park, however it is already significantly fragmented and may be required to potentially accommodate a large transport corridor. The small Mulgoa Nature Reserve and associated Biobanking sites occur near the south-western border of this Growth Area. Yarramundi SCA occurs on the western boundary but across the Nepean River, and Wianamatta NR occurs near the NW corner.

Table 5. Summary of all ecological communities within the GPECGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Scattered as small remnants and one larger remnant in the central portion, but with greater extent in the central north, mainly in the western ungazetted portion of Wianamatta Regional Park.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	A few very small remnants present south of the M4, with larger remnants within and near the gazetted and ungazetted portions of Wianamatta Regional Park.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northwest, with some small remnants in the southwest, often associated with watercourses.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Present to a very minor extent on the southwestern edge adjoining Mulgoa Nature Reserve
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains through the south and central areas.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Common in and near Orchard Hills in the south, and former ADI lands in the central north, with some areas in the ungazetted portion of Wianamatta Regional Park. Other scattered remnants, particularly in the east.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches in the south west, primarily in pastoral settings and on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Restricted to one linear polygon in the eastern portion of Wianamatta Regional Park.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Hawkesbury-Nepean River, primarily near Penrith Lakes.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Present as mostly-linear remnants along South Creek and Eastern Creek and tributaries, with some scattered occurrences, including along the M4.

3.2.1.4 Western Sydney Aerotropolis Growth Area (WSAGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Castlereagh Forests & Woodlands near the localities of Kemps and Badgerys Creeks, and potentially in the vicinity of the water pipeline crossing of Luddenham Road. Riverflat Eucalypt Forest remains to varying degrees along most watercourses, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. Swamp Oak Forest occurs mainly along South Creek and some tributaries. There are currently no NPWS reserves in this Growth Area. The small Kemps Creek Nature Reserve occurs just outside the south-eastern corner and Gulguer Nature Reserve and Bents Basin State Conservation Area are near the south-western corner.

Table 6. Summary of all ecological communities within the WSAGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Restricted to the Kemps and Badgerys Creek area as three patches of remnants.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	As above: two patches with smaller remnants nearby and on slightly higher ground than 724.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northeast, with one remnant in the centre.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains but very little remains, and most occurrences are linear.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	The most common PCT in this Area, with remnants throughout on the dominant shale terrain.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Only very small patches in the far south.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain and Hunter valley	Present as mainly very linear remnants along most watercourses but largely absent from the southernmost portion.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principal source of threatened flora records in NSW is the OEH BioNet database, which includes most records held by the NSW Herbarium (specimen-based), as well as sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may not have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet are original – most are simply replicate records based on specimens held in other herbaria.

The preliminary assessment of threatened species records undertaken for the preparation of this Expert Report reiterated the merit of reviewing BioNet data and resolving a range of errors, rather than simply using data 'as held'. *Acacia pubescens* records within BioNet were reviewed, and numerous corrections were made, though the majority of these relate to the assigned spatial accuracy scores and to clarifying or correcting location placements and descriptions. Not all records were able to be checked in that stage, and a second review for records in or near the Growth Areas was conducted to further improve data quality. The reviews eliminated a range of errors and allowed many records that were otherwise too spatially vague, to be refined such that they were suitable for habitat modelling and for general reference. Not all records were reviewed, and inaccuracies remain in the dataset, but records are now far more accurate in terms of their identification of the species, their location, and their spatial accuracy score.

BioNet data should only be treated as indicative, not least because there has not been comprehensive survey of all of the Growth Areas or environs, and surveys have been variously constrained. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate.

Field survey undertaken by consultancy firms engaged by DPE (Biosis and Ecoplanning) did not add any records of this species. Fellow botanists engaged by DPE to prepare Expert Reports also reported that no new records of this species were found by them.

4.1.1 Existing records by Growth Area

Acacia pubescens records in Greater Macarthur Growth Area

There is one duplicated record (NSW Herbarium and Wildlife Atlas) in this Growth Area. It is a 1960 collection that only gives the location as 'Minto'. This record was reviewed and given a 5000 m spatial accuracy to reflect the potential spatial variability within this suburb. There are no modern or spatially accurate records from this Growth Area, but there are several just beyond the northeast corner within current and former Defence Department land at Moorebank / Holsworthy. Part of this population is now within a Biobank reserve. There are also several records from an industrial area in Prestons, just north of the northern end of the Growth Area. There is one record near the central eastern boundary of the Growth Area at Kentlyn.

Acacia pubescens records in Wilton Growth Area

The species has been never been recorded within or near the WGA. The nearest records are approximately 14, 19 and 24 km from the WGA boundary to the northwest, northeast, and southeast. There is no apparent reason that the species could not occur here, as there are PCTs that the species is known to occur in. However, outside its core range on the Cumberland Plain, the species appears to be very sparsely distributed, with substantial distances between what are now quite disjunct remnant populations. This Growth Area may be naturally devoid of this species, or it could be present in unsurveyed habitat or in seedbank.

Acacia pubescens records in Greater Penrith to Eastern Creek Growth Area

There are seven records of the species in the southeast of this Growth Area. Some are duplicates or capture separate apparent plants at a scale finer than the resolution of GPS units used to record the sightings. All occur in the vicinity of the M4, Roper Road and Eastern Creek. There is only one location on the M4 in a small, thin section of remnant vegetation that has likely been subject to some supplemental planting. The other locations are associated with a very thin strip of apparently remnant vegetation bordering a large industrial site east of Eastern Creek off Sargents Road, Minchinbury. Some of the plants may be within Daraga Badu Reserve, but most of that land lacks tree cover, appears highly modified / degraded, and seems to be primarily associated with high voltage electricity easements and a floodway.

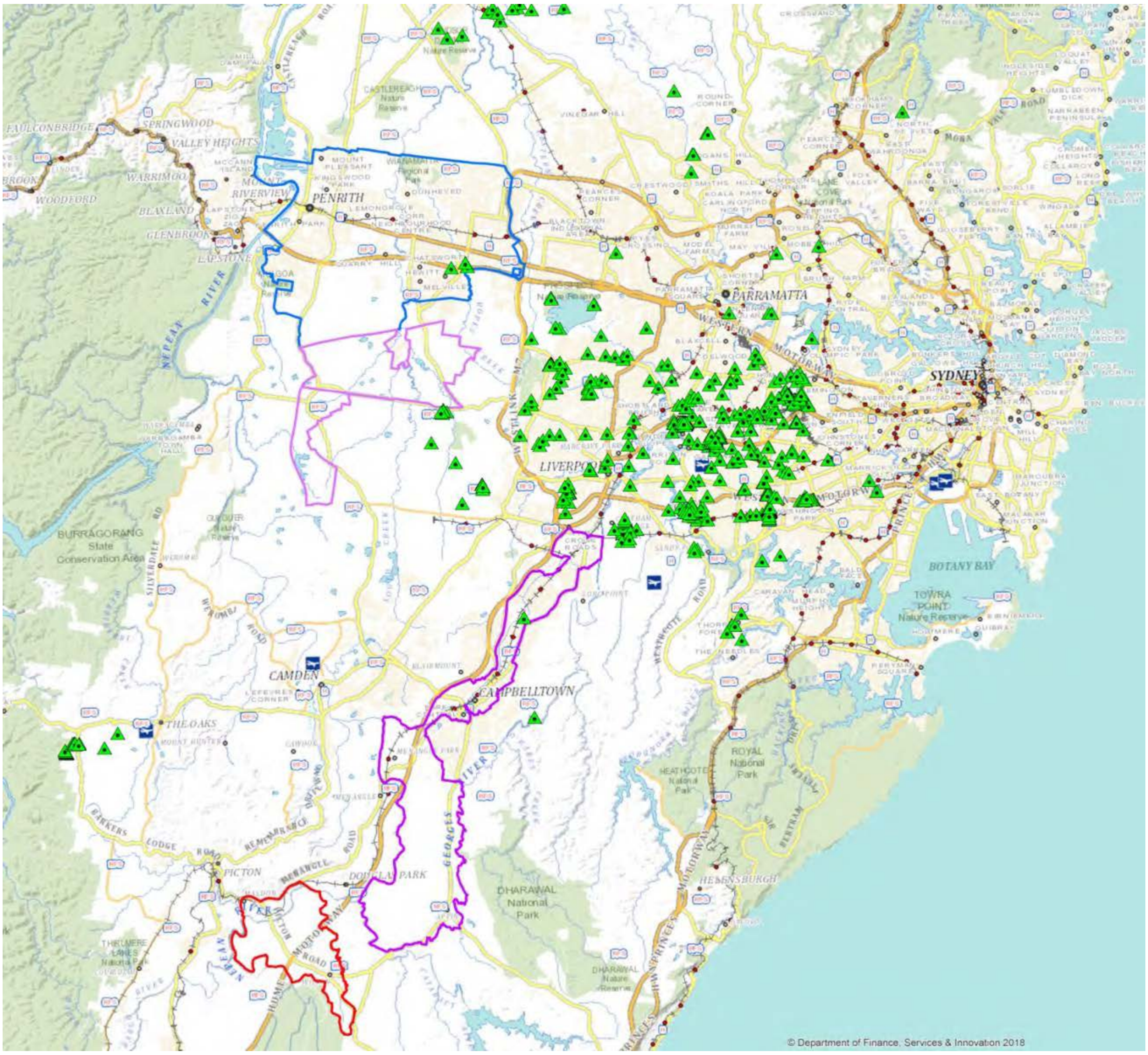
Acacia pubescens records in Western Sydney Aerotropolis Growth Area

The species is not currently known from this Growth Area but there are a small number of credible records immediately south of the Area's southeastern corner near Elizabeth Drive and Cross Street. All are associated with an isolated remnant of Paleogene-Neogene alluvium. Equivalent habitats occur north of Elizabeth Drive within the Growth Area but have been excluded from biocertification.

4.1.2 Prior surveys within each Growth Area

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods and findings across the study area.

The OEH Authorised Officer for *A. pubescens* was contacted in this regard. He advised that he does not hold a record of this information, so I contacted the manager of threatened biota matters in the Greater Sydney OEH office for further assistance. She committed to providing the relevant information by consulting key staff. I was included in the associated emails. No additional information about this species was provided.



Map 3. BioNet records (cleaned as of 26/11/18) relative to the Growth Areas

NB each point may not designate a collection or observation at that location, as most very old records lacked any co-ordinates or only supply coarse co-ordinates, and they may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

A BioNet map of the species' distribution gives a generally accurate indication of its known range, but not the extent of potential habitat. Large areas of private or corporate tenure have not been subject to the same level of survey effort as more accessible areas. An absence of records of the species where potential habitat remains should not be taken to indicate that the species does not occur there.

4.1.2 Prior surveys within each Growth Area

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods and findings across the study area.

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4.2 Summary of survey work undertaken for the biocertification assessment

4.2.1 Vegetation mapping

Vegetation mapping of the Cumberland Subregion was completed in stages by OEH in 2013 and 2016. These two vegetation layers have been used as the base to compile an updated vegetation community layer for each of the Growth Areas. This updated work has been completed by Biosis under contract to DPE. The mapping update includes checking plant community types and confirming the accuracy of boundaries to account for clearing or regrowth that may have occurred since the original mapping was completed. Field verification of the mapping was undertaken by Biosis and Ecoplanning, both of whom undertook vegetation surveys where access was permitted.

Vegetation in the Growth Areas was mapped and assessed based on five vegetation condition classes:

- Intact;
- Non-offsettable Grassland;
- Offsettable Grassland;
- Scattered Trees;
- Thinned.

4.2.2 Field survey effort

The information in section 4.2.2 has been provided by DPE but has been edited here to only deal with threatened flora where feasible. Further details are provided separately by DPE:

An initial 726 letters were sent to landholders within the Wilton and Greater Macarthur Growth Areas in late 2017 with a second letter following in March 2018. To increase the response rate, Biosis commenced targeted door-knocking in May 2018. From this, just under 20% of landholders within these Growth Areas allowed access to their property. However, this included access to large parcels of land owned by major developers, which allowed a reasonable amount of access, particularly for the Wilton Growth Area.

Floristic plot data collected:

- Wilton (86 plots across 6 PCTs)
- Greater Macarthur (82 plots across 9 PCTs)

Approximately 150 of the plots required to meet BAM requirements were obtained by supplementing Biometric plots from various recent assessments. This involved locating the previous plots and collecting additional data on stem classes, number of large trees, and litter cover to meet BAM requirements. The ecologists had no trouble locating the original survey sites and found that the additional data was quick and easy to collect (approximately 30 minutes per site). The remaining plots in Wilton and Greater Macarthur, and all of the plots in Western Sydney Aerotropolis and Greater Penrith to Eastern Creek consisted of new plots surveyed for this project. All plots were sampled according to the methods prescribed by the BAM Manual (OEH 2017). This includes collecting information on species cover and abundance from 20 x 20 m or equivalent configuration plots within each vegetation zone.

A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Growth Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council.

Floristic plot data collected:

- Western Sydney Aerotropolis (53 plots across 6 PCTs)
- Greater Penrith to Eastern Creek (26 plots across 7 PCTs)

Targeted survey for threatened species

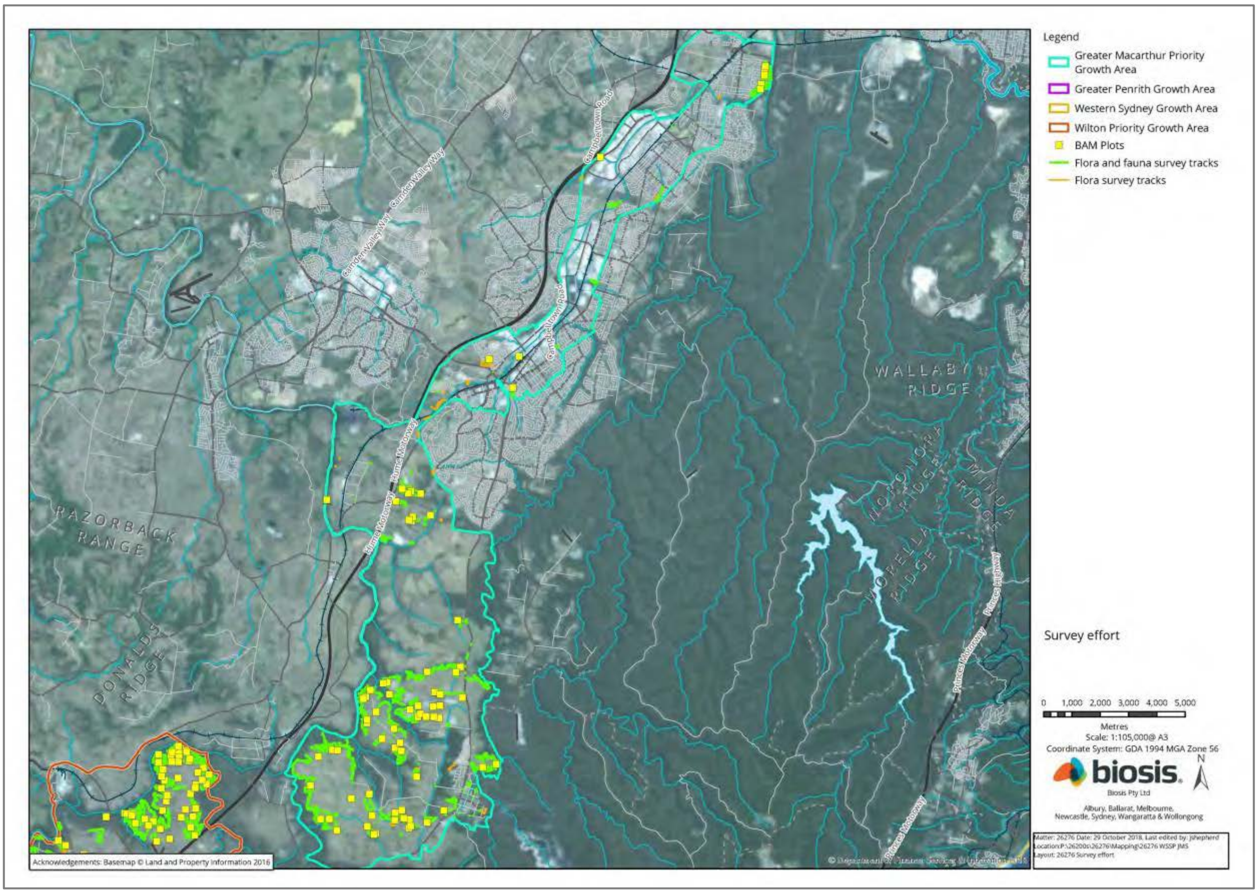
Targeted survey for threatened plant species has been conducted on lands where access has been granted. Vegetation transects and random meanders for threatened flora was conducted by Ecoplanning and Biosis in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey has included effort through each PCT and vegetation zone and has extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m).

Likely habitat for most threatened flora species comprised areas of lower disturbance. This includes areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora.

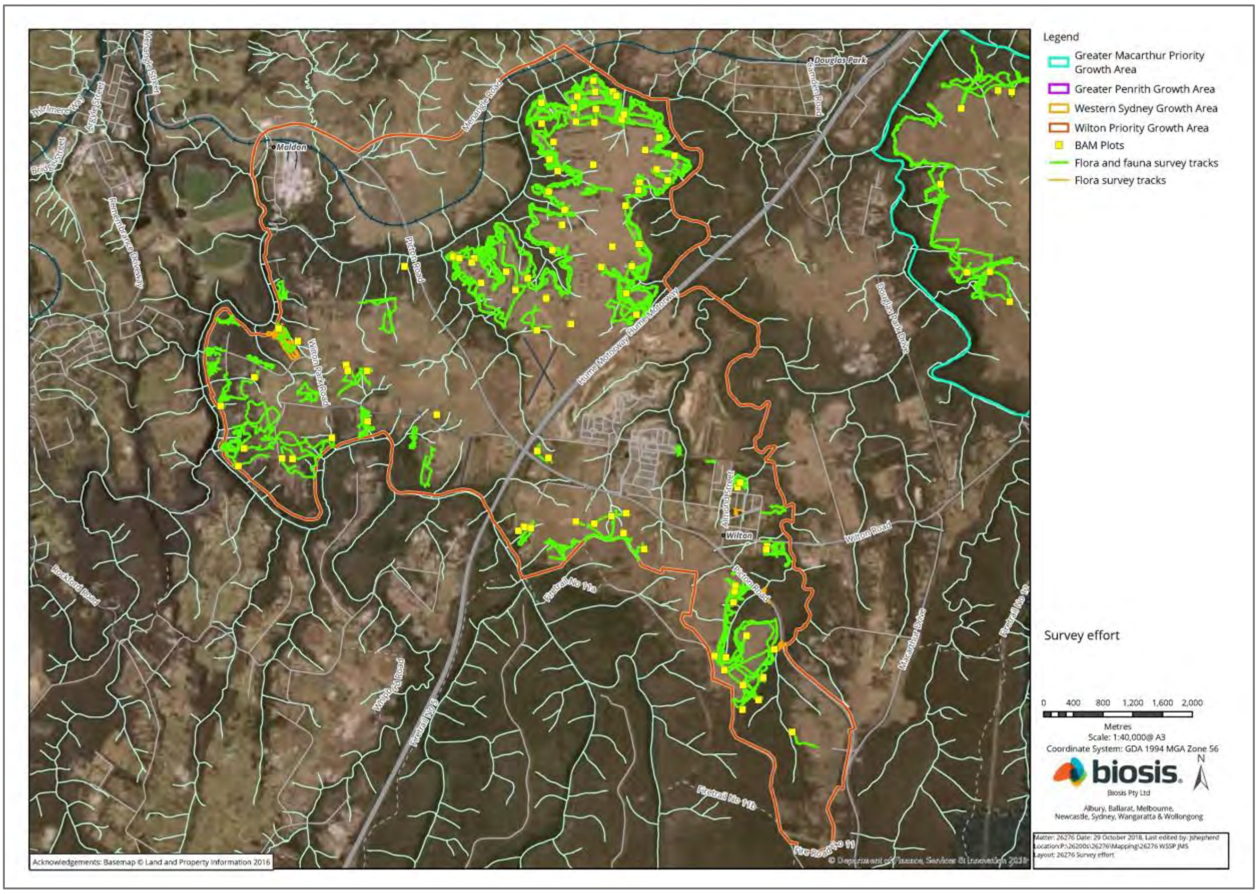
Table 7. Survey effort for threatened plant species *and* fauna habitat by PCT

PCT No.	Area of PCT in Growth Area (ha)	Area of PCT in urban zone (ha)	Field survey area (ha)	Percent of PCT surveyed within Growth Area (%)	Percent of PCT surveyed relative to urban zone (%)
724	191.3	57.0	12.1	6.3%	21.2%
725	167.4	51.4	6.9	4.1%	13.4%
781	68.9	5.6	0.9	1.4%	16.8%
830	21.6	0.8	1.7	7.8%	206.5%
835	1175.8	287.3	30.5	2.6%	10.6%
849	3078.3	637.6	125.0	4.1%	19.6%
850	522.9	294.3	36.1	6.9%	12.3%
883	7.4	0.0	0.5	6.8%	
1081	74.2	0.0	0.2	0.3%	
1105	138.6	0.0	0.0	0.0%	
1181	780.7	0.2	39.6	5.1%	19794.4%
1292	39.8	0.0	0.3	0.7%	
1395	3326.6	486.9	483.4	14.5%	99.3%
1800	232.6	20.2	7.3	3.1%	36.2%
TOTAL	**9826.1**	**1841.3**	**744.5**	**7.6%**	**40.4%**

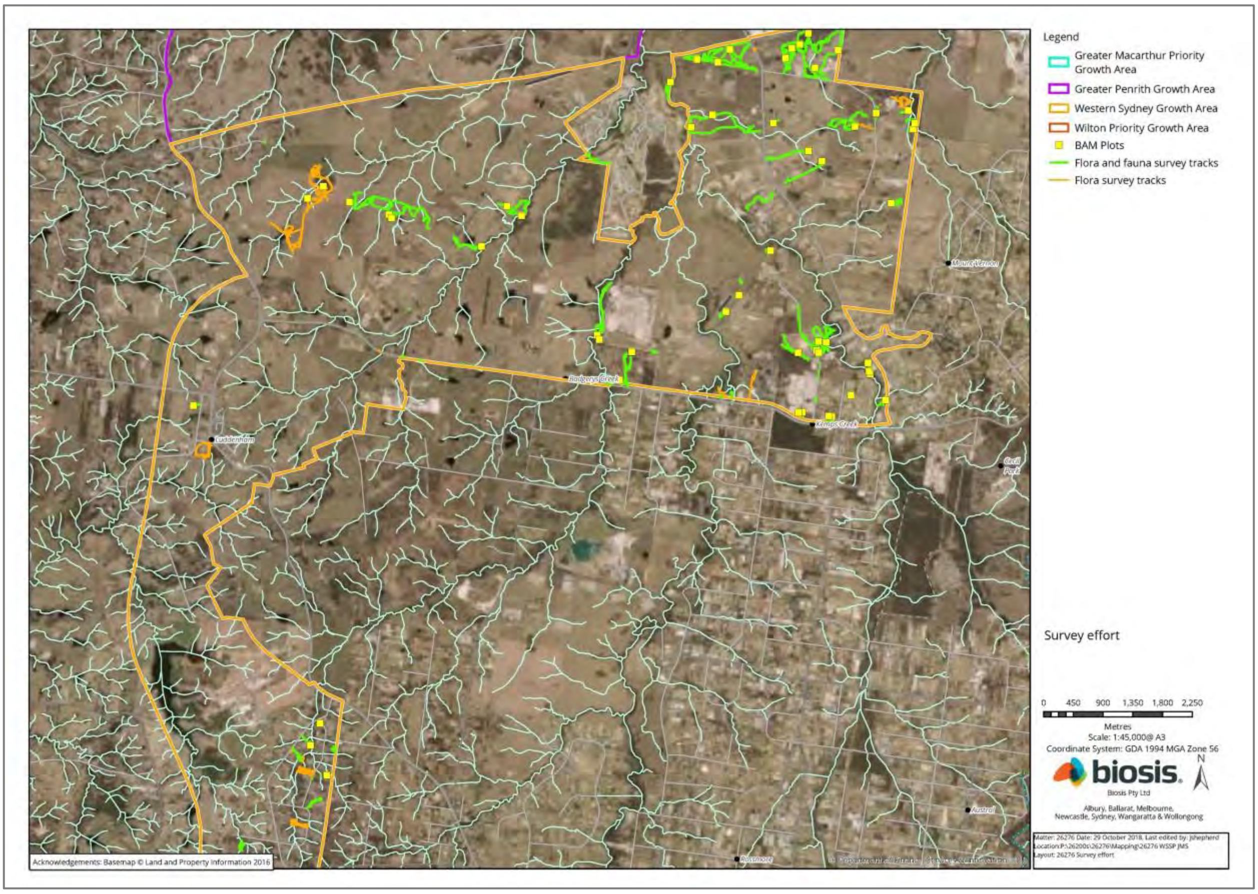
Field survey effort was not confined to the urban zone. Surveys occurred into nearby vegetation zoned for conservation. The urban zone has been revised over time and some areas where survey had already occurred were later removed. For these reasons, comparison of the survey area to the urban zone is indicative only. Survey effort has been calculated using a 20-metre buffer either side of GPS survey tracks. For the purposes of this analysis, the urban zone includes land zoned for future urban development plus transport corridors within the growth areas. It does not include any transport corridors outside the growth areas.



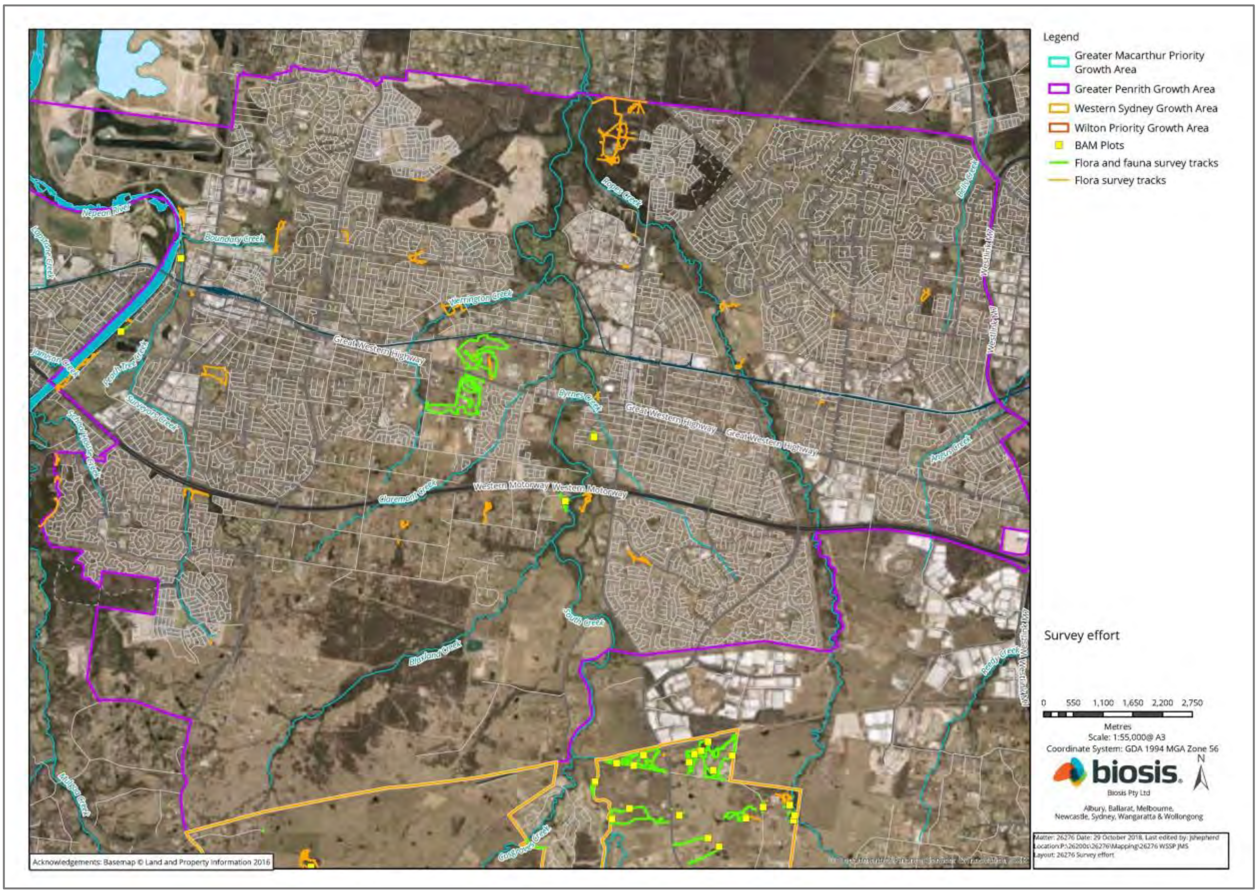
Map 4. GMGA survey effort (Biosis & Ecoplanning)



Map 5. WGA survey effort (Biosis and Ecoplanning)



Map 6. WSAGA ('Western Sydney') survey effort (Biosis and Ecoplanning)



Map 7. GPECGA survey effort (Biosis and Ecoplanning)

4.2.3 Survey constraints –timing / site conditions

As noted earlier, severe drought affected all of the study areas for some or all of the survey period. The Wilton and Greater Macarthur GAs were only surveyed during drought, whereas the Greater Penrith & Eastern Creek and the Aerotropolis GAs were surveyed both during intense drought and the subsequently slightly wetter conditions that followed in the Spring of 2018. Whilst wetter, drought remained present, and fellow botanist, Robert Miller, reported that vegetation was evidently drought-affected across all of the Growth Areas into November.

Drought, combined with increased intensity and extent of total grazing pressure, meant that affected surveys are likely to have under-recorded the target species compared to normal conditions. Whilst drought alone is unlikely to cause *A. pubescens* to die back to rootstock or die and only remain as seedbank, when combined with increased herbivory due to drought, this is a far more likely outcome.

4.2.4 Survey constraint – surveys undertaken by generalists / non-experts

Even when the prescribed OEH survey methods are used, a combination of site-based constraints, a species' ecology and a lack of familiarity with the species creates a situation where it is likely that it can be present in plant form, but not recorded, or present only as seedbank.

Acacia pubescens, like *P. nutans* and *A. bynoeana* is one of several threatened plant species that should not be treated as absent simply because it was not observed in plant form. If suitable habitat occurs, the species should be considered present unless there are clear reasons to rule otherwise. That approach is taken in this Report in relation to the designation of 'species polygons' (i.e. maps of where the plant is known or likely to occur).

4.3 Surveys completed for this Report

I undertook a very brief survey of potential habitat for *P. nutans, A. bynoeana* and *A. pubescens* in the locality of Kemps Creek in mid-November 2018. Robert Miller was also present to survey for his target species. He examined some sites that I did not. He is very familiar with these species and did not report any new sightings of *A. pubescens*.

The main remnant habitat in this locality is just to the south of the WSAGA but was checked by Miller for reference purposes. That remnant was seen to be largely unmanaged and degrading due to several threats, and it is feasible that the species is now restricted to seed bank at that location, though it could be present on disturbance margins that were not traversed.

Relatively little potential habitat remains for this species in the WSAGA, and whilst little of this was available to be surveyed by me or by consultants engaged by DPE, all such habitat has been excluded from the proposed urban footprint. The map below shows the transects associated with a brief survey within the WSAGA (northern line largely within a s.88b conservation area) and outside the WSAGA (short southern line).

Map 8. GPS track logs (purple lines)

I did not survey for any of my target species in the GPECGA because most of the potential habitat is either reserved, or proposed for reservation by OEH, and because of logistical constraints (time, property access). DPE offered access to a large area of remnant bushland in this Growth Area, but it was already excluded from the proposed urban footprint, so I did not take up that offer.

I did not survey the WGA, as the species is not known from or likely to occur there. Logical constraints were also a consideration.

I did not survey the GMGA due to a mix of logistical constraints and knowledge that most areas of potential habitat had already been excluded from the proposed urban footprint.

4.4 Assessment of species' presence

4.4.1 Greater Macarthur Growth Area

There are no modern or spatially accurate records of this species in this Growth Area, but suitable habitat is present. The extent of earlier habitat removal in the two thirds of the Growth Area has greatly limited where the species might remain amongst the now urban and industrial areas. Most of the potential habitat is present in the southern third of the Growth Area in what is largely rural land. Much of that area is fragmented by clearing of the higher and more arable shale-based vegetation, primarily leaving the shale/sandstone transitional vegetation and the sandstone vegetation associated with gullies.

4.2.2 Wilton Growth Area

The species is not known from this Growth Area but could be present in most of the remaining native vegetation, with the exception of the sandstone-based terrain around the gullies and larger watercourses. Most of the potential remnant habitat occurs around the edges of the Growth Area, primarily associated with the shale/sandstone transition. Much of that environment is or has been grazed but remains potentially viable habitat.

4.2.3 Greater Penrith to Eastern Creek Growth Area

The species is present in this Growth Area, and most of the native vegetation that remains in this heavily cleared Area is potential habitat for this species. The largest areas of potential habitat are within the former Australian Defence Industries land in the far north, some of which is within or proposed to become part of Wianamatta Regional Park; and the Orchard Hills Defence site in the southwest.

4.2.4 Western Sydney Aerotropolis Growth Area

Extensive clearing has meant that relatively little native vegetation remains in this Growth Area, however, the species could be present in most of the associated remnants. The most likely potential habitat is limited to a few patches of remnant vegetation in the localities of Kemps Creek and Badgerys Creek. Other areas occur throughout the Growth Area.

4.5 Assessment of suitable habitat for *Acacia pubescens*

4.5.1 Description and relative significance of potential habitat

As per the findings presented earlier in Table 2, combined with expert knowledge, the following PCTs are regarded as potential habitat for *A. pubescens*. Not all of these PCTS are present in all of the Growth Areas, and not all occurrences or parts of these communities are likely to support the species in plant or seedbank forms. Wetter and sometimes more thickly vegetated areas associated with drainage lines are less likely habitat. Riparian buffer exclusions will be used as a component of the 'species polygons' discussed later. All vegetation condition classes are included:

Table 10. PCTs known or likely to be habitat for *A. pubescens*

PCT	PCT Name	Relative significance
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Very High
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Very High
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Low
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain	Moderate
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Very Low
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Low
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Very Low

The following sections describe the relative habitat value and local occurrences of each PCT mapped in each Growth Area.

Greater Macarthur Growth Area

The vegetation mapping provided for use in the project indicates that there is **2364.2 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs.

Table 11. Potential habitat in the GMGA

PCT	Distribution	Relative habitat value
835	Scattered remnants in the northern two-thirds.	Low on the basis of PCT association.
849	Scattered remnant throughout.	Moderate on the basis of PCT association
883	Four very small polygons at Macquarie Fields	Low on the basis of PCT association but also because of a long history of mowing and weed invasion.
1081	A small remnant at Leumeah (Smiths Creek) is the only occurrence in this Growth Area.	Low on the basis of PCT association and being restricted to a single urban remnant that is likely to be significantly compromised.
1395	Common in the far south from around Menangle Park through Gilead to Appin area; between cleared shale landscapes and sandstone gullies	Moderate to high depending on shale content – high shale content is of lower habitat value. Unlikely habitat when near watercourses

Wilton Growth Area

The vegetation mapping provided for use in the project indicates that there is **1742.7 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs.

Table 12. Potential habitat in the WGA

PCT	Distribution	Relative habitat value
849	A few medium to large remnants, mainly in the northern half, and some are in 'derived grassland' condition.	Moderate on the basis of PCT association. Likely reduced value in derived grassland remnants.
1081	Uncommon and restricted to three patches above sandstone gorges, mainly on or near northern edges.	Low on the basis of PCT association but habitat quality appears good.
1395	Common around and near margins between cleared shale landscapes and sandstone gullies.	Very Low based on PCT association over the four Growth Areas, but probably Moderate in this Growth Area. Unlikely habitat when near watercourses.

Greater Penrith to Eastern Creek Growth Area

The vegetation mapping provided for use in the project indicates that there is **2640.4 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs.

Table 13. Potential habitat in the PECGA

PCT	Distribution	Relative habitat value
724	Uncommon, mostly in the central north, but also the centre, with smaller remnants further east. Very little combined extent.	Very high based on PCT association
725	Largely restricted to a few relatively large remnants in the central north, primarily in Wianamatta Regional Park (east) and nearby. Smaller remnants to the east in largely urban areas.	Very high based on PCT association
835	Relatively common along drainage lines, so most remnants are linear.	Low on the basis of PCT association. Many remnants are likely to be significantly degraded by weeds, though this species can survive in such situations.
849	The most extensive PCT in this Growth Area but largest remnants are Orchard Hills (SW) and former ADI lands (central north).	Moderate on the basis of PCT association. Not so likely to be found in the north due to prior survey efforts over some years.
883	Only one polygon in eastern Wianamatta Regional Park (in Biosis map)	Very low on the basis of PCT association plus the very small area involved.

<u>Western Sydney Aerotropolis Growth Area</u>

The vegetation mapping provided for use in the project indicates that there is **721.4 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs.

Table 14. Potential habitat in the WSAGA

PCT	Distribution	Relative habitat value
724	Uncommon, restricted to localities of Kemps Ck and Badgerys Ck. Very little combined extent.	Very high based on PCT association plus proximate records.
725	Uncommon, restricted to localities of Kemps Ck and Badgerys Ck. Very little combined extent.	Very high based on PCT association plus proximate records.
835	Relatively common along drainage lines, so most remnants are linear.	Low on the basis of PCT association. Many remnants are likely to be significantly degraded by weeds, though this species can survive in such situations.
849	The most extensive PCT in this Growth Area but many remnants are grazed.	Moderate on the basis of PCT association and proximate records, though these are associated with other PCTs

4.5.2 Species habitat polygons

Species habitat polygons generated by this report relate to the extent of potential habitat that is proposed to be cleared for urbanisation or transport corridors (Maps 9-11). These habitat polygons and associated calculations were generated to inform biodiversity offset requirements. The data presented in this section does not deal with species habitat outside proposed urban and allied zones as those areas are treated as conservation zones or are excluded from urban and associated transport zones for a range of reasons.

The habitat polygons include all relevant condition classes of relevant PCTs as identified in this Report. In this case, all condition classes are included.

As part of the formulation of the species habitat polygons, graded riparian exclusion buffers were used in recognition that *A. pubescens* does not occur in riparian vegetation. Buffers are relatively small for this species as *A. pubescens* can occur in riverflat/creekflat situations. The buffer distances increase with the mapped Strahler stream order as shown in Table 15. The accuracy of the buffers is limited by available data, including the mapped location of streams. The buffer is applied either side of the mapped stream centreline. Note that these riparian buffer distances are a different concept and serve a different purpose to those applied by DPE for the purposes of protecting streamside vegetation and watercourses in its planning within the Growth Areas.

Table 15. Stream exclusion buffers

Stream order	Buffer distance (m)
1	5
2	10
3	15
4	20
5	25
6	30
7	40

As *A. pubescens* can occur in quite modified sites, all condition classes are included for the relevant PCTs identified as potential habitat.

Furthermore, as this species can occur in sites that are so modified that they would not be mapped as native vegetation, this report may under-estimate the extent of potential habitat. This should be considered an inherent methodological constraint. The only alternative to the PCT-based approach taken here would seem to be mapping all areas with suitable soil/geology as potential habitat, and not excluding what would otherwise be viewed as ‘cleared’ land. I do not consider that practical in this context. I consider that land not mapped as native vegetation is less likely to support this species, and that if the species were present there, such populations may be less viable because of the extent of habitat modification. I suggest that if feasible within the scope of biocertification, there remain a provision that if a threatened plant species is detected in any surveys or works, OEH be advised and assessments undertaken by that agency with a view to conserving or translocating the material if feasible.

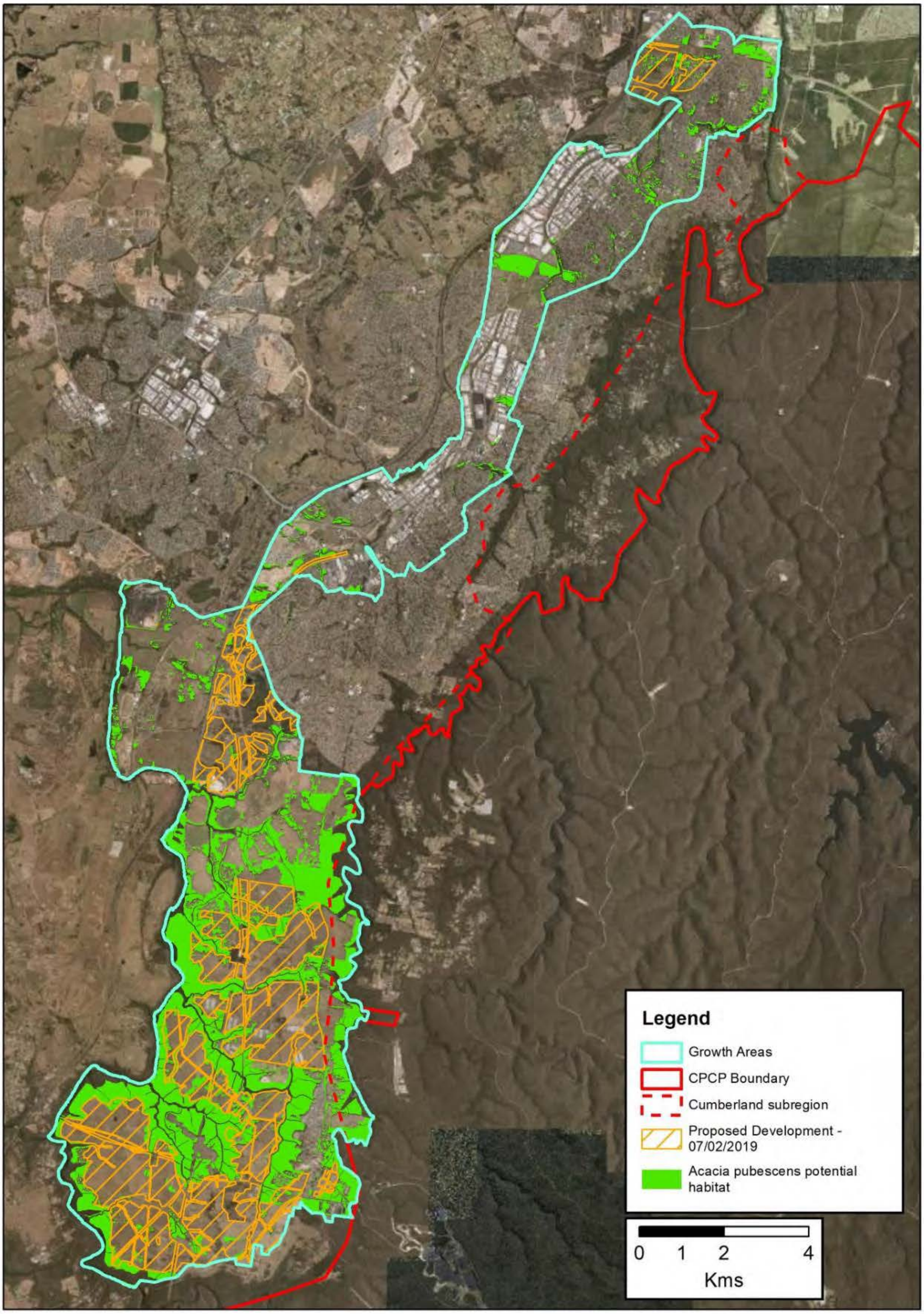
Species polygons in the form of GIS shape files were provided to the Biodiversity and Sustainability Branch of DPE in November 2018. Analysis of the area of potential habitat that is subject to development/removal in each of the four growth areas is shown in Table 16. A summary of the potential habitat that may be removed as a percentage of total potential habitat present in the growth areas is presented in Table 16.

These figures are based on precautionarily modelled *potential* habitat, and do not necessarily equate with *actual* habitat, nor do they provide any information of potential population sizes or population viability. It is unlikely that a large percentage of the potential habitat identified in this Report would actually support *A. pubescens* because this species is naturally rare and patchily distributed, even though it can be locally abundant in favourable conditions.

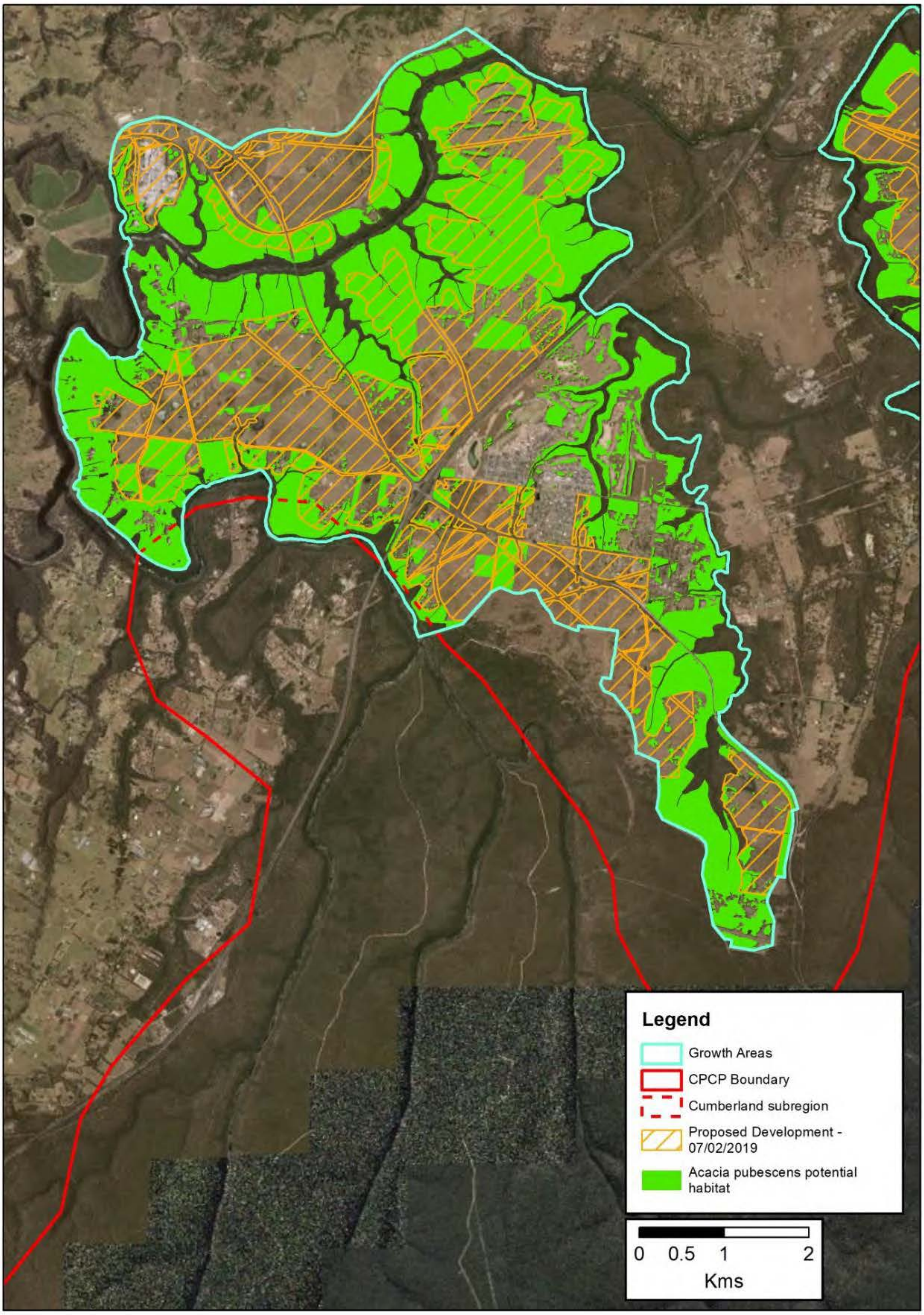
Table 16. Potential habitat and proposed removal of potential habitat by Growth Area

Growth Area	**Area of potential habitat (ha)**	**Area of potential habitat removal (ha)**	**% area of potential habitat removal by GA**
Greater Penrith to Eastern Creek	2640.4	105.6	4.0
Western Sydney Aerotropolis	721.4	325.4	45.1
Greater Macarthur	2364.2	251.4	10.6
Wilton	1742.7	543.5	31.2
Transport corridors **(all GAs)**	-	277.7	3.7
TOTAL	**7468.8**	**1503.6**	**20.1**

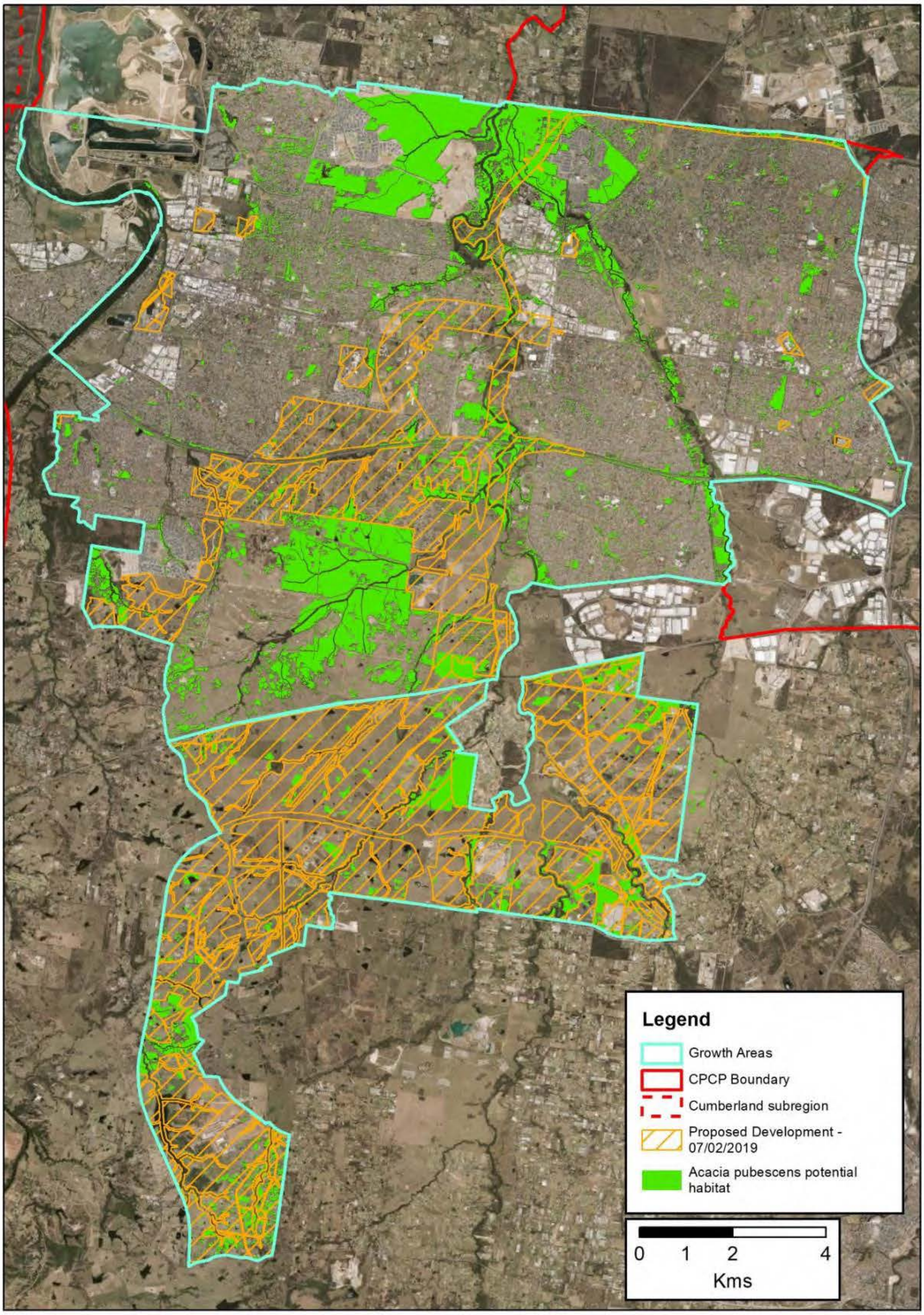
Map 9 Greater Macarthur - Potential habitat and proposed urban/transport habitat removal



Map 10 Wilton - Potential habitat and proposed urban/transport habitat removal



Map 11 Greater Penrith & Eastern Creek plus Western Sydney Aerotropolis
– potential habitat and proposed urban/transport habitat removal



5. Summary and conclusion

Within the four Growth Areas, *Acacia pubescens* is historically known from a single record in the Greater Macarthur Growth Area and from seven modern records (some apparent replicates) in a small area of the Greater Penrith to Eastern Creek Growth Area. Proximate records occur near all of the Growth Areas other than Wilton. Potential habitat exists across all of the Growth Areas and has been identified, ranked and mapped to generate 'species polygons' that inform calculations of biodiversity offsets and the design of the proposed urban footprint.

Based on current information, the proposed urban footprint and associated transport corridors of all four Growth Areas would destroy 1503.6 hectares of potential habitat for *A. pubescens*. This equates to 20.1% of the area of potential habitat identified in those Growth Areas. Not all of the area proposed for removal is of equal value as potential habitat, and different PCTs and condition classes have different probabilities of supporting *A. pubescens*. The actual extent of conflict between habitat for the species and proposed clearing for urbanisation is likely to be much smaller as the species is naturally rare and patchily distributed, even though it can be locally common where conditions are favourable.

As this species is relatively tolerant of significant disturbance and can persist as long-lived seedbank or as root suckers, it can occur in highly modified sites that may not be mapped as native vegetation, so are not captured by the PCT-based modelling of potential habitat used in this Report. It is likely that highly modified sites that might support the species in some form are of relatively low significance for it in the context of the much larger areas of more intact potential habitat that are excluded from urbanisation and associated clearing. It is also feasible that disturbance associated with urbanisation, particularly the creation of bushfire Asset Protection Zones between bushland conservation areas and housing, could advantage this species, especially where the habitat has not burnt for many years. More frequent, moderate intensity burning of bushland that represents known or likely habitat for this species, may, within limits, also advantage it compared to low frequency and/or very cool burning.

The positioning of the bushland/urban interface and associated infrastructure such as APZs should have regard to this species' habitat and ecology, and appropriate buffers and other strategies are required to prevent direct and indirect harm to this species as a result of the urbanisation of adjoining lands. For example, potential habitat should not be compromised by the placement of housing nearby as might prevent that habitat being managed for conservation, especially in terms of bushfire risk management. DPE has informed me that APZs would be accommodated within the proposed urban footprint, not in the non-biocertified bushland areas that may adjoin it.

The absence of records of this species from areas of potential habitat does not mean it could not be present. This is because:

- not all areas have been surveyed historically or recently;
- all surveys have a range of limitations, and recent efforts were likely constrained by drought;
- not all discoveries of threatened species are disclosed; and
- large areas of potential habitat are highly likely to have fire regimes that do not favour this species, meaning it may currently occur in very low numbers, in dense and inaccessible habitat, or as seedbank, yet could appear in substantial numbers after an appropriate fire or equivalent disturbance.

These factors have been considered in the preparation of the species habitat polygons that will inform DPE in relation to biodiversity offset obligations.

6. Information used in the assessment

6.1 DP&E or OEH resources

- BioNet data (internal access provided under license for use in this Expert Report and associated dataset cleaning for the purposes of species habitat modelling to meet EPBC Act requirements)
- Atlas of Living Australia on-line (partial use to check for records not in BioNet)
- EMU data (NSW Herbarium specimen database, provided by OEH)
- OEH on-line threatened species profile
- OEH Threatened Species Data Collection on-line
- OEH BioNet Vegetation Classification Database (previously known as VIS)
- EPBC Act Listing/Conservation Advice
- OEH PCT (vegetation) maps for Sydney Metropolitan and Cumberland Plain
- Field data from Biosis and Ecoplanning consultancies engaged by DPE
- GIS layers and maps provided by DPE and its contractors

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7. Acknowledgements

I acknowledge the contributions of DPE staff, particularly Dayle Green, Greg Steenbeeke and Christian Marando (GIS), and DPE contractor Darren James (GIS) in the preparation and refinement of this document and associated maps. My contractor, Rhys Grogan, also assisted with GIS output in the form of drafts of the 'species polygons'.

Consultant botanist, Robert Miller assisted with fieldwork at Kemps Creek, and provided information about field observations associated with searches for his target species and with opportunistic sitings of my target species.

OEH staff assisted with some aspects of data availability and with the processing of many amendments to BioNet records.

8. Statement of professional independence

Whilst I was engaged and funded by DPE to prepare this Expert Report, and draft reports and maps were reviewed by DPE staff, I was not coerced by DPE to amend my work in any manner that I did not otherwise agree with. I believe that I had appropriate professional independence in the preparation of this document and associated maps.

I also declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses with property in the Growth Areas, nor do I have other active clients with real estate or associated commercial interests in the Growth Areas.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for a large number of private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation.

I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields.

I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management.

I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections, and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps, and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy-making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Founding member of the Ecological Consultants Association of New South Wales (did not renew due to my relocating to Victoria and later to the ACT).
- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honey Bee.

Species / population	Work conducted
Acacia bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Recognised by OEH as a species expert under BC Act (Nov 2018).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset.
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA
Callistemon linearifolius	Fieldwork, research, successful nomination, advice to RMS and NPWS, PAS2 review
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going)
Callistemon purpurascens	Described new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going)
Calotis glandulosa	Fieldwork (new and extended populations, Kosci NP), CAM review
Calotis pubescens	Fieldwork (new population, Kosci NP), CAM review

Species / population	Work conducted
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council and OEH, CAM reviews
E. aquatica	Fieldwork, advice to Council and Forestry Corporation
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel
E. kartzoffiana	Fieldwork, research, expert witness
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination and advice to NSWSC – listing pending
Gyrostemon thesioides	Successful nomination

Species / population	Work conducted
Helichrysum calvertianum	Fieldwork, research, nomination, advice to NSWSC – listing pending
Hibbertia fumana	Research, minor fieldwork, expert witness
*H. incana (*syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset.
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable - listing pending
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH

Species / population	Work conducted
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All of the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DEE re Cwlth listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DEE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DEE Recovery Plan update, advice to OEH
Elderslie Banksia Scrub Forest	Major review for DEE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DEE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping, advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping, advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping, and advice about revised listing, advice to DEE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent)
Robertson Basalt Tall Open-forest	Modelling and mapping, advice to NSW SC

Ecological community	Nature of engagement
Robertson Rainforest	Modelling and mapping
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters research. Formally published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping
Southern Highlands Shale (Forest &) Woodland	Major contributor to DEE listing, drafting of Listing and Conservation Advices, advice to OEH about revision of NSW listing, modelling and mapping. Contracted to prepare listing for upgrade to CE.
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils and to OEH/SC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping, advice to OEH
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to DEE listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advices
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy,* 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Edited but not refereed publications

Douglas, S.M. 2014. "When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum". *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. "Black Gum: a threatened tree of upland New South Wales and Victoria." *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. "Species profile and monitoring of Dampiera fusca". *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. "Endangered plant discovered" (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. "Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong". News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. "Phoenix flora: a post-fire discovery in the ACT". *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. "Phoenix flora" (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. "Mysteries of the Megalong Valley: another rare plant for the Blue Mountains." *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. "Land of the living dead – tree decline in urban areas". *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. "Bushland weeds – more on native weeds". *Environment NSW*, December

Douglas, S.M. 2000. "Regional Parks". *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. "Community biodiversity surveys". *National Parks Journal,* 40(3)

Douglas, S.M. 1996. "Mapping our urban bushland". *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. "Healing the Hawkesbury: start with bushland protection". *National Parks Journal*. 38(4)

Public media coverage

2004, November 6. "Bright flowering spot after fire" - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran
- Supervisor for undergraduate dissertation, "Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve" (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation "Riparian Vegetation of upper Cattai Creek" (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**
- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**

- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report – Cumberland Plain Land Snail

Expert report on the Cumberland Plain Land Snail, *Meridolum corneovirens* (Pfeiffer, 1851) in the Penrith, Western Sydney Aerotropolis, Greater Macarthur and Wilton Growth Areas, Stephanie A. Clark, December 2018

Strategic assessment for Cumberland Plain Conservation Plan

Expert report on the Cumberland Plain Land Snail, *Meridolum corneovirens* (Pfeiffer, 1851) in the Penrith, Western Sydney Aerotropolis, Greater Macarthur and Wilton Growth Areas.

Prepared for the New South Wales Department of Planning & Environment

Stephanie A. Clark

December, 2018

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http://www.invertebrateidentification.com/

Contents

1. Introduction

1.1 Project context

The Department of Planning and Environment is currently preparing a strategic assessment to identify development impacts and conservation outcomes within four new urban growth areas on the Cumberland Plain in Western Sydney. Expert reports may be used as part of the threatened species assessment as outlined in the Biodiversity Assessment Method (BAM).

The BAM requires surveys for all 'Species Credit Species' (SCS) identified as likely to occur in the study area unless an expert report is prepared, or the species is assumed to be present. The Department of Planning and Environment engaged Biosis and Ecoplanning to undertake surveys for candidate SCS within the growth areas in accordance with the BAM and Office of Environment and Heritage (OEH) threatened species survey guidelines. Surveys were undertaken over the period November 2017 to November 2018.

1.2 Purpose of the expert report

Large areas of suitable habitat were unable to be surveyed due to land access issues and the snail is an uncommon species that can easily be misidentified. For these reasons an expert report on *Meridolum corneovirens* was required to supplement the data collected as part of the survey effort.

The purpose of this report is to provide an assessment of the current status and potential presence of *Meridolum corneovirens* within four defined Growth Areas of Western Sydney and to determine whether:

a) The species is unlikely to be present and thus requires no further assessment; or
b) The species is known or likely to be present, and if so the report must provide estimates of potential habitat within the Growth Areas and the proposed urban development zones.

1.3 The study area

The strategic assessment covers four growth areas in Western Sydney:

- Greater Penrith to Eastern Creek Urban Investigation Area
- Western Sydney Aerotropolis Growth Area
- Greater Macarthur Growth Area
- Wilton Growth Area

The Greater Penrith to Eastern Creek and Western Sydney Aerotropolis Growth Areas are located in the western part of the Sydney Metropolitan Area between Llandilo in the north and Bringelly in the south and Emu Heights in the west and Eastern Creek in the east. The Greater Macarthur and Wilton Growth Areas are located in the south western part of the Sydney Metropolitan Area, between Casula in the north and Wilton in the south and Tahmoor in the west and Holsworthy in the east (see Figure 1).

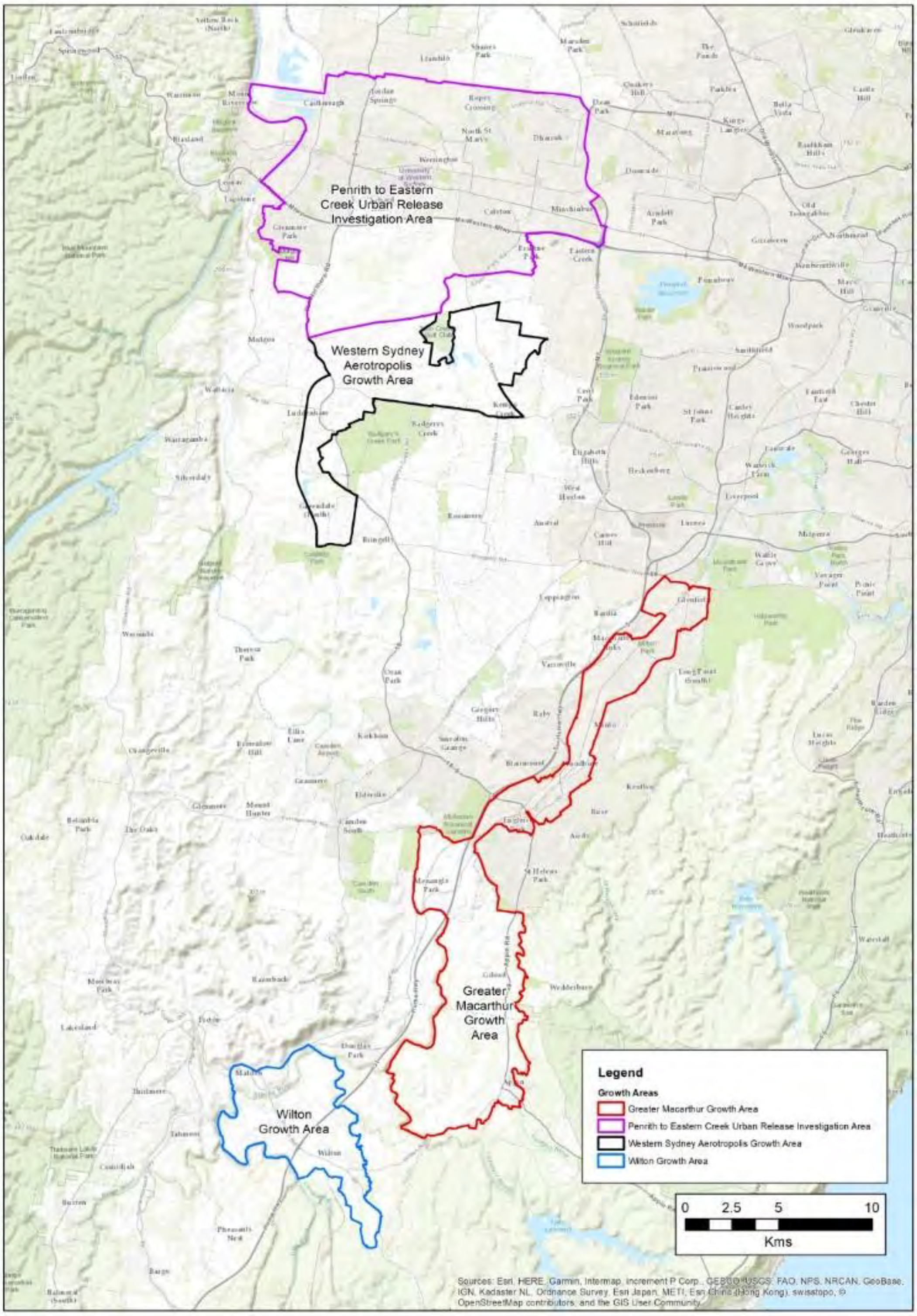

Figure 1. Showing the location of the four growth areas.

1.4 Reasons for use of an expert report

An expert report for *Meridolum corneovirens* is required as part of the threatened species assessment for the Cumberland Plain Conservation Plan for the following reasons:

1. Large areas of habitat were not able to be surveyed. Not all land holders allowed ecologists to enter their property and conduct BAM surveys or targeted fauna surveys. This restricted the opportunity to visit all potential areas of habitat within the proposed development footprint, especially within the Greater Macarthur Growth Area. The initial surveys focussed on flora species and did not specifically target *Meridolum corneovirens.*
2. Section 4.4 of the NSW Guide to Surveying Threatened Plants (OEH 2016) provides for the consideration of 'site survey and an expert report' where areas are large. This species has been searched for during the survey but is very cryptic. Preparation of an expert report will supplement the field surveys to identify the area of occupancy and likely density of individuals.
3. The species' relatively small size, its cryptic habitat, its ability to remain dormant in unfavourable environmental conditions and it can be easily overlooked/missed by non-specialists.

1.5 Credentials of expert

Dr Stephanie Clark is an invertebrate taxonomist with more than 30 years of experience in the identification and taxonomy of molluscs (and in particular gastropods). She currently consults worldwide on invertebrate identification through her business Invertebrate Identification Australasia.

Dr Clark was the first expert to be approved by OEH as an Expert under section 6.5.2.4 of the Biodiversity Assessment Method on the 15 May 2018 (valid for the next six years). A resume is included in the Appendix.

2 Species information

2.1 Species description

The shell is globose to subglobose in shape (Figure 2), up to about 24mm in height and 29mm in width. Spire moderately elevated. Aperture roundly ovate, up to about 14mm in height and 19mm in width. Total number of whorls 4.8–5.7. Last teleoconch whorl rounded, or with slight angulation; up to about 21mm in height. Shell sculpture consists of coarse growth lines and weak pustules. Teleoconch periostracal sculpture of weak zigzag ridges. Protoconch sculpture weakly pustulose. Shell uniform brown to tan or olive green, darker coloured individuals not uncommon. Red umbilical patch typically absent, occasionally faintly present. Red subsutural band very thin. Inner lip white (rarely pale pink), strongly reflected, largely occluding umbilical depression in adults, lip thin and not reflected in juveniles. Outer lip moderately deflected below midline of last whorl. Umbilicus closed to slightly open in adults, open in juveniles (modified from Clark, 2009).

The colour of the body of the snail is grey and the mantle is pale yellow (typical) to yellow.

Figure 2. Specimen of *Meridolum corneovirens* from Mulgoa.

2.2 Life cycle

Little is known of the biology, fecundity and longevity for the species. It is a hermaphrodite and capable of selfing, it lays clutches of about 20-25 small, round, white eggs in moist, dark places (Clark, 2009, Ridgeway *et al*., 2014), such as at the base of grass clumps and under logs (Figure 3). The snails probably live between 2-5 years but can certainly estivate in the soil or under logs etc for several months, especially when conditions are dry, such as those prevailing in Sydney in 2018. They feed predominately on fungi, but have been observed eating fresh dead individuals of *M*. *corneovirens* and other carrion, paper, plant detritus and old shells (Clark, personal observations; Ridgeway *et al*., 2014).

The snails are generally active at night or on moist, warm overcast days.

A  B. 

Figure 3. A. *Meridolum corneovirens* laying eggs in a grass clump at Mount Druitt. B. Three egg clutches of *Meridolum corneovirens* that were found under a log at Kemps Creek.

2.3 Distribution and abundance

Meridolum corneovirens is endemic to the Cumberland subregion in the western portion of Sydney, from Pitt Town in the north to Tahmoor in the south and from Georges Hall in the east to Mowbray Park in the west (Clark, 2005; 2009, NSW OEH Cumberland Plain Land Snail – profile). The total number of individuals of *M*. *corneovirens* across its range is unknown, nor the densities that the species can occur. The species can be relatively common when suitable habitat is present. However, most known populations are found on relatively small, isolated patches of habitat that are often surrounded by some combination of industrial, agricultural or urban development.

2.4 Habitat requirements

Meridolum corneovirens is wholly restricted to western Sydney and is primarily associated with the critically endangered Cumberland Plain Woodland ecological community. However, it has also been found in the following listed ecological communities: Moist Shale Woodland, Shale Gravel Transition Forest, Shale Sandstone Transition Forest, Cooks River/Castlereagh Ironbark Forest, Castlereagh Scribbly Gum Woodland, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest. It can be found in leaf litter, grass tussocks, under logs and non-natural debris such as cardboard and old furniture etc. Where conditions permit it will bury into loose soil up to 10 cm such as under logs and around the bases of trees (Clark, 2009; Ridgeway et al., .2014).

3 Description of the study area

3.1 Land use history

From the early 1800s there has been extensive clearing of the native vegetation for agricultural, industrial and urban development, which has resulted in a significant reduction in the extent of the native vegetation, leading to increased fragmentation and isolation of the remaining remnants. This increased fragmentation has led to a loss of biodiversity and to the spread of invasive and non-indigenous species.

The extensive clearing, fragmentation and degradation of the remaining vegetation remnants has led to a reduction in the distribution, extent and abundance of *M. corneovirens* that existed prior to European settlement.

3.2 Landscape context

The majority of the study area consists of gentle undulating hills and valleys and is bounded by the sandstone cliff lined valleys of the Nepean River on the western, southern and south western boundaries and the Georges River on the south eastern boundary and the Cecil Hills Ridge and the Castlereagh sand deposits along the northern and eastern boundaries.

3.3 Native vegetation communities

Meridolum corneovirens inhabits a range of vegetation types across the study area, although most typically it is found in the Cumberland Plain Woodlands.

Meridolum corneovirens has been recorded from the following plant communities which are found within one or more of the four growth areas:
724 – Broad-leaved Ironbark – Grey Box – *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain;
725 –Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion;

830 - Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain;
835 - Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain;
849 - Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain;
850 - Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain;
1395 - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain;

Meridolum corneovirens will potentially be found in any remaining intact or relatively intact remnants / patches of suitable habitat, especially if there is a well-developed leaf litter layer, plenty of woody debris on the ground and few exotic/invasive species. It can also be found at the boundaries of plant communities that do provide suitable habitat and those that typically do not such as where Cumberland Plain Woodland adjoins Swamp Oak Floodplain Forest in the western parts of the Cumberland Subregion.

4 Assessment of species presence and habitat

4.1 Existing records and surveys

Meridolum corneovirens has previously been recorded from a number of locations across the Greater Penrith to Eastern Creek, Western Sydney Aerotropolis and Greater Macarthur Growth Areas but not to date in the Wilton Growth Area (Clark, 2009, Bionet, 2018, Clark, personal observations from 1998-2002) (Figures 4-6).

To the best of the author's knowledge there have been no region-wide surveys for *M. corneovirens* across the four growth areas or the entire range of the species since 1999 when the author was asked by NPWS to survey 130 sites across the greater Sydney area. During this survey the species was detected at 61 sites, of which 14 fall within the growth areas defined here (10 in Penrith, 4 in Greater Macarthur).

The majority of the previous records are from targeted surveys for development sites by the author and other consultants, general collecting by the author (89 sites), colleagues and other random observations by the general public, local and state government personnel.

4.2 Surveys completed for the biocertification

Targeted fauna surveys were completed by Biosis during the period November, 2017 to November, 2018. Surveys on foot covered a total area of 100 hectares across the four growth areas calculated by applying a 20m buffer either side of GPS survey tracks. This represents around 5% of the future development footprint (where surveys were concentrated) and around 1% of the total vegetated habitat within the growth areas (GIS analysis supplied by DPE, November 2018).

Meridolum corneovirens was found at three locations by Biosis staff. Two of these locations were previously known to the author, being south of Goldsmith Ave and Wianamatta Regional Park (formerly known as the ADI site). However, the conditions since the beginning of the biocertification process have been extremely dry and warm with well below normal rainfall. Although Ecoplanning and Biosis have conducted extensive surveys across the study area, the statistics above confirm that the vast majority of these surveys were botanical in nature and not targeted toward fauna species such as *M*. *corneovirens*.

The targeted fauna surveys that have been conducted by Ecoplanning and Biosis have been hampered by issues such as limited access to properties, extremely dry conditions, concentrating limited staff resources towards surveying for the larger threatened vertebrate species and a lack of specialised knowledge about *M*. *corneovirens*, resulting in low detection rates. In addition, there is a very similar looking, closely related species, *M*. *sheai* Clark, 2009, which can be found in the shale-sandstone transition forest and sandstone forest community types within the Greater Macarthur and Wilton Growth Areas.

4.3 Surveys completed for this assessment

The extended dry period, cold night time temperatures and access issues since 6 June, 2018 has made detecting *M*. *corneovirens* relatively difficult. Nonetheless, between 6-30 June and 30 October to 15 November, 2018, the author detected evidence for *M*. *corneovirens* at 23 locations (8 in the Greater Penrith to Eastern Creek Growth Area; 2 in the Western Sydney Aerotropolis Growth Area and 13 in the Greater Macarthur Growth Area) (Figures 4-6).

Attempts were made to verify a number of BioNet records from around Gordon Lewis Oval, Appin and along the southern side of the Nepean River, west of Elladale Creek, Appin but because of the extremely dry and cool conditions no evidence for the species was found. The author was unable to access the Macquarie Road Reserve, Ingleburn, due to the area being fenced off. Campbelltown City Council was contacted and were happy to provide access but unfortunately this was not possible on the day and it was decided to organise a site visit at a future to be determined date.

The vast majority of the individuals of *M*. *corneovirens* encountered were empty shells and fragments, while less than 20 living specimens, all juveniles and subadults were observed at 10 sites (four in the Greater Penrith to Eastern Creek and six in the Greater Macarthur Growth Areas). The largest number of living individuals observed at a site was 10 (juveniles and subadults) at Goldsmith Ave (within the Greater Macarthur Growth Area), after heavy rain earlier in the day. At the other nine locations only one or two living snails were observed and all were buried in the leaf litter or under logs and woody debris.

Within the Wilton Growth Area relatively little of the potential habitat was accessible and the only occasion that *Meridolum* was found was at the Shingle Hill property off Picton Rd on 20 June, where two very long dead specimens of what appear to be *M*. *sheai* were found. The day before staff from Biosis had recorded the presence of a number of individuals of *M*. *corneovirens* from the more open areas of the property between a farm dam and Picton Rd, but on later examination of some voucher specimens these were identified as *Cornu aspersum*, the Common Garden Snail.

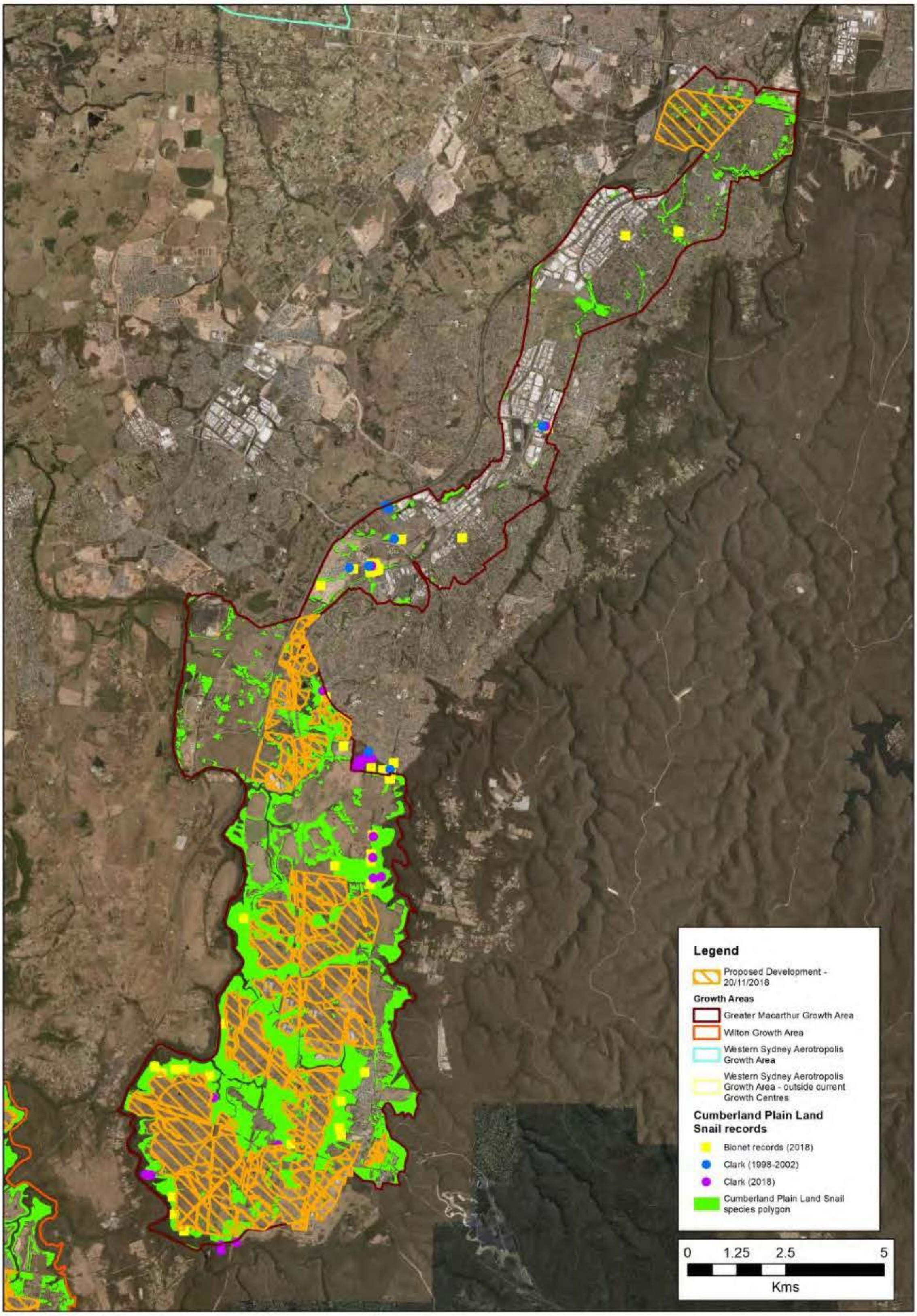

Figure 4. Map of the Greater Macarthur Growth Area showing the records of *Meridolum corneovirens* and the species polygons are in green. The yellow squares are the BioNet records (2018), the purple dots are records found during the current survey and the blue dots are records found by the author between 1998 and 2002.

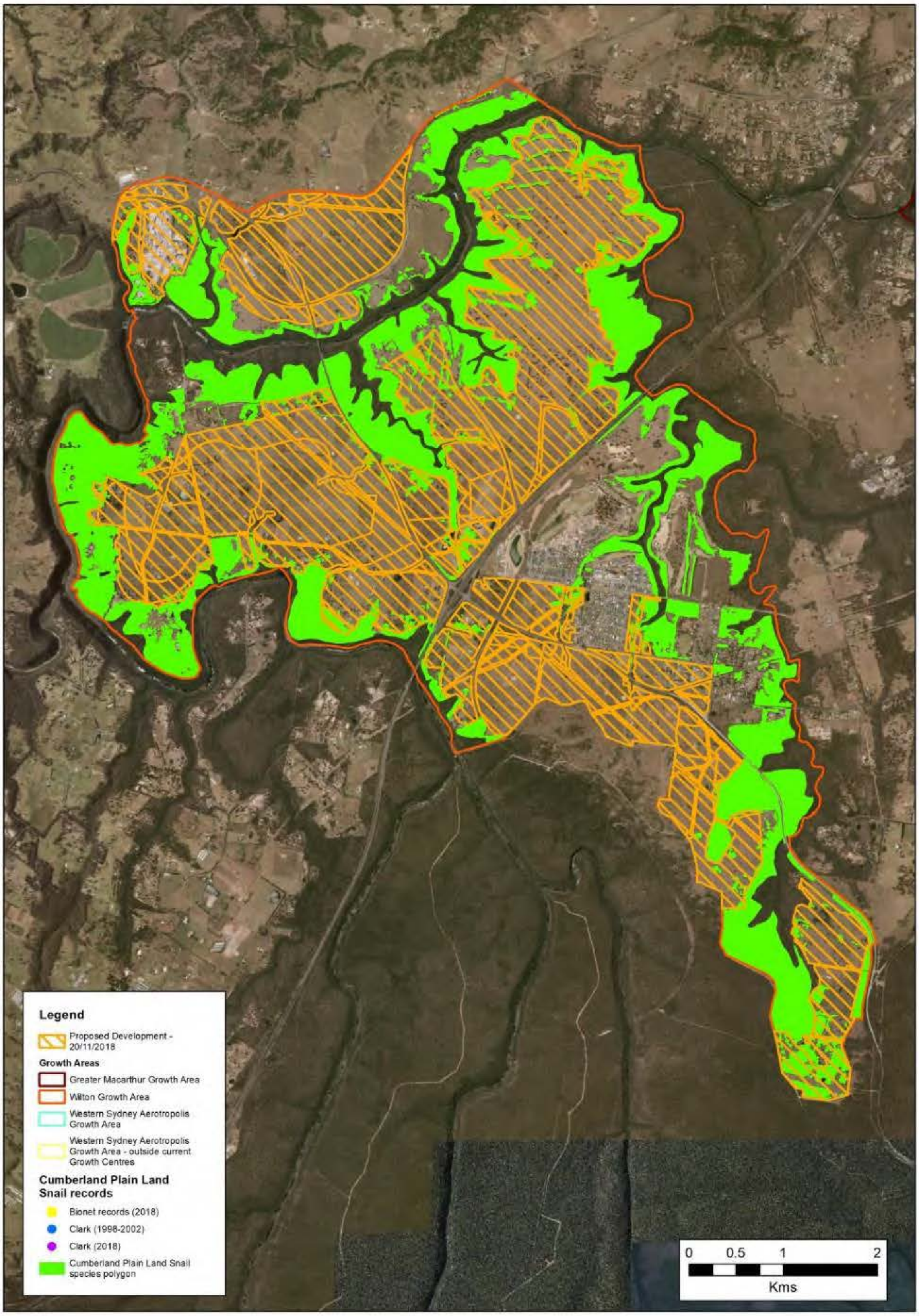

Figure 5. Map of the Wilton Growth Area showing the species polygons in green. Currently no records for *M*. *corneovirens* have been found in the area. However, the closely related species *M*. *sheai* has been recorded within and just outside of the growth area in 2017-2018.

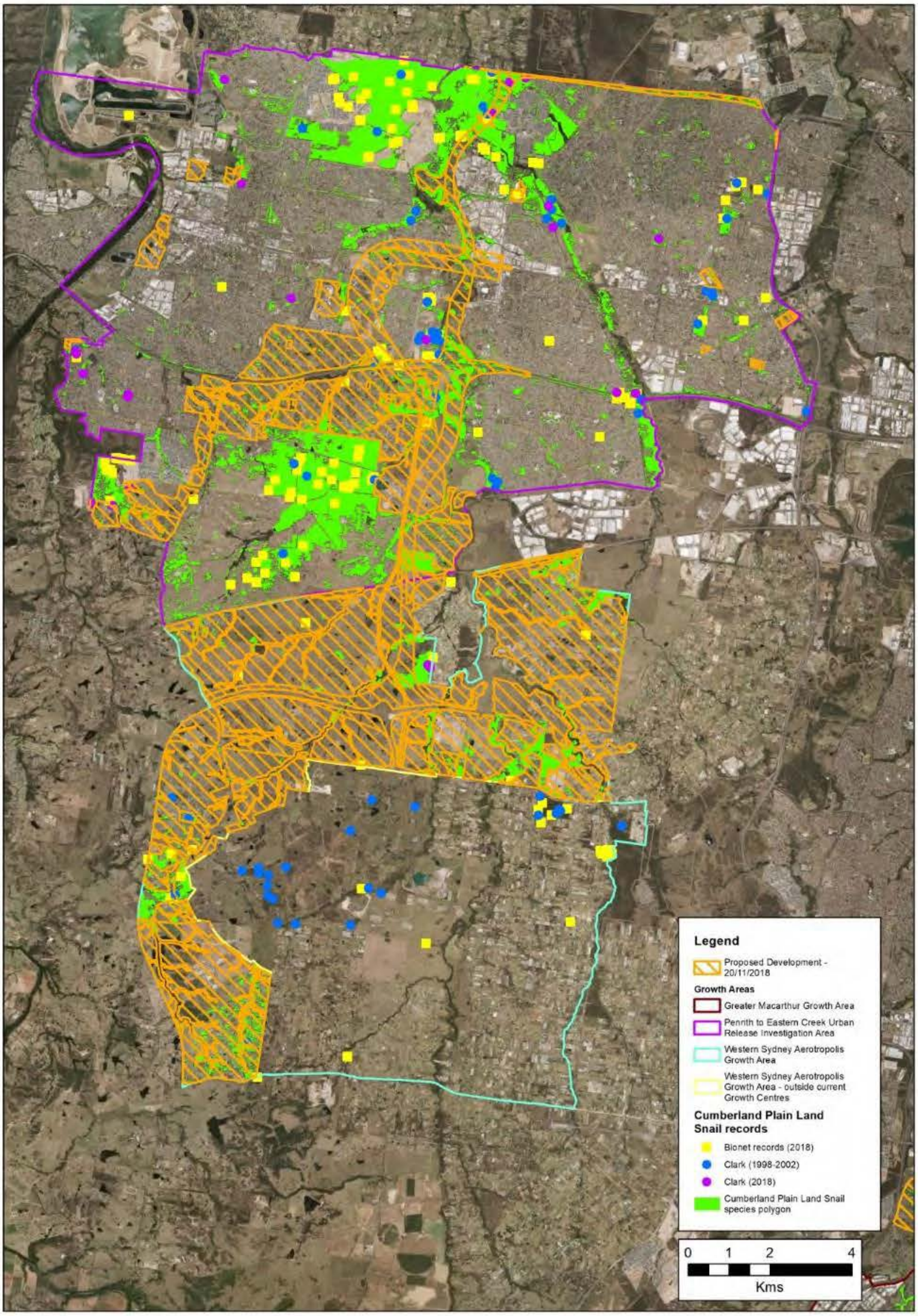

Figure 6. Map of the Penrith and Western Sydney Aerotropolis Growth Areas showing the species polygons in green. The yellow squares are the BioNet records (2018), the purple dots are records found during the current survey and the blue dots are records found by the author between 1998 and 2002.

4.4 Assessment of species presence

Likelihood of species presence

There are 13 records of *M. corneovirens* that fall within the future development footprint of the Greater Penrith to Eastern Creek Growth Area, mostly in the transportation corridors. There are six records that fall within the future development footprint of the Western Sydney Aerotropolis. While, no records were found within the future development footprint for the Greater Macarthur and Wilton Growth Areas (Figures 4-6).

However, there is potential for *M. corneovirens* to be found in areas of suitable habitat within the biocertification areas that have yet to be surveyed, or that have been surveyed but conditions were not conducive to detecting the species at the time of the survey, especially if there is plenty of leaf litter and woody debris.

Justification for determining presence

The species polygons (Figures 4-6) are based on a combination of the vegetation communities where the species has been found during the current survey and previous surveys, and the assumption that where suitable habitat is present within the growth areas that the species is likely to be present but due to a variety reasons (such as access issues and extremely dry conditions) the species has not been detected.

4.5 Assessment of suitable habitat

Suitable habitat within the growth areas

Suitable habitat was presumed to include all the PCT's mentioned above that had been mapped as either intact or thinned that occurred across the four growth areas.

Species polygons

Figures 4-6 show the species polygons for *M. corneovirens* across the four growth areas.

Estimate of area of habitat

Across the four growth areas there is a total of 6953.3 hectares of potential habitat for *M. corneovirens* (Table 1), with a total of 987.0 hectares found within the future development footprint, of which:

- 2421.3 hectares occur within the Greater Macarthur Growth Area of which 215.5 hectares occur within the future development footprint
- 2788.3 hectares occur in the Greater Penrith to Eastern Creek Growth Area of which 351.0 hectares occur within the future development footprint
- 592.9 hectares occur within the Western Sydney Aerotropolis and of which 259.0 hectares occur within the future development footprint
- 1150.8 hectares occur within the Wilton Growth Area of which 161.6 hectares occur within the future development footprint.

The total area in hectares of each of the different PCTs listed above in which *M. corneovirens* can potentially be found across each of the growth areas are listed in Table 1. The Greater Penrith to Eastern Creek Growth Area contains the largest area of suitable habitat as well as the highest number of records for *M. corneovirens*.

PCT	GMGA	GPECGA	WSA	WGA	Totals
724 intact		69.2	3.3		72.5
724 thinned		65.7	49.5		115.2
725 intact		87.4	19.8		107.2
725 thinned		33.9	16.4		50.3
830 intact	2.2	2.8			5.0
830 thinned	16.4				16.4
835 intact	56.4	321.4	13.4		391.2
835 thinned	121.3	496.6	111.2		729.1
849 intact	94.9	430.7	29.3	4.2	559.1
849 thinned	176.5	1225.5	344.2	70.3	1816.5
850 intact	86.8	0.2			87.0
850 thinned	133.8	52.9	5.8		192.5
1395 intact	1296.2			543.2	1839.4
1395 thinned	436.8	2.0		533.1	971.9
Totals	2421.3	2788.3	592.9	1150.8	6953.3

Table 1. Lists the area of each of the different PCTs (in hectares) that provide known or suitable habitat for *M. corneovirens* across the four growth areas. GMGA - Greater Macarthur Growth Area; GPECGA - Greater Penrith to Eastern Creek; WSA - Western Sydney Aerotropolis; WGA – Wilton Growth Area.

5 Information used in this assessment

The information used to make the above assessment is drawn from the literature (Clark, 2005, 2009; Cumberland Plain Land Snail – profile) and the authors' personal observations and knowledge of the species built up over the past 30 years. The author also prepared the original Cumberland Plain Large Land Snail as it was then called, threatened species information and environmental impact assessment guidelines information sheets in 1999.

Additional records were obtained by searching the BioNet and ALA (Australian Living Atlas) databases. Biosis and Ecoplanning provided records that they found during the surveys they carried out for the current project.

Vegetation mapping for the growth areas was provided by DPE.

GIS analysis of the PCT's and preparation of the species polygons following the authors' requirements were provided by Darren James (DAJ Environmental).

6 References

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7 Appendix: Curriculum Vitae of Stephanie Clark

PERSONAL

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E-mail: meridolum@ozemail.com.au
Citizenship Australian and American

EDUCATION

Ph.D., 2005. University of Western Sydney, New South Wales, Australia. Taxonomy and conservation.
M.Sc., 1998. Macquarie University, New South Wales, Australia. Taxonomy and genetics.
B.App.Sc., 1990. University of Technology, Sydney, New South Wales, Australia. Major biochemistry.

PROFESSIONAL EXPERIENCE

Current and/or completed:

1997 - present. Consultant work (Invertebrate Identification Australasia - Owner) for various Australian and United States councils, government agencies (State, Commonwealth and Federal), environmental consultancies, mining companies and developers on short and medium term projects dealing mostly with molluscs and insects (particularly endangered species assessments).

Oct 2017 - Completed Biodiversity Assessment Method (BAM) course.

Aug 2017 – Sept 2017. Conduct one day snail identification workshops for the Department of Agriculture & Water Resources, biosecurity biomonitoring sections in Sydney, Melbourne and Perth.

Sept 2016 - Mar 2017. Identified almost 4000 lots of North American land and freshwater molluscs for the Field Museum of Natural History, Chicago, IL.

July 2016 – Dec 2016. Formally describe the US federally endangered freshwater snail, the Banbury Lanx for the Boise Office of the US Fish and Wildlife Service.

Feb 2015 – Mar 2016. Preparing a list of all the names, synonyms and combinations applied to the non-marine molluscs of North America, for the Field Museum of Natural History, Chicago, IL.

Oct 2014 – Feb 2016. Prepare a status report for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) on the Shortface Lanx (*Fisherola nuttallii*) in Canada.

Jan 2013. Conducted a one day workshop on the identification of the endangered Cumberland Land Snail (*Meridolum corneovirens*) for the Ecological Consultants Association of NSW, Mount Annan, NSW, Australia.

June 2011 – present. Contracted with Deixis Consultants to write a Field Guide to the freshwater Molluscs of the Pit-Sacramento Rivers, California by the Cantara Trustee Council Grant Program.

GRANTS

Clark, S.A. and Harris, P. State of Alabama Department of Conservation and Natural Resources - Distribution, life history, conservation and systematics of Alabama's Pebblesnails. Oct 2004 - Sept 2006. $26,930.

Clark, S.A. Hawkesbury Postgraduate Research Award - PhD, University of Western Sydney. Jan 2000 - Oct. 2002. $47,250.

Ponder, W.F. and Clark, S.A. Australian Biological Resources Study - Interactive CD-Rom guide and key to the freshwater Mollusca of Australia. Jan 1999 - Dec 2001. $90,000.

PROFESSIONAL SOCIETIES

American Malacological Society;
Conchological Society of Great Britain and Ireland;
Malacological Society of London;
Malacological Society of Australasia;
Member of the IUCN SSC Mollusc Specialist Group;
The Ecological Consultants Association of New South Wales.

RESEARCH INTERESTS

Systematics, population and conservation genetics of invertebrates particularly terrestrial and freshwater molluscs.

EXPERIENCE

I have over 30 years' experience in the collection, identification and taxonomy of marine, estuarine, freshwater and terrestrial molluscs in 28 countries and 41 US states. I have over 12 years' experience using allozyme electrophoresis to study speciation and population genetics particularly of molluscs but also some work with reptiles and spiders and at least 5 years' experience analysing DNA data. I have about 6 years' experience preparing material for and using a scanning electron microscope and have dissected individuals from several hundred populations of freshwater and terrestrial molluscs.

LEGAL EXPERIENCE

I have served as an expert witness for the Land and Environment Court of New South Wales on six occasions since 1997 and have provided expert testimony for several other cases.

PROFESSIONAL ACTIVITIES

Research Associate at the Field Museum of Natural History, Chicago, Illinois, June, 2010 to present.

Vice President of the Chicago Shell Club, Chicago, Illinois, May, 2010 to May, 2016.

Courtesy Postdoctoral Researcher, Division of Malacology at the Florida Museum of Natural History, Gainesville, Florida, September, 2009 to 2016.

Invited participant at the IUCN Red List workshop assessing the Red List status of the world's freshwater molluscs, organised jointly by the Zoological Society of London, the Encyclopedia of Life (EOL), International Union for Conservation of Nature (IUCN), and the IUCN SSC Mollusc Specialist Group. Held in London, United Kingdom, February, 2010.

Served on the Status Review Panel for the federally endangered Idaho Springsnail (*Pyrgulopsis robusta*), in Boise, Idaho, for the United States Fish and Wildlife Service, Western Region, October, 2005.

TELEVISION

Short interview about my PhD project on the endangered endemic Sydney land snail *Meridolum corneovirens*, aired on 'Totally Wild' (a children's educational program on wildlife and the environment), Australia wide, 7 May 2002.

Short interview regarding the endangered endemic Sydney land snail *Meridolum corneovirens* and how the Olympic Coordinating Authority (OCA) has helped in its conservation, aired on 'A Current Affairs' (a prime time news and current affairs program) Australia wide on the 15 September, 1998.

RADIO

Short interview with Brian Bury, 4BC, Brisbane, about Australian native snail diversity aired Nov. 2002.

NEWSPAPER/INTERNET

Several interviews about molluscs, endangered species and rediscovering a species previously thought to be extinct, with national, local and internet media outlets, both in Australia and the United States since 2002.

Some examples:
ABC News: When Birds Overshadow Snails -- And Why That's a Problem
http://abcnews.go.com/Technology/story?id=734467&page=1

http://www.cofc.edu/~fwgna/archive/9May05.html

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Expert report – *Dillwynia tenuifolia*

Expert report for *Dillwynia tenuifolia*, Paul Rymer, March 2019

Cumberland Plain Conservation Plan

Expert report for *Dillwynia tenuifolia* March 2019

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1. Introduction

1.2 Purpose of the expert report

The Department of Planning and Environment is currently preparing a strategic assessment to identify development impacts and conservation outcomes within new urban growth areas on the Cumberland (Interim Biogeographic Regionalisation for Australia [IBRA] subregion) in Western Sydney. Expert reports may be used as part of the threatened species assessment as outlined in the Biodiversity Assessment Method (BAM).

This document outlines the need for an expert report for the threatened plant species *Dillwynia tenuifolia* and the suitability of the expert who is proposed to prepare the report. The expert report is intended to supplement the data collected as part of the current survey effort.

1.3 Project context

The NSW Government is identifying areas for future urban development and associated infrastructure in Western Sydney. These future urban areas cover four priority growth areas: Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These new growth areas are all located within the Cumberland Plain Interim Biogeographic Regionalisation for Australia (IBRA) sub-region.

As part of the planning for the priority growth areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify development and conservation outcomes for the growth areas.

1.4 The study area

The study area is the Cumberland, Western Sydney, focusing on the urban growth areas: Wilton, Greater Macarthur, Western Sydney Aerotropolis and Penrith to Eastern Creek (Figure 1).

Greater Penrith & Eastern Creek Growth Area (GPECGA)

A large portion of this Growth Area is already urbanised, with several areas of industrial land use. Significant rural and peri-urban areas remain in the central north, the centre, and the southwest. Large areas of remnant vegetation are present in the far north (former Australian Defence Industries site, now in part Wianamatta Regional Park), and the Orchard Hills Defence facility. Mining of alluvium for sand and soil continues in the far northwest of the area in the Penrith Lakes locality.

Western Sydney Aerotropolis Growth Area (WSAGA)

This Growth Area adjoins the Greater Penrith & Eastern Creek area, extending south to the locality of Greendale, west of Bringelly. It is currently largely rural, with villages at Luddenham and Kemps Creek. Most rural areas are pastoral, but there are significant areas of more intensive rural use, including poultry and egg production, a large cattle feedlot and associated fodder cropping, and some market gardens and enclosed fruit and vegetable production. Quarrying occurs at the localities of Badgerys Creek and Kemps Creek.

Greater Macarthur Growth Area (GMGA)

The GMGA occurs in southwestern Sydney on predominantly shale soils that have been heavily cleared for agriculture and urban or industrial use. The northernmost section has long-established urban and commercial / industrial land use, while the southern section is largely rural (pastoral, minor cropping), with some villages and primarily subsurface mining (e.g. coal and coal seam gas). It extends from urban Glenfield in the north, to the rural village of Appin in the south.

Wilton Growth Area (WGA)

The Wilton Growth Area is the most southerly of the four Western Sydney Growth Areas dealt with in this Report. It extends from the village of Douglas Park in the north, to the village of Wilton in the south. It is primarily rural (pastoral) area with some more intensive agriculture, significant but mostly underground mining (primarily coal), and some long-established villages. The Hume Highway dissects this Growth Area.

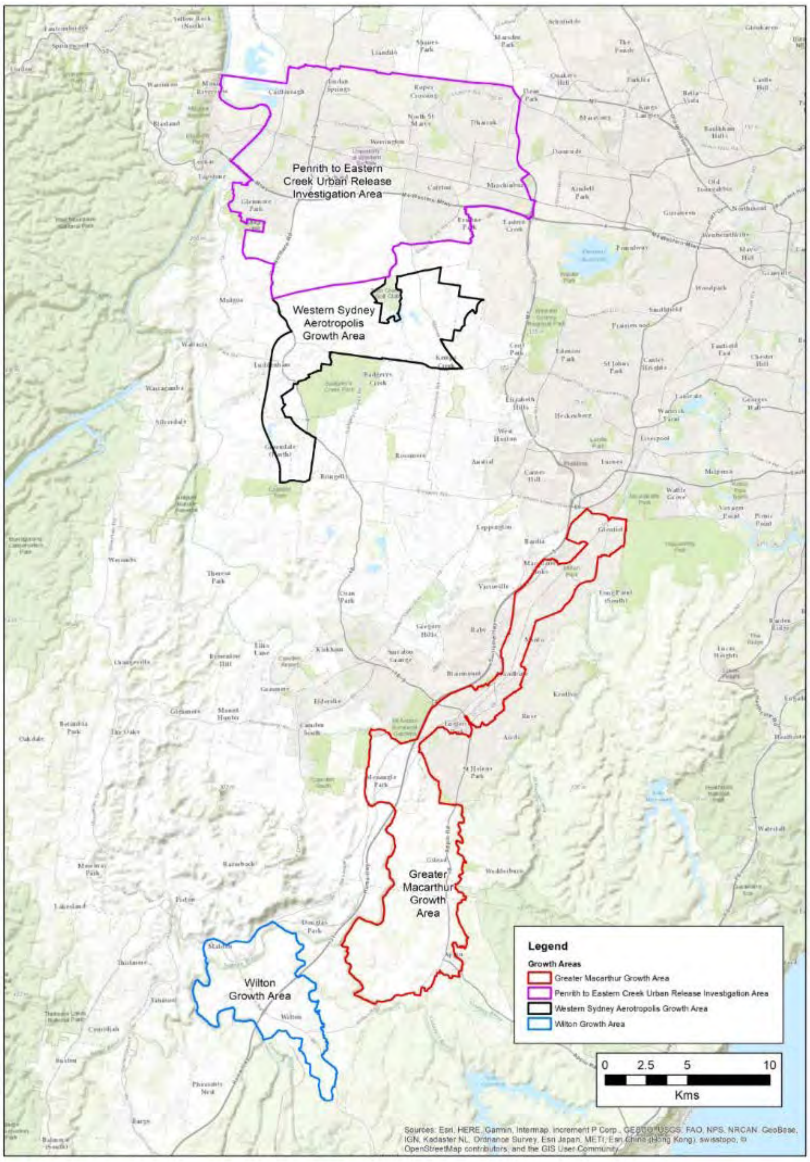


Figure 1: Map of the urban growth areas in Western Sydney

1.5 Reasons for use of an expert report

An expert report for *D. tenuifolia* is required as part of the threatened species assessment for the Cumberland Plain Conservation Plan for the following reasons:

1. Areas of habitat were not able to be surveyed. Not all land holders allowed the ecologists to enter their property and conduct BAM surveys. This restricted the opportunity to visit all potential areas of habitat within the proposed development footprint.
2. Section 4.4 of the NSW Guide to Surveying Threatened Plants (OEH 2016) provides for the consideration of 'site survey and an expert report' where areas are large. Based on site surveys and Bionet data, the species is unlikely to occur within the Wilton or Greater Macarthur growth areas. However due to the cryptic nature of this species outside the peak flowering season an expert in the species is required to determine whether suitable habitat exists.

1.6 Credentials of expert

Dr Paul Rymer is a senior lecturer at the Hawkesbury Institute for the Environment, Western Sydney University. He teaches and researches plant biology with a focus on conservation biology. Paul has contributed to the understanding of the biology and management of several threatened species, including *D. tenuifolia* and *Persoonia bargoensis* that were the focus of his postgraduate research. He has published his work in peer reviewed scientific journals, and provided reports to land managers.

2 Species information

2.1 Species description

"*Dillwynia tenuifolia* is a low spreading pea-flower shrub to a metre high. Its leaves are small and narrow (linear-terete, soft, 4-12mm long, with the tip often bent downwards). The wide orange-yellow and red pea-flowers are usually single, at or near the tips of the branches. Seed pods are brownish, egg-shaped, 4-5mm long with reticulate seeds. Both the singular orange flowers and the stem hairs distinguish it from the similar and more common yellow-flowered *Dillwynia glaberrima* and *D. floribunda*."
https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10226

2.2 Life cycle

Dillwynia tenuifolia is a fire sensitive (Auld 1996), perennial, woody, leguminous shrub (Harden 1991). Flowering occurs sporadically throughout much of the year, with a peak in flower production from August to October. Flowers are hermaphroditic and protandrous, and are commonly found individually on lateral branchlets. Seeds mature in December when they are released into the soil. Seed are physically dormant with a hard seed coat, requiring cracking (via physical disturbance or the heat of fire) to allow water to enter and germination to proceed. Seed can remain viable in the soil for several decades (Auld 1996), such that large soil stored seed banks can accumulate in healthy populations and regeneration may occur even when the standing population has expired some time before.

2.3 Distribution and abundance

Dillwynia tenuifolia is an endemic species that forms large populations within a restricted geographic range and specific habitat [predominately the Castlereagh Ironbark Forest (9e); (Benson 1992)]. It is limited to New South Wales, with the core distribution on the Cumberland , west of Sydney, and disjunct populations in the Lower Blue Mountains and Lower Hunter Region (records in the National Herbarium of NSW).

The core distribution is in the Cumberland from Windsor and Penrith east to Dean Park near Colebee. Other populations in western Sydney are recorded from Voyager Point and Kemps Creek in the Liverpool LGA, Luddenham in the Penrith LGA and South Maroota in the Baulkham Hills Shire. Disjunct localities outside the Cumberland include the Bulga Mountains at Yengo in the north, and Kurrajong Heights and Woodford in the Lower Blue Mountains.
https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10226

2.4 Habitat requirements

Dillwynia tenuifolia is predominately found in the Castlereagh Ironbark Forest (9e); (Benson 1992) on shale-transition soils.

"In western Sydney, may be locally abundant particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland."
https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10226

3 Description of the study area

3.1 Land use history

The Cumberland, Western Sydney, has a long history of land clearing for agricultural, industrial and urban development. Less than 7% of the native vegetation remains, much of which is distributed in small isolated remnant patches.

3.2 Landscape context

The study area for this report comprises the growth areas of Greater Macarthur (Campbelltown and Appin) and Wilton (see Figure 1). It is located within the Cumberland subregion on Triassic Wianamatta Group Shales and transitional shale/sandstone areas in south-eastern parts of the Cumberland, Western Sydney. The eastern and southern margins are within the Sydney Cataract subregion defined by the Triassic Hawkesbury Sandstone plateau. The study area is within the Hawkesbury-Nepean and Georges River catchments.

Greater Macarthur Growth Area

The Greater Macarthur PGA extends from Glenfield in the north to Appin in the south. The northern zone is already well developed with remnant vegetation largely restricted to creek-lines or small patches associated with open space reserves. Southern parts of the area, south of Rosemeadow, comprise primarily agricultural lands with larger patches of remnant vegetation associated with the Nepean and Georges Rivers, and associated tributaries.

Wilton Growth Area

The Wilton PGA occurs to the south of the Greater Macarthur Growth Area extending from Douglas Park in the north to south of Wilton. The boundaries closely follow the Nepean River in the north and west, and a tributary Allens Creek in the east. Away from the river and creeks the higher areas are largely cleared for agriculture and hobby farms. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The Woronora sandstone plateau (within the Upper Nepean State Conservation Area) forms the southern boundary. The Hume Highway dissects the growth area.

Greater Penrith to Eastern Creek Growth Area (GPECGA)

The GPECGA is a relatively large area that extends from Rooty Hill, Minchinbury and Hassell Grove in the east, across the Cumberland to the Hawkesbury-Nepean River in the northwest, then south through Jamisontown, Glenmore Park, to the intersection between The Northern Road and the Warragamba Water Supply Pipelines in the far south-west. The predominant geology is Wianamatta Shale on flat to gently undulating terrain that has been extensively cleared for agriculture, and later for housing and industrial use, with some remnant vegetation on current and former Defence holdings. The shale soils support(ed) Cumberland Plain Woodlands. Overlying the extensive shale deposits are small areas of weathered Tertiary alluvium e.g. Shalvey and Willmot, that are much more common to the north. These support(ed) the Castlereagh Woodlands complex of vegetation types, which is strongly associated with several threatened plant species. More common are broadly linear deposits of Quaternary alluvium along watercourses such as South Creek and Eastern Creek, and on the flood terraces of the Hawkesbury-Nepean River. Other lithologies occur but are very rare and of very small extent.

Western Sydney Aerotropolis Growth Area (WSAGA)

The WSAGA abuts the GPECGA's southernmost border near the locality of Sovereign (east of Mulgoa), then extends south past Greendale, northeast to the locality of Badgerys Creek, east to Kemps Creek, and northward to the vicinity of Mount Vernon, excluding Twin Creeks Golf Course and associated settlement. The lithology and soils are broadly similar to that of the GPECGA, being effectively just an extension of that area to the south to incorporate the developing Badgerys Creek Airport and environs. The area is even more severely cleared of native vegetation, except along some streams and on rare occurrences of steeper terrain. It contains no NPWS reserves, with the nearest being the small Kemps Creek Nature Reserve, outside the Area to the southeast. Gulguer Nature Reserve and Bents Basin State Conservation Area occur to the southwest of Greendale

3.3 Native vegetation communities

There are 14 different vegetation communities (PCTs) found in the urban growth areas. The PCTs are associated with different soils and topology, as well as history of land use and disturbance. The four growth areas differ in the composition of PCTs (Table 1).

Table 1. Area of PCTs by Growth Area (highlighting the PCTs D. tenuifolia is associated)

PCT	PCT name *	Greater Macarthur	Greater Penrith to Eastern Creek	Western Sydney Aerotropolis	Wilton	TOTAL (ha)
724	Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel		138.3	52.9		191.3
725	Cooks River Castlereagh Ironbark Forest		127.5	39.9		167.4
781	Freshwater wetland		65.4	3.5		68.9
830	Forest Red Gum – Grey Box shrubby woodland on shale	18.8	2.8			21.5
835	Forest Red Gum – Rough-barked Apple grassy woodland	186.6	826.3	162.9		1175.8
849	Grey Box – Forest Gum grassy woodland on alluvial flats	444.5	1794.0	550.1	289.8	3078.3
850	Grey Box – Forest Gum grassy woodland on shale (southern)	269.9	80.8	7.7	164.5	522.9
883	Hard-leaved Scribbly Gum – Parramatta Red Gum healthy woodland	0.9	6.5			7.4
1081	Red Bloodwood – Grey Gum woodland	7.5			66.7	74.2
1105	Rive oak open forest of major streams	44.4	94.2			138.6
1181	Smooth-barked Apple – Red Bloodwood – Sydney peppermint healthy open forest on slopes of dry sandstone gullies	414.8			365.9	780.7
1292	Water Gum – Coachwood riparian scrub along sandstone streams	1.3			38.5	39.8
1395	Narrow-leaved Ironbark – Broad-leaved – Grey Gum open forest	1895.5	2.0		1429.1	3326.6
1800	Swamp Oak	4.1	118.4	110.1		232.6
TOTAL (ha)		3288.3	3256.2	927.1	2354.5	9826.1

* of the Cumberland, Sydney Basin Bioregion

Each vegetation polygon was assigned to one of four vegetation condition categories by DPE based on LiDAR and nearmap remote sensing data, along with field validation:

1. Intact - Visual inspection of the Nearmap imagery showed significant patches of continuous canopy and the CHM (Canopy Height Model) showed vegetation returns for both the upper and mid storeys.

2. Thinned – Visual inspection of the Nearmap shows patches of continuous canopy but less dense and the CHM presented only canopy and ground returns.

3. Scattered trees – Visual inspection of Nearmap imagery and LiDAR canopy polygons showed one or a few likely native trees surrounded by cleared land.

4. Grassland – Treeless areas which were visually assessed to be potential native grassland and were not in areas of improved pasture or cropland.

4 Assessment of species presence and habitat

4.1 Existing records and surveys

BioNet records for *D. tenuifolia* generally support the description of the distribution in 2.3. There are a number of outlier points that may be mis-identifications if not significant expansion of geographic range.

Notably, *D. tenuifolia* is absent from the Wilton and Greater Macarthur growth areas. There is however an outlier record immediately to the southeast of Wilton and there is similar vegetation to that in which the species is found in the core distribution.

Western Sydney Aerotropolis growth area, includes a significant population of *D. tenuifolia*. There is a cluster of records in Kemps Creek, which is the most southerly population of the species. The Kemps Creek population is listed as a Threatened population.

There are clusters of records in the Greater Penrith to Eastern Creek urban growth area around St Marys. A large number of records from Marsden Park, Shanes Park, Llandillo, Cranebrook on the northern edge of the GPECGA. Further to the north there are large populations from Richmond to Windsor.

4.2 Surveys completed for the biocertification

Surveys completed by Biosis and Ecoplanning on behalf of DPE were provided (Figure 2).

They include 11 records of *D. tenuifolia* in Kemps Creek (-33.86978667, 150.7902583, ALT 70.5 m). All of which are within the Western Sydney Aerotropolis growth area.

Figure 2: Map of D. tenuifolia records provided by BIOSIS aaround Kemps Creek in WSAGA

An additional two records of *D. tenuifolia* were provided from Dr Peter Weston at the Royal Botanic Gardens Sydney, who observed the species while undertaking field surveys for other expert reports.

GJ3 - Castlereagh Nature Reserve, Northern Rd, Londonderry, 33°40'44.9"S, 150°44'37.3"E, 52 m, Tertiary alluvium, brown, gravelly clay-loam, 0°, dry sclerophyll forest, sparse shrubby understory. This record is north of the GPECGA.

GJ7 - Bill Anderson Reserve, Kemps Creek site 2, 33°52'53.2"S, 150°47'19.0"E, 66 m, Bringelly Shale, red-brown sandy loam, <5°N, disturbed dry sclerophyll woodland, moderately dense shrubby understory.
This record is immediately south of the Western Sydney Aerotropolis growth area.

4.3 Surveys completed for this assessment

My own records of occurrence and knowledge of habitat preference of *D. tenuifolia*, combined with those provided through DPE via email and in the spatial portal were used to plan field work and target sites for assessment. I plotted the target sites on Google Earth for use in the field via my smartphone (Figure 3).

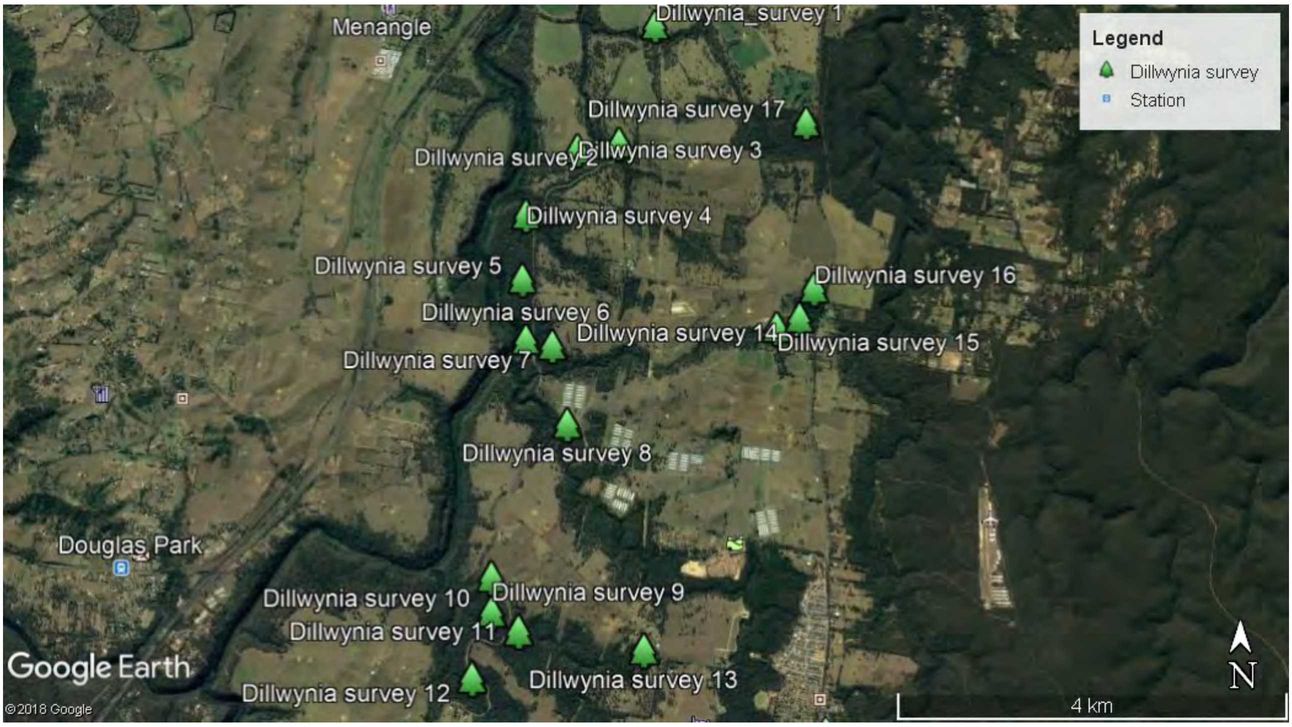


Figure 3: Map of planned survey sites in the Greater Macarthur Growth Area.

The target site was located on the ground via google map navigation tool. In many cases access to the site was prevented by locked gates, or private property owners not providing permission. Additional sites were sought on the ground in adjacent areas, and others based on alternative records of occurrence from the Atlas of Living Australia.

A full list of sites where ground surveys have been conducted are in the appendix.

Ground surveys were conducted on foot with a visual search of the suitable habitat. The search effort at each site varied by the survey area and typically ranged from 15-60min. Some sites were much larger and represented a series of occurrence records that were traversed on foot (c. 2 hour). A random walk was used to cover as much ground as possible searching for the target species. The search included living and dead plants, along with examination of the leaf litter / upper soil profile for plant fruits and seeds.

A photo was taken of the site along with a screenshot of the map to confirm the survey was conducted. When a target plant or other significant plant was located a photo was taken with a map screenshot for the location details.

4.4 Assessment of species presence

Likelihood of species presence

Species Distribution Models (SDM) have been conducted to estimate the suitable habitat for D. tenuifolia in the Cumberland bioregion. The SDM used records of occurrences from field surveys along with spatially valid records from the Atlas of Living Australia (ALA; www.ala.org.au) combined with temperature, rainfall and soil GIS layers to conduct a MaxENT model predicting habitat suitability at 1km grid scale. Mean annual temperature was the most important variable in the SDM followed by precipitation seasonality, annual precipitation, and temperature seasonality (Table 2). While soil layers contributed a lower percentage to the overall SDM they were important in refining the local patterns within the Cumberland.

Table 2: The relative importance of the variables in the MaxENT species distribution model.

Variable	Percent contribution	Permutation importance
Temperature - annual mean (Bio01) (el874)	31.5	63.1
Precipitation - seasonality (Bio15) (el882)	20.2	12.6
Precipitation - annual (Bio12) (el893)	19.3	1.7
Temperature - seasonality (Bio04) (el892)	17.4	3.3
Drainage - average (el670)	5.1	10.2
Clay % (el814)	3.5	0.7
Phosphorus - plant-available pre-European (el811)	2.4	5.9
Moisture - average (el669)	0.5	1.9
Carbon - organic (el665)	0.2	0
Nitrogen - plant-available pre-European (el831)	0	0.6

The SDM for *D. tenuifolia* provided an accurate prediction of the habitat suitability within the Cumberland (Figure 4). The predicted habitat suitability was tested with 25% of the observation records, demonstrating the SDM accuracy at >95%. Furthermore, the main populations within the Cumberland are all within areas of high habitat suitability. Some of the areas predicted as suitable for *D. tenuifolia* do not have any valid occurrence records (notably Penrith), while other areas native vegetation has been converted into industrial or urban developments. The species persistent soil seedbank and ability to persist in small degraded sites (e.g. roadside verges) would support the integrity of the SDM habitat suitability for low quality vegetation classes (Figure 4).

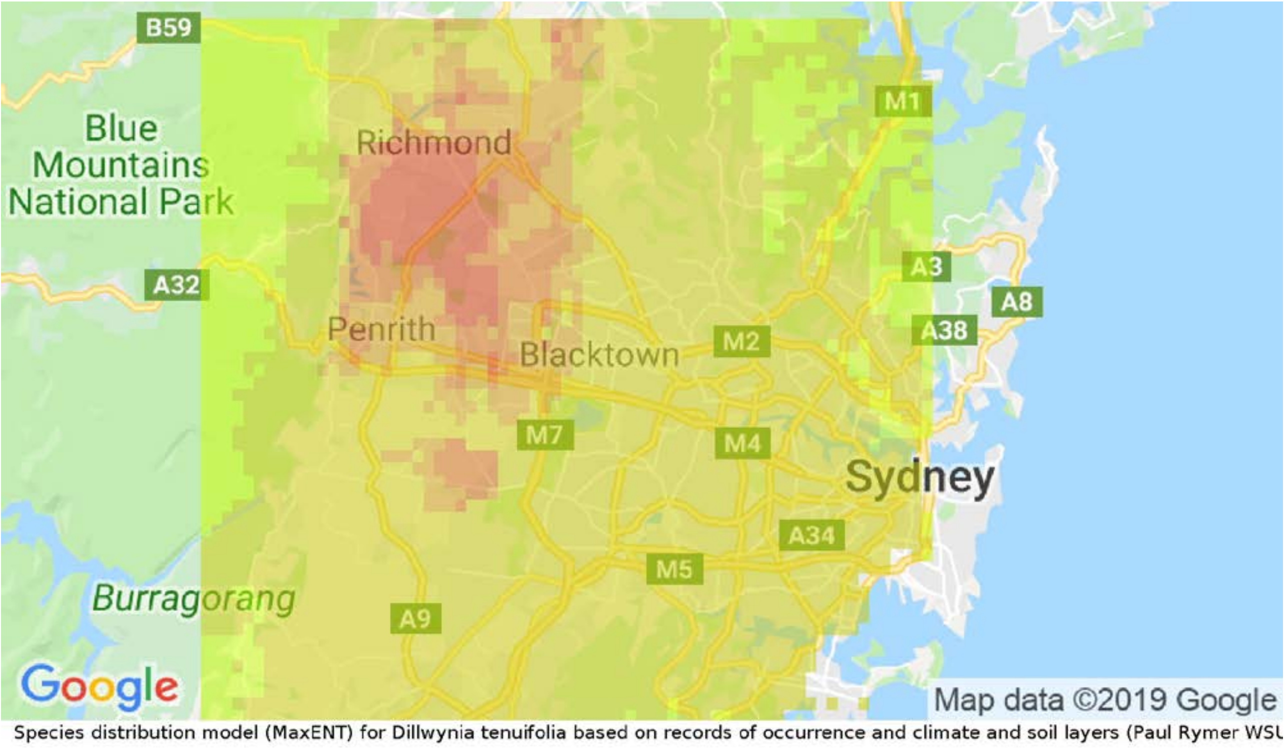


Figure 4: Dillwynia tenuifolia habitat suitability in the Cumberland predicted based on the MaxENT species distribution model. Grid cells with darker red colours are more suitable (max 85%), orange intermediate (~30%), and yellow/green is the lowest suitability (min 5%).

URBAN GROWTH AREAS

Dillwynia tenuifolia is not likely to occur in the Wilton or Greater Macarthur growth areas. The field surveys targeting areas with previous records, and in potential habitat, did not find any *D. tenuifolia* plants in this area. The SDM confirmed there is low habitat suitability in Wilton or Greater Macarthur growth areas.

Western Sydney Aerotropolis Growth Area

The most southerly known population of *D. tenuifolia* is found in Kemps Creek partly within the Western Sydney Aerotropolis Growth Area.

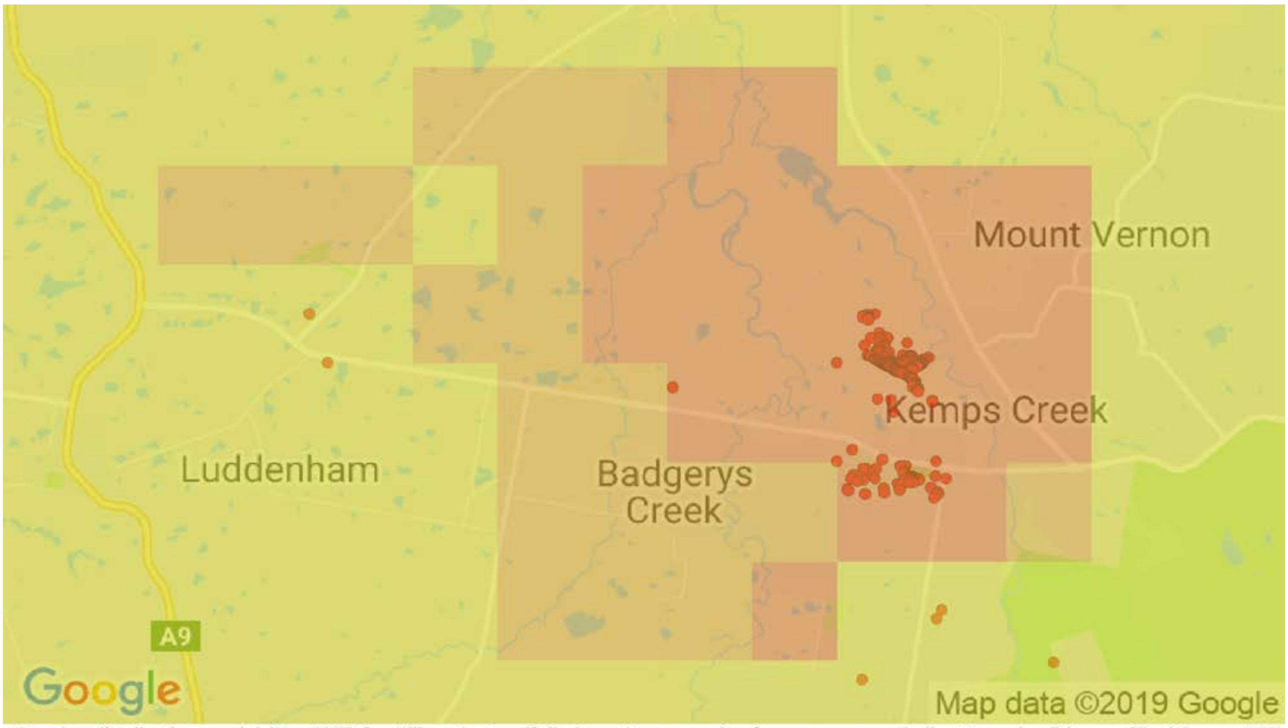
An 'Endangered Population' has been declared under the NSW Biodiversity Conservation Act 2016 for the area bounded by Western Road, Elizabeth Drive, Devonshire Road and Cross Street, Kemps Creek in the Liverpool Local Government Area. It is managed under the OEH Saving Our Species program. Which is immediately to the south of the Western Sydney Aerotropolis Growth Area. Major threats include weeds, inappropriate fire regimes, illegal dumping and development of adjacent sites (https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10225).

Field surveys confirmed a large population of *D. tenuifolia* in the Kemps Creek area (see observation records in the appendix). There is a patch south of Elizabeth Drive, Kemps Creek, in a large remnant block of native vegetation between Western Road and Cross Street. The Kemps

Creek population of *D. tenuifolia* continues north of Elizabeth Drive (inside the Western Sydney Aerotropolis Growth Area) along Clifton Avenue where there is second patch in remnant native vegetation on either side of Clifton Avenue (lot 90 (west) and lot 316 (east)).

Historic and contemporary development in this area has impacted on the extent of occupation and the population size of *D. tenuifolia*. Long periods between fire in the remnant vegetation may have reduced the standing population of plants, however it is likely there is a viable soil stored seedbank from which plants could re-establish following fire or soil disturbance.

The SDM confirms the Kemps Creek area as having high habitat suitability (Figure 5). This corresponds to the Castlereagh Ironbark Forest and shale-transition soils, along with the large clusters of recent and historic sightings in the area.



Species distribution model (MaxENT) for Dillwynia tenuifolia based on records of occurrence and climate and soil layers (Paul Rymer WSU

Figure 5: Dillwynia tenuifolia habitat suitability focusing on the Kemps Creek population. Grid cell colour indicates suitability: darker red (max 85%), orange (~30%), yellow/green (min 5%). Red points are the records of occurrence for D. tenuifolia.

The Western Sydney Aerotropolis Growth Area draft plan (https://www.planning.nsw.gov.au/Plans-for-your-area/Priority-Growth-Areas-and-Precincts/Western-Sydney-Aerotropolis/Map) has zoned the Kemps Creek population in predominantly 'Flexible Employment' and marginally 'Non Urban Land'. The route of the proposed M12 motorway would go over the northern Clifton Avenue patch, representing more than half of the Kemps Creek population. While this is outside of the area specified as the Kemps Creek Endangered Population, the northern patch of the Kemps Creek population (Figure 5) is likely to be part of the same genetic population, which is genetically isolated from the core distribution (Rymer etal. 2002). Development in the surrounding area has been listed as a threat to the viability of the Kemps Creek Endangered Population. Negative impacts include a reduction in the effective population size with loss of plants in the adjacent area, increased nutrient and weed loads, inappropriate fire regimes and altered hydrology.

GPECGA has a large number of records of occurrence and some well-established populations of *D. tenuifolia*. Field surveys have validated the occurrence of plants in Minchinbury, St Marys, Ropes Crossing and Shanes Park. The SDM highlights these areas as high habitat suitability for *D. tenuifolia* (Figure 6). There is also substantial populations of *D. tenuifolia* to the north of Penrith to Eastern Creek, notably the Shanes Park population on the northern edge. As with other areas in the Cumberland historic and contemporary development has impacted on the extent of occupation and the population size of *D. tenuifolia*, however improved land management and ecological restoration could re-establish viable populations. On the other hand, urban development can have negative impacts on adjacent remnant vegetation and plant populations through increased nutrient and weed loads, inappropriate fire regimes and altered hydrology.

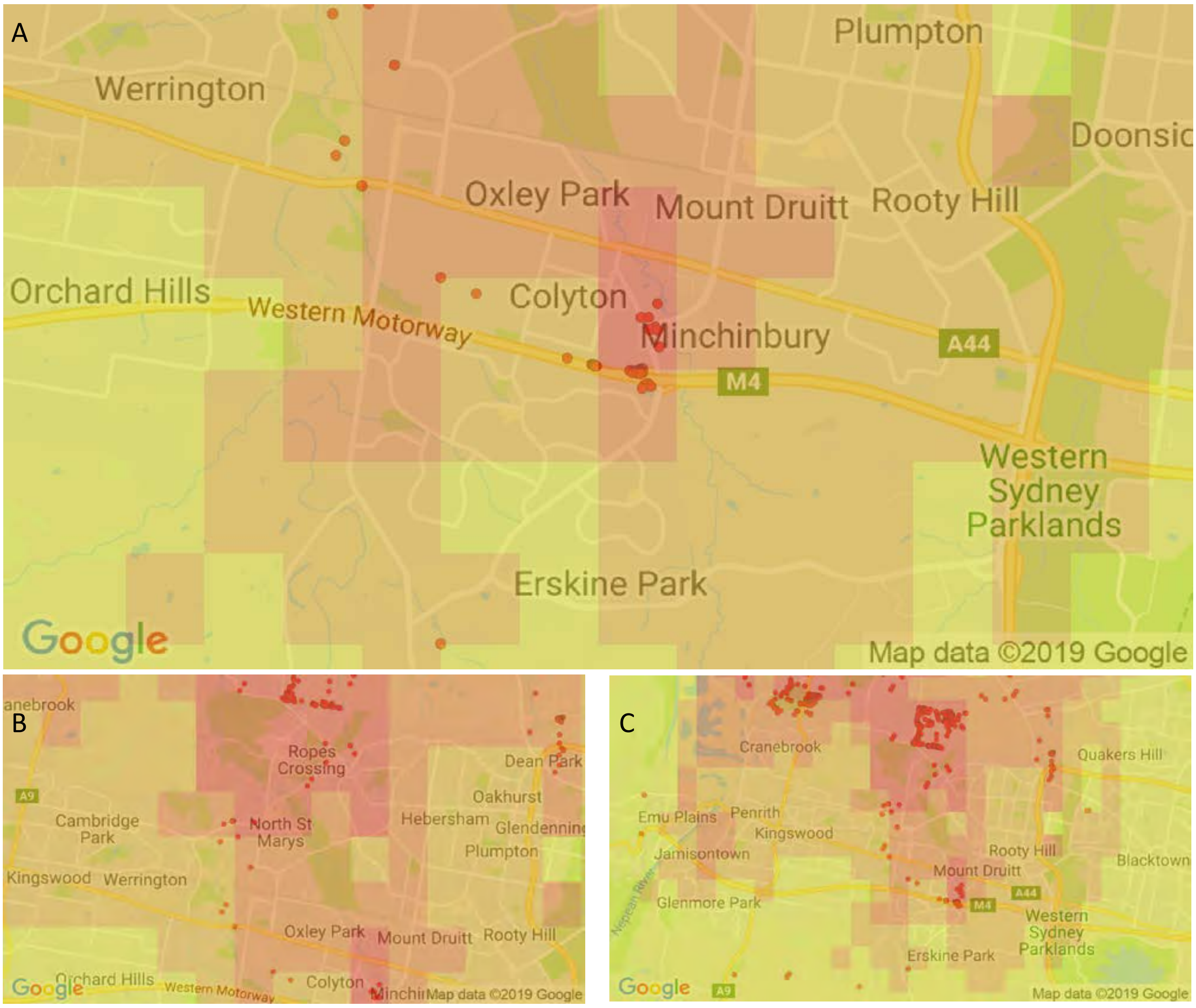


Figure 6: *Dillwynia tenuifolia* habitat suitability focusing on (A) Minchinbury, (B) Penrith and Eastern Creek area, and (C) surrounding area. Grid cell colour indicates suitability: darker red (max 85%), orange (~30%), yellow/green (min 5%). Red points are the records of occurrence for *D. tenuifolia.*

Justification for determining presence

Based on the field surveys, collated records of occurrence, and species distribution models I have assessed the likelihood of species occurrence on the proposed growth areas. Several of the records available in BioNet are incorrect in the species identification, or location information. Priority of records:

1. Current survey documented species being present
2. Records from trusted surveys with taxonomic expertise
3. Records in BioNet from multiple years and collectors
4. Other records were questioned for integrity

4.5 Assessment of suitable habitat

Suitable habitat within the growth areas

Dillwynia tenuifolia is associated with the “Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays” classified in PCTs 724, 725, 849, and 883.

Populations of *D. tenuifolia* can develop large soil stored seedbanks, which can persist as viable seed for several decades. As such populations can remain viable in intact and degraded vegetation (scattered, thinned) in interconnected large and small patches, including roadside plants (Figure 7).

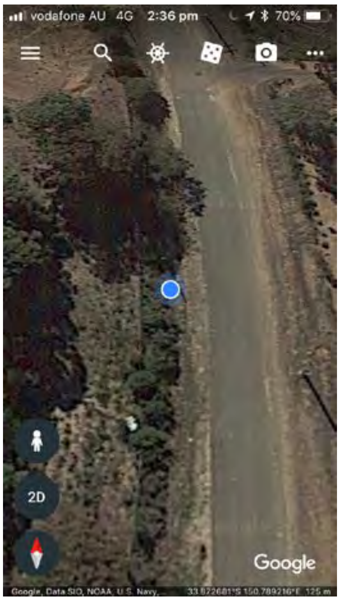


Figure 7: Roadside population of D. tenuifolia recorded along Clifton Avenue, Kemps Creek.

Species polygons

A map of species polygons for the Western Sydney Aerotropolis and Penrith to Eastern Creek growth areas was produced by Darren James (dajenvironmental) based on the area of occurrence (2km grids) overlayed with the PCTs (listed above) (Figure 8).

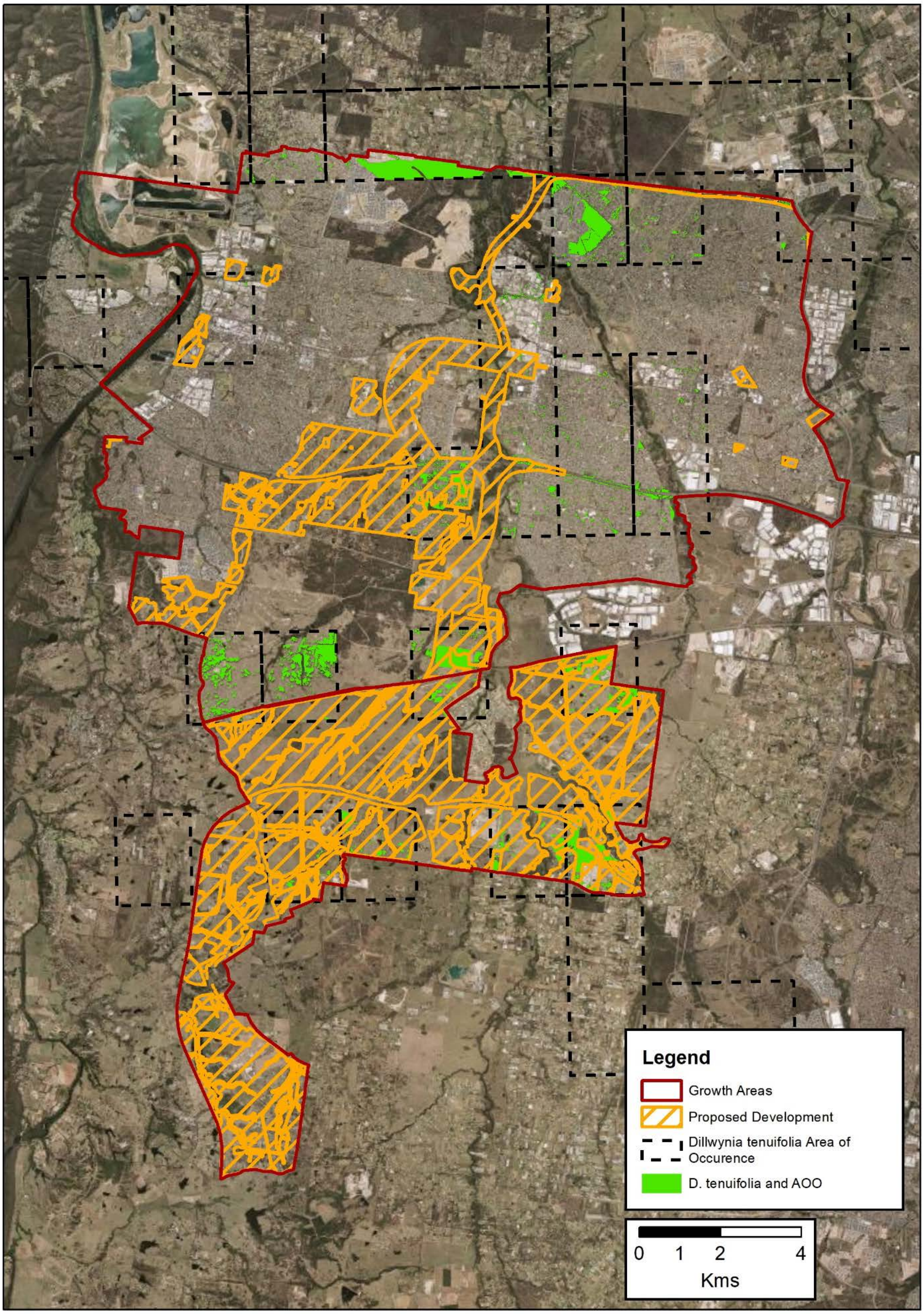


Figure 8: Map of vegetation polygons in areas and habitat that D. tenuifolia is known to occur.

5 Areas in growth areas

The total area of *D. tenuifolia* habitat within the Greater Penrith and Eastern Creek (GPEC), and Western Sydney Airport Growth Areas is estimated to be 606 ha and 225 ha, respectively (total 831 ha; Table 3). *Dillwynia tenuifolia* had the greatest habitat area within the growth areas in the Grey Box - Forest Red Gum grassy woodland (68% total area; 564 ha PCT 849), with intermediate habitat area in Cooks River Castlereagh Ironbark Forest and Broad-leaved Ironbark - Grey Box vegetation (16% [133 ha] PCT 725; 15% [127 ha] PCT 724), and less than 1% in Hard-leaved Scribbly Gum Parramatta Red Gum woodland (6.5 ha PCT 883) (Table 3). The majority of vegetation was in the condition thinned or scattered trees (Table 3). This reflects the overall abundance of the PCTs in the growth areas (Table 1).

Table 3: The total area of D. tenuifolia habitat within the Greater Penrith and Eastern Creek (GPEC), and Western Sydney Airport Growth Areas by vegetation zone (PCT) and condition.

PCTs	Condition	GPEC	Western Sydney Airport Growth Area	Grand Total
724	Intact	21.5	3.3	24.8
724	Scattered Trees	3.1	0.1	3.2
724	Thinned	53.5	45.8	99.3
725	Intact	59.4	21.1	80.5
725	Scattered Trees	6.0	2.8	8.8
725	Thinned	29.3	14.4	43.7
849	DNG	4.8	24.5	29.2
849	Intact	11.0	22.2	33.2
849	Scattered Trees	33.7	40.9	74.6
849	Thinned	377.2	50.0	427.2
883	Intact	6.4	0.0	6.4
883	Thinned	0.1	0.0	0.1
Grand Total		**605.9**	**225.0**	**830.9**

The habitat area impacted was greater in the Western Sydney Aerotropolis Growth Area (121.3ha) than the Greater Penrith and Eastern Creek Growth Area (101.2 ha) (total 222.5 ha; Table 4), despite only representing approximately a quarter of the total habitat area for *D. tenuifolia* in the urban growth areas (Table 3). The Grey Box - Forest Red Gum grassy woodland is the most impacted (164.4 ha PCT 883) then Broad-leaved Ironbark - Grey Box (39.1 ha PCT 724) followed by Cooks River Castlereagh Ironbark Forest (18.1 ha PCT 725). Overall 26% of the habitat would be impacted within the growth areas; 29% PCT 883, 30% PCT 724 and 14% PCT 725. The majority of the vegetation condition was thinned.

Table 4: The D. tenuifolia habitat area impacted in the growth areas by PCT and condition.

PCT	Condition	GPEC	Western Sydney Airport Growth Area	Grand Total
724	Intact	1.0	0.0	1.0
724	Scattered Trees	0.1	0.1	0.2
724	Thinned	19.6	18.3	37.9
725	Intact	2.8	0.4	3.2
725	Scattered Trees	0.0	2.5	2.5
725	Thinned	7.0	6.4	13.4
849	DNG	4.8	21.5	26.3
849	Intact	1.4	6.6	8.0
849	Scattered Trees	1.6	34.7	36.3
849	Thinned	62.9	30.9	93.8
Grand Total		**101.2**	**121.3**	**222.5**

6 Information used in this assessment

Data, maps and information provided by DPE and project partners can be found in the appendix.
Vegetation mapping, field surveys and planning information provided via spatial viewer BioNet records

7 References

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Rymer, P.D., E.C. Morris & B.J. Richardson (2002). Breeding system and population genetics of the vulnerable plant Dillwynia tenuifolia (Fabaceae). Austral Ecology. 27:241-248.

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Tozer MG (2003) The native vegetation of the Cumberland, western Sydney: a systematic classification and field identification of communities. Cunninghamia 8, 1-75.

8 Appendices

Curriculum vitae

Paul Rymer

Senior Lecturer in Plant Ecological Genetics

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Brief career history of Dr Paul Rymer

Research Interests: Ecology and evolution, biodiversity hotspots, weeds, and climate change.

Qualifications

- PhD, University of Wollongong, 2006
- BSc (Honours), University of Western Sydney, 2000

Employment

- Lecturer in Ecological Genetics, Western Sydney University, 2014
- Research Lecturer, University of Western Sydney, 2011
- Associate Researcher, Royal Botanic Gardens Sydney, 2010
- Marie Curie Incoming International Fellow, Imperial College London, 2008
- Postdoctoral Researcher, University of Oxford, 2006

Main Research grants

2017 NSW Environmental Trust “Assisted migration under climate change”

2016 HIA Green Cities “Which plant where and why database”

2016 HIA Pollination “Healthy bee populations for sustainable pollination in horticulture”

2015 ARC Linkage “Do hotter and drier regions harbour adaptive variation for climate change?”

2014 ARC Linkage “Identifying regions of high drought mortality risk for tree species in NSW”

2013 NSW Environmental Trust “Grey Box psyllid induced mortality”

2013 UWS Partnership Program “Adaptive potential to climate change” DPaW

2012 UWS Partnership Program “Genetic issues in restoration” Greening Australia

2009-2007 Marie Curie Fellowship “Pollinators drive flora speciation”

Evidence for quality of research outputs:

I have published 33 peer-reviewed scientific journal articles, with an H-index of 11. My work on plant speciation and population genomics attracted some attention, with Linder (Molecular Ecology DOI: 10.1111/j.1365-294X.2010.04798.x) highlighting its importance in the field. My recent work has been published in several high quality journals, including Molecular Ecology, Molecular Phylogenetics and Evolution, New Phytologist and Global Change Biology. A book chapter on plant markers for conservation genetics was requested by the preeminent Geneticist Robert Henry.

Teaching

I have actively contributed to undergraduate and postgraduate teaching at several institutions, and currently I am teaching Botany, Principles of Evolution, and Biological Adaptation to Climate Change at WSU. I have supervised six MSc research projects at Imperial College London, University of Oxford, and University of Wollongong. I am currently supervising five PhD, three Masters, and several undergrad research projects.

Other research leadership and community roles:

Much of my research has been applied to understanding plant rarity (and conversely invasiveness), which has produced valuable information for land managers. The findings of my work have been directly incorporated in recovery plans for endangered species. My work on neotropical trees has been used to develop best practice guidelines for seed sourcing for natural restoration. I have contributed as a scientific expert to the Priorities Action Statement 2 process for OEH management of threatened species. I have taken up a committee positions for the development of recovery plans, Cumberland Conservation Corridor Reference Group (Department of the Environment), and Greening Australia’s Grassy Groundcover Research Project advisory group (Greening Australia). Outreach to high school students through the development of material for the HSC Agriculture syllabus (Department of Education).

Dr Paul Rymer – ten most relevant publications

1. Flores-Rentería L, Rymer PD, Riegler M. (2017) Unpacking boxes: integration of molecular, morphological and ecological approaches reveals extensive patterns of reticulate evolution in the box eucalypts. Molecular Phylogenetics and Evolution, 108, pp. 70-87

Complex evolutionary histories are unpacked through a multi-faceted approach where incomplete lineage sorting is the dominant pattern in widespread species.

2. Blackman CJ, Aspinwall MJ, Tissue DT, Rymer PD (2017) Genetic adaptation and phenotypic plasticity contribute to greater leaf hydraulic tolerance in response to drought in warmer climates. Tree Physiology https://doi.org/10.1093/treephys/tpx005

Intraspecific variation in hydraulic traits are revealed among provenances and growth temperatures. We show support for local adaptation to hot climates through enhanced resilience to drought.

3. Huang G, Rymer PD, Duan H, Smith RA, Tissue DT (2015) Elevated temperature is more effective than elevated [CO2] in exposing genotypic variation in *Telopea speciosissima* growth plasticity: Implications for woody plant populations under climate change. Global Change Biology 21 (10), pp. 3800-3813 [Cited 1, JIF 8.044]

Coastal genotypes from mesic climates were found to have a greater capacity to increase growth in response to warming and elevated CO2 campared the non-responsive upland genotype. The finding support the prediction that upland taxa will be under threat with climate change.

4. Drake JE, Aspinwall MJ , Pfautsch S, **Rymer PD**, Reich PB, Smith RA, Crous KY, Tissue DT , Ghannoum O & Tjoelker MG (2014) The capacity to cope with climate warming declines from temperate to tropical latitudes in two widely distributed *Eucalyptus* species. Global Change Biology, 21 (1), pp. 459-472 [Cited 15, JIF 8.044]

This paper provides support for the hypothesis that climate change will negatively affect the warm edge of a species' distribution more than trees from moderate- or cool origins. The climatic gradient explored along the east coast of Australia provides insights into the importance of physiological tolerance and gene flow for resilience to climate change.

5. **Rymer PD**, Sandiford M, Harris SA, Billingham MR, Boshier DH (2013) Remnant *Pachira quinata* pasture trees have greater opportunities to self and suffer reduced reproduction due to inbreeding depression. *Heredity* doi: 10.1038/hdy.2013.73 [Cited 9, JIF 3.805]

Habitat fragmentation is a key threatening process. This study shows how trees can respond to altered mate availability through labile selfing and enhanced pollen movement with implication for conservation.

6. ***Rymer PD**, Dick CW, Vendramin GG, Buonamici A, Boshier D (2013) Recent phylogeographic structure in a widespread 'weedy' Neotropical tree species, *Cordia alliodora* (Boraginaceae). *Journal of Biogeography*. [Cited 18, JIF 4.590]

A species with the largest continuous latitudinal range (40°S-40°N) across major geographic and environmental barriers was genetically characterised revealing the species origin, historical dispersal patterns and regions of adaptive variation.

7. McPherson H, van der Merwe, M, Delaney SK, Edwards MA, Henry RJ, McIntosh E, Rymer PD, Milner ML, Siow J, Rossetto M.(2013) Capturing chloroplast variation for molecular ecology studies: A simple next generation sequencing approach applied to a rainforest tree. BMC Ecology 13, 8 [Cited 46, JIF 2.360]

A novel approach was developed to sequence complete chloroplast genomes for phylogenetic and population genomic analyses.

8. ***Rymer PD**, Johnson SD, Savolainen V (2010). Pollinator behaviour and plant speciation: can assortative mating and disruptive selection maintain distinct floral morphs in sympatry? *New Phytologist* 188(2): 426-436. [Cited 17, JIF 7.672]

This paper was the first to demonstrate the utility of molecular markers in understanding pollinator behaviour and the speciation process within populations.

9. ***Rymer PD**, Manning JC, Goldblatt P, Powell MP, Savolainen V (2010). Evidence of recent and continuous speciation in a biodiversity hotspot: a population genetic approach in southern African gladioli (*Gladiolus*; Iridaceae). *Molecular Ecology* 19(21): 4765-4782. [Cited 29, JIF 6.494]

Highlighted by Peter Linder (Uni Zurich) as novel in understanding the ongoing speciation process and the origin of biodiversity hotspots. A reviewer commented "putting the ecology back into molecular ecology"

10. *M. Rossetto, D. Crayn, A. Ford, P. Ridgeway, **P.D. Rymer** (2007) The comparative study of range-wide genetic structure across related, co-distributed rainforest trees reveals contrasting evolutionary histories. *Australian Journal of Botany*, 55, 416-424. [Cited 19, JIF 1.355]

A comparative study that identifies broad patterns of genetic structure in rainforest trees. We explored the effect of different life-histories and geographic barriers were shown to determine gene flow.

Expert report – Green and Golden Bell Frog

Expert report for the Green and Golden Bell Frog (*Litoria aurea*), Francis Lemckert, 2019

Strategic assessment for Cumberland Plain Conservation Plan - Expert report for the Green and Golden Bell Frog (*Litoria aurea*)

Francis Lemckert

Principal Ecologist

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1. Introduction

The NSW Government is identifying areas for future urban development and associated infrastructure in Western Sydney. Four priority Growth Areas (GA) have been nominated in South Western Sydney:

- Wilton Growth Area
- Greater Macarthur Growth Area (Campbelltown and Appin)
- Western Sydney Airport Growth Area (Aerotropolis)
- Greater Penrith to Eastern Creek Growth Area.

The locations of these four GAs are provided in Figure 1. All are located within the Cumberland Subregion Interim Biogeographic Regionalisation for Australia sub-region.

1.1 Purpose of the expert report

Section 6.5.2 of the Biodiversity Assessment Method sets out the following essential requirements for the preparation of an expert report:

- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made
- demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report
- identify the expert and provide evidence of their expert credentials.

The report needs to determine whether:

- The species is unlikely to be present, in which case no further assessment is required, or
- The species is likely to be present in which case the expert report must provide estimates of habitat area within the biodiversity certified development footprint.

1.2 Project context

The Department of Planning and Environment (DPE) has been tasked with preparing the Cumberland Plain Conservation Plan (the Plan) that will identify development and conservation outcomes within each of the above four listed GAs. The Plan will be strategically assessed and approved using Biodiversity Certification (Biocertification) enabled under the *Biodiversity Conservation Act 2016* (BC Act) and strategic assessment and approval to be carried out under *the Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The strategic assessment process will lead to:

- the identification of a preferred conservation outcome for the Cumberland Subregion
- an assessment of the likely impacts of proposed urban development
- identification of mitigation measures that deliver good conservation outcomes
- a streamlined development approval processes.

A biodiversity assessment report will be pepared to assess the conservation benefits and development impacts of the Plan and determine the acceptability of the conservation outcomes in the context of the above state and national legislation. The current approach is that DPE will prepare a single, integrated assessment report that addresses the requirements of both the BC Act and the EPBC Act. A core aspect of the conservation program will be the development of offsets for impacts on threatened biodiversity.

Biocertification is being used to identify conservation areas within the Cumberland Subregion that meet the criteria to be purchased for the required offsetting. Biocertification will ensure that biodiversity values are assessed, and conservation issues resolved early in the planning process. Certification supports a more streamlined and cost-effective land-release process than site-by-site assessment.

1.3 The study area

The location of the Cumberland Subregion and the four Growth Areas is provided in Figure 1. Information for each of these areas was determined from a range of data layers including:

- Native vegetation: CumberlandPlainWest_2013_E_4207 & SydneyMetroArea_2013_v2_0_E_3817
- LEP Layers Land Zoning (LZN)
- Altitude: Central West Sydney Surrounds 2m Contours & Contours 50m, Outer Sydney South 2m Contours, Central West Sydney Surrounds 2m Contours and Outer Sydney North 2m Contours
- Waterbodies: Roadnet MDS 2018
- Biodiversity Certification Land: Subject Lands for the Biocertification of Sydney Region Growth Centres SEPP and related EPIs (GrowthCentreLandCertification)

The Wilton Growth Area (hereafter WGA) is centred around the township of Wilton, which is approximately 63 km southwest of Sydney and covers an area of approximately 4082 ha. The WGA is approximately 23 km from the coast at its eastern boundary and covers an altitudinal range of 64 to 300 m ASL. Approximately 1824 ha (45%) of the WGA is covered in retained native vegetation, which is essentially confined to the southern end of the GA adjacent to an area of dissected escarpment. The majority of the WGA is rural agricultural land used for a variety of activities including grazing, hobby farming and cropping (Figure 2). There is relatively little road development across the majority of the WGA, with the major roads being restricted to the northern end where there is also the main centre of urbanisation (accounting for approximately 20% of the WGA). The WGA contains significant permanent streams in the form of the Nepean River that runs along or within its western and northern boundaries and Allens Creek that forms the northern half of its eastern boundary. Shepherds Creek runs off Allens Creek and into the central part of the GA. These stream all have largely retained riparian vegetation, albeit often highly disturbed, and so retain the potential to serve as significant corridors for vegetation dependent biodiversity. Numerous artificial water bodies (> 200) are mapped throughout the GA, with the exception of the area of the Wilton Township itself. Many more unmapped water bodies are present through the creation of farm dams and reservoirs (Figure 2).

The Greater Macarthur Growth Area (GMGA) is centred around the township Campbelltown-Macarthur, approximately 43 km southwest of Sydney, but extending from West Appin in the South to Glenfield in the north (Figure 3). The GMGA covers an area of approximately 11046 ha, is approximately 24 km from the coast on its eastern border and covers an altitudinal range of 4 to 262 m ASL. Approximately 3038 ha (28%) of this GA remains covered in retained native vegetation, which is also concentrated at the southern end, with the southern half dominated by land used for rural agricultural purposes and, as for the WGA, there is relatively little road development across this area. The M1 motorway runs along the western edge of the GMGA and likely represents a significant barrier to dispersal for biodiversity. The northern half of the GMGA is highly developed and heavily fragmented by numerous roads. Urbanisation covers approximately 35% of the GMGA area. The most significant river within the GMGA is the Nepean River and its tributaries that are located in the southern end of the GCMA, with the main River forming a large part of the western boundary of the GA. Sections of the Nepean have retained riparian vegetation, but large parts of the banks are essentially cleared or the vegetation highly degraded. Peter Meadows Creek flows east to west in the northern part of the GA and ultimately joins into the Georges River and so also provides some degree of potential connectivity as a corridor for movement. Numerous artificial water bodies have been created within the rural portion of the GMGA (Figure 3).

The Western Sydney Aerotropolis Growth Area (WSAGA) is centred around the township of Badgery's Creek, approximately 41 km west of Sydney and so the coast (Figure 4). The WSAGA covers an altitudinal range of 32 to 120 m ASL. The WSAGA includes a section that is outside the current GAs that is excluded from assessment in this expert report (area indicated in Figure 4). Within the assessed area, there is relatively little retained natural vegetation (approximately 865 ha or 13%) that is highly fragmented and with no patch larger than 137 ha. The WSAGA is predominantly rural agricultural land, with overall percentages being 83% rural lands and 11% urbanised. Road development follows the same pattern being very limited across the WSAGA. There creeks present within the WSAGA have patchy retained riparian vegetation. As for the other GAs there are numerous artificial water bodies present in the rural land-use areas (Figure 4).

The Greater Penrith to Eastern Creek Growth Area (GPEC) is located approximately 50 km west of Sydney (Figure 5). The GPEC is relatively flat, covering an altitudinal range of 8 to 102 m ASL. Retained native vegetation cover is minimal (3229 ha = 17%) and fragmented, but with a largest retained area of 549 ha. Unlike the other GAs, the majority of the GPEC is urbanised land (11867 ha = 64%) and rural lands account for only 3501 hectares (18%). There is substantial road development across the majority of the GPEC, which is likely to form a barrier to movement for any species existing within this GA. The Penrith Lakes form an obvious area of once natural wetlands (Figure 5), but much is highly modified for recreational use and this modification continues to increase. This system only partially falls in the GPEC. Major creeks or rivers within the GPEC are the Nepean River on the western boundary, the Ropes Creek system that runs through the eastern part of the GPEC and South Creek that runs through the centre of the GPEC. The riparian vegetation along these larger streams varied in extent and condition and they run usually through highly urbanised environments, preventing frogs from moving between them or to any other water bodies within the matrix, reducing their value as corridors. Artificial water bodies are scattered across the GPEC, but are not in the same numbers as to for the other GAs (Figure 5).

1.4 Reasons for use of an expert report

Section 6.5.2.8 b of the Biodiversity Assessment Method (OEH 2017) places two specific requirements for where an expert report can be used instead of surveys:

- an expert report can only be used instead of a survey for species to which species credits apply
- an expert report may be obtained instead of undertaking a species survey at a development site, clearing site, land to be biodiversity certified or a biodiversity stewardship site.

The GGBF meets the first criteria, being a species credit species under the *Biodiversity Conservation Act 2016*. For the second point, this report is being prepared for the consideration of impacts in the area of the Cumberland Plain Conservation Plan as part of a strategic biodiversity assessment involving biodiversity certification under the *Biodiversity Conservation Act 2016* and Strategic assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999*. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. Hence it meets the criteria as land to be biodiversity certified.

The GGBF is known to inhabit the types of landscapes present within all four of the GAs and records exist across much of the Cumberland Subregion (Figure 1). Insufficient field survey has been carried out to adequately assess the presence of the GGBF within the GAs, with extensive areas of potential habitat occurring on private lands that cannot be accessed. In addition, the spring/summer period over 2017/2018 had below average rainfall and rainfall is critical to initiate calling and reproduction in the GGBF. The conditions were sufficiently unfavourable to prevent an adequate survey outcome even in those areas that could be accessed (see Section 1.6). Activity of the GGBF at the best available reference site of Sydney Olympic Park indicated that very little calling took place over the designated survey period, minimising the chances of detecting any populations present within the four Growth Areas.

On that basis, an expert report was determined to be required for this species.

Credentials of expert

Dr Lemckert is an Ecologist that has been undertaking studies into the ecology and management of frogs since 1986 and has been a principal ecological consultant since 2011. His skills include survey design/ implementation/ targeted species surveys, data handling, analysis and interpretation and the production of high level reports including papers published in international peer-reviewed journals and technical reports and recovery plans for the Commonwealth and NSW Governments. He has also been an expert witness for the assessment of the impacts of alleged illegal clearing for the Commonwealth, NSW and Local Governments (Hornsby Council) and provided expert advice to NSW DPI for legal considerations over the potential for forestry operations to impact on rock outcrop dependent species. At the broadest level Dr Lemckert represented Forests NSW (now Forestry Corporation NSW) as a reptile and amphibian expert in the Comprehensive Regional

Assessments and Regional Forest Agreement Process carried out between 2000 and 2002 and as an expert in fauna management for negotiations over a new Threatened Species License for harvesting operations in 2014. He provided an expert review of the developed assessment process for impacts on Matters of National Environmental Significance for two proposed Coal Seam Gas Developments in Queensland and has completed two rounds of expert review of the status of Australia's amphibians for the IUCN.

Dr Lemckert is an acknowledged expert on eastern Australian frogs having completed his MSc and PhD on the ecology and management of frogs in this region and has published over 70 papers (or book chapters) in Australian and International peer-reviewed journals. He has been used by both the NSW and Commonwealth Governments as an expert witness in court cases assessing the impacts of land clearing on threatened frogs. He is member of the Amphibian Specialist Group of the IUCN, secretary of the NSW Declining Frog Working Group of NSW and past president of the Australian Society of Herpetologists. He co-supervised two PhD students, a Master of Applied Science Student and three Bachelor of Science (Honours) students who completed theses addressing issues of frog biology and conservation.

Dr Lemckert can demonstrate his expertise on the GGBF through the following publications and reports:

Lemckert, F.L., & Mahony, M.J. 2018. The status of Decline and Conservation of Frogs in Temperate Coastal South-eastern Australia. **Pp 59-72** In: *Amphibian Biology Volume 11 - Conservation and Decline of Amphibians: Eastern Hemisphere (Australia, New Zealand and Pacific Islands)*. H. Heatwole and J. Rowley (Eds.). CSIRO Publishing, Melbourne.

Lemckert, F.L. 2017. *Surveys for the Green and Golden Bell Frog at Meroo for the Saving our Species Research Program*. Report to NSW Office of Environment and Heritage.

Mahony, M.J., Hamer, A.J., Pickett, E.J., McKenzie, D.J., Stockwell, M.P. Garnham, J.I., Keely, C.C., Deboo, M., O'Meara, J., Pollard, C.J., Clulow, S., **Lemckert, F.L.**, Bower, D.S., & Clulow, J. 2013. Identifying conservation and research priorities in the face of uncertainty: a review of the threatened bell frog complex in eastern Australia. *Herpetological Conservation and Biology* **8:**519-538.

Penman, T.D. & **Lemckert F.L.** 2008. Monitoring the green and golden bell frog: current problems and an alternative approach. *Australian Zoologist* **34:**373-378.

Hero, J-M., Gillespie, G., Cogger, H., **Lemckert, F.** & Roberston, P. 2008. *Litoria aurea*. Pp 256 In: *Threatened Amphibians of the World.* S.N. Stuart, M. Hoffman, J.S., Chanson, N.A. Cox, R.J. Berridge, P.J. Ramani & B.E. Young (Eds). Lynx Edicions, Barcelona, Spain.

Hero, J-M., Gillespie, G., Cogger, H., **Lemckert, F.** & Robertson, P. 2004. *Litoria aurea*. The IUCN Red List of Threatened Species 2004: e.T12143A3325402. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T12143A3325402.en. Downloaded on 17 May 2018.

Lemckert, F.L. 1998. *Survey report for the green and golden bell frog at Badgerys Creek, NSW*. Unpublished report for Biosis Pty. Ltd.

Lemckert, F.L. 1996. Surveys for the green and golden bell frog, *Litoria aurea*, by the State Forests of New South Wales. *Australian Zoologist* **30:**208-213.

In addition, he is recognised as an expert in the species having been engaged by:

- NSW Office of Environment and Heritage to be part of the expert panel determining the categorisation of this species under the Saving Our Species (SOS) program and in determining the populations requiring specific management to meet the SOS requirement to have a viable population maintained 100 years into the future.
- NSW Roads and Maritime Services to conduct expert surveys for this species in the area around Sydney Airport, Gerringong, Shortland to Sandgate, South Nowra and Berry to Bomaderry, locating the species at Gerringong and South Nowra (2011-2016).
- Port Kembla Coal Terminal to conduct annual ongoing monitoring of this species as part of a Green and Golden Bell Frog Management Plan (2014-2017).
- John Holland Group and Daracon to provide expert advice and survey for this species at Kooragang Island for a rail and road corridor upgrade (2015-2016).
- EPBC surveys for the GGBF at Port Kembla to determine the presence/absence of this species in relation to a proposed development along Masters Road (2014).
- Repeat surveys at Wollongong Golf Course as part of pre-clearing of drainage culverts (2013).
- Provided expert opinion on the status of this species during assessments undertaken for the IUCN in 2001 and 2016.
- Provided expert opinion on the habitat requirements, sub-population status and reservation requirements for the Green and Golden Bell Frog during the NSW Government's Comprehensive Regional Assessment program (2000-2001).
- Distribution surveys through its historic range between Sydney, NSW, and the Gippsland area of eastern Victoria, as part of a project to look at overlap zones and pre-mating isolating mechanisms between the GGBF and the Southern Bell Frog (*Litoria raniformis*) (1986-1987).

Specific to the Growth Areas, Dr Lemckert has:

- Carried out a series of surveys for the GGBF to meet EPBC standards for the development of the Franciscan Monastary Site on Narrellan Road at Blair Athol.
- Undertaken a survey for the GGBF in the study area for the proposed second airport at Badgery's Creek.
- Conducted biodiversity surveys in the Cordeaux catchment area as part of mine site impact assessments.

Dr Lemckert's full CV is provided as Appendix A of this report.

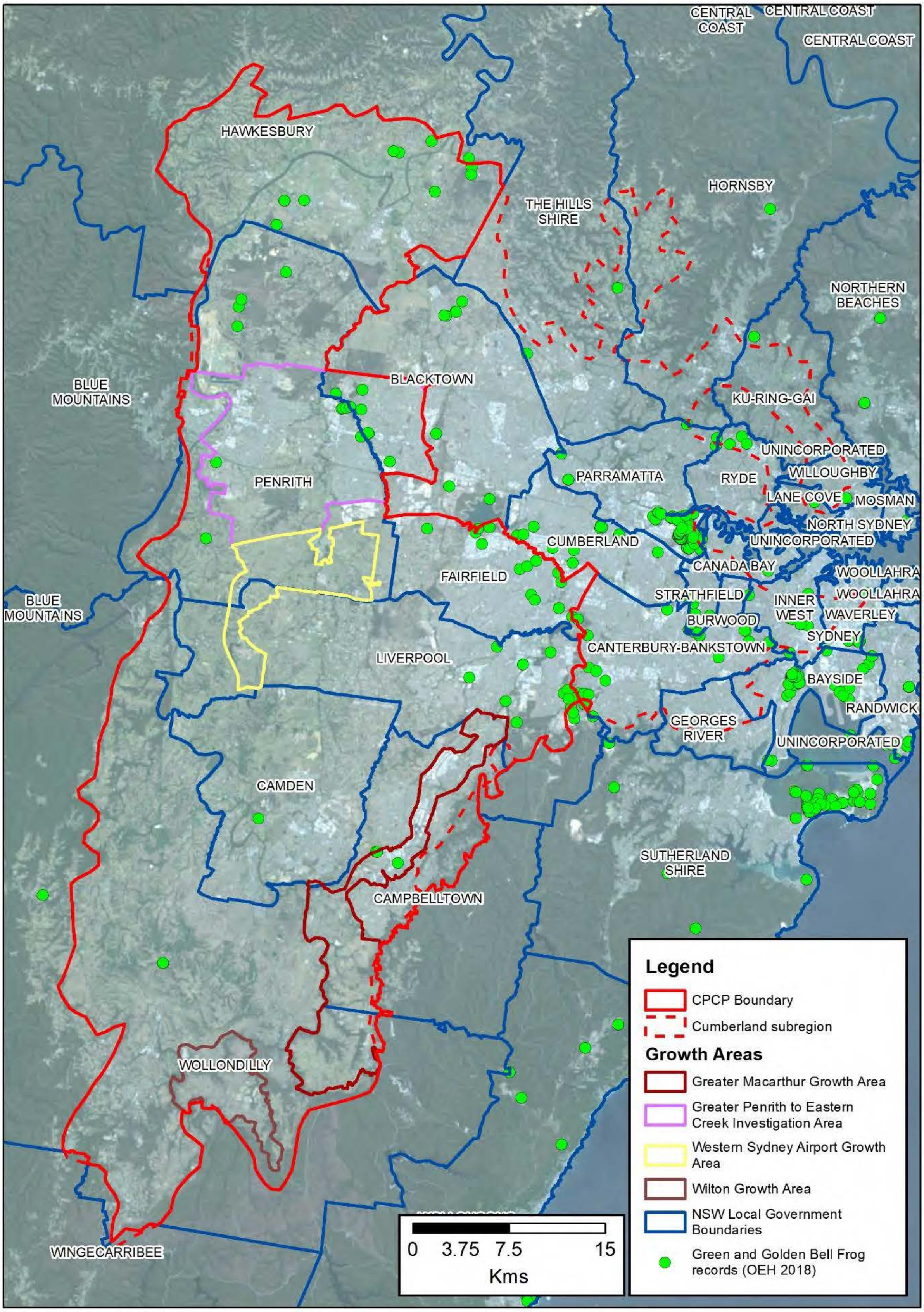

Figure 1. Location of the Cumberland Subregion and associated records for the Green and Golden Bell Frog

1.5 Species surveys conducted on behalf of the Department of Planning and Environment

The following information was provided for the survey process adopted for this project.

Land Access

The Department of Planning and Environment (DPE) sent letters to all landholders within the development footprint.

An initial 726 letters were sent to landholders within the Wilton and Greater Macarthur Growth Areas in late 2017 with a second letter following in March 2018. To increase the response rate, Biosis commenced targeted door-knocking in May 2018. From these efforts, just under 20% of landholders within these growth areas allowed access to their property. However, this included access to large parcels of land owned by major developers which allowed a reasonable amount of access, particularly for the Wilton Growth Area.

A total of 432 letters were sent to landholders across the WSAGA between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking, resulting in a response rate of 21%.

Targeted letters were sent to landholders in the GPEC from November 2017 and August 2018 and 177 landholders provided access to their properties. An additional three landholders provided permission via doorknocking (12% response rate). The Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council.

Targeted survey for threatened species

Field sampling was undertaken across the four growth areas by consulting ecologists from Biosis and Ecoplanning. Targeted survey for threatened fauna species has been conducted on lands where access has been granted, or through ‘drive by’ and ‘over the fence’ assessments. Targeted fauna survey conducted by Biosis focused on Gang-gang Cockatoo, Glossy Black-Cockatoo, Large-eared Pied Bat, White-bellied Sea-Eagle, Little Eagle, Square-tailed Kite, Cumberland Plain Land Snail, Southern Myotis, Squirrel Glider and Greater Glider. No frogs were included in this survey, but there was still the potential for the GGBF to be detected incidentally.

Extent of surveys

The extent of the surveys undertaken for fauna have been provided by Biosis and are provided in Appendix 1. The survey tracks indicate that a relatively broad area set of surveys have been conducted in each of each GAs, but that still extensive sections of each GA have had no coverage.

2 Species information

2.1 Species description

The GGBF is an endemic Australian tree frog that is a member of the family Hylidae. It is a relatively large species, ranging in an adult size for males of 57-69 mm and females 65-108 mm snout to vent length (Tyler and Knight 2009). The species gets its name from the typical colour of the body which is often a vivid green splotched with gold. However, in some individuals the back may be almost entirely green whereas other have dominant gold markings (See Plates 1-3 in Appendix 2). There is a pale creamish-white stripe running along the side, extending from the upper eyelids usually almost to the groin. The species also has blue or bluish-green markings in the thighs and groin. The snout is relatively pointy and the belly granular. There is rarely a mid-dorsal stripe, which distinguishes this frog from the Southern Bell Frog, *Litoria raniformis*.

Plate 1. Typical adult Green and Golden Bell Frog

2.2 Life cycle

The GGBF is considered to have a calling season that extends from spring to autumn (Lemckert and Mahony 2008). Within that period of time calling is tied strongly to rainfall events. The advertisement call is a “whaaark whaaark whaark whark” that is produced by the male. Calling occurs mainly at night, but occasionally males will call during the day when conditions are especially favourable (DEC 2005). The males call in groups floating on the surface of the water usually holding on to emergent vegetation, with males synchronising their calls with a lead calling male so that they all call essentially at the same time (Barker et al, 1995; Pyke and White 2001). This may help to confuse predators by masking individual calls. Male GGBF reach sexual maturity at around 45–50 mm snout-vent length (DEC 2005), which would usually be reached in the first season after metamorphosis.

Females of the GGBF reach sexual maturity at a snout-vent length of around 65 mm, which usually takes to their second season after metamorphosis (DEC 2005). Female GGBF produce a particularly large number of eggs for an Australian species, with Pyke and White (2001) suggesting an average clutch size is about 3700 eggs, but with van de Mortel & Goldingay (1996) recording a maximum clutch of 11,682 eggs. Egg size is around 4 mm in diameter.

Spawn is laid among aquatic vegetation, with it initially floating on the water surface as a mass, but sinking within 24 hours of being laid. The eggs typically hatch 2–5 days after ovipositing/fertilisation (Anstis 2013) with water temperature playing a role in development time (eggs hatch faster in warmer water) and can hatch in less than one day.

The tadpoles can tolerate salinity levels of six parts per thousand (ppt) without any apparent effects, while salinity of 8 ppt or higher decreases growth rates and increases mortality rates (Christy and Dickman 2002). The pH of a pond does not appear to affect the likelihood of the eggs to hatch (Pyke and White 2001).

Tadpoles grow at variable rates depending on conditions and availability of food. They can reach up to 80 mm in length before metamorphosis, although they will do so at smaller body lengths. Time to metamorphosis is variable and dependent on conditions and time of year, taking between two and eleven months, but with a mean of three months (Anstis 2013). Tadpoles may overwinter if breeding occurs late in autumn. They would be expected to typically eat algae and other aquatic vegetation and can often be seen sucking at the surface of the water, presumably to take in organic material floating on the water surface. But their actual diet has not been studied. As for most species, it is likely that tadpoles will also eat dead animal material if it is available, including other tadpoles.

2.3 Distribution and abundance

Broad distribution

The distribution has been recorded as from Yuraygir National Park on the far North Coast of NSW to around Lakes Entrance in south-eastern Victoria (White and Pyke 2008). Notably, Courtice and Grigg (1975) completed a detailed study of the distribution of the GGBF and in Gippsland found it only as far west as Marlo where it abutted and had a potential hybrid zone with *Litoria raniformis*, which was the species found to the west of that point. In the mid-1980s the species was recorded at least 60 km further west at Nowa Nowa and *Litoria raniformis* were no longer present in that location (F. Lemckert Pers. Obs.) and then 15 km further west at Lakes Entrance by White and Pyke (2008). This may suggest a slight westward expansion of the species in Victoria since the 1970s. Historically the species was known from a number of sites at least 50 km inland into the NSW ranges including at Bathurst (White and Pyke 1999), Bungendore (Humphries 1979) and 30 km inland at Ulong on the NSW north coast (Moore 1961). The furthest and now only extant “inland” population is near Hoskinstown in the Southern Tablelands of NSW (Osborne et al. 2008). Natural GGBF populations are also known from three islands off the coast of NSW; Bowen Island, Kooragang Island and Broughton Island (DEC 2005). Extra-limital populations have been introduced to New Zealand (Pyke et al. 2002), and New Caledonia and Vanuatu (Pyke and White 2001) with the species occurring in high densities in some areas (M. Mahony Pers. Comm.).

The extent of occurrence of the species in 1999 within Australia was estimated to be approximately 150,000 km² (Mahony 1999), but there are no more recent estimate and the extent of occurrence is probably continuing to reduce as populations are known to be continuing to decline (Mahony et al. 2013).

Distribution one the Cumberland Subregion

A total of 13146 records for the GGBF are available on the Cumberland Subregion (based on NSW BioNet records), with the broad distribution of these records being shown in Figure 1. This is a large number of records, but is highly skewed by the records from Sydney Olympic Park and the majority (>95 %) come from the eastern third of the Cumberland Subregion, none of which is included in the GAs. The records from the actual GAs are very limited, with just 12 record sites being available from the GPEC and two from the GMGA. The limited number of records in the western half of the Cumberland Subregion suggests that the GGBF may never have been common or widespread across this region, despite the apparently adaptable nature of this frog (see Section 2.4) and the presence of habitat that otherwise looks suitable for the GGBF.

The Draft NSW GGBF Recovery Plan (DEC 2005) lists one core populations for this species located within or near a Growth Area, being the St Marys population centred around St Marys, Mt Druitt, Prospect and Riverstone that is part of the GPEC.

Abundance

The GGBF was recorded as once being a very abundant and widespread frog (Goldingay 1996). Fletcher (1889) stated that this species was commonly be encountered in the Sydney area and Harrison (1922) noted that this species was "probably our best known frog" and was "known to me since childhood". Extensive surveys for the species by Courtice and Grigg (1975) in the early 1970s recorded it very regularly and abundantly across coastal NSW and into southeast Victoria. However, there was a serious decline of the species in the 1980s, with the timing being uncertain, but with frogs having disappeared from many historic sites by 1987 (F. Lemckert Pers. Obs.). By 1996 the GGBF was regarded as rare by White & Pyke (1996) and its recorded declines recognised to be of concern (White 1995). Populations of over 1000 frogs were (and likely still are) present at Kooragang Island, Broughton Island and Homebush (Hamer et al. 2002), but the other locations it is known from are much smaller populations (DEC 2005). Even in 2005 the GGBF was recognised as having declined to less than 50 populations in NSW (DEC 2005) and the declines have been continuing (Mahony et al. 2013). The amphibian chytrid fungus has been implicated as the main driver of these severe declines (Mahony et al. 2013), although habitat loss (Goldingay 1996) and introduced predatory fish (Pyke and White 1999, Goldingay 2008) have also been suggested to have played significant roles in population declines and losses.

Over the short-term the GGBF can exhibit significant local population fluctuations when conditions result in high tadpole survivorship (eg, Daly 2014). The GGBF has a life cycle that fits what is termed to be an R-selected species (Hamer and Mahony 2007), producing large numbers of offspring and adults have relatively shorter lifespans. Hence, there is a relatively rapid turnover of individuals and survival of the local population depends on occasional very successful seasons, when population size and area utilised rapidly increase, interspersed with years of low recruitment when numbers fall away and there are local extinctions in less favourable areas of habitat. This is considered to be a typical pattern for amphibians (Alford and Richards 1999). In fact, The GGBF has been suggested to be a colonising species with a series of its attributes suit this lifestyle: habitat generalist, high fecundity, rapid growth, early sexual maturity, and relative high dispersal ability (Hamer & Mahony 2007). White and Pyke (1999) suggests that the GGBF rapidly move into areas of newly created breeding habitat that represent sites with little competition for the developing tadpoles from other species, are open and so provide good thermal environments and lack or have minimal predators such as dragonfly larvae or fish present. Such a lifestyle is atypical of frog species that have undergone significant broader declines.

Nearly all currently known populations within Australia are located within 10 kilometres of coastal locations (Mahony et al., 2013). This is most likely due to the inhibition of the amphibian chytrid fungus by salt, either through flooding or windborn, as the fungus in relatively intolerant of salt (Stockwell et al 2012). Hence more coastal locations are relative havens from the impacts of chytrid. As, salinity levels of at least 1–2 ppt can be beneficial to the GGBF because this kills pathogens such as the chytrid fungus. Interestingly, Christy and Dickman (2002) identified saltwater intrusion in coastal wetlands due to landscape changes to be a potential threat to GGBF breeding sites. Dryland salinity might then also represent a threat to GGBF should it occur, but this seems to be a minimal issue based on current evidence.

Plate 2. Examples of typical breeding habitat for the Green and Golden Bell Frog at: a) Wilton and b) Penrith Lakes – large permanent ponds with emergent and/or fringing vegetation.

Plate 3. Examples of habitat at Ropes Creek: a) Bushland for foraging and b) Dry creek bed that would flood to form breeding habitat.

2.4 Habitat requirements

Breeding Habitat

Breeding sites for the GGBF include a wide range of natural water bodies and the species has been recorded inhabiting all but fast flowing streams (Pyke & White 1996). It also inhabits many human-created environments, including highly disturbed sites such as abandoned mines and quarries (Pyke et al. 2002), as well as artificial wetlands that have been created at both Kooragang Island (Hamer et al. 2002) and Sydney Olympic Park (Darcovich and O'Meara 2008). Pyke & White (1996) undertook a review of the known breeding habitat of the GGBF and found that they preferred to breed in water bodies that were still, shallow, ephemeral, unshaded, with aquatic plants and free of the Plague Minnow (*Gambusia holbrooki*) and other predatory fish. This study also found that breeding occurs in a significantly higher proportion of sites with ephemeral (temporary) ponds, rather than sites with fluctuating or permanent ponds. Hamer et al. (2002) found a similar result for the GGBF populations at Kooragang Island where larger males would move to ephemeral water bodies to opportunistically breed at them, although reproduction was also associated with permanent water bodies. The frogs in that study also tended to remain relatively faithful to one water. The presence of the Plague Minnow does not exclude GGBF from breeding in a water body, but success appears to be dependent on the presence of more complex aquatic vegetation, which allows the GGBF to breed successfully (Hamer et al. 2002). Hence the Plague Minnow does still appear to have a significant role in determining the likely presence of the GGBF in most situations.

Non-breeding habitat

Non-breeding habitat for the GGBF is unusual for an Australian frog in that the species appears to remain generally associated with water bodies (remain within 50 metres) rather than dispersing away from water bodies into more terrestrial non-breeding habitats (100-300 metres from the breeding site), which is typical of most frogs (Lemckert 2004). Terrestrial habitats immediately adjacent to water bodies are used for foraging and shelter and preferably consist of grassy areas and vegetation no higher than woodlands and contain a range of diurnal shelter sites such as logs, rocks or dense vegetation (Pyke and White 1996). However, there are observations of GGBF using taller forests (eg. dry sclerophyll forest at Nowra; M. Greenlees Pers. Comm. and dense woodlands at Meroo, FL Pers. Obs.) and foraging in suburban backyards (DEC 2005), again demonstrating the apparent adaptability and lack of habitat specificity of this frog. Females have been observed to show site fidelity for shelter and foraging sites in areas adjacent to breeding sites (Hamer 1998, Pyke and White 2001).

Shelter sites are used when GGBFs are inactive and so vulnerable and are of added importance in providing secure over-wintering locations. Studies at Kooragang Island have suggested that females may use slightly different non-breeding areas to males and may have very important and specific over-wintering areas located in dense vegetation (M. Mahony Pers. Comm.). Whether this is the same for other populations is unknown, but there is evidence from Sydney Olympic Park that females there also concentrate in certain locations (J. O'Meara Pers. Com.).

Another unusual aspect of the GGBF is its well known habit of basking, typically within areas of aquatic vegetation, apparently to increase body temperatures (Pyke and White 2001). Basking in frogs is unusual (being generally nocturnal), but such activities in ectotherms typically allow for periods of greater activity or faster digestion of food items and, whilst the importance of this activity for its physiological requirements is not known, individual GGBF appear to bask regularly. On this basis, it is likely that basking is an important physiological activity for the GGBF. Basking typically occurs within or on the edge of emergent aquatic vegetation, which likely allows individuals the option to make a rapid escape from diurnal predators. The presence of water bodies that contain emergent vegetation are known important determinants of the presence of GGBF (Pyke and White 1996; Hamer et al. 2002) and form an important resource for the GGBF and in the consideration of their potential presence.

Whilst GGBF may retain a closer association with water bodies and appear to generally be faithful to a single water body for their general activities, they can move along and between different water bodies, particularly as part of migrations to and from breeding sites (Hamer et al. 2002). Studies have revealed that the species move distances of up to 1 kilometre (Hamer et al. 2008) and mark/recapture studies have found individuals moved up to 3 kilometres (Pyke & White 2001). Individual GGBF even have the potential to disperse as far as 10 kilometres (White & Pyke 2008). There are records of GGBFs several hundred metres from major drainage lines or other waterbodies (Gillespie 1996) and this may represent long-distance dispersal between water bodies. Hamer et al. (2008) noted that male GGBFs at Kooragang Island often moved > 200 metres to reach an ephemeral breeding site, crossing over extended grassland areas and other habitats including disturbed habitats.

Christy (2001) and Muir (2008) indicated that terrestrial movements of the GGBF are primarily undertaken through more open environments that contained patches of shelter such as rocks, logs or ponds or areas of thick vegetation. Such habitats provide relatively little impediment to the movements of frogs, but allow for individuals to seek shelter as required. Terrestrial movements are typically undertaken at night and are most likely associated with rainfall events (F. Lemckert Pers. Obs.) which would provide protection against desiccation.

Mahony (1999) cautions that the studies that have been carried out since the declines of the GGBF do not necessarily identify the actual preferred requirements of the species. He notes that the changed environment and factors causing the declines may have “altered” the optimal habitats for the species in comparison to their habitat use patterns prior to the declines. This is based on the fact that the use of ephemeral breeding sites was not noted for the bell frog group in earlier habitat descriptions. Such altered habitat use has been noted for other species such as *Litoria lorica* that now is only present in open rocky streams whereas it was once known as a rainforest stream species (Puschendorf 2011). This change is attributed to the impacts of the chytrid fungus, with the frog only surviving in a relatively extreme environment where the fungus is affected by the hotter conditions. Given the chytrid fungus appears also to have been at least a significant contributor (and probably the major one) to the decline of the GGBF, there is a significant potential that the GGBF is now living successfully only in a different set of environments to what it historically did. However, that is unlikely to ever be confirmed.

Metapopulation dynamics

A critical consideration in the likely presence/absence of the GGBF are metapopulation dynamics. The GGBF is considered to follow a classical metapopulation structure with the “local” population consisting as a series of patchy populations within the larger metapopulation. Individuals move regularly between a mosaic of wetlands across a broad area throughout a single breeding season (Hamer et al. 2008; Hamer & Mahony 2010). There is high site-specific population turnover with local extinctions being balanced by colonisations by regularly dispersing individuals, but with the overall population remaining stable. There are core sites that provide ongoing and regular reproductive success and that maintain long-term populations, but the major part of the population dynamics is driven by inter-year success of breeding at a range of available breeding sites, with years of very good reproductive success leading to opportunities to expand ranges and colonise new sites. On Kooragang Island, GGBF typically reside in permanent waterbodies where they exhibit high site fidelity, but during periods of high rainfall disperse over several hundred metres to breed at ephemeral water bodies that have flooded (Hamer et al. 2008). Reproductive activity (e.g. calling) typically occurs over several nights at these ephemeral waterbodies, with individuals returning to core permanent waterbodies. In times of poor rainfall, the core sites become the refuges for the species and Valdez et al. (2015) found that probability of occupancy of a site increased at large and permanent wetlands.

Following on from this is the identified need for connected sites to allow this population interaction. Hamer (2016) found that the presence of the GGBF at sites at Nowra was dependent on accessibility of ponds, a factor mediated both by the presence of vegetation and the extent of roads in the area, with the presence of roads providing a likely serious barrier to pond use. The presence of vegetation directly around ponds correlated significantly with the potential for greater species diversity. The type of pond available also was important, with the species avoiding steep sided concrete ponds. The apparent negative impacts of roads was confirmed in follow up work (Hamer 2018) where it was again found that the extent of accessible habitat (habitat close to ponds and not isolated from the pond by a road) positively influenced the likelihood of pond occupancy. Extinctions of GGBF were significantly more likely to occur at ponds in areas with higher densities of roads, but were significantly less likely at ponds with higher aquatic vegetation cover. The spatial arrangement of wetlands and the extent of wetlands measured in a 1 kilometre radius has been found to be an important predictor of pond occupancy by GGBF in studies by Hamer et al. (2002), Hamer and Mahony (2010) and Valdez et al. (2015) with more ponds, closer together ponds and already occupied ponds increasing the potential for the GGBF to be present or occupy a previously unoccupied pond (Puschendorf et al. 2011).

This information provides the following important points when trying to assess the potential presence of the GGBF in any area:

- The GGBF is more likely to be present where multiple suitable breeding sites are within a close enough proximity for frogs to migrate between them with relative ease
- The GGBF is more likely to be present where multiple non-breeding water bodies are present in an area and within close enough proximity to allow migration between them (and breeding sites) with relative ease
- The GGBF is more likely to be present where the connectivity of breeding and non-breeding habitat contains a matrix (vegetation and shelter) that facilitates migration
- The GGBF is more likely to be present at a location when there are other GGBF occupied ponds in close proximity.

Vegetation associations

The OEH profile records the GGBF to be associated with a broad range of vegetation formations and classes within the Sydney Basin Interim Biogeographic Region, the location of the GAs (https://www.environment.nsw.gov.au/threatenedspeciesapp/profileData.aspx?id=10483&cmaName=Sydney+Basin). These are:

Dry sclerophyll forests (shrub/grass sub-formation)

Cumberland Dry Sclerophyll Forests

Dry sclerophyll forests (shrubby sub-formation)

Sydney Coastal Dry Sclerophyll Forests
Sydney Hinterland Dry Sclerophyll Forests

Forested wetlands

Coastal Floodplain Wetlands

Freshwater wetlands

Coastal Freshwater Lagoons

Grassy woodlands

Coastal Valley Grassy Woodlands

Miscellaneous ecosystems

Highly disturbed areas with no or limited native vegetation
Water bodies, rivers, lakes, streams (not wetlands)

Rainforests

Dry Rainforests

The most important feature to note is that this list of vegetation associations is relatively broad covering wetlands and swamps, woodlands, dry sclerophyll forests and dry rainforest. That is essentially all possible environments present within the Cumberland Subregion and reflects the understanding that the GGBF is a very adaptable species with little in the way of habitat limitations. This also conforms with the GGBF being recognised for its use of highly disturbed environments and areas without native vegetation. In the context of assessing the likely presence/absence and, if present, the abundance of this species, the type of vegetation present has little relevance. The value of vegetation is it being present to provide GGBF shelter and locations where food may be found.

2.5 Threats

The GGBF is listed as is listed as endangered under the BC Act and vulnerable under EPBC Act.

The IUCN lists the threats to the GGBF as "IUCN: "*The cause(s) of the apparent declines observed in populations of all taxa within the L. aurea complex are unclear (Gillespie et al. 1995).*

Investigations of disappearances among the group have primarily focused on L. aurea and L. castanea and two major directions in research have been pursued: the role of increased ultraviolet radiation; and the impact of the introduced fish, Gambusia (Mahony 1999). It is also possible that disease, such as a viral infection or chytrid fungus, might have contributed to the decline of this species (W. Osborne pers. comm.). Chytrid fungus was detected in this species in Hoskinstown and Homebush Bay in Sydney, New South Wales".

The OEH profile for this species lists the following as threats to this species:

- Alteration of drainage patterns and stormwater runoff.
- Frog Chytrid Fungus, a fungal pathogen.
- Predation by feral animals such as foxes.
- Herbicides and other weed-control measures.
- Road mortality, where populations are already small due to other threats.
- Predation by exotic fish such as Plague Minnow.
- Loss of suitable breeding habitat through alteration by infilling and destruction of wetlands.
- Current knowledge of the status of the population and threats to the population is poor.
- Species occurs on private land where land management practices may not be suitable for the species, e.g. grazing and loss of breeding habitat.
- Changes in salinity due to sea level rise. Frogs are unable to breed in waters with salt concentrations of greater than 6 parts per 1000.
- Overgrowth of pond vegetation leading to declining water temperature.
- Small population size.
- Lack of information regarding habitat permanency.
- Drying of breeding habitat as a result of increased temperatures and more frequent droughts.
- Lack of landscape connectivity leading to isolation of small populations.
- Heavy metal pollution.
- Four-wheel drives impacting habitat.

The SPRAT profile for this species lists the following threats:

- Habitat removal.
- Habitat degradation (which includes siltation, changes to aquatic vegetation diversity or structure reducing shelter, increased light and noise, grazing, mowing, fire).
- Habitat fragmentation.
- Reduction in water quality and hydrological changes (for example, pollution, siltation erosion and changes to timing, duration or frequency of flood events).
- Disease (for example, infection of the frog with chytrid fungus (*Batrachochytrium dendrobatidis*) resulting in chytridiomycosis).
- Predation by introduced predators including the Plague Minnow (*Gambusia holbrooki*), Cats (*Felis catus*) or Foxes (*Vulpes vulpes*).
- Introduction or intensification of public access to GGBF habitats.

In regards to the GAs, the following would be of relevance when considering impacts:

- habitat loss (through changes resulting from flooding)
- fuel reduction burning
- introduced aquatic predators (access to breeding streams)
- spread of the amphibian chytrid fungus.

One specific consideration for the likely presence and abundance of the GGBF is the location of a site relative to the coast with essentially all currently known populations located within 10 kilometres of the ocean (Mahony et al. 2013). This is likely to be a result of the impacts of the amphibian chytrid fungus, with the influence of salt closer to the coast inhibiting the growth of the fungus to a sufficient degree to minimise its otherwise very serious negative effects.

3 Description of the study area

3.1 Land use history

The following information has been derived from the Cumberland Plain Recovery Plan (DECCW 2010a). At the time of European settlement, the Cumberland Subregion would have consisted of extensive areas of grassy woodlands were present along with wooded areas including ironbark and turpentine forests, dry rainforests, and floodplain communities. Agricultural development commenced before 1800 and by the middle of the 19th century most of the region was either being grazed or was cultivated. Clearing for agriculture was later supplemented by clearing for residential, commercial and industrial purposes.

NPWS (2002) noted that only 13% of the pre-1750 extent of the region's vegetation remained as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas. The majority (76%) of the remaining bushland is privately owned, and only 8% is protected within the formal reserve system. The region's bushland is also highly fragmented, comprising 2,446 individual remnants (DECCW 2010b), but the 81 largest remnants contain 51% of the remaining bushland. Many of these large, intact remnants occupy public land and so can be expected to be maintained into the foreseeable future. Larger remnants are typically more diverse and resilient than smaller remnants, being less susceptible to 'edge effects' and being less likely to be fully subjected to catastrophic events. Biodiversity loss caused by habitat fragmentation has been demonstrated to significantly increase once clearing levels exceed 70% of the landscape (Freudenberger et al. 1997; WALGA 2004) and this threshold has been passed on the Cumberland Subregion.

3.2 Landscape context

Cumberland Subregion

Tozer (2003) notes that the Cumberland Plain is based on the extent of soils derived from three main geological units: Wianamatta group shales, Tertiary alluvium and Holocene alluvium (in areas draining Wianamatta group shales). Tozer states that:

"*West of Parramatta, the Cumberland Plain forms an elongated ellipse stretching from Sackville in the north to Thirlmere in the south, with the western boundary marked by the monocline of the Blue Mountains to the west of Penrith. East of Parramatta the Plain is truncated by the*

Hornsby Plateau in the north and the Woronora Plateau to the south, and finally terminates near the city centre.

The Cumberland Plain comprises gently undulating plains and low hills, rising gradually from the flat, low lying areas just above sea level in the north to an altitude of around 350 m on the rolling hills of the Razorback Range in the south. Two low ridgelines project northward from this elevated southern region as far as Mount Druitt and Orchard Hills respectively. The eastern ridge forms a watershed between the drainage channels flowing north to the Hawkesbury River and those draining east into the Georges River. Separating the two ridges is the upper catchment of South Creek, which forms the major drainage channel of the Plain. Rising gradually to the north-west of the Plain, the broadly dissected Hornsby Plateau lies between 100 to 200 m above the northern half of the Plain. On the Hornsby Plateau, Wianamatta Shale soils are located predominantly along three broad ridgelines running approximately north-west from North Sydney to Hornsby and from Ryde to Castle Hill, and north from Castle Hill to Arcadia."

Tozer 2004 also provides the following summary of geology and soils, which in turn is derived from Chapman and Murphy (1989), Hazelton et al. (1990) and Bannerman and Hazelton (1990).

"*The oldest geological units outcropping within the study area are of sedimentary origin and were laid down during the middle Triassic period. Of these, the Wianamatta group is the dominant feature and occurs throughout the Cumberland Plain and on plateau tops and ridges on the Blue Mountains and Hornsby plateaus. It comprises claystone, siltstone, laminite and fine to medium grained lithic sandstone weathering to low fertility soils ranging in texture from loam to heavy clay. The Wianamatta group conformably overlies the discontinuous Mittagong Formation and Hawkesbury Sandstone. The former comprises inter-bedded and laminated, fine to medium-grained quartz sandstone and siltstone, and constitutes passage beds between the Wianamatta Group and the Hawkesbury Sandstone.*

Hawkesbury Sandstone weathers to form sandy–loam soils of very low fertility. The Mittagong Formation and Hawkesbury Sandstone outcrop on the margins of the study area especially along watercourses where the overlying shale has eroded during the development of a streambed.

On the Cumberland Plain, the Wianamatta group is overlain by unconsolidated sediments deposited in two geological periods. The deposition and reworking of silty-clayey sands and gravels along watercourses has been ongoing throughout the Quaternary period. These constitute some of the most fertile soils of the Plain and are particularly extensive on the floodplains of the Hawkesbury–Nepean River in the north of the study area. Sediments dating from the Tertiary Period occur in two main localities: to the south of Richmond in the north-west part of the study area and south of Liverpool in the south-east. These comprise sand, clay, gravel and volcanic breccia of both colluvial and alluvial origin and give rise to soils of low fertility. In the vicinity of Agnes Banks tertiary sediments are overlain by low parallel dunes of quartz sand eroded from the upper catchment of the Hawkesbury–Nepean and deposited by wind during the quaternary period. These sandy soils are of very low fertility."

Key climate statistics for the weather stations located within each GA are shown in Table 1. These data show a decreasing mean maximum from north to north and a corresponding increase in mean minimum temperatures, which is mainly due to the north to south increase in elevation.

Rainfall is relatively similar across the range except that the far northern area at Penrith Lakes has a distinctly lower mean rainfall.

The NSW BAM provides no mandatory applicable habitat constraints for the GGBF, but includes following indicative habitat constraints as being within 1 kilometre of semi-permanent/ephemeral wet areas, within 1 kilometre of swamps and within 1 kilometre of water bodies. This mirrors the understanding of the requirements of the species provided in Section 2.4.

Table 1. Key climatic statistics for weather stations in the Growth Areas (taken from the Bureau of Meteorology).

Weather station	Mean annual rainfall (mm)	Mean maximum temperature (°C)	Mean minimum temperature (°C)
Penrith Lakes AWS	718.6	31.0	5.3
Orchard Hills Treatment Works	832.7	28.5	5.3
Badgerys Creek McMasters F	794.3	28.6	3.8
Camden Airport	782.1	23.8	10.3
Picton Council Depot	800.9	23.4	8.8

Growth Areas

All four GAs contain at least some parts that provide a diversity of water bodies including streams and rivers in dissected gorges, streams on more open floodplains (historically probably chains of ponds), large numbers of farms dams and reservoirs and numerous ephemeral water bodies located amongst pasture lands. The lands also include industrial sites that may hold settling ponds and bunded areas for water collection as well as old quarries and excavations that hold water. All of these water bodies form potentially suitable breeding and shelter sites for the GGBF

3.3 Native vegetation communities

The remnant native vegetation of the Cumberland Subregion is very varied in nature and consists of wet and dry forests, woodlands with grassy and shrubby understories and wetland and riparian vegetation communities. The different PCTs listed as occurring across the four GAs are:

Dry sclerophyll forests (shrub/grass sub-formation)

- 724 Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion;
- 725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.

Freshwater wetlands

- 781 Freshwater wetland.

Grassy woodlands

- 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion;
- 835 Forest Red Gum - Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion;
- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion;
- 850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion.

Dry sclerophyll forests (shrubby sub-formation)

- 774 Coast Banksia scrub on sand of the Elderslie area, Sydney Basin Bioregion;
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion;
- 1081 Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion;
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion.

Forested wetlands

- 1105 River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion;
- 1292 Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion;
- 1800 Swamp Oak open forest.

4 Assessment of species presence and habitat

4.1 Existing records and surveys

The records of the GGBF available within the boundaries of the priority GAs are shown in Figures 2-5. These figures also provide the locations of records from areas immediately adjacent to the GAs, which are also be important to consider when meeting the requirement that multiple pond populations exist in close proximity and need to be linked in order to maintain metapopulation processes. The existing records demonstrate that:

- There are no records present within the Wilton GA itself or within 5 kilometres of its boundaries.
- The GMGA has a series of 4-5 GGBF records restricted to a very small area around Blair Athol. There are no other records inside or within 5 kilometres of the GA.
- The WSAGA has no records within its boundaries and only two individual records within 5 kilometres of its boundaries: one to the north east and the other the north west.
- The GPEC has a series of 11 records associated with Ropes Creek in its eastern half and a single record from Glenmore Park in its western half. There are also a series of other records scattered to the north east and west indicating that this GA is central to the records of the GGBF on the Cumberland Subregion.

The concentration of 4-5 very recent (2012-2014) records from a very small area at Blair Athol (Figure 3) provides some very recent records for the species. However, indications from the environmental officer at Campbelltown Council (Alex Cave) are that these records are of frogs that escaped a captive colony and that no original natural population was present. A population could potentially have established in that location, but all of the animals captured were juvenile frogs and no records have been obtained after 2014 indicating that the population disappeared.

The absence of records from some parts of the Cumberland Subregion may possibly be due to a lack of survey works, especially prior to the decline of the species in the 1980s. Various historic surveys will have been conducted across the region, although the extent of this work is poorly documented and generally unavailable to view. This will include surveys have been carried out around Badgery's Creek as part of a succession of assessments for the proposed second Sydney Airport site. I have personally conducted surveys in this area in the late 1990s as well as surveys at Orchard Hills, Blair Athol, Macarthur and along the Nepean River near Picton in areas included as part of this Biocertification process. None of these surveys provided any records of the GGBF and none of the surveys are freely available to the public to view. There would certainly be many more such surveys for developments that have no means of being accessed to properly assess survey effort. However, any records of GGBF should have been provided to the NSW BioNet and it would seem highly likely that the survey effort has been sufficient to reasonably indicate that the GGBF is at best rarely present within the assessed Biocertification lands.

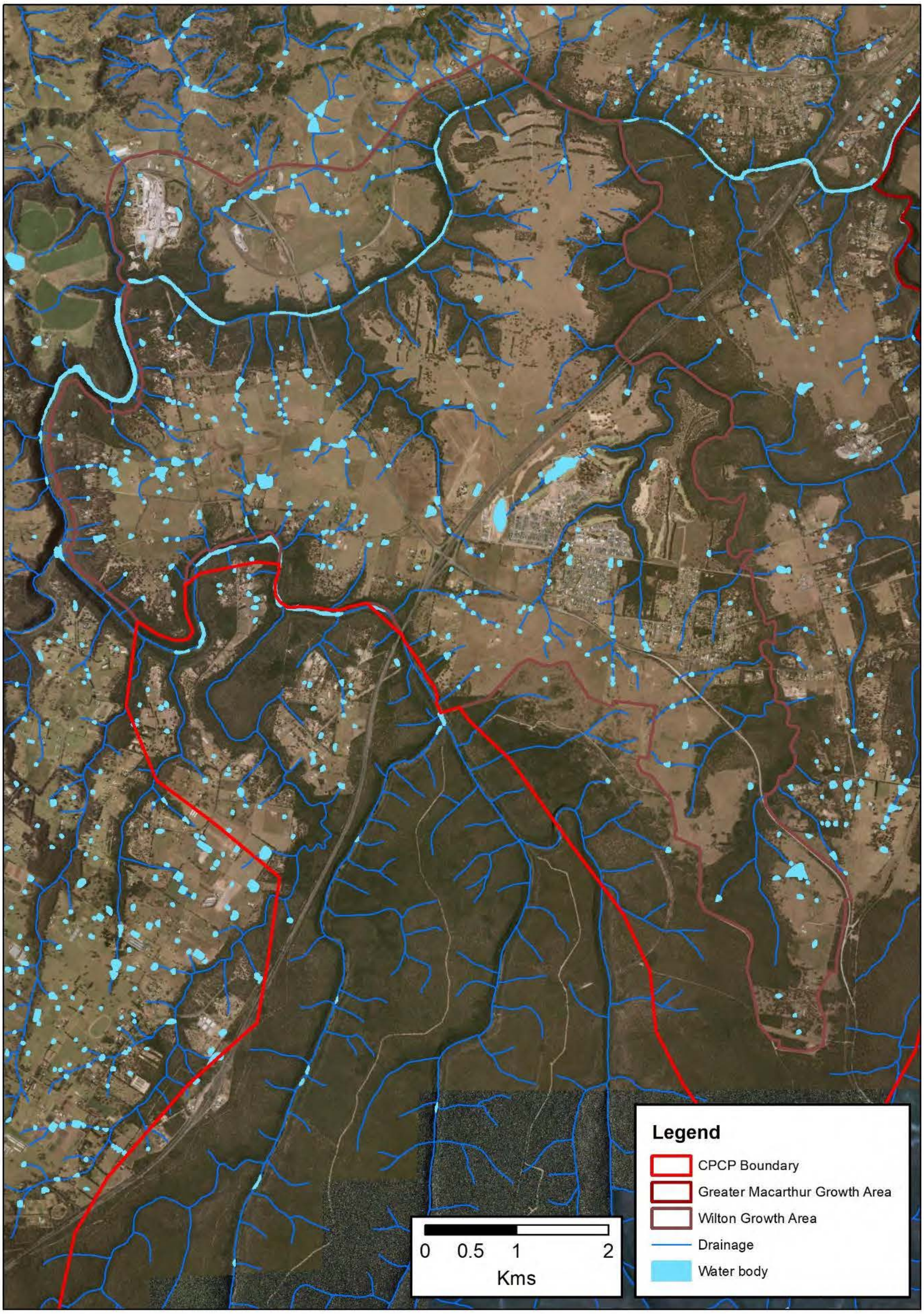

Figure 2. GGBF records from and mapped water bodies for the Wilton Growth Area

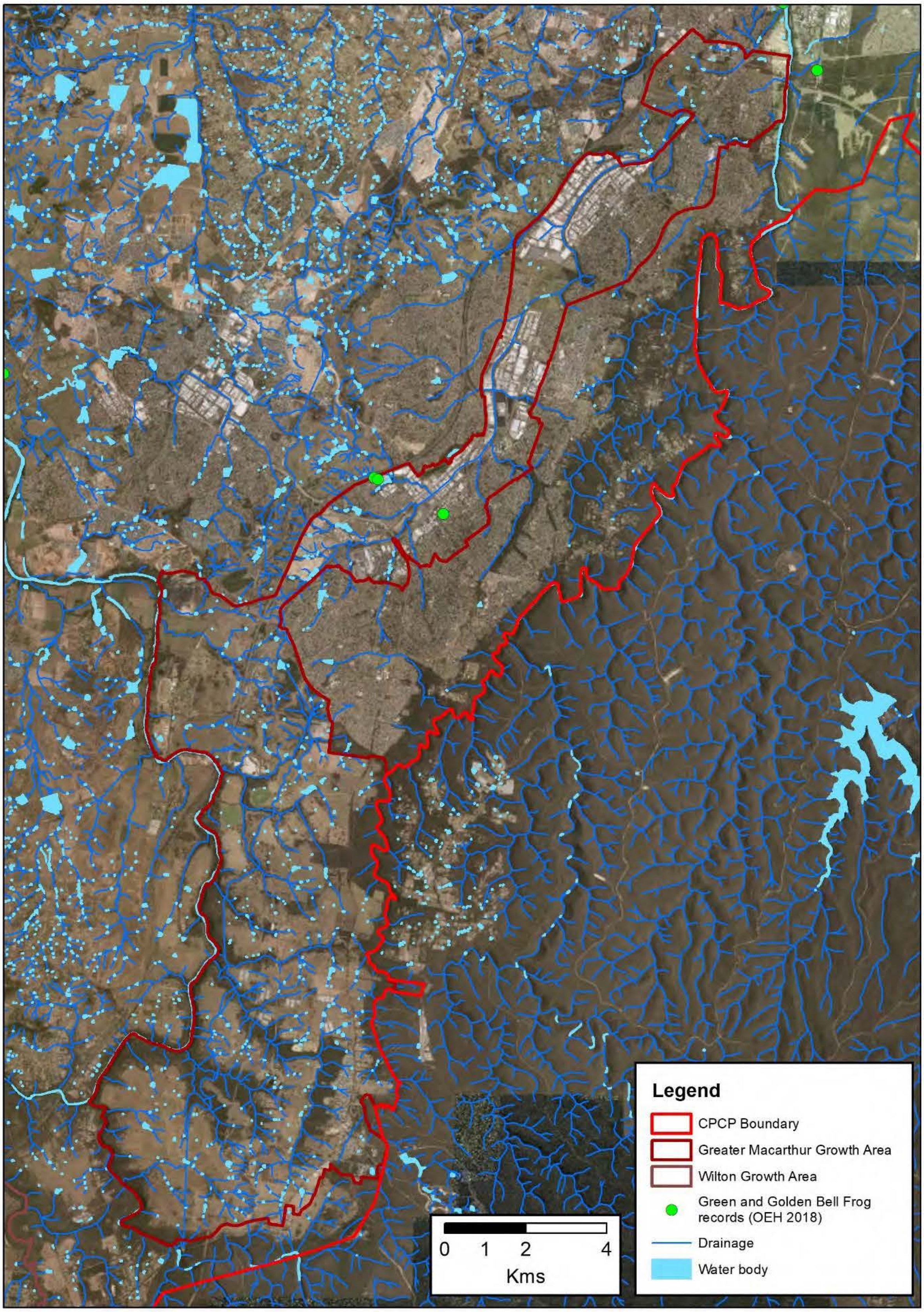

Figure 3. GGBF records from and mapped water bodies for the Greater Macarthur Growth Area

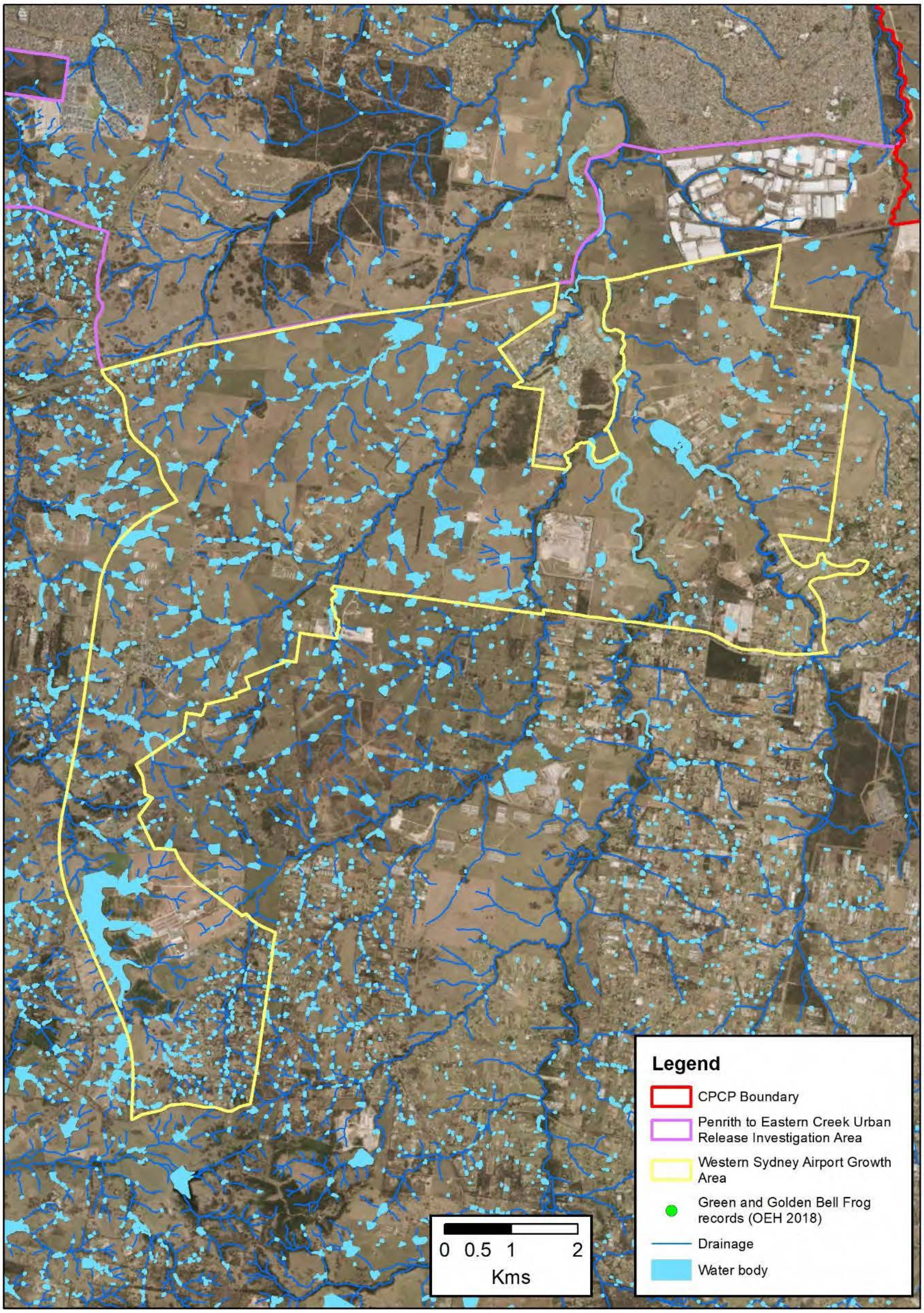

Figure 4. GGBF records from and mapped water bodies for the Aerotropolis Growth Area (Map provided by DoPE)

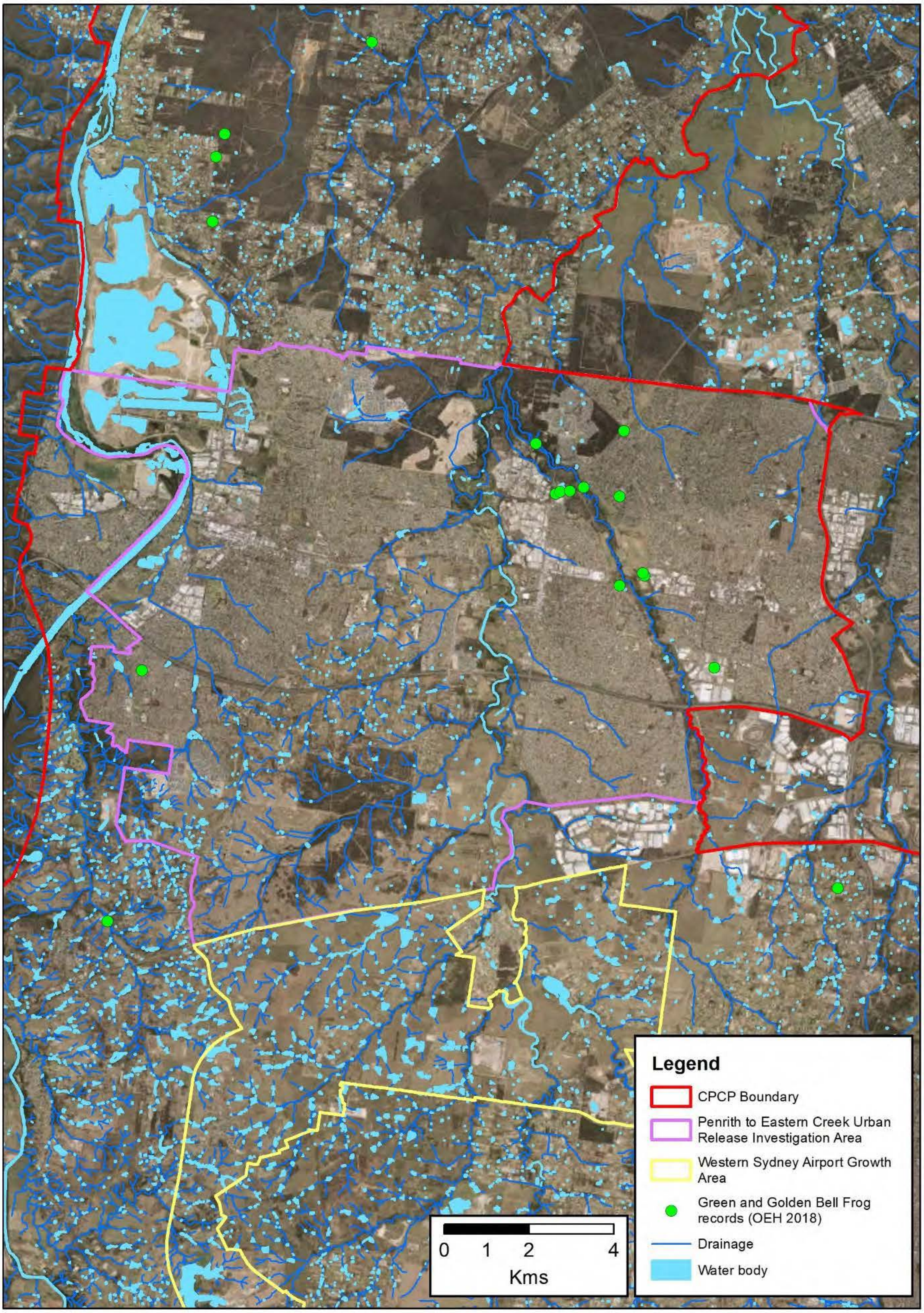

Figure 5. GGBF records from and mapped water bodies for the Greater Penrith to Eastern Creek Growth Area (Map provided by DoPE)

Three points are clearly evident. Firstly, that few actual records have been obtained for the GGBF on the area of the Cumberland Subregion under consideration and it would appear that the species has never been common in this area. Secondly, the majority of records are from prior to 1990, indicating that most populations are likely to now be extinct. This fits in with the pattern of declines noted for the GGBF by Mahony et al. (2013) that noted populations to rarely persist more than 10 kilometres from the coast. The entire study area meets this criterion. Thirdly, the few records that are available tend to be clustered into discrete areas. This is typical of the GGBF that is more likely to be found at sites where there are other nearby records (Hamer and Mahony 2010; Hamer 2018) and is attributed to the metapopulation structure of this species that requires a series of supporting and interacting sub-populations (in this case based around water bodies) in order for the species to have long-term success.

4.2 Surveys completed for the Biocertification

Surveys were completed by Biosis and Ecoplanning on behalf of DPE. The extent of the surveys are provided in the maps listed in Appendix 2.

4.3 Surveys completed for this assessment

No field surveys were specifically completed for this assessment to locate GGBF. As noted before, access to most of the potential breeding habitat is not available and time did not allow for this outcome. Instead, brief and broad habitat assessments were conducted within each of the four priority GAs to provide an understanding of the available habitats and their quality. This looked for features such as the availability and proximity of natural and artificial water bodies and the matrix of vegetation or other habitats between water bodies. These assessments confirmed the initial assessment that the built up areas provide little suitable habitat of any type for the GGBF, but the more rural locations are broadly suitable for GGBF populations to persist and include large numbers of human created water bodies.

4.4 Assessment of species presence

Likelihood of species presence

Studies have demonstrated a strong relationships to exist between the probability of occupancy of a pond by GGBF and the connectivity of wetland sites within the landscape. This relationship is evident in two forms. Firstly, in the spatial arrangement of permanent wetlands, allowing a short enough distance and suitable matrix of intervening habitat for frogs to move between ponds. Secondly, in the total area of wetlands within a 1 km-radius around a pond, which provides multiple interactive breeding sites within an area (Hamer et al. 2002; Hamer & Mahony 2010; Valdez et al. 2015; Hamer 2018). Hence consideration of the presence of the GGBF at a local scale is based on the presence of a high density of water bodies that are well connected by both proximity and suitable habitat to move through.

A second consideration is that at a much larger scale where water bodies greater than 10 kilometres from coast are unlikely to contain the frog, presumably because salinity levels are too low to play any significant role in attenuating chytrid. Sites greater than 10 kilometres from the coast may still be viable where they have an “anti-fungicidal” environment (ie, have chemical properties that inhibit growth). It is not feasible to map such locations based on historic use and it would be unlikely that such site properties would be extensive enough to provide clear guidance that the species would be present. If such did exist, it would seem very likely that the species would already have been recorded there. Hence the best understanding of the suitability of sites is based on previous records of the GGBF.

Justification for determining presence

Wilton

It has been determined that the GGBF is not likely to currently be present within the WGA. Copland (1957) records a specimen from the Picton area and so the GGBF was once present at least immediately adjacent to the WGA. However, there are no available records specific to the WGA and the distance to the coast indicates it is unlikely the GGBF would persist in the WGA.

No species polygon is provided as the species is not considered present within the WGA. The majority of the available habitat (rural lands) is suitable for this species and it could potentially return or colonise the WGA if the impacts of the amphibian chytrid fungus can be overcome.

Greater Macarthur Growth Area

It has been determined that the GGBF is not likely to currently be present within the broad GMGA. The only records of the species within the area are the very recent records of juvenile GGBF from around the Blair Athol area (Figure 3). As noted, these records are believed to be of individuals that escaped from a semi-captive colony and no extant "native" population was likely present. There are also no indications that a population has established as a result of the escape these individuals. Whilst, as for the Wilton area, it would seem likely that the GGBF was once present within the WGA, there is no evidence that it is currently present and the distance to the coast of the GMGA indicates it is unlikely to be able to persist in the current environment without some known source populations.

Figure 7 provides the species polygon of determined habitat area for the GGBF in the GMGA, although I again note that this is based on likely escaped frogs. This covers the locations of known records, the riparian zone joining those records and a buffer of 1000 m around that riparian zone and records that is the area deemed likely for GGBF to use for foraging, shelter, breeding and as migratory habitat as they move between water bodies and riparian areas.

Western Sydney Aerotropolis Growth Area

It has been determined that there is not likely to be a population of the GGBF currently present within the WSAGA. There are no records from within the GA, despite the presence of suitable habitat in rural areas in the form of a high density of water bodies. There is no evidence that it is currently present and the distance to the coast indicates it is unlikely that the GGBF would persist in this area. The two most closely associated records (Figure 4) are single records not closely aligned with other records and so it is unlikely that a larger stable population has been or is present within the WSAGA.

Greater Penrith to Eastern Creek Growth Area

It has been determined that a population of the GGBF may remain present within the GPEC. There are a number relatively recent records from within and immediately adjacent to the GPEC located along the Ropes Creek corridor (Figure 8) and areas of suitable habitat remain along that corridor in the form of a high density of water bodies within undeveloped lands. It is not certain that the population still remains, given the ongoing declines noted for the GGBF, but the survey completed for the Biocertification has not been adequate to establish the current status of the GGBF population.

Figure 8 provides a species polygon for the GGBF within the GPEC. This covers the locations of known records, the riparian zone joining those records and a buffer of 1000 m around that riparian zone and records that is the area deemed likely for GGBF to use for foraging, shelter, breeding and as migratory habitat as they move between water bodies and riparian areas.

4.5 Assessment of suitable habitat

The information in Section 2 demonstrates the ability of the GGBF to use a broad range of habitats and only urbanised areas represent unsuitable habitat, mainly because of the absence of breeding ponds and the high density of roads and buildings that form barriers to movements.

All four GAs contain suitable habitat matrix in the form of rural areas with a numerous water bodies within close proximity (< 500 metres). This should provide both breeding and non-breeding water bodies sufficiently close to allow GGBF to migrate between them and with adjacent vegetation and shelters that they would allow them to successfully do so. These surrounding areas would also provide over-wintering sites and vegetated areas to provide supplies of invertebrates as food for GGBF. The presence of the Plague Minnow would potentially limit the presence of the GGBF in some or most areas, but it is not possible to determine the extent of this effect without visiting the water bodies and the GGBF can still inhabit sites with the Plague Minnow where there is suitable emergent vegetation and where fish free ephemeral sites develop, which could be in most places across the broad landscape.

Habitat only is likely to be unsuitable where there is a matrix of roads of more than single carriageways in both directions. Larger roads represent barriers in both distances that frogs must cover in exposed conditions and carry volumes of traffic that may prohibit the successful crossing by frogs. The more rural areas of the GAs generally do not have many or even any such roads traversing them and so they should provide a suitable environment for the GGBF in at least this respect.

Species polygons

Predicted polygons for the GGBF are provided only for the GMGA (Figure 7) and GPEC (Figure 8). This is because it is considered that only these two areas may contain extant populations of the GGBF with evidence to demonstrate that they have historically been present within the two GAs. The species polygon that indicates the distribution of GGBF populations within the GA, with the polygons being based on the presence of known populations or recent records. The polygon covers the locations of known records, the riparian zone joining those records and a buffer of 1000 m around that riparian zone and records that is the area deemed likely for GGBF to use for foraging, shelter, breeding and as migratory habitat as they move between water bodies and riparian areas. The extent that these overlap with proposed development areas are also indicated.

As noted before, the figures also include highlighted areas that have been designated as potential migratory corridors for GGBF should populations return to the landscape in the future. These represent areas that GGBF would be predicted to use to move around and recolonise the GAs, if this was able to take place. They essentially follow the known riparian strips associated with rivers or where a series of identified water bodies provide the opportunity for GGBF to migrate through a series of stepping stones. These corridors do not represent current habitat that needs consideration under the Biocertification process and they do not constitute polygons of habitat for the GGBF. Rather they have been noted simply for consideration for broader scale conservation planning, should that be of interest, under the premise that the GGBF will ultimately recover from its current declined state (through disease immunity or behavioural changes) that will allow them to recolonise suitable habitats. I note that I have included a broad corridor of non-riparian area as a potential movement corridor on the western side of the WGA, as the loop of the river provides for a broad patch of land that may provide a means of the GGBF migrating across that patch if it were ever to recover.

Estimate of area of habitat

The estimated area of suitable GGBF habitat in each GA (the species polygon) and the area of this habitat expected to be impacted by development (falls within the footprint) is provided in Table 2. The latter is minimal and only exists for the GPEC.

Realistically all of the rural landscape contains suitable habitat with a range of suitable breeding ponds providing habitat for the GGBF. However, it is expected the GGBF will only persist in areas with known populations and that can maintain a metapopulation structure. Sufficient historic survey has been conducted to conclude that additional significant populations are not now present within the GAs.

Table 2. Areas of identified suitable habitat and area of habitat within each Growth Area

Growth Area	**Area of habitat (ha)**	**Area within development footprint (ha)**
Wilton	0	0
Greater Macarthur	238.8	0
Western Sydney Aerotropolis	0	0
Greater Penrith to Eastern Creek	1421.6	13.1

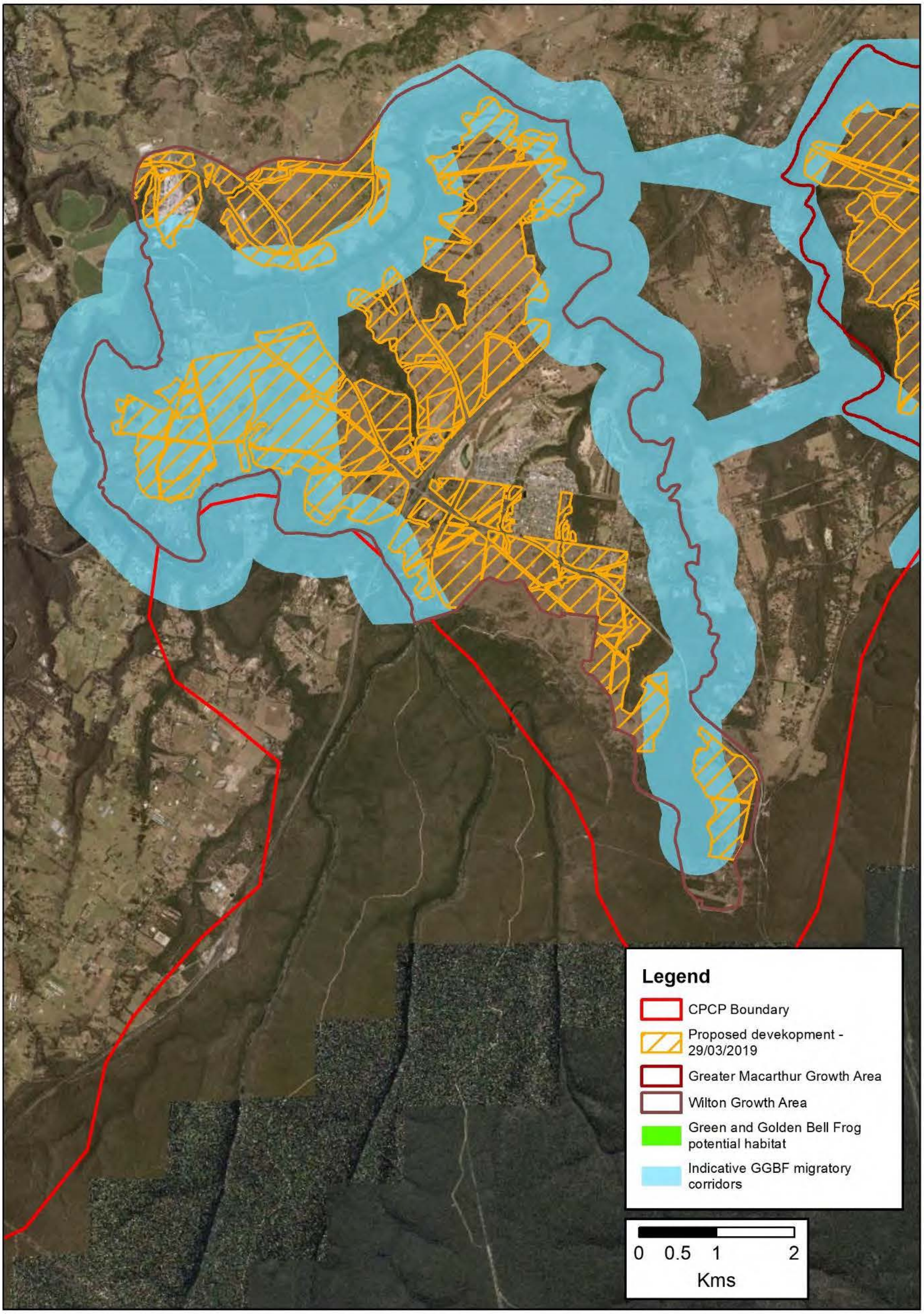

Figure 6. Polygon and potential migratory habitat for the Green and Golden Bell Frog relative to the Wilton Growth Area (Map provided by DPE)

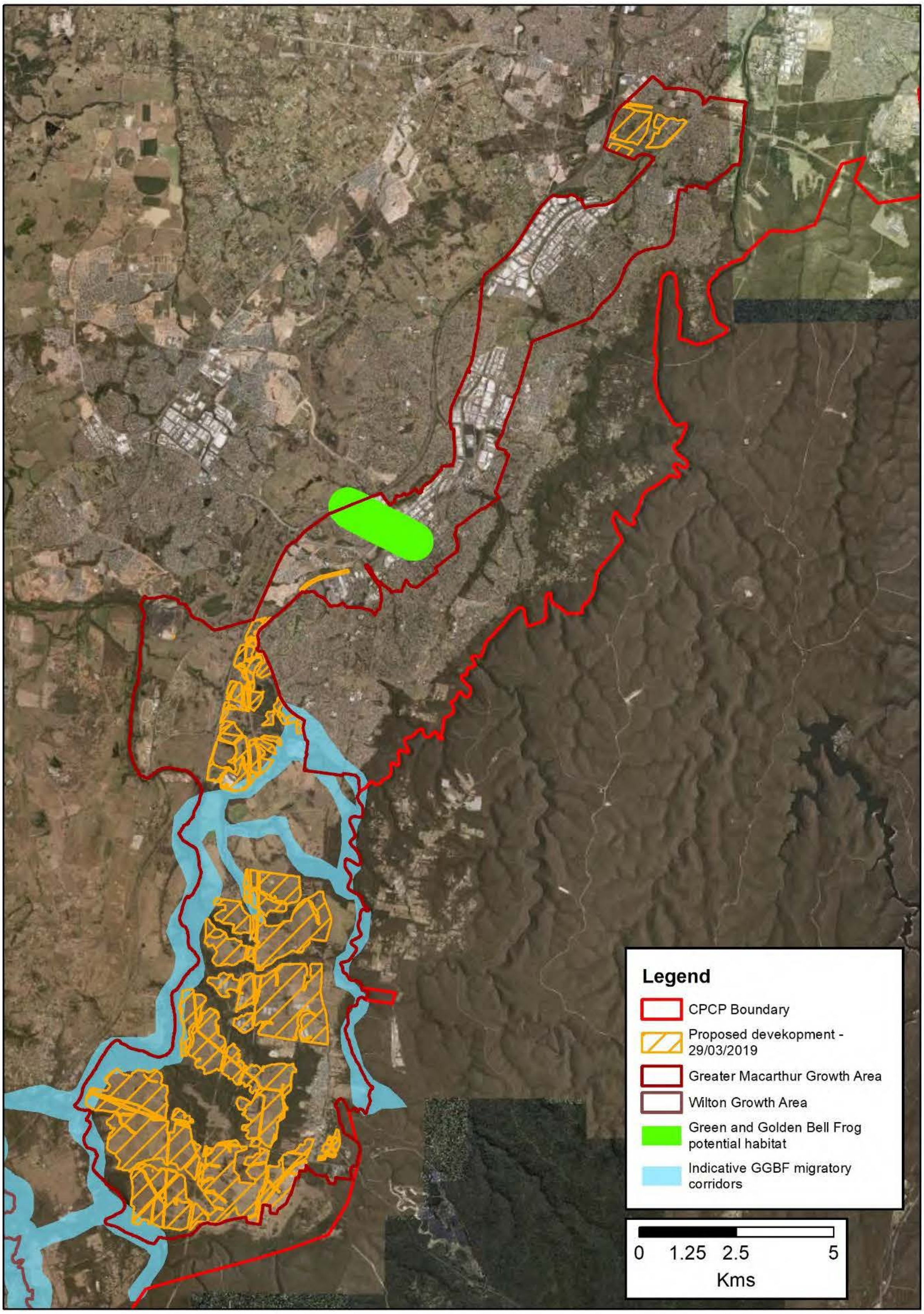

Figure 7. Polygon for Green and Golden Bell Frog habitat within the Greater Macarthur Growth Area (Map provided by DPE)

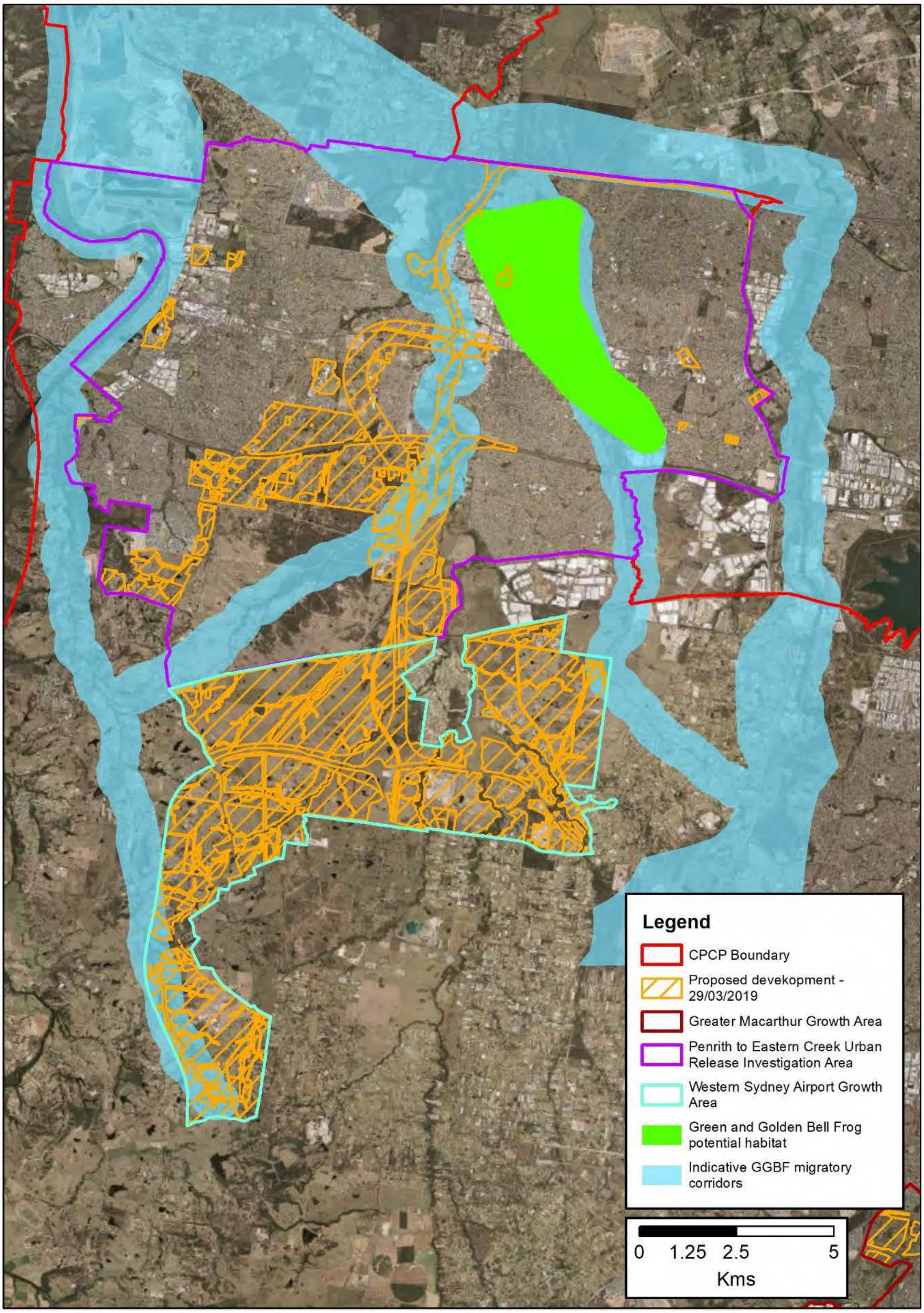

Figure 8. Habitat polygons and identified likely future migration corridors for the Green and Golden Bell Frog relative to the Greater Penrith to Eastern Creek and Western Sydney Aerotropolis Growth Areas (Map provided by DPE)

5 Information used in this assessment

Data, maps and information provided by DPE and project partners are noted through the report

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7 Appendices

Appendix 1: Curriculum vitae

Member of the Surbana Jurong Group

Dr Francis Lemckert

Principal Environmental Scientist - Environment

Years of Industry Experience

- 30+ Years

Qualifications, Training and Memberships

- PhD University of Newcastle
- Master of Science, University of Sydney
- Bachelor of Science, University of Sydney
- Australian Society of Herpetologists (Past-President, Vice-President and Secretary)
- NSW Declining Frogs Working Group (Secretary)
- Amphibian Specialist Group of the IUCN
- Conjoint University of Newcastle, Australian Museum

Key Skills and Competencies

- Fauna and flora monitoring
- Fauna survey
- Fauna research
- Expert reporting under the BAM
- Specialist fauna knowledge
- Impact and ecological assessment
- Wildlife survey training
- Government agency consultation
- Herpetology

Professional Overview

Frank has been a professional scientist since 1992, specialising in the ecology and management of threatened vertebrates, particularly frogs. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland) establishing long-term research programs into the management of forest fauna and developing strategies to mitigate the impacts of human disturbances. His specialty is the ecology and management of frogs, but he also has detailed knowledge of threatened reptiles and microbat management, and has conducted hundreds of surveys for all of the vertebrate groups. Frank has worked extensively with the NSW state and federal Governments on varying issues of fauna management and is experienced in the application of NSW and federal legislation regarding the conservation of threatened species and communities. At a technical level he has participated in the preparation of a draft NSW/National recovery plan for *Heleioporus australiacus*, expert advice and review on Impact Assessment Guidelines for the *Litoria aurea*, *Litoria raniformis* and *Litoria olongburensis* and a review of the National Recovery Plan for the stream frogs of SE Queensland. He also assisted in assessing the Vic Forests fauna survey and assessment program for threatened fauna. Frank has also worked extensively with the Australian Biological Resources Study to undertake biodiversity surveys across NSW and into far southern Queensland.

Frank has a long history in fauna monitoring and management having developed broad scale monitoring strategies for vertebrate fauna when at NSW DPI. He completed a review of the methods available to undertake frog monitoring, including linking in with current river monitoring programs and developed a pilot reptile survey program for the Pilliga State Forests. He monitoring works included using both traditional population counts and consideration of more recently developed presence-absence modelling and his works included using mark-recapture techniques. He has published papers on optimal monitoring methods and its analysis and has been an author on more than 90 peer-reviewed national and international scientific publications and has undertaken presentations at more than 50 conferences across the world.

Finally, Frank has had a long history in wildlife management education, having been the lead on the wildlife training school program conducted in NSW continuously since 1993. This program has provided in-depth training on fauna and flora survey, management and identification in all parts of NSW and has been attended by more than 1000 people including government regulators, consultants and NGO staff. The courses have emphasised practical hands-on demonstrations of survey techniques to demonstrate the most effective use of the different traps and monitoring methods and approaches available and included recognised experts on the target groups. Information lessons also included talks on the ecology and management of target threatened species for any given area and course.

Relevant Project Experience

Mona Vale Road Upgrades

In regards to Mona Vale Road, Frank worked as a sub-contractor to Ecosure to provide expert surveys and technical advice on the survey and impact assessment for the Red-crowned Toadlet and Giant Burrowing Frog for both the Mona Vale Road East and Mona Vale Road West upgrade projects. This provided the first records for the Giant Burrowing Frog (*Heleioporus australiacus*) in that area and also recorded several locations for the Red-crowned Toadlet (*Pseudophryne australis*) as well as records of the Eastern Pygmy Possum (*Cercartetus nanus*) as part of nocturnal surveys. He also provided reviews of impact assessments for the Mona Vale Road west report covering all aspects of the surveys and the assessments for all of the threatened fauna. It also considered the impacts of fragmentation of the proposed upgrade and methods to mitigate impacts.

Warringah Council Crown Lands surveys

Between 2011-2013 Frank also completed a detailed reptile and frog survey of the available crown lands in the Warringah Council (now part of Northern Beaches Council) Local Government Area. This included targeted surveys for all reptiles and frogs likely to be present and provided detailed information to the Council to inform planning of development proposals into the future. These surveys provided additional record sites for the Giant Burrowing Frog and Red-crowned Toadlet in the LGA.

Saving our Species targeted surveys – Green and Golden Bell Frog (*Litoria aurea*)

Frank was engaged by the NSW Office of Environment and Heritage to undertake four rounds of targeted surveys for the Green and Golden Bell Frog in the area around Meroo Lake on the south coast of NSW. This required repeat surveys of transects to count the frogs and the collection of site data to be used in a broader analysis of Green and Golden Bell Frog habitat preferences. Frank completed the surveys successfully, locating hundreds of individuals and provided a report on time as required.

Princes Highway upgrade at South Nowra

Frank completed targeted and monitoring surveys and EPBC and EP&A/TSC Act assessments for the Green and Golden Bell Frog and hollow using fauna and was the appointed Project Herpetologist. He also produced two EPBC Referrals for the Green and Golden Bell Frog, guided the development of mitigation works, produced fauna rescue guidelines and advised on the ongoing scientific monitoring program.

Dee Why Town Centre Bat Management

Frank was the technical lead on several projects managing the impacts of drainage culvert upgrades on threatened microbats present in Dee Why. This included the identification of bats present, mapping of bat roosting sites, completion of an SIS and ongoing monitoring of the bats through the works to ensure impacts remained within acceptable limits. The bats present proved to be Eastern Bentwing-bats (*Miniopterus schreibersii oceanensis*) and the works times to minimise impacts at sensitive times for the bats.

Pacific Highway upgrade for Oxley Highway to Kempsey and Frederickton to Eungai

Frank has been involved in a diversity of fauna related work for this project including population and mitigation monitoring surveys for the Giant Barred Frog (*Mixophyes iteratus*) and Green-thighed Frogs (*Litoria brevipalmata*) and provided review and quality assurance for reports on monitoring for Giant Barred Frogs, Green-thighed Frogs, Brush-tailed Phascogales, Squirrel Gliders, Hairy Joint Grass, *Maundia triglochinoides*, Koalas and Glossy Black Cockatoos. He also reviewed works on water quality, underpass use, fauna crossings, nest box use and road-kill.

Expert Witness Somersby land clearing

In 2016 Frank provided expert advice to DoEE on the potential impacts of alleged illegal land-clearing on the Giant Burrowing Frog at Somersby on the NSW Central Coast. This includes a site search to locate the presence of tadpoles (located in the central stream) and an assessment of the value of the cleared habitat to this frog and the likely long-term effects on the local population.

Threatened Frog Monitoring and Modelling – Hornsby Council

In 2015-2016 Frank completed surveys of known record sites for the Red-crowned Toadlet and the Giant Burrowing Frog in the Hornsby Local Government Area to provide data on the location of these two species within areas adjacent to areas of housing and in undeveloped locations. The data provided the basis for an ongoing monitoring program to be carried out by Council and assess if housing was impacting the local water quality and the frogs. Habitat modelling was also produced for the Giant Burrowing Frog, allowing Council to better target assessment requirements for development applications.

Expert review - Pacific Highway threatened frog monitoring program

Frank was commissioned to provide an expert review of the proposed frog monitoring program to assess the impacts and success of mitigation for approximately 130 km of the Pacific Highway in northern NSW. This expert review considered the thoroughness and technical relevance of the proposed program and covered Giant Barred Frogs, Green-thighed Frogs, Wallum Sedge Frogs Brush-tailed Phascogales, Squirrel Gliders, Hairy Joint Grass, *Maundia triglochinoides*, Koalas and Glossy Black Cockatoos. He also reviewed works on water quality, underpass use, fauna crossings, nest box use and road-kill.

Forests NSW fauna monitoring strategy

Between 2008 and 2011 Frank assisted in developing a state-wide fauna monitoring strategy for Forests NSW, concentrating on the herpetological component. This lead to a working paper on options for frog monitoring and undertaking a pilot program for reptile monitoring in the Pilliga Forests of northwest NSW.

Selected Publications

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Lemckert, F., Haywood, A. & Brassil, T. 2006. Correlations between frogs and pond attributes in central New South Wales, Australia: What makes a good pond? Applied Herpetology 3: 67-82.

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Lemckert, F., Penman, T. & Haywood, A. 2011. Adaptive monitoring using the endangered northern corroboree frog (*Pseudophryne pengilleyi*) as a case study. Proceedings of the International Academy of Ecology and Environmental Sciences 1: 87-96.

Lemckert, F., Penman, T. & Mahony, M. J. 2013. Relationship of calling intensity to micrometeorology in pond breeding frogs from central eastern New South Wales. Proceedings of the International Academy of Ecology and Environmental Sciences, 3 (2), 170-180.

Lemckert, F., Brassil, T., Kavanagh, R. & Law, B. 2006. Trapping small mammals for research and management: how many die and why? Australian Mammalogy 28: 201–207.

Mahony, M.J., Hamer, A.J., Pickett, E.J., McKenzie, D.J., Stockwell, M.P., Garnham, J.I., Keely, C.C., Deboo, M., O'Meara, J., Pollard, C.J., Clulow, S., Lemckert, F.L., Bower, D.S.& Clulow, J. 2013. Identifying conservation and research priorities in the face of uncertainty: a review of the threatened bell frog complex in eastern Australia. Herpetological Conservation and Biology 8: 519-538.

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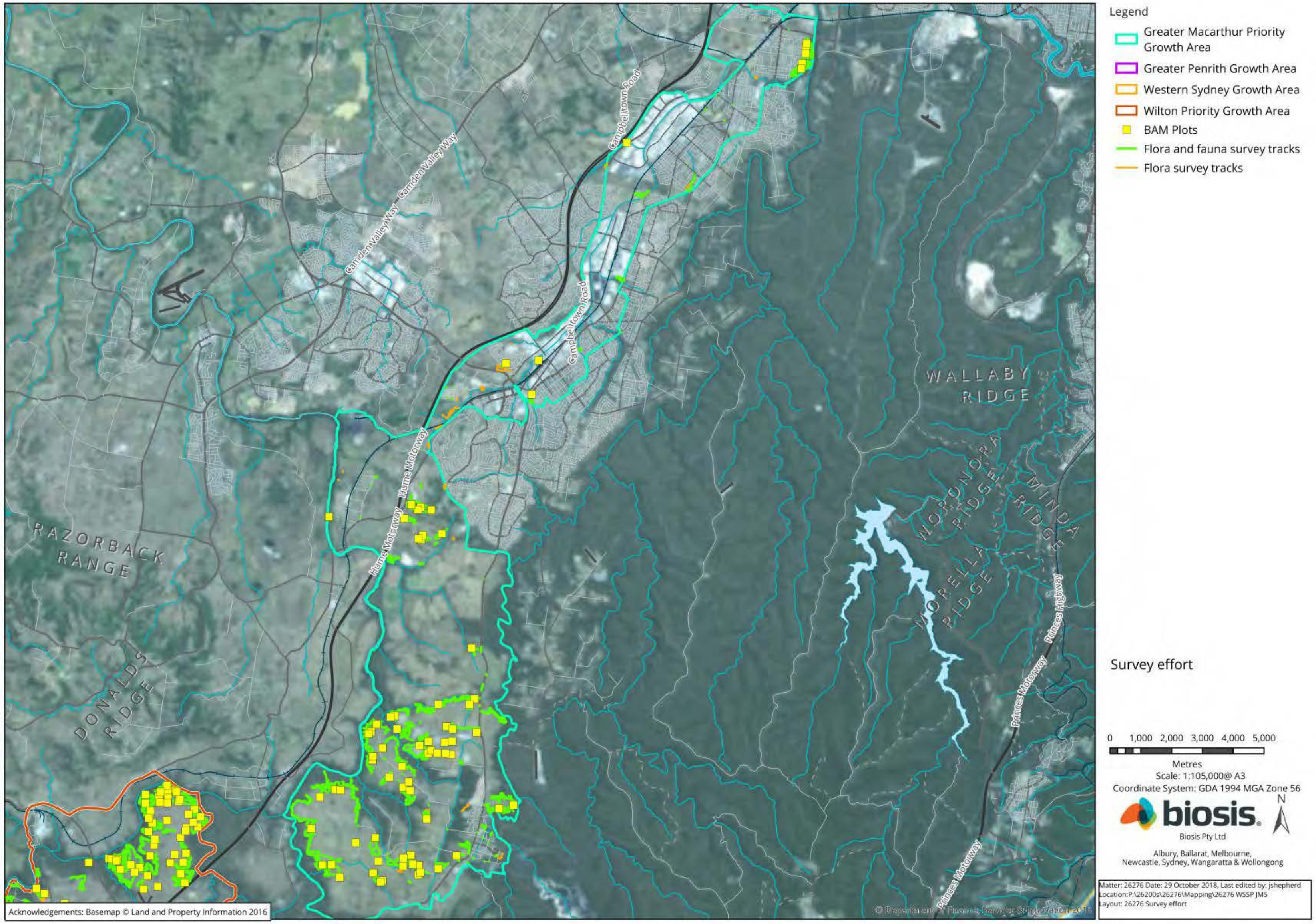
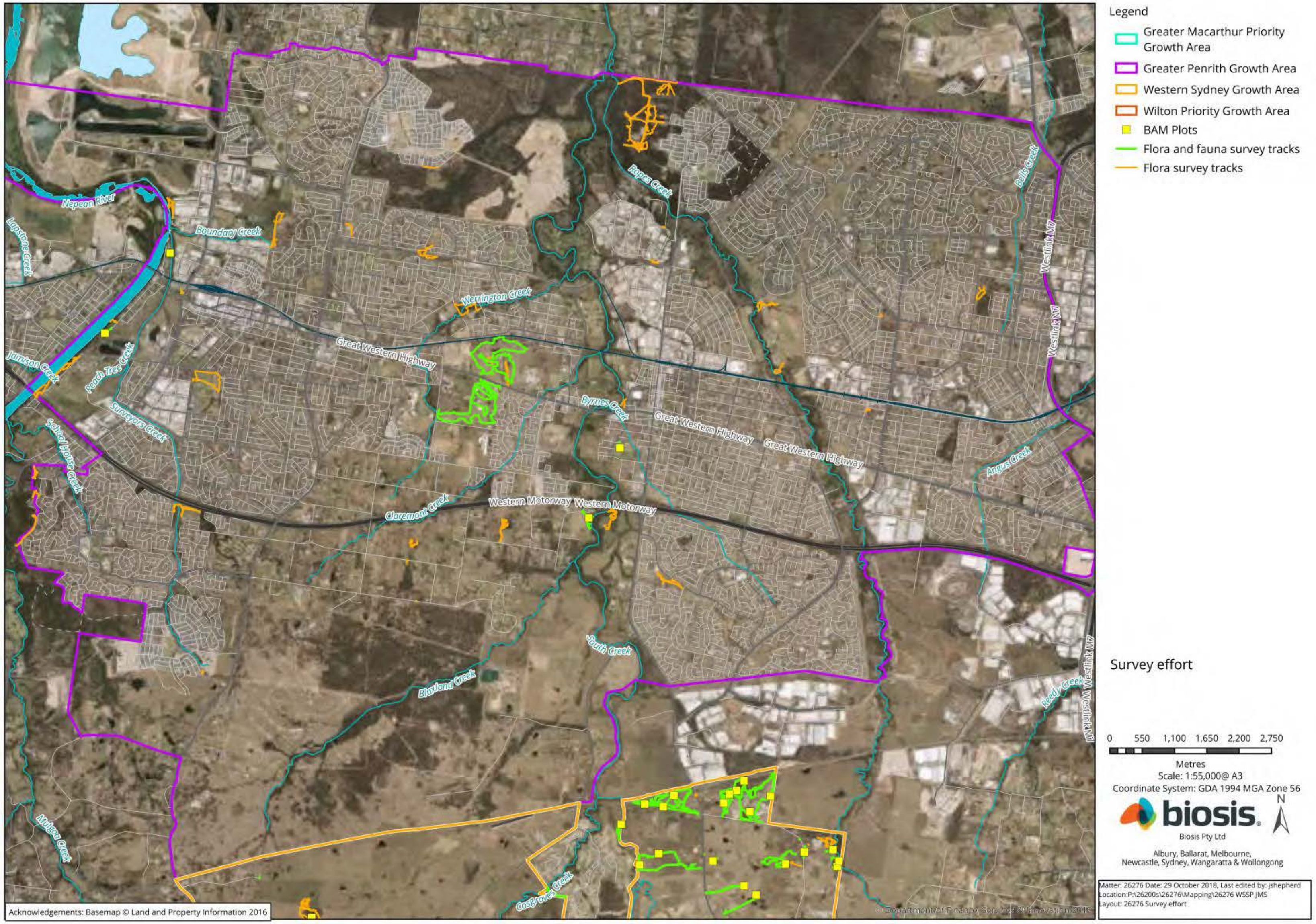
Appendix 2: Maps showing survey effort




Legend
Greater Macarthur Priority Growth Area
Greater Penrith Growth Area
Western Sydney Growth Area
Wilton Priority Growth Area
BAM Plots
Flora and fauna survey tracks
Flora survey tracks
Nepean River
Boundary Creek
Werrington Creek
Great Western Highway
Jamison Creek
Peach Tree Creek
Surveyors Creek
Byrnes Creek
Ropes Creek
Claremont Creek
Western Motorway
South Creek
Blaxland Creek
Cosgroves Creek
Mulgoa Creek
Angus Creek
Eastern Creek
Westlink M7
Reedy Creek
Survey effort
0 550 1,100 1,650 2,200 2,750
Metres
Scale: 1:55,000@ A3
Coordinate System: GDA 1994 MGA Zone 56
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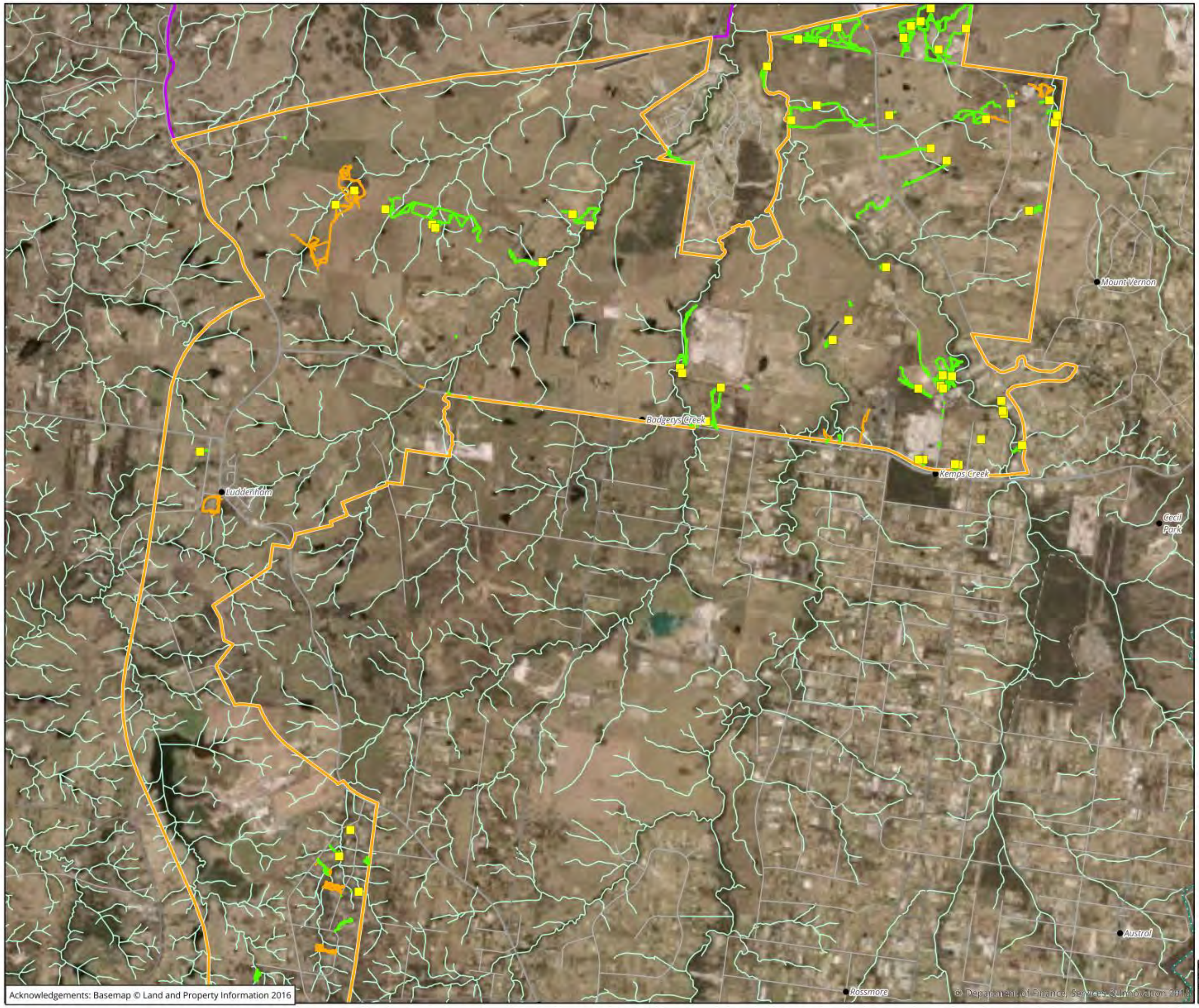
Biosis Pty Ltd
Albury, Ballarat, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong
Matter: 26276 Date: 29 October 2018, Last edited by: jshepherd
Location:P:\26200s\26276\Mapping\26276 WSSP JMS
Layout: 26276 Survey effort
Acknowledgements: Basemap © Land and Property Information 2016



Legend

- Greater Macarthur Priority Growth Area
- Greater Penrith Growth Area
- Western Sydney Growth Area
- Wilton Priority Growth Area
- BAM Plots
- Flora and fauna survey tracks
- Flora survey tracks

Survey effort

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Metres

Scale: 1:45,000@ A3

Coordinate System: GDA 1994 MGA Zone 56

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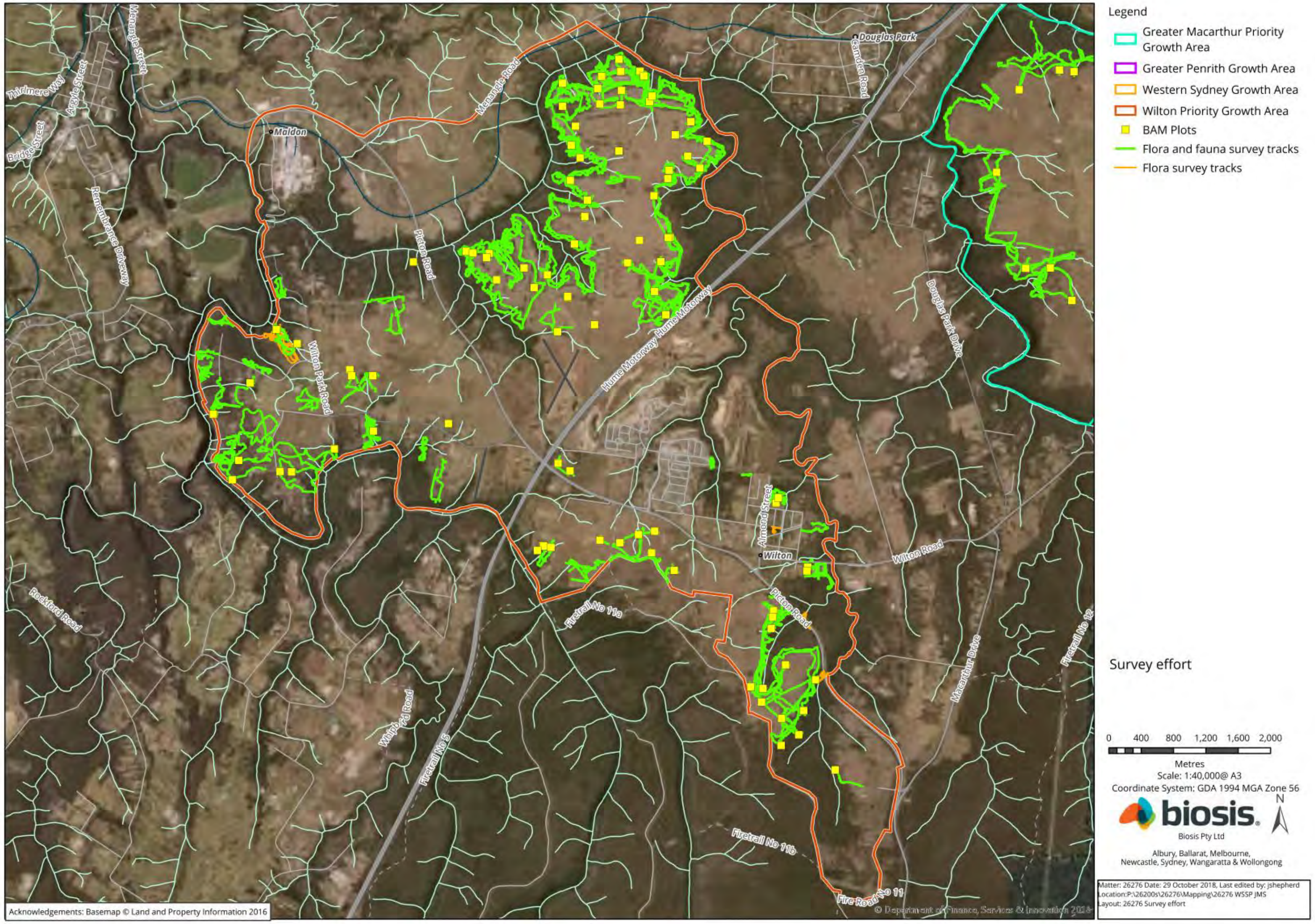
Legend
Greater Macarthur Priority Growth Area
Greater Penrith Growth Area
Western Sydney Growth Area
Wilton Priority Growth Area
BAM Plots
Flora and fauna survey tracks
Flora survey tracks
Survey effort
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Metres
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Acknowledgements: Basemap © Land and Property Information 2016
Maldon
Douglas Park
Wilton
Hume Motorway
Wilton Park Road
Picton Road
Wilton Road
Almond Street
Menangle Road
Douglas Park Drive
Macarthur Drive
Firetrail No 11a
Firetrail No 11b
Firetrail No 5
Fire Road No 11
Rockford Road
Argyle Street
Thirlmere Way
Bridge Street
Remembrance Driveway
Menangle Street
Camden Road
Wallaby Rd Road
Firetrail No 12

Expert report – *Grevillea juniperina* subsp. *juniperina*

Expert report on the Juniper-leaved Grevillea, *Grevillea juniperina* subsp. *juniperina* in the Greater Macarthur and Wilton Growth Areas, Peter H. Weston, June 2018

Expert report on the Juniper-leaved Grevillea, *Grevillea juniperina* subsp. *juniperina* in the Western Sydney Aerotropolis Growth Area, and Greater Penrith to Eastern Creek Urban Release Area, Peter H. Weston, June 2018

Strategic assessment for Cumberland Plain Conservation Plan

Expert report on the Juniper-leaved Grevillea, *Grevillea juniperina* subsp. *juniperina* in the Greater Macarthur and Wilton Growth Areas

Peter H. Weston

Botanical Consultant

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0423 1245 508

1. Introduction

PURPOSE

I was engaged by the Department of Planning and Envionment in early June 2018, to produce an expert report on the distribution and abundance of *Grevillea juniperina* subsp. *juniperina* (Proteaceae) within the proposed Greater Macarthur and Wilton Growth Areas (collectively termed "the study area"). The aim of this exercise was to assess whether *Grevillea juniperina* subsp. *juniperina* (the "focal taxon") is native to either of the Growth Areas and, if so, to assess where suitable habitat is located and to estimate the numbers of plants of *Grevillea juniperina* subsp. *juniperina* that are likely to occur there.

According to Section 6.5.2 of the Biodiversity Assessment Method, an expert report must:

- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made
- demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report, and
- identify the expert and provide evidence of their expert credentials.

PROJECT CONTEXT

The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney, including the two growth areas that define the geographic scope of this report: the Greater Macarthur Growth Area and the Wilton Growth Area. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

STUDY AREA

The Greater Macarthur and Wilton Growth Areas are located in the south western part of the Sydney Metropolitan Area, between latitudes 33°57'29"S and 34°16'44"S and longitudes 150°37'12"E and 150°54'47"E.

CREDENTIALS OF EXPERT

I prepared this report as an independent botanical consultant but I am also currently an Honorary Research Associate at the at the New South Wales state herbarium (the National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust). In 2016, I retired from my role as a Senior Principal Research Scientist at the state herbarium, having worked there since 1982 as a Systematic Botanist and as curator of the herbarium's collections of specimens of Proteaceae (including *Grevillea juniperina*) (see my *Curriculum Vitae*, attached). I now work, part-time at the National Herbarium of New South Wales as an Honorary Research Associate. I have published, either as sole author or as a co-author, 50 papers on the systematics and ecology of the Proteaceae in the peer-reviewed scientific literature, including the most comprehensive phylogenetic analysis of the genus *Grevillea* yet published (Mast *et* al. 2015). As curator of Proteaceae at the state herbarium, I examined all specimens of *Grevillea juniperina* subsp. *juniperina* incorporated into the collection between 1982 and 2016. I was invited to contribute to floristic treatments of the Proteaceae for *Flora of New South Wales*, *Flora of Australia*, *Flora of the Perth Region*, *Flora of China*, *Flora of North America*, and to write the treatments of Proteaceae for *Families and Genera of Vascular Plants* and *Flowering Plant Families of the World* (see my *Curriculum Vitae*, attached). I was also asked to conduct a peer review of the essay on the ecology of the Proteaceae that accompanied the "Ecology of Sydney Plants" (Myerscough *et al.* 2000). Throughout my career I have participated in numerous collecting trips in the field, collecting specimens in all Australian states for the state herbarium. In documenting these specimens I had to describe the habitat at each collecting site, including associated plant species, substrate, aspect, degree and kind of disturbance. On some of those trips, I observed and collected *Grevillea juniperina* growing in the wild.

JUSTIFICATION FOR USE OF EXPERT REPORT

Grevillea juniperina subsp. *juniperina* has never been collected within, nor reported as growing as a native, in the study area. However, The OEH Threatened Species Data Collection indicates that *Grevillea juniperina* subsp. *juniperina* has the potential to occur in the following plant communities within the Wilton and Greater Macarthur Growth Areas:

- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain
- 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain

Moreover, a specimen of *G. juniperina* subsp. *juniperina* held by the state herbarium (B. Towle, NSW999291) was collected in June 2017, in a bushland remnant only 3.6 km west of the study area, raising the possibility that suitable habitat for *G. juniperina* subsp. *juniperina* might exist there. If this were so, *G. juniperina* subsp. *juniperina* might once have lived there, or even still exist in the study area as small, unrecorded populations.

Grevillea juniperina subsp. *juniperina* is a perennial shrub that is readily recognised at any time of year by its distinctive vegetative morphology. Conventional surveying would therefore be the most appropriate way to test for its presence, if unlimited access to the study area were allowed. Surveys were undertaken on all areas of land where landowners granted access. However, the survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH 2016) for field traverse surveys due to limitations imposed by land access.

These limitations and the possibility that *G. juniperina* subsp. *juniperina* might be native to the Greater Macarthur and Wilton Growth Areas triggered the need for an expert report.

SPECIES SURVEYS

An initial 726 letters were sent to landholders within the Growth Areas in late 2017. A second letter was sent in March 2018, and targeted door knocking occurred in May 2018. From this, just under 20% of landholders have responded. Surveys were undertaken on all areas of land where landowners granted access. Of the 14,984 hectares within the Wilton and Macarthur Growth Areas, of which 5,385 ha is potential native vegetation that could be impacted by development, DPE has completed surveys across 3,360 hectares (62% of the total survey area). Surveys for *Grevillea juniperina* subsp. *juniperina* were undertaken from November 2017 to May 2018, resulting in no sightings of the species recorded from the survey areas.

2. Species information

SPECIES DESCRIPTION

The following morphological description was produced by merging information from Makinson's (2000) descriptions of the Linearifolia Group, the Speciosa Subgroup, *Grevillea juniperina*, and *Grevillea juniperina* subsp. *juniperina*:

More or less erect to spreading dense divaricate shrub 0.5–1.5 m tall, to 3 m across; major branches appearing subcolumnar (leaves clustered on short lateral branchlets); foliage dense. Branchlets terete, tomentose to villous. Leaves spreading to ascending, often crowded on short lateral branchlets, usually rigid, often dark green with paler veins, entire, narrowly ovate to subulate or linear, angularly deltoid to trigonous in cross-section, 10–22 mm long, 0.6–0.8 mm wide, pungent, needle-like, with dissimilar upper and lower surfaces; upper surface usually with 3–5 longitudinal veins, the midvein and intramarginal veins usually very prominent, sparsely covered with appressed hairs; margins strongly and angularly revolute; lower surface usually fully enclosed, usually densely sericeous or occasionally openly so, rarely glabrous, or open-tomentose; juvenile leaves scarcely broader than adults. Conflorescence terminal, occasionally also axillary and subterminal, usually simple or occasionally 2 (–4)-branched; unit conflorescence erect or slightly decurved, acropetal, subsecund; floral rachis 1–17 mm long. Flowers zygomorphic; torus slightly oblique. with perianth style similar to perianth or a little paler. Perianth densely to openly subsericeous outside with biramous hairs only, bearded inside between 2.5 and 9 mm above base, red, yellow, pale orange, or rarely greenish; tepals remaining coherent over at least the basal third, independently recoiled above (usually the ventral pair more strongly so). Pistil (13–) 20–25 mm long; style glabrous except for minute scattered erect simple hairs extending from back of style-end down at least 3 mm and sometimes almost to ovary, similar colour to perianth or a little paler; pollen-presenter usually oblique or occasionally lateral. Follicles narrowly ovoid or oblong-ellipsoidal, 10–18 mm long, colliculose to smooth, not ridged. Seeds ellipsoidal; margins revolute, a waxy strip on one side extending into a short apical elaiosome.

LIFE CYCLE

Grevillea juniperina subsp. *juniperina* is a perennial, woody plant that germinates from an ellipsoidal seed (Makinson 2000). Germination is significantly enhanced by fire: in a germination experiment, a treatment of smoke plus heat raised the germination percentage from 5-13% observed in the control treatment to 60% (Morris 2000). Seedlings are readily identifiable because their leaves differ minimally from adult leaves and the characteristic growth pattern with abundant lateral short shoots starts when seedlings are less than 10 cm tall. The duration of the juvenile growth phase and the longevity of plants are unknown (Benson & McDougall 2000). Plants are known to be killed by fire (Olde & Marriott 1995, Makinson 2000) and are not known to spread vegetatively (Benson & McDougall 2000), so this taxon can be classed as an obligate seeder. Flowering occurs mainly from August to September, with sporadic flowers appearing in other months (Makinson 2000).The flowers of all subspecies of *Grevillea juniperina* are visited by nectar-feeding birds (Olde & Marriott 1995), which are presumed to be their pollinators (Benson & McDougall 2000). Fertilized carpels develop into follicular fruits that open at maturity, releasing one or two flat seeds, each of which bears a wing-like terminal elaiosome. The seeds are dispersed by wind and also possibly by ants, which may collect the seeds for their edible elaiosomes.

DISTRIBUTION AND ABUNDANCE

Grevillea juniperina subsp. *juniperina* occurs naturally on the northern Cumberland Plain, in Sydney's Western Suburbs, in an area bounded by Scheyville National Park, Agnes Banks Nature Reserve, Mulgoa, Kemps Creek, and Blacktown (OEH Wildlife Atlas, accessed 2/7/2018, Atlas of Living Australia, accessed 3/7/2018). Within this polygon, it is sporadically distributed but often locally abundant in both intact native vegetation and in highly disturbed habitats such as pastures and road cuttings. Collectors' notes on local abundance usually note multiple plants at collecting sites and vary in their estimates of plant numbers from solitary individuals to populations of over 1000. At my site GJ5 (Appendix 1, figure 3), an embankment of a road cutting that is being recolonised by native vegetation, I estimated a population of 5000 plants (including seedlings) in an area of less than one hectare.

A herbarium specimen collected from Gundungarra Reserve, Spring Farm, 4 km north west of the "waist" in the study area (NSW999291), is a geographic outlier that is unlikely to represent a natural occurrence of *Grevillea juniperina* subsp. *juniperina*. Herbarium records that were classed as naturalised occurrences by their collectors, and by R.O. Makinson in curatorial notes, include one from the Melbourne suburb of Heathmont (NSW 834413) and another from Penrose, 67 km south west of the study area (NSW971120).

HABITAT REQUIREMENTS

Makinson (2000: 210) notes that *Grevillea juniperina* subsp. *juniperina* "grows in open dry sclerophyll (eucalypt-dominated) forest or woodland at altitudes of less than about 50 m, in sandy to clay-loam soils and red pseudolateritic gravels." The substrates on which *Grevillea juniperina* subsp. *juniperina* most frequently occurs are sandy to gravelly Cenozoic alluvia, although it also grows on soils derived from Bringelly Shale (Wianamatta Group) and interfaces between these substrates. It has not been recorded on Ashfield Shale, which has a significantly higher phosphate content than Bringelly Shale (Martyn 2018). The vegetation associations in which it has been recorded include

Cumberland Plain Woodland (e.g. figure 1), Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland (e.g. figure 2) and Shale/Gravel Transition Forest.

Makinson (2000: 211) also notes that “this subspecies shows some ability to colonise mechanically disturbed areas where open ground surface persists; repeated disturbance appears to eliminate it. Populations are often restricted to infrequently managed road verges [e.g. figure 3] or ungrazed semi-cleared land [e.g. figure 4].” At two such disturbed sites where I observed it to be growing (sites GJ2, GJ5, Appendix 1), *Grevillea juniperina* subsp. *juniperina* had vigorously colonised the habitat, with plants representing all life cycle stages from seedlings less than 7 cm tall (e.g. , figure 5) to large, reproductively mature shrubs .

Figure 1. *Grevillea juniperina* subsp. *juniperina* growing in Cumberland Plain Woodland on Bringelly Shale on the eastern side of Park Road, Marsden Park (site GJ1, Appendix 1).

3. Description of the study area

LAND USE HISTORY

The following account is based largely on information gathered from Liston (1988), except where otherwise stated. The first human inhabitants of the study area were Aborigines who moved there many thousands of years ago. People of the Dharawal group were occupants of the study area when Europeans first started to settle in the Sydney Region in 1788. These hunter-gatherers would have managed the grassy woodlands that grew on Wianamatta Shales of the area using fire-stick farming methods (Benson & Howell 1990). In 1816 a large group of them were massacred by soldiers at Appin and by 1830 their community life in the Campbelltown area had disintegrated.

In 1788, six months after Sydney was founded, two bulls and four cows escaped from Sydney Cove. European exploration of the study area commenced in 1795, when 61 naturalised descendants of

Figure 2. *Grevillea juniperina* subsp. *juniperina* growing in Castlereagh Scribbly Gum Woodland on Tertiary alluvium at The Northern Road, Castlereagh Nature Reserve (site GJ3, Appendix 1).

Figure 3. *Grevillea juniperina* subsp. *juniperina* has colonised about 0.4 km of the north eastern embankment of a road cutting through Bringelly Shale on Richmond Road at Marsden Park (site GJ5, Appendix 1) .

Figure 4. A population of *Grevillea juniperina* subsp. *juniperina* plants growing in semi-cleared land on the western side of Park Road, Marsden Park (site GJ2, Appendix 1).

Figure 5. Two seedlings of *Grevillea juniperina* subsp. *juniperina* plants growing in semi-cleared land on gravelly Tertiary alluvium on the western side of Park Road, Marsden Park (site GJ2, Appendix 1) .

those bulls and cows were discovered near Menangle, in an area that became known as "the Cowpastures". Those cattle had discovered a plentiful source of fodder on the alluvial flats of the Nepean River and adjacent grassy woodlands on Wianamatta Shales, which also proved to offer more fertile farming land than sandy soils derived from Hawkesbury Sandstone. By the end of 1809, 34 settlers had been granted land at Minto and Glenfield for farming. Further land was granted to settlers at Appin in 1811, Macquarie Fields and Airds in 1816 and at Campbelltown in 1820. From then to the 1950s, land use in both growth areas was dominated by agriculture, which necessitated extensive clearing of native vegetation from the more fertile alluvial and clayey soils. Agricultural activities conducted in the areas have included the cultivation of wheat (which was curtailed in 1864 when the whole crop was destroyed by an infestation of rust disease) and other cereal crops, grazing of sheep, cattle and horses, intensive production of pigs and poultry, and the cultivation of fruit and vegetables. Campbelltown grew slowly as an urban centre during the 19th century and first half of the 20th century, but population growth accelerated after 1950 due to the rezoning of agricultural land for housing development in the northern part of the Macarthur Growth Area, electrification of the railway line as far south as Macarthur in 1963, the release of the Three Cities Plan (Campbelltown-Camden-Appin) in 1972 and subsequent construction of a number of large-scale housing commission projects from 1973.

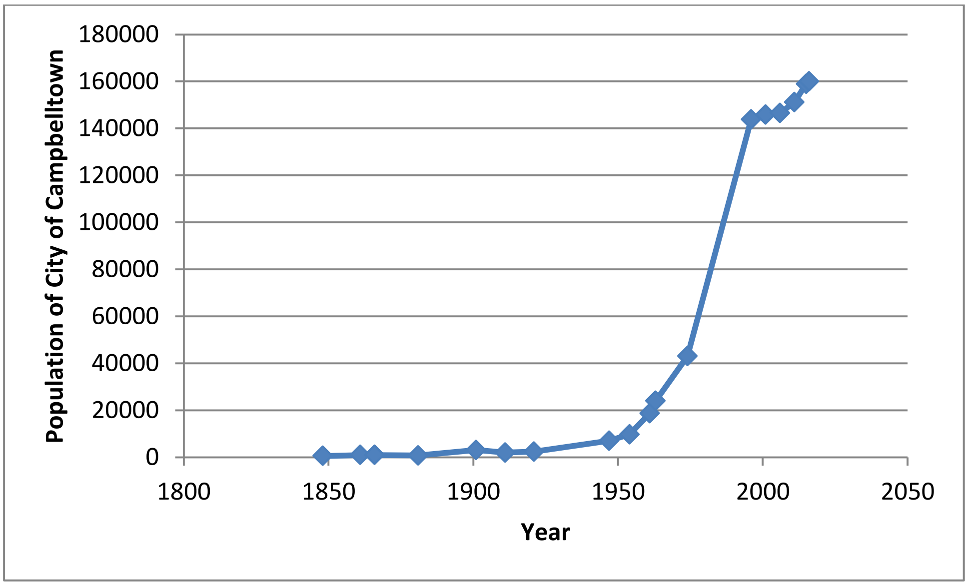

Figure 6. Population growth of Campbelltown, 1848-2016, assembled from data presented at https://www.campbelltown.nsw.gov.au/AboutCampbelltown/History/Campbelltowntimeline

Land use in the northern part of the Macarthur Growth Area is now dominated by residential housing, light industry and transport infrastructure, with only small pockets of pasture and urban bushland remaining intact, albeit weed-infested. In the southern half of the Macarthur Growth Area, south of the "waist" between Mt Annan and Glen Alpine, and in the Wilton Growth Area, land use is still largely rural, with the exception of limited residential and industrial development around Appin and Wilton. Agriculture has been largely restricted to soils derived from Wianamatta Shales and alluvium. Most areas of exposed Hawkesbury Sandstone either still support native vegetation or have been cleared for residential development.

HISTORY OF BOTANICAL EXPLORATION IN THE GROWTH AREAS

The first botanist to collect plant specimens in the same region as the growth areas was Joseph Banks' employee, George Caley, who in 1802 made several expeditions from Prospect through the Cowpastures, reaching Mount Hunter, Menangle and Thirlmere Lakes (Webb 1995). Caley returned to the area in 1803, 1804, 1805 and 1807, once in the company of the great Scottish botanist Robert Brown. Caley mapped a section of Georges River near Ingleburn, following it to Appin, and explored the upper Nepean River system as far as Douglas Park and Appin Falls on the Cataract River (Webb 1995). On these trips, Caley and Brown made extensive botanical collections, from which Brown described numerous species that were new to science, including *Grevillea juniperina*, which they collected near Prospect in 1803. The next botanical collector to visit the area was Franz Sieber, an Austrian who spent six months in the Sydney Region in 1823, during which time he collected specimens of 300 plant species (Ducker 1990), including many that are native to the study area. Botanical exploration of the area then became almost dormant until the late 19th century, when it intensified under the influence of J.H. Maiden, curator of the new Technological Museum, and later director of the Sydney Botanic Gardens. Botanists associated with Maiden, including R.T. Baker, J.L. Boorman, A.A. Hamilton, W.F. Blakely and E. Cheel made several thousand collections in the study area in the late 19th and early 20th centuries (National Herbarium of N.S.W. specimen database), long after much of the native vegetation on Wianamatta Shales and alluvia had been cleared for agriculture. Botanical exploration of the remnant vegetation of the study area has continued to the present day

LANDSCAPE CONTEXT

The Greater Macarthur and Wilton Growth Areas are located on the southern to south eastern rim of the Cumberland Plain, the central part of the saucer-shaped sedimentary Sydney Basin. Here, the uppermost strata of the Sydney Basin, Cenozoic alluvia patchily overlie the Triassic Wianamatta Group, mostly comprising Bringelly and Ashfield Shales, which, in turn overlie Triassic Hawkesbury Sandstone (Martyn 2018). Scattered small volcanic intrusions occasionally pierce the sedimentary strata, such as at Mt Annan, 0.7 km west of the "waist" in the middle of the Greater Macarthur Growth Area.

The most commonly exposed substrate in the northern part of the Greater Macarthur Growth Area is Ashfield Shale, over which patches of Bringelly Shale have been preserved on the western side, while Quaternary alluvia have accumulated in the valleys of Bow Bowing and Bunbury Curran Creeks (NSW Department of Minerals and Energy 1991, NSW Department of Mineral Resources 1985). Here, minor tributaries of the Georges River, such as Redfern, Smiths and McBarrons Creeks have exposed Hawkesbury Sandstone in narrow, shallow but steep-sided valleys.

In the southern half of the Greater Macarthur Growth Area, Bringelly Shale and Quaternary alluvium are restricted to the north west at Menangle Park. Further south, the Nepean and Georges Rivers and their tributaries have cut deep gorges through the Ashfield Shale, exposing large areas of Hawkesbury Sandstone on the steep valley sides and on the adjacent, flat to gently sloping valley borders. Large areas of transitional substrate exist here, where Ashfield Shale colluvium thinly covers Hawkesbury Sandstone or mixes with sandstone-derived soil. The landscape of the Wilton Growth Area resembles that of the southern half of the Greater Macarthur Growth Area but here the predominant substrate is Hawkesbury Sandstone over which an archipelago of thin islands of Ashfield Shale are preserved.

As the Greater Macarthur and Wilton Growth Areas are located on the southern to south eastern rim of the Cumberland Plain, they are gently tilted from south south west to north north east. However, topography also varies locally, with erosion having produced gently rolling landscapes over much of the area but steep-sided valleys contain the major water courses. The lowest point is in the far north east at Glenfield, where the banks of the Georges River are at 15 m altitude, but the land nearby rises to an altitude of 60 m at the junction of Campbelltown Road and Camden Valley Way. In the southern end of the Greater Macarthur Growth Area, just south east of Appin, the altitude reaches 260 m but drops to 230 m on the banks of the Georges River . The Wilton Growth Area varies in altitude from 105 m in the bottom of the Nepean Gorge to 305 m near its southern tip on the Picton Road.

Topographic variation as well as distance from the sea influences climate. The area just west of the Greater Macarthur Growth Area has the lowest average annual rainfall and the highest average January maximum temperature in the Sydney Region (Benson & Howell 1990). Both growth areas are subject to winter frosts.

NATIVE VEGETATION

In terms of the plant community types recognised in the Bionet Vegetation Classification and the vegetation maps that were prepared for this project, the remnant native vegetation of the growth areas consists of:

- 830 Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain;
- 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain;
- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain;
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain;
- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain;
- 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney;
- 1292 Water Gum – Coachwood riparian scrub along sandstone streams;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain.

Plant community types 830, 849 and 850 grow on Wianamatta Shales, 835 on quaternary alluvium, 1081 and 1395 on Hawkesbury Sandstone under a thin layer of Ashfield Shale or shale colluvium and 1181 and 1292 on Hawkesbury Sandstone.

In the course of this project, I visited 23 sites in the field, 19 of which were either in, or adjacent to, the Growth Areas, 20 of which I characterised in detail (Appendix 1).

In the northern half of the Greater Macarthur Growth Area, native vegetation is restricted to small, mostly long, narrow patches of urban bushland, most of which line water courses. A few of these are conserved as council reserves. I visited four bushland remnants either in, or close to the northern part of the Greater Macarthur Growth Area (sites N1, N7, N13, N14, Appendix 1), two of which I characterised in detail (N1, N7). I found all of these to include substantial weed infestation, especially close to water courses. Two species of privet, *Ligustrum sinense* and *L. lucidum*, were the most common woody weeds growing on sandstone, while African Olive (*Olea europea* subsp. *cuspidata*) was common on Wianamatta Shales. Common herbaceous weeds included naturalised grasses, Bridal Creeper (*Asparagus asparagoides*) and, near watercourses, Wandering Jew (*Tradescantia fluminensis*). Dumped household and garden rubbish was common near road access points in most patches of remnant bushland.

In the southern half of the Greater Macarthur Growth Area, and in the Wilton Growth Area, patches of remnant native vegetation become progressively more plentiful, on larger blocks of land, as one moves south but they are still mostly associated with water courses. According to the vegetation maps that were prepared for this project, by far the most abundant plant community type here is 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain. This community type occurs on flat to gently sloping land, on clayey to loamy soils derived from Asfhield shale or shale colluvia over Hawkesbury Sandstone, often adjacent to steep-sided gorges of exposed Hawkesbury Sandstone (e.g. site N8, figure 7).

Figure 7. Plant community type 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, on Ashfield shale colluvium over Hawkesbury Sandstone at Shingle Hill, Wilton (site N10, Appendix 1).

Although almost all of this community type is coded as "intact" in the vegetation maps, I found the condition of these remnants variable, depending on the extent of grazing by stock to which they had been subjected. At one of my sites (site N3, Appendix 1), a shrub stratum was completely absent and all herbaceous plants had been grazed close to the ground (figure 8).

The sides of the gorges of the Nepean and Georges Rivers and their major tributaries are typically covered by plant community type 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (e.g. site N11, figure 9). In some places this forms a mosaic with plant community type 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain.

Figure 7. Heavily grazed understory vegetation in plant community type 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain at Allen Creek, Wilton (site N3, Appendix 1).

Small, mostly degraded remnants of plant community types 849 and 850 are scattered on Ashfield Shale in the Wilton Growth Area and southern part of the Macarthur Growth Area.

POTENTIAL HABITAT

In its core distribution, *Grevillea juniperina subsp. juniperina* on sandy to gravelly Tertiary alluvia, although it also grows on soils derived from Bringelly Shale (Wianamatta Group) and Quaternary alluvia and interfaces between these substrates. It is recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition Forest.

Figure 8. Plant community type 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney east of Appin (site N11, Appendix 1).

Figure 9. Plant community type 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain east of Appin (site N12, Appendix 1).

The OEH Threatened Species Data Collection indicates that *Grevillea juniperina subsp. juniperina* has the potential to occur in the following plant community types within the Wilton and Greater Macarthur Growth Areas:

- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain;
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain;
- 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain.

Plant community types 849 and 850 are represented in the Growth Areas mostly as small, degraded fragments. Plant community type 883 is absent from the Wilton Growth Area and is represented in the Greater Macarthur Growth Area by a tiny, degraded fragment totalling less than one hectare at Macquarie Fields.

4. Assessment of species presence and suitable habitat

SPECIES RECORDS AND HABITAT ASSESSMENTS

Grevillea juniperina subsp. juniperina has never been recorded in the study area, nor has any formal habitat assessment ever been conducted there. However, on 19 June 2017 the focal taxon was collected adjacent to the study area by Brian Towle at Gundungarra Reserve, Spring Farm, 4 km north west of the “waist” in the Greater Macarthur Growth Area (specimen NSW999291), in a disturbed remnant of Grey Box – Forest Red Gum grassy woodland on Bringelly Shale.

I interviewed two botanists who have published comprehensive taxonomic treatments of *Grevillea*, Robert O. Makinson and Peter M. Olde, to ask for their personal opinions on the likelihood of *Grevillea juniperina subsp. juniperina* being native to the study area. Both are familiar with, and have described the morphology, distribution and ecology of this taxon and Olde has also written on its horticultural attributes. Both consider the core of its distribution to be the area bounded by Scheyville, Richmond, Penrith and Blacktown. Makinson has observed one plant of *Grevillea juniperina subsp. juniperina* growing at Bill Anderson Reserve, Kemps Creek, and thought that this was most probably a wild occurrence, representing the southern limit of distribution of the taxon. Makinson had determined the identity of Towle’s collection from Spring Farm as *Grevillea juniperina subsp. juniperina* but was ambivalent about whether this represented a wild record or garden escape. Olde believes that the southern limit of *Grevillea juniperina subsp. juniperina* is north of Luddenham and considers the Kemps Creek and Spring Farm occurrences both to represent garden escapes.

PRIOR SPECIES SURVEYS

Grevillea juniperina subsp. *juniperina* is a perennial shrub that is readily recognised at any time of year by its distinctive vegetative morphology. Conventional surveying would therefore be the most appropriate way to test for its presence, if unlimited access to the study area were allowed. Surveys were undertaken on behalf of DPE on all areas of land where landowners granted access, amounting to 3,360 hectares (62% of the urban development footprint). However, the survey effort for this species did not meet the recommendations in the OEH threatened species guidelines for field traverse surveys due to limitations imposed by land access. No sightings of the species were recorded from the survey areas.

ASSESSMENT OF SPECIES PRESENCE

Grevillea juniperina subsp. *juniperina* is unlikely to be growing wild in either the Greater Macarthur Growth Area or the Wilton Growth Area and has probably never been native to either of these areas.

JUSTIFICATION FOR DETERMINATION

Evidence and arguments supporting the hypothesis that *Grevillea juniperina* subsp. *juniperina* is, or once was native to the study area

There is some evidence that suitable habitat for *Grevillea juniperina subsp. juniperina* exists in the study area. Two of the substrate classes on which *Grevillea juniperina subsp. juniperina* is found growing within its core distribution, Bringelly Shale and Cenozoic alluvia, occur patchily in the Greater Macarthur Growth Area north of Gilead and as a small patch of Bringelly Shale 3 km SW of Appin (NSW Department of Minerals and Energy 1991, NSW Department of Mineral Resources 1985). The focal taxon is therefore adapted to growing on soils that occur in part of the study area. Three of the plant community types in which *Grevillea juniperina subsp. juniperina* grows in its core distribution are also represented in the study area and some of these patches occur on the focal taxon's preferred substrates.

The population of four plants of *Grevillea juniperina subsp. juniperina* that was recently discovered at Gundungarra Reserve, in a patch of degraded remnant Grey Box – Forest Red Gum grassy woodland on Bringelly Shale, just outside the study area, might be native there. This habitat closely resembles small remnant patches of Cumberland Plain woodland that are scattered through the western side of the Greater Macarthur Growth Area north of Gilead and south west of Appin. It is conceivable that small populations of *Grevillea juniperina subsp. juniperina* like the one at Gundungarra Reserve might have survived in patches of remnant bushland on private property that have never been accessible to botanical collectors, including those who have surveyed parts of the growth areas for this project. The presence of *Grevillea juniperina subsp. juniperina* at Gundungarra Reserve also shows that it is capable of growing in the study area.

Most native vegetation originally growing on Bringelly Shale and alluvia in the study area was cleared for agriculture before intensive botanical exploration of the area commenced in the late 19th century, potentially destroying populations of the taxon before they could be discovered. Thus absence of evidence for the presence of the focal taxon in the study area should not be construed as evidence of original absence.

Evidence and arguments against the hypothesis that *Grevillea juniperina* subsp. *juniperina* is, or once was native to the study area

The history of botanical exploration of the study area suggests that if *Grevillea juniperina subsp. juniperina* had originally been native there, then it would probably have been collected or reported there at some time in the last 210 years. George Caley made multiple botanical collecting expeditions through the study area before any land had been granted to settlers and did not collect

Grevillea juniperina subsp. *juniperina* there, although he had earlier collected it near Prospect. One would expect Caley to have collected it if it had been as abundant here as it is in remnant bushland in its core distribution. Franz Sieber collected plant specimens in the study area in 1823, shortly after land started to be cleared there but did not collect *Grevillea juniperina* subsp. *juniperina* either. Intensive botanical exploration of the study area began in the late 19th century, and has continued to the present day and yet none of the numerous botanists who worked there have collected or reported it.

Two of the three plant community types that are potential habitat for *Grevillea juniperina* subsp. *juniperina* in the study area (849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain) were originally common and widespread between the core distribution of the taxon and the study area 24 km to the south east (Benson 1992). Moreover, two of the substrates on which *Grevillea juniperina* subsp. *juniperina* is known to occur, Bringelly Shale and Cenozoic alluvia, collectively underlie almost the whole area separating the study area from the core distribution of the focal taxon. If *Grevillea juniperina* subsp. *juniperina* had originally been native to the study area, one would expect some evidence of its existence in this intervening area to have accumulated since intensive botanical exploration of the Cumberland Plain commenced in the late 19th century. The only such evidence that I could find from the Wildlife Atlas and herbarium records was one observation of two plants at Bill Anderson Reserve, Kemps Creek and the recent discovery of four plants at Gundungarra Reserve, Spring Farm. The former of these records arguably represents a native occurrence at the margin of the focal taxon's natural distribution but the latter is very dubious as a native occurrence.

I visited Bill Anderson Reserve, Kemps Creek (sites GJ6-GJ8, Appendix 1), and spent a total of 3 hours and 45 minutes searching for *Grevillea juniperina* subsp. *juniperina* and characterising three sites there, including sites at which R.O. Makinson and G. Steenbeeke had told me that they had previously seen individual plants. The whole of this reserve could be classed as suitable habitat for the focal taxon on the basis of substrate (Bringelly Shale) and associated plant species but I could find no plants of it there. This reserve varies in altitude from 50 to 70 m, which is higher than anywhere within the core distributional range of *Grevillea juniperina* subsp. *juniperina*, where it is typically locally abundant in suitable habitats. Its rarity at Kemps Creek is consistent with this locality being at the limit of its ecological tolerance.

Brian Towle reported finding four healthy plants growing in a thicket of *Bursaria spinose* at Gundungarra Reserve, Spring Farm in June 2017 but when I visited this site 12 months later I found all four plants dead (site GJ9, Appendix 1). Their cause of death is most likely to have been water stress caused by drought: in the period May 2017 to June 2018, Campbelltown weather station recorded 317.2 mm of rainfall, less than half the mean annual rainfall of 824 mm (Bureau of Meteorology 2018). The death of these plants calls into question the bioclimatic suitability of this site as a sustainable habitat for *Grevillea juniperina* subsp. *juniperina.* This population was unlike any I had seen in the focal taxon's core distributional range. The plants were all very large, reproductively mature shrubs varying from 1.3 to 2.0 m tall and therefore at least 10 years old if one assumes a rate of growth in height of 13 to 20 cm per year. There was no evidence of seedling recruitment, unlike the populations that I had examined in the Castlereagh –Marsden Park – Shanes Park area, all of which included plants of diverse size classes.

The unusual size distribution and unexpected location of this population seem best explained by an anthropogenic origin. These plants might all be of the same or similar age, having germinated from seeds that escaped here from a local garden after construction of the suburb began in the early 1990s (https://profile.id.com.au/camden/about/?WebID=230, accessed, 21/7/2018). Two collections from naturalised populations of *Grevillea juniperina* subsp. *juniperina* are held by the National Herbarium of NSW – one from Heathmont, a suburb of Melbourne (NSW834413), the other from Penrose, 67 km south west of the study area (NSW971120), demonstrating that garden escapes of this species are likely. A notable feature of both of those collections was the observation of the presence of seedlings, unlike the population at Gundungarra Reserve. Alternatively, the plants at Gundungarra Reserve might have been planted there when the park was established at the same time as the suburb of Spring Farm. Plants used for landscaping purposes are often vegetatively propagated from single, selected clones and this could explain the absence of seedlings, if *Grevillea juniperina* subsp. *juniperina* is reproductively self-incompatible like some other species of *Grevillea* (Smith & Gross 2002). A third plausible scenario is that the plants at Gundungarra Reserve established there from dumped garden waste. The western side of this park, bordering a powerline easement, is an informal garbage dump, with abundant household refuse and garden waste, including discarded plant pots and plant material strewn through this side of the reserve.

The main reason for requiring an expert report on *Grevillea juniperina* subsp. *juniperina* is that three plant community types in which it is typically found in its core range occur in the study area. These were inferred to be potential habitat for the focal species, implying that it might occur, as yet undiscovered, in remnants of those community types within the growth areas. However, the distribution of *Grevillea juniperina* subsp. *juniperina* is also correlated with other environmental variables, such as substrate and altitude. In its core distributional range, it occurs below 50 m altitude (Makinson 2000), but records from Kemps Creek that were unknown to Makinson in 2000, extend its altitudinal range to 70 m. Land under 70 m occurs in two parts of the study area. In the northern half of the Greater Macarthur Growth Area, such low lying land occurs on substrates such as Ashfield Shale and Hawkesbury Sandstone on which *Grevillea juniperina* subsp. *juniperina* has never been recorded and where blocks of intact native vegetation seldom exceed 10 ha in area. Land below 70 m altitude is also found on the banks of the Nepean River between Menangle and Spring Farm but here the land is vegetated with a plant community type in which *Grevillea juniperina* subsp. *juniperina* has not been recorded: 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain. None of the sites that I visited and characterised in or near the study area matched the habitat of the focal species in its core distributional range (Appendix 1). It is reasonable to conclude that no suitable habitat for *Grevillea juniperina* subsp. *juniperina* now occurs within the study area.

Even if suitable habitat did occur in the study area prior to clearance of land for agriculture, this would not be compelling evidence supporting the former presence of *Grevillea juniperina* subsp. *juniperina* there. Other causal factors such as biogeographic history are also important determinants of plant distributions. Absence of the focal taxon from Bringelly Shale and Cenozoic alluvia south of Kemps Creek might reflect a history of incomplete range expansion: it might have originated on the northern Cumberland Plain but not yet dispersed into all of the habitats in which it was capable of growing and competing. Alternatively, it might have once covered a much larger area from which it later contracted as a result of stochastic processes such as high bushfire frequency in the southern Cumberland Plain.

LIKELIHOOD OF SPECIES PRESENCE

Figure 10 shows a frequency histogram of records of *Grevillea juniperina* subsp. *juniperina* from the OEH Wildlife Atlas, with the herbarium specimen from Spring Farm added into the data set, categorised in latitudinal samples 0.05 degrees wide. If the Spring Farm record is rejected as native, as I have recommended, then the frequency distribution resembles a unimodal Gaussian curve, which is typical of many plant species, as well as other kinds of organisms (Brown 1984). If we make the simplifying assumption that surveying and specimen collecting efforts have been unbiased across this range of latitudes within the Cumberland Plain, then this frequency distribution can be treated as a probability distribution. If this argument is accepted, then the whole of the study area lies outside of the curve enclosing all 1488 records. The probability of *Grevillea juniperina* subsp. *juniperina* occurring in the study area can then be conservatively estimated as less than 1/100.

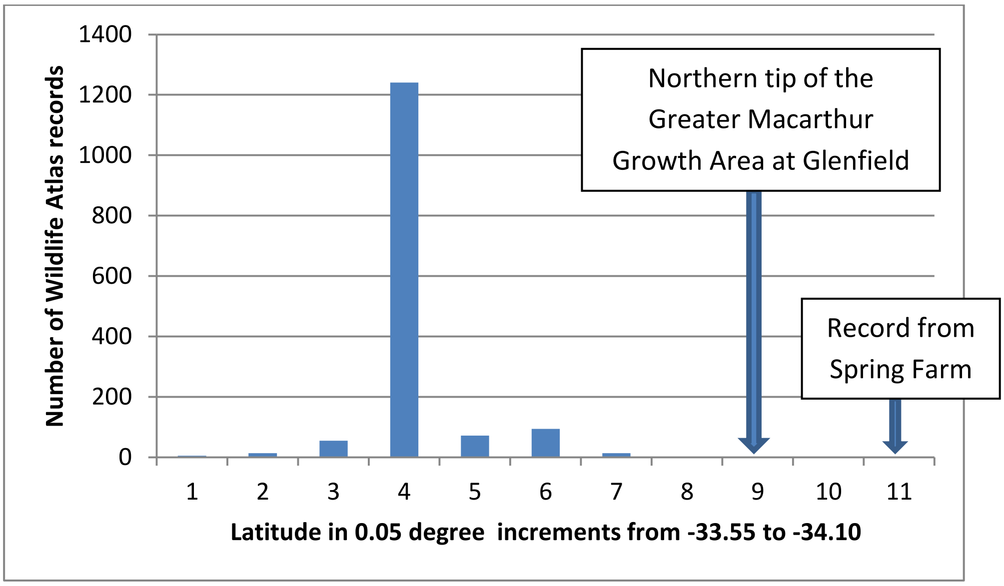

Figure 10. Frequency histogram of records of *Grevillea juniperina* subsp. *juniperina* from the OEH Wildlife Atlas classified according to latitude.

6. Acknowledgements

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8. Appendices

APPENDIX 1: Characterisation of habitat at selected sites

The tables on following pages record data that I collected at sitews both within and outside the study area. Several of these sites received “over the fence” assessments and were not characterised in detail. Each site that was characterised in detail was centred on an arbitrarily selected plant of *Grevillea juniperina* subsp. *juniperina* (sites numbered GJ1-GJ5, GJ9) or at places where the focal taxon had previously been reported (sites GJ6-GJ8) or at an arbitrarily point in the case of sites examined in or near the growth areas (sites N1-N14). At each site the precise latitude and longitude, altitude, substrate, soil description, slope and aspect were also recorded. Also, at each site all woody plant species and a few species of herbaceous plants that could be reliably identified from vegetative characters were recorded within a radius of 30 metres. Attributes of sites at which *Grevillea juniperina* subsp. *juniperina* was found (sites GJ1-GJ5, GJ9) were compared with comparable attributes of sites in or near the growth areas to assess whether any sites in the growth areas closely matched *Grevillea juniperina* subsp. *juniperina* sites.

Site	Location	Latitude	Longitude	Altitude	substrate
GJ1	Southern end of Park Rd, E side, Marsden Park	33°41'22.6"S	150°50'03.1"E	25 m	Bringelly Shale
GJ2	Junction of Walker Pde and Park Rd, Marsden Park	33°40'58.8"S	150°50'06.3"E	25 m	Tertiary alluvium
GJ3	Castlereagh Nature Reserve, Northern Rd, Londonderry	33°40'44.9"S	150°44'37.3"E	52 m	Tertiary alluvium
GJ4	Junction of Palmyra Ave and Stony Creek Rd, Shanes Park	33°43'09.1"S	150°46'52.7"E	25 m	Bringelly Shale-Tertiary alluvium
GJ5	Richmond Rd, Marsden Park	33°41'03.3"S	150°49'12.4"E	25 m	Bringelly Shale
GJ6	Bill Anderson Reserve, Kemps Creek site 1	33°52'55.2"S	150°47'21.4"E	70 m	Bringelly Shale
GJ7	Bill Anderson Reserve, Kemps Creek site 2	33°52'53.2"S	150°47'19.0"E	66 m	Bringelly Shale
GJ8	Bill Anderson Reserve, Kemps Creek site 3	33°52'41.7"S	150°46'53.7"E	50 m	Bringelly Shale
GJ9	Gundungarra Reserve, Spring Farm	34°03'38.9"S	150°44'15.0"E	125 m	Bringelly Shale
N1	Colong Reserve, Smiths Creek, Leumeah	34°03'22.6"S	150°50'24.3"E	87 m	Hawkesbury Sandstone
N2	Douglas Park bridge, Nepean River	34°11'32.5"S	150°42'48.6"E	110 m	Hawkesbury Sandstone
N3	Allens Creek, Wilton site 1	34°12'36.7"S	150°41'15.4"E	157 m	Hawkesbury Sandstone
N4	Allens Creek, Wilton site 2	34°12'25.7"S	150°41'17.9"E	201 m	Hawkesbury Sandstone
N5	Allens Creek, Wilton site 3	34°12'25.2"S	150°41'23.5"E	140 m	Hawkesbury Sandstone
N6	Ouesdale Creek, Appin	34°11'30.1"S	150°46'53.5"E	215 m	Hawkesbury Sandstone
N7	Noorumba Reserve, Rosemeadow	34°06'49.3"S	150°47'27.2"E	139 m	Ashfield Shale
N8	Shingle Hill, site 1	34°12'26.8"S	150°38'50.5"E	145 m	Hawkesbury Sandstone
N9	Shingle Hill, site 2	34°12'26.8"S	150°38'50.5"E	144 m	Hawkesbury Sandstone
N10	Shingle Hill, site 3	34°12'35.3"S	150°38'54.1"E	160 m	Mittagong Formation
N11	Georges River, Appin site 1	34°12'27.4"S	150°47'50.9"E	268 m	Hawkesbury Sandstone
N12	Georges River, Appin site 2	34°12'18.4"S	150°47'50.5"E	260 m	Hawkesbury Sandstone
N13	Bicentennary Reserve, Minto	34°00'49.7"S	150°51'11.5"E	35 m	Ashfield Shale
N14	Bunbury Curran Reserve, Macquarie Fields	33°59'00.2"S	150°53'51.7"E	15 m	Hawkesbury Sandstone

Appendix 1a: Environmental data for sites visited as part of this study (continued on next page)

Site	Soil description	Slope	Aspect	Vegetation structure (canopy)	Vegetation structure (understory)
GJ1	brown sandy loam	<5°	SW	dry sclerophyll forest-woodland	sparse shrubby understory
GJ2	brown gravelly clay-loam	0°		Partially cleared woodland	Shrubby thickets separated by open pasture
GJ3	brown, gravelly clay-loam	0°		dry sclerophyll forest	sparse shrubby understory
GJ4	brown , gravelly clay-loam	<5°	W	dry sclerophyll woodland	dense shrubby understory
GJ5	gravelly brown clay	20°	SW	Regenerating Dry sclerophyll woodland	sparse shrubby understory
GJ6	red-brown sandy loam	0°		Dry sclerophyll woodland	sparse to dense shrubby understory
GJ7	red-brown sandy loam	<5°	N	disturbed dry sclerophyll woodland	moderately dense shrubby understory
GJ8	red-brown sandy loam	<5°	NW	disturbed dry sclerophyll forest	dense shrubby understory
GJ9	brown clay	0°		Highly disturbed, remnant woodland	mosaic of shrubby thickets and weedy grassland
N1	black sand	0°		Disturbed dry sclerophyll forest	moderately dense shrubby understory
N2	black sand	0-20°	SW	Dry sclerophyll forest	sparse shrubby understory
N3	brown sandy loam	0°		Heavily grazed dry sclerophyll forest	no shrub layer
N4	brown sandy loam	0°		Heavily grazed dry sclerophyll forest	mosaic of shrubby thickets and clear ground
N5	pale grey-brown sand	5-30°	SE	Dry sclerophyll forest	moderately dense shrubby understory
N6	brown sandy loam	5-15°	SSW	Dry sclerophyll forest	mosaic of dense to moderately dense shrubby thickets
N7	red-brown clay	0°		Dry sclerophyll forest	moderately dense shrubby understory
N8	dark brown humus-rich sand	<5°	N	Dry sclerophyll woodland	sparse to dense shrubby understory
N9	dark brown humus-rich sand	<5°	W	Dry sclerophyll woodland	sparse to moderately dense shrubby understory
N10	brown loam	<5°	N	Dry sclerophyll forest	dense shrubby understory
N11	dark brown humus-rich sand	0°		Dry sclerophyll forest	sparse to moderately dense shrubby understory
N12	dark brown humus-rich sand	0°		Dry sclerophyll forest	sparse to moderately dense shrubby understory
N13				Dry sclerophyll forest	
N14				Dry sclerophyll forest	

Appendix 1a (continued): Environmental data for sites visited as part of this study

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Acacia binervata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Acacia binervia	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Acacia brownii	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Acacia elongata	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia falcata	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1
Acacia longifolia	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia mearnsii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Acacia parramattensis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia suaveolens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Acacia terminalis	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Acrotriche divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Actinotus helianthi	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Allocasuarina glareicola	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	0	1	0	1	1	1	1	0	0	1	0	1	1	1	0	1	1	1	1	1
Allocasuarina torulosa	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Angophora bakeri	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0
Angophora floribunda	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Astroloma pinifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Astrotricha latifolia	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0
Backhousia myrtifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Banksia serrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Appendix 1b: Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Banksia spinulosa	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	1	0	1	1
Beyeria viscosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Billardiera scandens	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Bossiaea obcordata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Bossiaea rhombifolia	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bursaria spinosa	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	1	0	0
Bursaria spinosa	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	1	0	0
Callistemon linearis	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopetalum gummiferum	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1
Correa reflexa	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0
Corymbia gummifera	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Crowea exalata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cryptandra amara	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptandra spinescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Dampiera stricta	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dampiera purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Daviesia corymbosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Daviesia ulicifolia	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dillwynia acicularis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Dillwynia rudis	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dillwynia sieberi	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Dillwynia tenuifolia	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >																			
Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Dodonaea falcata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea triquetra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Elaeocarpus reticulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Enchylaena tomentosa	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Eremophila debilis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriostemon australasius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Eucalyptus crebra	0	0	1	1	0	0	0	1	0	0	1	1	0	0	1	0	0	1	0	0
Eucalyptus eugenioides	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus fibrosa	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Eucalyptus globoidea	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Eucalyptus longifolia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus moluccana	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Eucalyptus paniculata	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Eucalyptus pilularis	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
Eucalyptus piperita	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1
Eucalyptus punctata	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	0	1
Eucalyptus sclerophylla	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1
Eucalyptus sieberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Eucalyptus sparsifolia	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	1	0	1
Eucalyptus tereticornis	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Exocarpos cupressiformis	1	0	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0
Exocarpos strictus	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	1	1	1	1	1
Goodenia hederacea	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Grevillea arenaria	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Grevillea diffusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
*Grevillea juniperina*subsp. *Juniperina*	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea mucronulata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Grevillea sericea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hakea laevipes	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Hakea sericea	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Hardenbergia violacea	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hibbertia aspera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hovea linearis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hovea purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Indigofera australis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Isopogon anemonifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Jacksonia scoparia	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunzea ambigua	0	1	0	1	0	1	1	0	1	1	0	1	1	1	0	0	1	1	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Lasiopetalum ferrugineum cordatum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Lasiopetalum ferrugineum ferrugineum	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Leptospermum polygalifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Leptospermum trinervium	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	1	1	1
Leucopogon ericoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Leucopogon juniperinus	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Leucopogon virgatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Lissanthe strigosa	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Lomandra longifolia	0	0	0	0	1	0	1	0	1	0	0	0	1	1	0	0	1	0	1	0
Lomandra obliqua	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Melaleuca decora	1	1	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Melaleuca erubescens	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca linearifolia	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0
Melaleuca nodosa	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micromyrtus minutiflora	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Myrsine variabilis	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Notelaea longifolia	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	1	1	1	0	0
Olearia viscidula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ozothamnus diosmifolius	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patersonia glabrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Patersonia sericea	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia lanceolata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Persoonia linearis	0	0	0	0	1	1	0	0	1	1	0	1	1	1	0	1	1	1	1	1
Persoonia nutans	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia pinifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Petrophile sessilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Phyllanthus hirtellus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pimelea linifolia	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pittosporum revolutum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >																		
Associated species	GJ1	GJ3	GJ4	GJ5	GJ6	GJ7	GJ8	GJ9	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Pittosporum undulatum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Platysace linearifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Podolobium ilicifolium	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0
Polyscias sambucifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pteridium esculentum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Pultenaea parviflora	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Stenocarpus salignus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Stylidium laricifolium	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Stypandra glauca	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Styphelia laeta	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Syncarpia glomulifera	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Westringia longifolia	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Xanthorrhoea media	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Xanthosia pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Xylomelum pyriforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

APPENDIX 2: PETER WESTON'S CURRICULUM VITAE

Personal details

Name: Peter Henry Weston.

Address: 18 Lyle Avenue, Lindfield, New South Wales 2070, Australia.

Date and place of birth: 22 October 1956, Lower Hutt, New Zealand.

Immediate family: wife (Susan) and three children (Timothy 33, Caitlin 31, Nicholas 27).

Nationality: Australian.

Interests: soccer, reading, guitar, orchid growing, cross-country skiing, bush walking.

Academic Qualifications

i) **B.Sc.** (first class honours; equal first in order of merit) School of Biological Sciences, University of Sydney; 1975-78, conferred 7 April 1979.
Thesis title: "The evolution and classification of *Boronia* Sm."

ii) **Ph.D.**, School of Biological Sciences, University of Sydney, 1979-83; conferred 18 May 1985.
Thesis title: "Systematics and biogeography of the Persooniinae (Proteaceae)".

Awards, Fellowships and Scholarships

2014	Nancy Burbidge Medal (awarded by the Australasian Systematic Botany Society to a person who has made a longstanding and significant contribution to Australasian systematic botany. It is the foremost award that can be conferred by ASBS).
2014	Australian Biological Resources Study-sponsored Winston Churchill Fellowship for an established career researcher in taxonomy.
2009	Grady L. Webster Structural Botany Publication Award for 2008 and 2009 from the Botanical Society of America. The BSA component of the award (it is awarded in alternate years by the BSA and the American Society of Plant Taxonomists) recognizes the most outstanding paper published in the *American Journal of Botany* in the field of structural and developmental botany (i.e., anatomy and morphology) over a two-year period. It was awarded to Gregory J. Jordan, Peter H. Weston, Raymond J. Carpenter, Rebecca A. Dillon and Timothy J. Brodribb for: "The evolutionary relations of sunken, covered, and encrypted stomata to dry habitats in Proteaceae," American Journal of Botany, Volume 95, Issue 5; May 2008.
2006	Carrick Award for Australian University Teaching from the Australian Learning and Teaching Council (one of five members of a teaching

team from the University of New England cited for Outstanding Contributions to Student Learning).

1992-93 Posting to Royal Botanic Gardens, Kew, as Australian Botanical Liaison Officer.

1982 Charles Gilbert Heydon Travelling Fellowship for the biological sciences (not taken up).

1980-82 University of Sydney Postgraduate Scholarship.

1979-82 Commonwealth Postgraduate Award.

1977 G.S. Caird Scholarship for Third Year Botany, University of Sydney.

1976 Slade Prize for Practical Plant Biology, University of Sydney.

Employment

Present Position: Honorary Research Associate, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney and independent botanical consultant.

Previous positions held:
2008-2016 Senior Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

2000-2008 Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1994-2000 Senior Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1989-1994 Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1982-1989 Scientific Officer, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1979-82 Part-time demonstrator, School of Biological Sciences, University of Sydney.

Adjunct and visiting university appointments

2013- Adjunct Associate Professor, La Trobe University.

2011- Adjunct Associate Professor, University of New South Wales.

2006 Visiting Lecturer, Rhodes University, Grahamstown, South Africa.

2004-2009 Adjunct Associate Professor, University of New England.

2000-2004 Adjunct Senior Lecturer, University of New England.

Administrative/management experience

2009 Acting Manager Plant Diversity

2002-2003 Member, Plant Diversity Research Program Leaders Committee
1998-99 Systematics Liaison Officer
1997-98 Member RBGS Market testing working party
1997 Member, RBGS advisory committee for restructuring senior management
1990-91 Systematics Co-ordinator
1996-98 Member, RBGS Joint Consultative Committee

Membership of Learned Societies

1996- Society of Australian Systematic Biologists
1984- Willi Hennig Society (Elected Fellow, 1992-, Council member, 1998-2000)
1979- Society of Systematic Biologists (member, Editorial Board 1993-95)
1978- Australasian Systematic Botany Society (formerly Australian Systematic Botany Society: President, 2009-2012, Vice President, 2008-2009, Chairman, Hansjörg Eichler Research Fund Committee, 1998-2002, Council member, 1996-2002)

Membership of External Committees

2015- Financial Grants Standing Committee (formerly the Grants Policy Standing Committee) of the Australasian Systematic Botany Society
2012-2013 Conference Organising Committee of *Systematics Without Borders*, a joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, University of Sydney (Chairman)
2011- Editorial Board, *Phytotaxa*
2008-2009 Corresponding Member, Editorial Advisory Committee, *Australian Systematic Botany*
2006-2014 Ira Butler Memorial Trophy Committee (a joint committee of the Australasian Native Orchid Society and the Orchid Society of New South Wales) (Chairman)
2004- Editorial Advisory Board, *Kew Bulletin*
2001-2006 Panel of Judges, Eureka Prize for Biodiversity Research
2000-2012 Bushland Management Advisory Committee, Lane Cove Council (Chairman, 2008-2010)
1999-2004 Editorial Advisory Committee, *Australian Systematic Botany*

Spoken presentations at conferences (not including presentations delivered by others)

2015 Building Our Botanical Capital, annual conference of the Australasian Systematic Botany Society: “A database of variation in floral characters in the Proteaceae, and implications for key questions in floral evolution”.
2014 Next Generation Systematics, annual conference of the Australasian Systematic Botany Society: Nancy Burbidge Memorial

Lecture: “Problems and progress in plant systematics since Nancy Burbidge”

2013 Genetics Society of Australasia conference, Sydney *Genetics in the Harbour City*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2013 Joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, Sydney, *Systematics Without Borders*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2012 Australasian Systematic Botany Society conference, Perth, *Local knowledge, global delivery*: “Contested, Uncontested and Potentially Controversial Taxonomic Changes in the Proteaceae: How Do They Differ?”

2011 37th annual conference of the South African Association of Botanists, *Plants in a Changing World* and 9th conference of the South African Society of Systematic Biologists, *Biodiversity Matters*; plenary address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

2011 XVIII International Botanical Congress, Melbourne: “Floral evolution in animal-pollinated Australian angiosperm clades: patterns and potential explanations”.

2010 VI Southern Connection Congress, Bariloche: “Cladistic biogeography, molecular dating, fossils and the Proteaceae”

2010 VI Southern Connection Congress, Bariloche: “Diversification of the Proteaceae in Mediterranean hotspots of the Southern Hemisphere and in tropical rainforests”

2010 Australian Systematic Botany Society conference *Systematic Botany Across the Ditch: Links Between Australia and New Zealand*; Keynote address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

1999 XVI International Botanical Congress, Saint Louis: “Historical biogeography of Proteaceae”.

1997 II Southern Connection Congress, Valdivia: “Cladistic biogeography of a key woody group: Proteaceae”.

1997 First Biennial International Conference of the Systematic Association, Oxford: “Rolf Sattler’s Plant Morphology and Cladistic Analysis”.

1996 *An International Symposium on the Biology of Proteaceae*, Melbourne: “ITS squence variation in the Proteaceae and what it tells us about phylogeny”.

1993 Joint conference of The Systematics Associations and The Linnean Society on *Models in Phylogeny Reconstruction*, London: “Direct methods for polarising character transformation series”.

1990 IXth meeting of the Willi Hennig Society, Canberra: “Transoceanic cladistic patterns in the Proteaceae”.

2003 The Third International Conference on *the Comparative Biology of the Monocotyledons*, Ontario: “Co-evolution of *Chiloglottis* (Orchidaceae) and its Thynnine wasp pollinators”.
2005 XVII International Botanical Congress, Vienna: “Food is good but sex is better: the evolution of deceptive pollination in the tribe Diurideae (Orchidaceae)”.
2006 Australian Systematic Botany Society conference, Cairns, *Plant Diversity in the Tropics*: “A new suprageneric classification of the Proteaceae”.
2007 5th Southern Connection Congress, Adelaide: “‘I’m not dead yet’ – Gondwana (the Proteaceae are at least partially congruent with Gondwanic fragmentation)”.
1989 Australian Systematic Botany Society symposium, on *Gondwanan Elements in the Australian Flora*, Sydney: “Transpacific cladistic patterns in the Proteaceae and Elaeocarpaceae”.
1988 Symposium on *Panbiogeography of New Zealand*, Wellington: “Problems with the statistical testing of panbiogeographic hypotheses”.
1985 Australian Flora Foundation Symposium on *Waratahs*, Canberra: “Drifting waratahs or continents?”
1984 Australian Systematic Botany Society symposium on *Cladistics, Systematics and Phylogeny*, Canberra: “A reappraisal of Nelson's direct method of character analysis”.

Refereeing manuscripts, grant applications, reports and examining postgraduate theses (last five years)

2016: *Australian Systematic Botany*; *Botanical Journal of the Linnean Society*, *National Research Foundation* (South Africa).
2015: *American Journal of Botany*; Australian Research Council (4); *Australian Systematic Botany*; *Muelleria*; *Nuytsia*; *Phytotaxa*; *PLOS One*; *Telopea* (6).
2014: Australian Research Council (3); *Australian Systematic Botany* (2); *Cunninghamia*; *Journal of Biogeography* (2); *Muelleria*; National Research Foundation (South Africa); *Orchadian*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Plant Systematics and Evolution*; *Telopea* (3).
2013: Australian Research Council; *Australian Systematic Botany*; *Biology Letters*; *Cladistics*; *Diversity and Distributions*; *Evolution*; *Journal of Biogeography*; *New Zealand Journal of Botany*; *Taxon*; *Telopea*.
2012: Australian Research Council (3); *Australian Systematic Botany*; “Darwin, Then and Now” (chapter of book published by University of Chicago Press); *Diversity and Distributions*; *Journal of Biogeography*; National Research Foundation (South Africa); *Phytokeys*.

Research

My research has been in the theoretical and practical aspects of systematic botany, with emphasis on the theory and practice of phylogenetic analysis, and the broader uses to which phylogenetic knowledge may be applied. I have phylogenetically analysed groups in the plant families Proteaceae, Fabaceae, Orchidaceae, Rutaceae, Winteraceae and Lauraceae, contributed to more general analyses of angiosperm phylogeny, and used the results of these analyses to improve biological classification and to test theories of historical biogeography, trait evolution, co-evolution and adaptation. I have earned an international reputation for my contributions to both theoretical and empirical developments in this field.

Herbarium curation and collections

My curatorial responsibilities at the National Herbarium of New South Wales have included the families Rutaceae (1982-1998), Proteaceae (1982-2016), Orchidaceae (1986-2016) and Fabaceae subfamily Faboideae (1986-2016). I have collected plant specimens (mostly angiosperms) in Australia, England, New Zealand, New Caledonia, Chile, South Africa, and Argentina, mostly for the herbarium and living collections of the Royal Botanic Gardens and Domain Trust, Sydney. Duplicates of my collections have been distributed to over 20 herbaria in 8 different countries.

Teaching

I have been actively involved in the preparation and teaching of four third year undergraduate courses in biosystematics:
Western Sydney University (2015-2017): “Principles of Evolution” (unit 300980), “Botany” (unit 300836).
University of New South Wales (2010-2016): “Assembling the Tree of Life” (BIOS3221)
University of New England (2000-2010): Biosystematics (Biosyst 301, Biosyst 302, Evol 301/501).
Botany Department, Rhodes University, Grahamstown, South Africa (February-March 2006): “Plant Biodiversity” course in collaboration with Associate Professor Nigel Barker.

I am currently co-supervising one postgraduate student:
Nanette Thomas (Ph.D., University of New England): Systematics of *Tasmannia* informs Biogeography of Winteraceae.

Postgraduate and honours students I have previously co-supervised include:
Margaret Stimpson (Ph.D., University of New England): Systematics, evolution and ecology of the *Banksia spinulosa* complex (graduated 2017).
Melita Milner (Ph.D., Australian National University): Phylogeography of *Lomatia and Telopea* (Proteaceae) in south eastern Australia (graduated 2015).
Samanta Oon (B.Sc. Honours, University of New South Wales): *Lomatia* likes it both ways: rampant bidirectional introgression of chloroplast genomes between two morphologically distinct species of Lomatia (Proteaceae) (graduated 2015).
Zoe Reynolds (B.Sc. Honours, Australian National University): Phylogenetic, taxonomic and functional turnover in Proteaceae assemblages (graduated 2013).

Emma McIntosh (B.Sc. Honours, University of Sydney): Hybridization and introgression between *Lomatia myricoides* and *L. silaifolia* (Proteaceae) (graduated 2011).
Margaret Stimpson (M.Sc.Stud., University of New England): Review of the *Banksia spinulosa* species complex (Proteaceae) (graduated 2011).
James Indsto (M.Sc., University of Wollongong): Pollination Ecology and Molecular Systematics of *Diuris* (Orchidaceae) of the Sydney Region (graduated 2010).
Nanette Thomas (Grad.Dip.Sci., University of New England): Phylogenetic analysis of Winteraceae (graduated 2009).
David McKenna (Ph.D., University of Wollongong: Demographic and ecological indicators for rarity in obligate-seeding *Persoonia* (Proteaceae) shrubs of the Sydney region, graduated 2007).
Paul Rymer (Ph.D., University of Wollongong: Plant rarity: species distributional patterns, population genetics, pollination biology and seed dispersal in *Persoonia* (Proteaceae), graduated, 2006).
Georgina Lloyd (B.Sc. Honours, University of Sydney: Pseudocopulation in two species of *Cryptostylis*: Implications for maintaining species integrity, graduated 2004)
Andrew Perkins (Ph.D., University of Sydney: Phylogenetic Systematics of the Genus *Calochilus* (Orchidaceae), graduated 2002).
Jim Mant (Ph.D., Australian National University: Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae), graduated 2002).
Siegfried Krauss (Ph.D., University of Wollongong: Systematic pattern and evolutionary process in the complex species *Persoonia mollis* (Proteaceae), graduated 1995).

I have examined 14 honours and postgraduate theses:
Australian National University (Ph.D., 2003, 2007, 2008)
University of Melbourne (Ph.D., 1995, 2011)
University of Newcastle (M.Phil., 2003)
University of Queensland (Ph.D., 2003)
University of Sydney (Ph.D., 1991, 1994, 1997, 2009)
University of Wollongong (B.Sc. Hons., 2001, 2003)
Victoria University (Ph.D., 2007)

Competitive Research and Infrastructure Grants

Peakall, R., Pichersky, E., Linde, C., Weston, P.H. (2015-2019) The biosynthesis and evolution of novel semiochemicals in orchids. $644,800, Australian Research Council Discovery Grant DP150102762.

Hoebee, S.E., Weston, P.H., & Edwards, T.J. (2015-18) Evolution in action or the demise of iconic Australian flora? $217,700, Australian Research Council Discovery Grant DP150100508.

He, T., Lamont, B., Weston, P.H., & Cowling, R. (2012-2014) Origin and evolution of plant functional traits in relation to fire. $310,000, Australian Research Council Discovery Grant DP120103389.

Rossetto, M., Crayn, D.M. & Weston, P.H. (2008-2010) Integrating molecular and morphological data for generic delimitation and species identification in Lauraceae. $73,333, Australian Biological Resources Study.

Cantrill, D., Murphy, D. & Weston, P.H. (2008-10) Understanding the origins of the Australian flora by integrating molecular phylogenies and fossil data in the Proteaceae. $88,900, Hermon Slade Foundation.

Rossetto, M. & Weston, P.H. (2007-2009) Speciation in the Australian flora: testing explanatory hypotheses in waratahs and their allies. $78,000, Hermon Slade Foundation.

Considine, J.A., Krauss, S.L. & Weston, P.H. (2002-2004) A biological basis for the efficient breeding of native plants for export markets: a case study with the Australian Goodeniaceae. $168,126, ARC – Linkage (Krauss and Weston representing industry partners)

Whelan, R.J., Ayre, D.J., England, P., Auld, T.D., & Weston, P.H. (2000-2002) Ecology and genetics of fire-sensitive *Persoonia* species: threatened species recovery and management. $126,480, Australian Research Council (ARC– SPIRT, Auld and Weston representing industry partners).

Trent, R. *et al.* (2000) Enhancement of DNA sequencing equipment for the Sydney University and Prince Alfred Molecular Analysis Centre. $600,000, Australian Research Council (ARC-REIF).

Weston, P.H. (1999-2001) Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae). $75,000, Hermon Slade Foundation.

Weston, P.H. (1997-2000) Taxonomic revision of *Dillwynia* (Fabaceae: Faboideae: Mirbelieae). $62,836, Australian Biological Resources Study.

Weston, P.H. & Thomson, J.A. (1993) A molecular approach to the evolution and biogeography of the Queensland tree waratahs. $4000, Queensland Wet Tropics Management Authority

Weston, P.H. & Thomson, J.A. (1991-92) A molecular approach to the evolution and biogeography of the waratahs. $80,100, Australian Research Council (large grants scheme).

Weston, P.H. (1984) Establishment of a data bank for eucalypt specimens held by NSW. $20,000, Australian Biological Resources Study.

Scientific Publications

[the numbers in square brackets following a reference indicates: 1. the journal's 2016-17 impact factor according to ISI Web of Knowledge, then the number of literature citations for the paper found by Google Scholar, as of 23 May 2018]

H-index = 32, total number of citations = 3831 as of 24 May 2018

1. Craw, R.C. & **Weston, P.H.** (1984) Panbiogeography: a progressive research program? *Systematic Zoology* 33: 1-13. [8.917, 90]

2. **Weston, P.H.**, Carolin, R.C., & Armstrong, J.A. (1984) A cladistic analysis of *Boronia* Sm. and *Boronella* Baill. (Rutaceae). *Australian Journal of Botany* 32: 187-203. [0.793, 48]

3. Morrison, D.A. & **Weston, P.H.** (1985) Analysis of morphological variation in a field sample of *Caladenia catenata* (Smith) Druce (Orchidaceae). *Australian Journal of Botany* 33: 185-195. [0.793, 11]

4. Crisp, M.D. & **Weston, P.H.** (1987a) Waratahs - how many species? Pp. 3-15, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 13]

5. Crisp, M.D. & **Weston, P.H.** (1987b) Cladistics and legume systematics, with an analysis of the Bossiaeeae, Brongniartieae and Mirbelieae. Pp. 65-130, in C.H. Stirton (ed.) *Advances in Legume Systematics Part 3* (Royal Botanic Gardens: Kew). [-, 126]

6. **Weston, P.H.** (1987) *Persoonia* (Proteaceae). Pp. 348-350, in N.G. Marchant *et al*. (eds.) *Flora of the Perth Region* (Western Australian Herbarium: Perth). [-, 0]

7. **Weston, P.H.** & Crisp, M.D. (1987) Evolution and biogeography of the Waratahs. Pp. 17-34, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 14]

8. **Weston, P.H.**, Wilson, P.G., & Hill, K.D. (1987) Identification of *Cannabis*. *Department of Agriculture New South Wales Miscellaneous Bulletin* 25: 148-150. [-, 0]

9. **Weston, P.H.** (1988a) A revision of *Hicksbeachia* (Proteaceae). *Telopea* 3: 231-239. [0.6, 3]

10. **Weston, P.H.** (1988b) Indirect and direct methods in systematics. Pp. 27-56, in C.J. Humphries (ed.) *Ontogeny and Systematics* (Columbia Univ. Press: New York). [-, 75]

11. **Weston, P.H.** (1989) Problems with the statistical testing of panbiogeographic hypotheses. *New Zealand Journal of Zoology* 16: 511. [0.811, 6]

12. **Weston, P.H.** (1990) Notes on *Boronia* (Rutaceae) in New South Wales, including descriptions of three new species. *Telopea* 4: 121-128. [0.6, 6]

13. **Weston, P.H.** & Johnson, L.A.S. (1991) Taxonomic changes in *Persoonia* (Proteaceae) in New South Wales. *Telopea* 4: 269-306. [0.6, 9]

14. Crisp, M.D. & **Weston, P.H.** (1991) *Almaleea*, a new genus of Fabaceae from south-eastern Australia. *Telopea* 4: 307-311. [0.6, 10]

15. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae), a new genus from New Guinea and eastern Australia. *Telopea* 4: 497-507. [0.6, 12]

16. **Weston, P.H.** (1991) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium*, *Pultenaea* and *Dillwynia* (Fabaceae). Pp. 2-19, 452-455, 456-461, 481-497, 499-504, in G. Harden (ed.) *Flora of New South Wales* vol. 2 (New South Wales Univ. Press: Sydney). [-, 0]

17. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae) and *Almaleea* (Fabaceae). Pp. 29-30, 497-498, in G. Harden (ed.) *op. cit.* [-, 0]

18. **Weston, P.H.** & Porteners, M.F. (1991) *Boronia*, *Eriostemon* and *Phebalium* (Rutaceae). Pp. 227-236, 250-254, 255-263, in G. Harden (ed.) *op. cit.* [-, 0]

19. Porteners, M.F. & **Weston, P.H.** (1991) *Correa* and *Crowea* (Rutaceae). Pp. 247-249, 254-255, in G. Harden (ed.) *op. cit.* [-, 0]

20. Crisp, M.D. & **Weston, P.H.** (1991) *Telopea*. Pp. 30-31, in G. Harden (ed.) *op. cit.* [0.6, 0]

21. Gross, C.L. & **Weston, P.H.** (1992) *Macadamia jansenii* (Proteaceae), a new species from central Queensland. *Australian Systematic Botany* 5: 725-28. [0.75, 7]

22. Crisp, M.D. & **Weston, P.H.** (1993) Geographic and ontogenetic variation in morphology of Australian waratahs (*Telopea*: Proteaceae). *Systematic Biology* 42: 49-76. [14.387, 74]

23. Gilmore, S., **Weston, P.H.**, & Thomson, J.A. (1993) A simple, rapid, inexpensive and widely applicable technique for purifying plant DNA. *Australian Systematic Botany* 6: 139-148. [0.75, 38]

24. **Weston, P.H.** (1993) Key to genera, *Cyrtostylis*, *Cryptostylis*, *Zeuxine*, *Cheirostylis*, *Pseudovanilla*, *Erythrorchis*, *Epipogium*, *Gastrodia*, *Oberonia*, *Liparis*, *Dendrobium*, *Calanthe*, *Phaius*, *Geodorum*, *Dipodium*, *Cymbidium*, *Sarcochilus*, *Rhinerrhiza*, *Peristeranthus*, *Papillilabium*, *Schistotylus*, *Plectorrhiza*, *Taeniophyllum* (Orchidaceae). Pp. 134-138, 218-219, 219-221, 221-233, 236-247, in G. Harden (ed.) *Flora of New South Wales* vol. 4 (New South Wales Univ. Press: Sydney). [-, 0]

25. **Weston, P.H.** & Hill, K.D. (1993) *Bulbophyllum* (Orchidaceae). Pp. 233-236, in G. Harden (ed.) *op. cit.* [-, 0]

26. **Weston, P.H.** & Crisp, M.D. (1994) Cladistic biogeography of Waratahs and their allies (Embothrieae: Proteaceae) across the Pacific. *Australian Systematic Botany* 7: 225-249. [0.75, 72]

27. **Weston, P.H.** (1994) The Western Australian species of subtribe Persooniinae (Proteaceae: Persoonioideae: Persoonieae). *Telopea* 6: 51-165. [0.6, 17]

28. **Weston, P.H.** & Johnson, L.A.S. (1994) Three new species of *Persoonia* (Proteaceae) from Queensland. *Telopea* 6: 31-37. [0.6, 1]

29. **Weston, P.H.** (1994) Methods for rooting cladistic trees. Pp. 125-155, in D.J. Siebert, R.W. Scotland and D.M. Williams (eds.) *Models in Phylogeny Reconstruction* (Oxford Univ. Press: Oxford). [-, 36]

30. Crisp, M.D. & **Weston, P.H.** (1995) Mirbelieae. Pp. 245-282, in J.J. Doyle and M.D. Crisp (eds.) *Advances in Legume Systematics Part 7: Phylogeny* (Royal Botanic Gardens: Kew). [-, 36]

31. Crisp, M.D. & **Weston, P.H.** (1995) Subtribe Embothriinae (Proteaceae). *Flora of Australia* 16: 382-390. [-, 0]

32. Crisp, M.D., Linder, H.P. & **Weston, P.H.** (1995) Cladistic biogeography of plants in Australia and New Guinea: congruent pattern reveals two endemic tropical tracks. *Systematic Biology* 44: 457-473. [8.917, 119]

33. Thomson, J.A., **Weston, P.H.** & Tan, M.K. (1995) A molecular approach to tracing the major lineages in *Pteridium*. Pp. 21-28, in R.T. Smith and J.A. Taylor (eds.) *Bracken: an Environmental Issue* (University of Leeds: Leeds). [-, 13]

34. **Weston, P.H.** (1995) Key to the genera of Proteaceae in Australia, Subfamily Persoonioideae, Subfamily Bellendenoideae, Subtribe Gevuininae, Subtribe Hicksbeachiinae. *Flora of Australia* 16: 41-46, 47-125, 125-127, 409-410. [-, 0]

35. Bernhardt, P. & **Weston, P.H.** (1996) The pollination ecology of *Persoonia* (Proteaceae) in eastern Australia. *Telopea* 6: 775-804. [0.6, 46]

36. **Weston, P.H.** & Crisp, M.D. (1996) Trans-Pacific biogeographic patterns in the Proteaceae. Pp. 215-232, in A. Keast & S.E. Miller (eds.) *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processes* (SPB Academic Publishing: Amsterdam). [-, 34]

37. **Weston, P.H.** & Johnson, L.A.S. (1997) *Persoonia hindii* (Proteaceae), a new species from the Newnes Plateau, New South Wales. *Telopea* 7: 199-203. [0.6, 5]

38. Jobson, P.C. & **Weston, P.H.** (1998) *Dillwynia glaucula* (Fabaceae: Mirbelieae), a new species from the Southern Tablelands, New South Wales. *Telopea* 8: 1-5. [0.6, 1]

39. **Weston, P.H.** (1999) *Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8: 159-164. [0.6, 4]

40. Crisp, M.D., Gilmore, S.R. & **Weston, P.H.** (1999) The phylogenetic relationships of two anomalous species of *Pultenaea* (Fabaceae: Mirbelieae) from molecular and morphological data, and description of a new genus. *Taxon* 48: 701-714. [2.447, 19]

41. Jobson, P.C. & **Weston, P.H.** (1999) Two new species of *Dillwynia* (Fabaceae: Mirbelieae), from the Southern Tablelands of New South Wales. *Telopea* 8: 363-369. [0.6, 0]

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Strategic assessment for Cumberland Plain Conservation Plan Expert report on the Juniper-leaved Grevillea, *Grevillea juniperina* subsp. *juniperina* in the Western Sydney Aerotropolis Growth Area, and Greater Penrith to Eastern Creek Urban Release Investigation Area

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1. Introduction

1.1 Purpose of the expert report

I was engaged by the Department of Planning and Envionment in September 2018, to produce an expert report on the distribution and abundance of *Grevillea juniperina* subsp. *juniperina* (Proteaceae) within the proposed Western Sydney Aerotropolis Growth Area, and Greater Penrith to Eastern Creek Urban Release Investigation Area (collectively termed "the study area"). This immediately followed my submission of a similar report on the same species for the Greater Macarthur and Wilton Growth Areas (Weston unpublished) The aim of this exercise was to assess whether *G. juniperina* subsp. *juniperina* is native to either of the Growth Areas and, if so, to assess where suitable habitat is located and to estimate the area occupied by *G. juniperina* subsp. *juniperina* in the study area and within the development footprint.

According to Section 6.5.2 of the Biodiversity Assessment Method, an expert report must:
- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made
- demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report, and
- identify the expert and provide evidence of their expert credentials.

1.2 Project context

The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney, including the two growth areas that define the geographic scope of this report: the Western Sydney Aerotropolis Growth Area and the Greater Penrith to Eastern Creek Urban Release Investigation Area. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

1.3 Study area

The study area is located in the western to south western part of the Sydney Metropolitan Area, between latitudes 33.712°S and 33.941°S and longitudes 150.654°E and 150.857°E (figure 1).

1.4 Reasons for use of expert report

Grevillea juniperina subsp. *juniperina* is represented by numerous collections and observations within the Greater Penrith to Eastern Creek Urban Release Investigation Area, and from at least one observation in the Western Sydney Aerotropolis Growth Area. *G. juniperina* subsp. *juniperina* is a perennial shrub that is readily recognised at any time of year by its distinctive vegetative morphology. Conventional surveying would therefore be the most appropriate way to test for its presence, if unlimited access to the study area were allowed. Although sizeable blocks of the

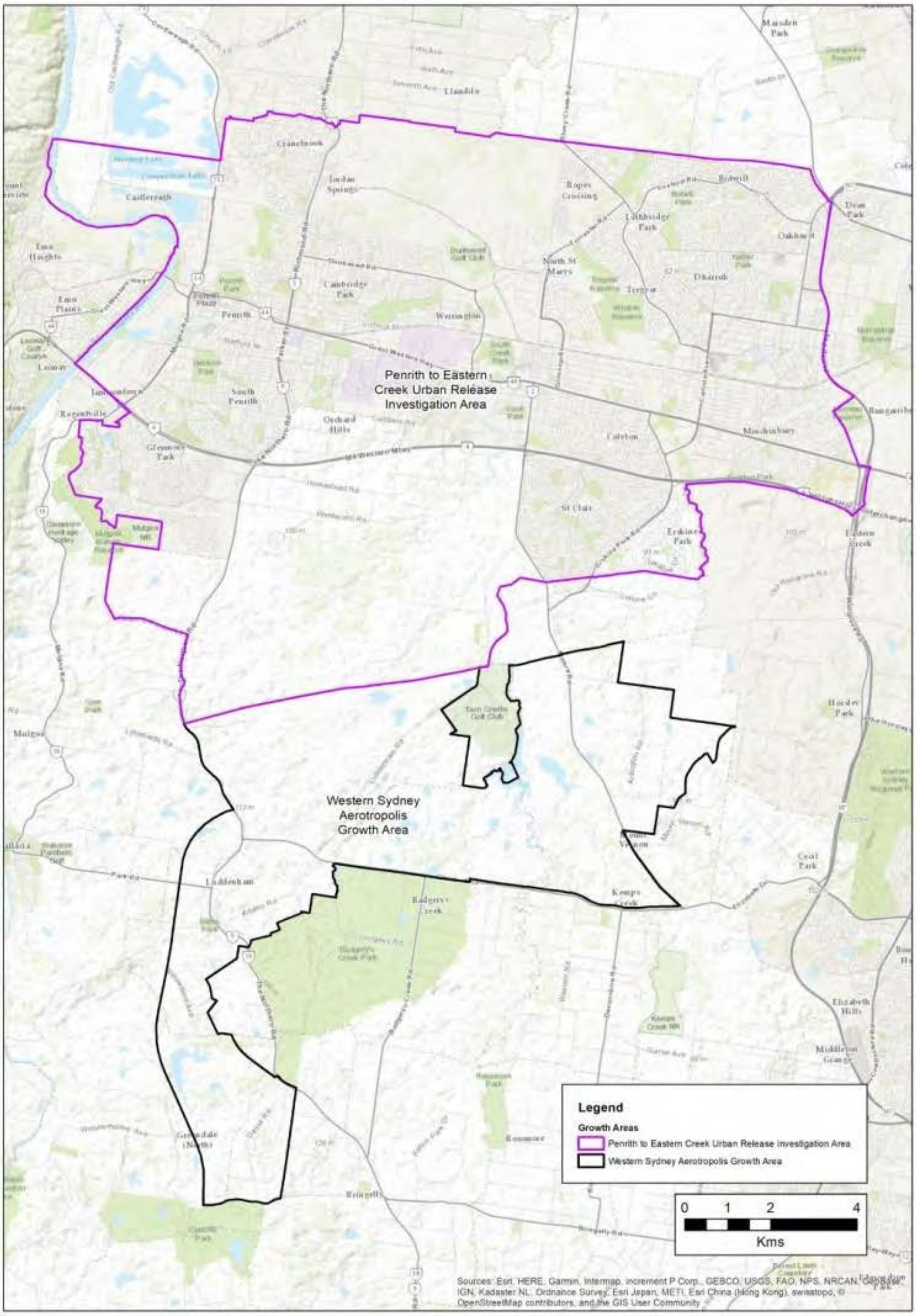

Figure 1. The Greater Penrith to Eastern Creek Urban Release Investigation Area (outlined in purple) and the Western Sydney Aerotropolis Growth Area (outlined in black). © OpenStreetMap contributors.

remnant bushland are found in public reserves, most of the native vegetation occurs on private land or land managed by the Australian Department of Defence. Only 13.5% of landowners granted permission for surveys to be conducted on their land and the Australian Department of Defence was not one of them. An alternative approach involves the construction of a general habitat model for *Grevillea juniperina* subsp. *juniperina*, which can then be used to identify suitable habitat on all land tenures across the two Growth Areas. The limitations of land access necessitated the latter approach. The need for expert knowledge of the ecology of *Grevillea juniperina* subsp. *juniperina* in creating a habitat model triggered the need for an expert report.

1.5 Credentials of expert

I prepared this report as an independent botanical consultant but I am also currently an Honorary Research Associate at the at the New South Wales state herbarium (the National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust). In 2016, I retired from my role as a Senior Principal Research Scientist at the state herbarium, having worked there since 1982 as a Systematic Botanist and as curator of the herbarium's collections of specimens of Proteaceae (including *Grevillea juniperina*) (see my *Curriculum Vitae*, attached). I now work, part-time at the National Herbarium of New South Wales as an Honorary Research Associate.

I have published, either as sole author or as a co-author, 50 papers on the systematics and ecology of the Proteaceae in the peer-reviewed scientific literature, including the most comprehensive phylogenetic analysis of the genus *Grevillea* yet published (Mast *et* al. 2015). As curator of Proteaceae at the state herbarium, I have examined all specimens of *G. juniperina* subsp. *juniperina* in the collection. I was invited to contribute to floristic treatments of the Proteaceae for *Flora of New South Wales*, *Flora of Australia*, *Flora of the Perth Region*, *Flora of China*, *Flora of North America*, and to write the treatments of Proteaceae for *Families and Genera of Vascular Plants* and *Flowering Plant Families of the World* (see my *Curriculum Vitae*, attached). I was also asked to conduct a peer review of the essay on the ecology of the Proteaceae that accompanied the "Ecology of Sydney Plants" (Myerscough *et al.* 2000). Throughout my career I have participated in numerous collecting trips in the field, collecting specimens in all Australian states for the state herbarium. In documenting these specimens I had to describe the habitat at each collecting site, including associated plant species, substrate, aspect, degree and kind of disturbance. On some of those trips, I observed and collected *Grevillea juniperina* growing in the wild.

In June 2018 I was appointed to prepare an expert report on *Grevillea juniperina* subsp. *juniperina* in the Greater Macarthur and Wilton Growth Areas (Weston unpublished), during the preparation of which I characterised in detail the associated plant species and other ecological attributes of five plots, each of 30 metre radius at which I found *G. juniperina subsp. juniperina*. I am personally familiar with this taxon and the habitats in which it lives.

In November 2018 I was approved by the Office of Environment and Heritage as a species expert for *Grevillea juniperina* subsp. *juniperina* under section 6.5.2 of the Biodiversity Assessment Method. This approval is current for a period of six years.

1.6 Species surveys

Letters were sent by the Department of Planning and Environment to all landholders within the development footprint to request access. A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking, resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Urban Release Investigation Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council. Surveys were undertaken on all areas of land where landowners granted access. Access to the Defence Establishment Orchard Hills, which includes large patches of native vegetation, was not provided.

A targeted survey for threatened species was conducted on lands where access was granted. Vegetation transects and random meanders for threatened flora were conducted by the Ecoplanning Pty Ltd and Biosis Pty Ltd in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey included effort through each plant community type and vegetation zone, and extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m). Likely habitat for most flora species comprised areas of lower disturbance. This included areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora. One incidental observation of *Grevillea juniperina* subsp. *juniperina* was made in the study area during this survey, at North St Marys.

The percentages of remnant native vegetation in the growth areas that were sampled in the threatened species survey were 1.0% in Greater Penrith to Eastern Creek and 7.1% in the Western Sydney Aerotropolis. The percentages of sampled remnant native vegetation that were covered by the urban development footprint were 7.9% in Greater Penrith to Eastern Creek and 18.4% in the Western Sydney Aerotropolis. These data include a 20 m buffer from survey tracks.

2. Species information

2.1 Species description

The following morphological description was produced by merging information from Makinson's (2000) descriptions of the Linearifolia Group, the Speciosa Subgroup, *Grevillea juniperina*, and *G. juniperina subsp. juniperina*:

More or less erect to spreading dense divaricate shrub 0.5–1.5 m tall, to 3 m across; major branches appearing subcolumnar (leaves clustered on short lateral branchlets); foliage dense (see figure 2). Branchlets terete, tomentose to villous. Leaves spreading to ascending, often crowded on short lateral branchlets, usually rigid, often dark green with paler veins, entire, narrowly ovate to subulate or linear, angularly deltoid to trigonous in cross-section, 10–22 mm long, 0.6–0.8 mm wide, pungent, needle-like, with dissimilar upper and lower surfaces; upper surface usually with 3–5 longitudinal veins, the midvein and intramarginal veins usually very prominent, sparsely covered with appressed hairs; margins strongly and angularly revolute; lower surface usually fully enclosed, usually densely sericeous or occasionally openly so, rarely glabrous, or open-tomentose; juvenile leaves scarcely broader than adults. Inflorescence terminal, occasionally also axillary and subterminal, usually simple or occasionally 2 (–4)-branched; unit conflorescence erect or slightly decurved, acropetal, subsecund; floral rachis 1–17 mm long (see figure 3). Flowers zygomorphic; torus slightly oblique. with perianth style similar to perianth or a little paler (see figure 3). Perianth densely to openly subsericeous outside with biramous hairs only, bearded inside between 2.5 and 9 mm above base, red, yellow, pale orange, or rarely greenish; tepals remaining coherent over at least the basal third, independently recoiled above (usually the ventral pair more strongly so). Pistil (13–) 20–25 mm long; style glabrous except for minute scattered erect simple hairs extending from back of style-end down at least 3 mm and sometimes almost to ovary, similar colour to perianth or a little paler; pollen-presenter usually oblique or occasionally lateral. Follicles narrowly ovoid or oblong-ellipsoidal, 10–18 mm long, colliculose to smooth, not ridged. Seeds ellipsoidal; margins revolute, a waxy strip on one side extending into a short apical elaiosome.

2.2 Life cycle

Grevillea juniperina subsp. *juniperina* is a perennial, woody plant that germinates from an ellipsoidal seed (Makinson 2000). Germination is significantly enhanced by fire: in a germination experiment, a treatment of smoke plus heat raised the germination percentage from 5-13% observed in the control treatment to 60% (Morris 2000). Seedlings are readily identifiable because their leaves differ minimally from adult leaves and the characteristic growth pattern with abundant lateral short shoots starts when seedlings are less than 10 cm tall. The duration of the juvenile growth phase and the longevity of plants are unknown (Benson & McDougall 2000). Plants are known to be killed by fire (Olde & Marriott 1995, Makinson 2000) and are not known to spread vegetatively (Benson & McDougall 2000), so this taxon can be classed as an obligate seeder. Flowering occurs mainly from August to September, with sporadic flowers appearing in other months (Makinson 2000).The flowers of all subspecies of *Grevillea juniperina* are visited by nectar-feeding birds (Olde & Marriott 1995), which are presumed to be their pollinators (Benson & McDougall 2000). Fertilized carpels develop into follicular fruits that open at maturity, releasing one or two flat seeds, each of which bears a wing-like terminal elaiosome. The seeds are dispersed by wind and also possibly by ants, which may collect the seeds for their edible elaiosomes. A buried soil seed bank accumulates at a site after plants reach reproductive maturity.

2.3 Distribution and abundance

Grevillea juniperina subsp. *juniperina* occurs naturally on the northern part of the Cumberland Subregion of the Sydney Basin IBRA Bioregion, in Sydney's Western Suburbs, in an area bounded by Pitt Town, Agnes Banks, Castlereagh, Mulgoa, Kemps Creek, and Blacktown (OEH Wildlife Atlas, accessed 2/7/2018, Atlas of Living Australia, accessed 3/7/2018). Within this polygon, it is sporadically distributed but often locally abundant in both intact native vegetation (figure 4) and in highly disturbed habitats such as pastures (figure 5), road cuttings, and abandoned railway platforms (figure 6). Collectors' and observers' notes on local abundance usually note multiple plants at recording sites and vary in their estimates of plant numbers from solitary individuals to populations of over 1,000. At some sites its population density is high. For example, between my sites PEC1 and PEC2, in Wianamatta Regional Park, I conducted a survey of reproductively mature plants of *G. juniperina subsp. juniperina* along two transects that were 1 m wide and a total of 1,285 m long (Appendix 1), in which I recorded 246 plants, a density of 1,914 mature plants per hectare.

A herbarium specimen collected from Gundungarra Reserve, Spring Farm, 11 km south south west of the study area (NSW999291), is a geographic outlier. In my earlier expert report on *Grevillea juniperina* subsp. *juniperina* in the Greater Macarthur and Wilton Growth Areas (Weston unpublished a), I argued that this population is unlikely to represent a natural occurrence of *G. juniperina subsp. juniperina*. Herbarium records that were classed as naturalised occurrences by their collectors, and by R.O. Makinson in curatorial notes, include one from the Melbourne suburb of

Figure 2. A large plant of *Grevillea juniperina* subsp. *juniperina* growing on the road verge in front of 327 Luddenham Road, Orchard Hills.

Figure 3. A branchlet of *Grevillea juniperina* subsp. *juniperina* showing lateral short shoots, bearing crowded, needle-like leaves and an inflorescence of greenish-yellow flowers terminating a short shoot.

Heathmont (NSW 834413) and another from Penrose, 94 km south west of the study area (NSW971120).

2.4 Habitat requirements

Makinson (2000: 210) notes that *Grevillea juniperina* subsp. *juniperina* "grows in open dry sclerophyll (eucalypt-dominated) forest or woodland at altitudes of less than about 50 m, in sandy to clay-loam soils and red pseudolateritic gravels." Makinson (2000: 211) also notes that "this subspecies shows some ability to colonise mechanically disturbed areas where open ground surface persists; repeated disturbance appears to eliminate it. Populations are often restricted to infrequently managed road verges or ungrazed semi-cleared land." At two such disturbed sites where I observed it to be growing (sites GJ2, GJ5, Appendix 1), *Grevillea juniperina* subsp. *juniperina* had vigorously colonised the habitat, with plants representing all life cycle stages from seedlings less than 7 cm tall (e.g. , figure 5) to large, reproductively mature shrubs.

The threatened species profile of *Grevillea juniperina* subsp. *juniperina*, published online by OEH (2018) describes its habitat as follows:

- Grows on reddish clay to sandy soils derived from Wianamatta Shale and Tertiary alluvium (often with shale influence), typically containing lateritic gravels.
- Recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition Forest.

Figure 4. A population of *Grevillea juniperina* subsp. *juniperina* growing in intact PCT 849 on Bringelly Shale at Plumpton Park, Plumpton.

Figure 5. A population of *Grevillea juniperina* subsp. *juniperina* that has established in cleared pasture on St Marys Formation alluvium at Marsden Park.

Figure 6. A population of *Grevillea juniperina* subsp. *juniperina* that has established on the platform of the abandoned Dunheved Railway Station, North St Marys.

- Associated canopy species within Cumberland Plain Woodland and Shale/Gravel Transition Forest include *Eucalyptus tereticornis*, *E. moluccana*, *E. crebra*, *E. fibrosa* and *E. eugenioides*. Understorey species include *Bursaria spinosa*, *Dillwynia sieberi*, *Ozothamnus diosmifolius*, *Daviesia ulicifolia*, *Acacia falcata*, *Acacia parramattensis*, *Themeda australis*, *Aristida ramosa*, *Cymbopogon refractus*, *Eragrostis brownii*, *Cheilanthes sieberi*, *Dianella revoluta* and *Goodenia hederacea*.
- In Castlereagh Woodland on more sandy soils the dominant canopy species are *Eucalyptus fibrosa*, *E. sclerophylla*, *Angophora bakeri* and *Melaleuca decora*. Understorey species include *Melaleuca nodosa*, *Hakea sericea*, *Cryptandra spinescens*, *Acacia elongata*, *Gonocarpus teucrioides*, *Lomandra longifolia* and the threatened species *Dillwynia tenuifolia*, *Pultenaea parviflora*, *Micromyrtus minutiflora* and *Allocasuarina glareicola*.

The OEH Threatened Species Data Collection indicates that *Grevillea juniperina* subsp. *juniperina* has the potential to occur in the following plant community types within the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area:

- 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion;
- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion;
- 806 Derived grasslands on shale hills of the Cumberland Plain (50-300m asl);
- 807 Derived grasslands on shale plains of the Cumberland Plain (<100m asl);
- 808 Derived shrubland on Tertiary Gravels of the Cumberland Plain;
- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion;
- 850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion;
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion.

3. Description of the study area

3.1 Land use history

This section is based primarily on information from penrithhistory.com, a website maintained by Penrith Library (Penrith Library 2018), except where other sources are explicitly cited. The first human inhabitants of the study area were Aborigines who moved there many thousands of years ago. People of the Darug language group were occupants of the study area when the British first started to settle in the Sydney Region in 1788 (Logan 2011). These hunter-gatherers would have managed the grassy woodlands that grew on Bringelly Shale and Cenozoic alluvia of the area using fire-stick farming methods (Benson & Howell 1990). They used the natural landscape seasonally, taking advantage of different food sources depending on availability, establishing temporary open camps of simple gunyahs on higher ground near water courses. The Nepean River and its tributaries were significant sources of fish, shellfish and useful plants while the wooded plains and gentle hills were sources of game, edible tubers, seeds, fruits and materials for making clothing, tools and shelters (Logan 2011).

In 1789, 18 months after the founding of Sydney, Captain Watkin Tench led a group from Rose Hill to the Nepean River, followed soon by further expeditions from there to Razorback in the south and downstream to the Hawkesbury River in the north (Fitzhardinge 1967). The alluvial flats of the Nepean River and adjacent grassy woodlands on Wianamatta Shales, offered more fertile farming land than sandy soils derived from Hawkesbury Sandstone surrounding the Cumberland Subregion. However, violent clashes between the British and the Darug people led by Pemulwuy delayed settlement west of Prospect until 1802, when Governor King built a headquarters for his government stock reserve at what is now Rooty Hill (NSW Office of Environment and Heritage 2018). King went on to issue land grants at what are now Penrith and Cranebrook in 1804, and Orchard Hills, St Marys and Badgerys Creek in 1806. Further land grants were made in what are now Mulgoa and Greendale in 1810, and Luddenham in 1813. In 1815 the Great Western Road was completed between Parramatta and Bathurst, placing the northern part of the study area on what soon became a major transport artery. Completion of the western railway line from Sydney to Penrith in 1867 and its extension to Bathurst in 1876 significantly enhanced accessibility of the northern part of the study area. From first settlement in the early 19th century to the 1950s, land use in both growth areas was dominated by timber production, agriculture and quarrying, all of which necessitated extensive clearing of native vegetation, especially from the more fertile alluvial and clayey soils. Agricultural activities conducted in the areas have included the cultivation of wheat (which was curtailed in 1861 when the whole crop was destroyed by an infestation of rust disease) and other cereal crops, grazing of sheep, cattle and horses, intensive production of pigs and poultry, and the cultivation of fruit, vegetables, turf and cut-flowers (Wilkinson 2011). Industrial facilities that processed saw logs and agricultural produce, such as timber mills, flour mills, milk processing plants, cattle sale yards, tanneries, canneries and wineries began to be built early in the 19th century and mostly continued operating well into the 20th century. A few manufacturing plants, producing textiles, munitions and bricks were also developed in the 19th and early 20th centuries.

Penrith grew slowly as an urban centre during the 19th century and first half of the 20th century, but population growth accelerated after 1960 due to the establishment of several social housing projects by the N.S.W. Housing Commission. This was followed from the 1970s by the gradual rezoning of much of the agricultural land in the northern part of the Greater Penrith to Eastern Creek Urban Release Investigation Area is for urban development. Land use in this growth area is now dominated by residential housing, retail precincts, light industry and transport infrastructure, but Orchard Hills in the south is still largely rural. Most protected patches of remnant native vegetation are less than 20 Ha in area but the two largest reserves containing intact bushland, Wianamatta Regional Park in the north and The Defence Establishment Orchard Hills in the south, cover approximately 900 Ha and 1370 Ha respectively.

The Western Sydney Aerotropolis Growth Area is still largely rural but includes a staggeringly small area of remnant bushland in public reserves. The largest patch consists of about 3.5 hectares of weed-infested Grey Box – Forest Red Gum grassy woodland in Sales Park, Luddenham.

3.2 Landscape context

The Sydney Basin is a geological entity composed of sedimentary rocks that is shaped a bit like a tilted, triangular, art deco saucer. In the middle of this structure is the Cumberland Subregion, in the northern half of which is located the study area. Here, the uppermost strata of the Sydney Basin, Cenozoic alluvia, patchily overlie the Triassic Wianamatta Group, comprising Bringelly Shale, Minchinbury Sandstone and Ashfield Shale, which, in turn overlie Triassic Hawkesbury Sandstone, the Triassic Narrabeen Group and the Permian Shoalhaven Group (Martyn 2018). Scattered small Jurassic basalt diatremes occasionally pierce the sedimentary strata, such as at Lethbridge Park and Bidwill.

The most commonly exposed substrate in the study area is Bringelly Shale. Over this, the second most commonly exposed substrate, heavy, alluvial Quaternary clay, which has been eroded from Bringelly Shale, has accumulated in a branching pattern across the study area on the floodplains of

South Creek and its tributaries, including Kemps, Badgerys, Cosgrove, Blaxland, Claremont, Werrington and Ropes Creeks (NSW Department of Minerals and Energy 1991).

Other substrates are also exposed over a much smaller area on the northern and western margins of the Greater Penrith to Eastern Creek Urban Release Investigation Area. Two patches of Londonderry Clay, a Paleogene-Neogene alluvium, covering an area of about six square kilometres, have been preserved on the northern edge between St Marys and Shanes Park. On the western margin, between Mulgoa and the north-western corner, gravelly, sandy, silty and clayey Quaternary alluvia of the Cranebrook formation line the eastern bank of the Nepean River and its eastern tributaries, forming an extensive deposit up to four kilometres wide north of Regentville. On the western margin, several square kilometres of Ashfield Shale and a smaller area of Rickabys Creek Gravel, a Paleogene-Neogene alluvium, are exposed from Jamisontown to Glenmore Park.

The whole study area is gently tilted from south to north and all watercourses flow in that general direction. Topography varies subtly in the Greater Penrith to Eastern Creek Urban Release Investigation Area with low, rounded ridges alternating with flat-bottomed flood plains. The lowest point is in the north west corner at Upper Castlereagh, where the bank of the Nepean River is below 10 m altitude, and along the northern margin the altitude is less than 70 metres. The highest point in the Greater Penrith to Eastern Creek Urban Release Investigation Area is 93 metres in altitude at Sovereign, in the south west corner. Along the boundary between the two growth areas, altitude varies from 40 metres in the east to 90 metres in the west.

Topographic relief is still quite gentle, but more noticeable, with steeper slopes, in the Western Sydney Aerotropolis Growth Area. The altitude varies from 40 metres in the north eastern corner to 106 metres just south east of Luddenham village.

Topographic variation, as well as distance from the sea influence climate. The Cumberland Subregion is the driest part of the Sydney Region and also experiences the most extreme temperatures in the region. Key climate statistics for the three weather stations in the study area, for which data are freely available, are shown in table 1. The whole study area is subject to winter frosts.

Weather station	Mean annual rainfall (mm)	Mean maximum temperature (°C)	Mean minimum temperature (°C)
Penrith Lakes AWS (1995-)	718.6	31.0	5.3
Orchard Hills Treatment Works (1970-)	832.7	28.5	5.3
Badgerys Creek McMasters F (1995-)	794.3	28.6	3.8

Table 1. Key climatic statistics for weather stations in the growth areas.

3.3 Native vegetation communities

In terms of the plant community types recognised in the Bionet Vegetation Classification and the vegetation maps that were prepared for this project, the remnant native vegetation of the growth areas consists of:

- 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain (191.3 ha);
- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain (167.4 ha);
- 781 Freshwater wetland (68.9 ha);
- 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (2.8 ha);

- 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain (989.2 ha);
- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (2334.1 ha);
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain (88.5 ha);
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain (6.5 ha);
- 1105 River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion (94.2 ha);
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain (2.0 ha).
- 1800 Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley (228.5 ha).

In the study area, according to the vegetation mapping that was conducted for this project, the following substrates support the following plant community types:

- Quaternary alluvium, including Cranebrook Formation: PCTs 781, 835, 849, 850, 1105, 1800;
- Londonderry Clay: PCTs 724, 725, 835, 849;
- Bringelly Shale: PCTs 724, 725, 835, 849, 883;
- Ashfield Shale: PCTs 830, 835, 849, 1395.
- Rickabys Creek Gravel: 849.

PCT 849 is the most abundant plant community type throughout both growth areas, growing on most of the uncleared land above the zone of floodwater inundation, most commonly on Bringelly Shale. Over 50% of the two largest patches of remnant bushland, Wianamatta Regional Park and the Defence Establishment Orchard Hills is covered in PCT 849 and it covers most of the smaller reserves too. PCT 835 covers the second largest area and also occurs throughout the study area, vegetating the uncleared flood plains of South Creek and its tributaries on Quaternary alluvium, as well as the lowest part of the adjacent slopes. The banks of those creeks as well as some other blocks of low-lying land on Quaternary alluvium, are dominated by PCT 1800. PCTs 724 and 725 are dominant on Londonderry Clay in the northern part of the study area but also occur patchily elsewhere on Bringelly Shale, most notably in the Kemps Creek area and on a rectangular block of regenerating vegetation 0.6-0.8 km west of Luddenham Road, 0.2-0.6 km north of the Warragamba-Prospect water pipeline. PCT 1105 dominates remnant vegetation on the banks of the Nepean River north of Penrith, on Cranebrook Formation alluvium. The remaining plant community types occur only rarely as tiny fragments in the study area. About 6.5 ha of PCT 883 occurs in two patches at the eastern end of Wianamatta Regional Park and about 15 ha remains in a block 0.6 km north of Elizabeth Drive, Kemps Creek. PCT 1395 is represented by a sliver of two hectares on Ashfield Shale at Glenmore Park. PCT 830 is restricted to a fringe of under three hectares in area on the eastern the border of Mulgoa Nature Reserve.

Weed infestation is a problem throughout the study area. This is well illustrated by two sites at Claremont Meadows. The vegetation at a site beyond the eastern end of Caddens Road, on the flood plain of South Creek, which I visited but did not include in my sampling, consisted of a closed forest of *Ligustrum sinense*, *Ligustrum lucidum* (both natives of China, the latter extending to Japan) and *Olea europaea* subsp. *cuspidata* (native of Africa), with scattered emergent trees of *Eucalyptus tereticornis* and *E. amplifoli*a. This would have been a forest of PCT 835 before weed infestation converted it into a novel, derived plant community. Only 0.6 km to the west north west of that site is a superficially pristine block of PCT 724. Even here, however, *Ligustrum sinense* and *Ligustrum lucidum* already dominate the vegetation near South Creek, *Eragrostis curvifolia* is a common component of the ground stratum and seedlings of *Olea europaea* subsp. *cuspidata* are starting to establish throughout the reserve.

4. Assessment of species presence and habitat

4.1 Existing records and surveys

A search of *Grevillea juniperina* subsp. *juniperina* in the Bionet Atlas, conducted on 12 November 2018, returned 1513 observational records. The only targeted survey of this species of which I am aware was conducted by Teresa James in Plumpton Park in October 2007 (Teresa James personal communication). However, patterns in the dates and locations of Bionet records suggest that several intensive surveys of *G. juniperina subsp. juniperina* have been conducted in the 21st century, apparently as part of more general environmental surveys. Most of those were conducted outside the study area but the following are relevant to this report:

- 12 October 2007: 5 records reporting over 700 plants from what is now Wianamatta Regional Park;
- 8-11 September 2008: 4 records reporting approximately 1250 plants from the Defence Establishment Orchard Hills;
- 25 September to 2 November 2009: 118 records from the St Marys Sewage Treatment Plant;
- 6 March to 14 December 2015: 82 records from the Dunheved development site, for the St Marys Central Precinct Project;
- 16 February 2016: 1 record reporting >1000 plants West of Luddenham Rd, north of the Warragamba-Prospect water pipelines;
- 18 October 2016: 22 records reporting 115 plants from Wianamatta Regional Park.

4.2 Surveys completed for the biocertification

Apart from the surveys conducted for this expert report, no targeted surveys for *Grevillea juniperina* subsp. *juniperina* were conducted for biocertification of the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area. Several opportunistic observations were made by other consultants in the course of conducting more general surveys and expert reports on other species.

4.3 Surveys completed for this assessment

4.3.1 Survey Methods

In the course of preparing my expert reports on *Grevillea juniperina* subsp. *juniperina* and *Pterostylis saxicola* in the Greater Macarthur and Wilton Growth Areas (Weston unpublished a, b), I characterised twenty plots of native vegetation in detail, each plot being a circle of radius 30 m (an of area 2827 m^2), centred either on a plant of *G. juniperina subsp. juniperina* or *Pterostylis saxicola* or on an arbitrarily chosen point (at sites where both the *Grevillea* and the *Pterostylis* were absent). I have included data from nine of those plots as samples from outside the study area in my analyses for this report. I have also used the same methods to characterise 33 plots in and adjacent to the study area. I chose the locations with the aim of sampling patches of accessible, remnant bushland representing as broad an ecological range and geographic extent across the two Growth Areas as time would allow, sampling more plots in areas where *G. juniperina subsp. juniperina* had previously been recorded. Some habitats, such as freshwater wetlands, and substrates on which *G. juniperina subsp. juniperina* has never been recorded, such as Cranebrook Formation alluvia, were avoided. At each plot I listed all vascular plant species that could feasibly be identified, taking photographs of plants for later reference in cases where the plant's identity was in question. The latitude and longitude of the centre of each plot was determined using a GPS instrument. The altitude of each site was determined later from 1:25,000 topographic maps. The soil and topography at each site was described and the substrate identified using the Penrith 1:100,000 geological map (NSW Department of Minerals and Energy 1991) and 1:25,000 topographic maps.

I identified the plant community type in each plot using the PCT identification tool in Bionet, and my list of plant species found in each plot.

I conducted statistical analyses of association between presence or absence of *Grevillea juniperina* subsp. *juniperina* in my plots and several other binary variables using the Phi statistic and Fisher's exact test at http://vassarstats.net/tab2x2.html. The other binary variables were plant community types, and substrate Quaternary alluvium present or absent. As multiple tests were conducted, I applied a Bonferroni correction to the significance level s of the tests.

I conducted a census of reproductively mature plants of *Grevillea juniperina* subsp. *juniperina* along a pair of transects, each 1 m wide, oriented in a north-south direction in the eastern part of Wianamatta Regional Park, where multiple plants of the species had previously been recorded, to estimate population density there.

I kept an eye out for plants of *Grevillea juniperina* subsp. *juniperina* as I drove or walked from site to site within the study area. I also conducted a "drive by" survey of inaccessible properties in the southern part of the Western Sydney Aerotropolis, looking over boundary fences of private properties with remnant native vegetation on Willowdene Avenue, Luddenham, and Dwyer and Findley Roads and Francis Street, Greendale.

I developed an improved habitat model for *Grevillea juniperina* subsp. *juniperina*, using data from my own botanical surveys of 38 plots, the published literature, 1513 observers' and collectors' records of *G. juniperina subsp. juniperina* in the Bionet Atlas, vegetation mapping conducted for the Cumberland Plain Conservation Plan (Biosis unpublished), and the geological map of the area (NSW Department of Minerals and Energy 1991).

4.3.2 Results and Conclusions from my Surveys Completed for this Assessment

Site and ecological data for my plots are shown in Appendix 2. I sampled most plant community types and most substrates known in the study area in these plots. According to my identifications of plant community types, I found *Grevillea juniperina* subsp. *juniperina* in the following PCTs in my plots:

- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain (found in 17 plots, 10 of which also hosted *G. juniperina subsp. juniperina*);
- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain (found in 11 plots sampled, 9 of which also hosted *G. juniperina subsp. juniperina*);
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain (found in 2 plots, one of which also hosted *G. juniperina subsp. juniperina*);
- 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain (found in 1 plot, which also hosted *G. juniperina subsp. juniperina*).

Plant community types that I sampled, in which *G. juniperina subsp. juniperina* was absent, were the following.

- 850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain (3 plots);
- 1800 Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley (3 plots);
- 1081 Red Bloodwood - grey gum woodland on the edges of the Cumberland Plain (1 plot).

Substrates present in my plots were Londonderry Clay (11 plots, all with *Grevillea juniperina* subsp. *juniperina* present), Bringelly Shale (14 plots, 7 with *G. juniperina subsp. juniperina* present), Londonderry Clay-Bringelly Shale transition (1 plot, with *G. juniperina subsp. juniperina* present), St Marys Formation-Bringelly Shale transition (1 plot, with *G. juniperina subsp. juniperina* present), Quaternary Alluvium (8 plots, *G. juniperina subsp. juniperina* absent from all), Bringelly Shale-Quaternary Alluvium transition (1 plot, *G. juniperina subsp. juniperina* present).

The most striking positive association between habitat variables and presence of *Grevillea juniperina* subsp. *juniperina* was with Londonderry Clay, with all 11 plots on this substrate also hosting the grevillea, a relationship so strong that it did not need statistical testing. In contrast, none of the eight plots on Quaternary Alluvium hosted *G. juniperina subsp. juniperina*. This negative association proved to be statistically significant with a probability due to chance of 0.0013 in the 2-tailed test (significance level adjusted to 0.01 to account for multiple tests). Of the four plant community types in which *G. juniperina subsp. juniperina* was found, none turned out to be significantly associated with presence or absence of the grevillea. It seems reasonable to conclude that substrate type is a more powerful predictor of the presence or absence of *G. juniperina subsp. juniperina* than plant community type.

Comparison of observational records of *Grevillea juniperina* subsp. *juniperina* in the Bionet Atlas with the geological map shows that the association between substrates and plant records can be expressed with greater precision than has been done in the published literature. The substrates on which *G. juniperina subsp. juniperina* most frequently occurs are Londonderry Clay (a Paleogene-Neogene alluvium) and Bringelly Shale (a member of the Triassic Wianamatta Group). Most of the area of exposed Londonderry Clay occurs outside the study area but the density of observational records on this Paleogene-Neogene alluvium, both inside and outside the study area, confirms my conclusion from my plot data that this is a highly favoured substrate of *G. juniperina subsp. juniperina*. The favoured substrate that covers by far the largest area in the study area is Bringelly Shale. *G. juniperina subsp. juniperina* has also been recorded on laterised sand and clay of the St Marys Formation and on Rickabys Creek Gravel (both Paleogene-Neogene alluvia) but these substrates are much less extensive in area than either Londonderry Clay or Bringelly Shale. Rickabys Creek Gravel is very rare in, and St Marys Formation absent, from the study area.

Careful comparison of observational records of *Grevillea juniperina* subsp. *juniperina* with the distribution of Quaternary alluvia, a group of substrates that are mostly associated with the flood plains of existing watercourses in the Cumberland Subregion, supports my earlier conclusion based on my plot data that *G. juniperina subsp. juniperina* rarely, if ever, grows on these substrates. Sporadic inundation of these soils and the higher fertility of many of them, relative to Bringelly Shale and Paleogene-Neogene alluvia, probably explain why *G. juniperina subsp. juniperina* is absent from Quaternary alluvia. *G. juniperina subsp. juniperina* is also conspicuously absent from Ashfield Shale, another member of the Wianamatta Group, small outcrops of which occur on the western margin of the Greater Penrith to Eastern Creek Urban Release Investigation Area. Ashfield Shale has a significantly higher phosphate content than Bringelly Shale (Martyn 2018), which possibly explains the absence of *G. juniperina subsp. juniperina* from soils derived from it. All Proteaceae are highly efficient accumulators of soil phosphate, and moderate levels of this nutrient are toxic to many of them (Lambers *et al.* 2015).

The northern, eastern and western limits of the natural distribution of *Grevillea juniperina* subsp. *juniperina* can be explained simply by the distributions of its favoured substrates. However, its southern limit is much less well defined and I cannot explain it with confidence. The most dense populations of *G. juniperina subsp. juniperina* are found on Paleogene-Neogene alluvia, north of 33° 45' S. South of this latitude, the taxon occurs more patchily, forming sizeable populations at some suitable sites such as Pennard Crescent Luddenham (my plot GJ10), but being absent from other apparently suitable bushland remnants on Bringelly Shale nearby, such as the patch between Cosgrove Creek and Halmstad Boulevard, Luddenham (my plot WSA2). South of 33° 51' S, all known populations are small (fewer than 10 plants), sporadically distributed, and absent from most apparently suitable habitats.

Remnants of plant community type 849 growing on Bringelly Shale are liberally scattered between 33° 53' S and 34° 05' S but only one of these patches of bush is known to support a population of *Grevillea juniperina* subsp. *juniperina*. This is at 34° 03' 38.8'' S 150° 44' 15.5'' E, at Gundungarra Reserve, Spring Farm (my plot GJ9), approximately 14 km south of the southern end of the Western Sydney Aerotropolis Growth Area, where a population of four mature plants of *G. juniperina subsp. juniperina* was discovered in 2017. I have argued elsewhere (Weston unpublished a) that the population at Gundungarra Reserve is probably naturalised, resulting from a garden escape. However, this and other putatively naturalised populations are potentially informative about the limits of the taxon's ecological tolerance, so they should not be dismissed as irrelevant. The Gundungarra Reserve population is at 130 m altitude, which is higher than anywhere in the study area. However, a putatively naturalised population of eight plants from near Penrose grows at 650 m altitude, so altitude seems unlikely to be a limiting factor in the study area. The Penrose population occurs on "residual deposits of unconsolidated clayey coarse- to fine-grained sands to weakly consolidated sandy clay layers" (Triggs & Campbell 2016), analogous to Londonderry Clay, on which *G. juniperina subsp. juniperina* grows within its natural distribution. Whether the gradual thinning of the metapopulation of *G. juniperina subsp. juniperina* from north to south is due to ecological factors or to historical processes is unknown. Nevertheless, the probability of finding this species clearly declines as one moves south of 33° 45' S.

A historical process that may partly explain the patchy distribution of *Grevillea juniperina* subsp. *juniperina* within its distributional range is the potential effect of frequent fires. As plants of *G. juniperina subsp. juniperina* are killed by fire and populations regenerate by germinating from a buried seed bank in response to fire (see section 2.2), this species can be exterminated locally by frequent fires exhausting the soil seed bank. This can happen when a succession of fires occurs with an interval between fires that is less than the average time between germination and reproductive maturity. However, while such a process could explain the contrast mentioned above, between my plots GJ10 and WSA2, it seems unlikely to have affected an area as extensive as the whole southern half of the taxon's distribution.

Another historical process that could have produced the observed distribution is range expansion. If *Grevillea juniperina* subsp. *juniperina* originated in the northern part of the Cumberland Subregion and is still expanding into unfilled niche space in the southern Cumberland Subregion, then we would expect its populations to be smaller and scarcer than those in the north. This hypothesis could be tested using population genetic techniques but such a study is beyond the scope of this project.

4.4 Assessment of species presence

4.4.1 Likelihood of species presence

Grevillea juniperina subsp. *juniperina* is known with confidence in both the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area.

4.4.2 Justification for determining presence

The presence of *Grevillea juniperina* subsp. *juniperina* in the Greater Penrith to Eastern Creek Urban Release Investigation Area is uncontroversial, supported by hundreds of observational and collection records, as well as my observations at 16 of my survey plots there. Its presence in the Western Sydney Aerotropolis Growth Area appears to be marginal but at least one observational record from the western side of Luddenham Road, just south of the northern border of this Growth Area (0.2 km south of my plot PEC25), documents its presence there. The probability of it occurring naturally elsewhere not far inside the northern border of the Western Sydney Aerotropolis Growth Area (the Warragamba to Prospect water pipeline) is high, but most of that border was inaccessible to botanical surveys for this project. The probability of its presence south of Luddenham village seems low, given the evident thinning of its population density towards the south, but it is not zero. Small patches of apparently suitable habitat are scattered through this Growth Area, especially south of Luddenham, but almost all of them were inaccessible for surveying for this project.

4.5 Assessment of suitable habitat

4.5.1 Suitable habitat within the study area

Grevillea juniperina subsp. *juniperina* is known to occur naturally in four plant community types recognised in the Bionet Vegetation Classification. They are:

- 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain;
- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain;
- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain;
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain.

All of these plant community types have been recorded in the study area.

Grevillea juniperina subsp. *juniperina* also occurs on the margins of a fifth plant community type, 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain. This community usually grows on Quaternary alluvium, a substrate on which *G. juniperina subsp. juniperina* does not grow. However, ecological gradients between PCT 835 and adjacent plant community types, particularly PCT 849, are not clear-cut and do not always correspond exactly to transitions between substrate types. PCT 835 growing on Bringelly Shale should be included in the habitat model for *G. juniperina subsp. juniperina* to avoid excluding populations on the margins of alluvial flats.

Most records of *Grevillea juniperina* subsp. *juniperina* report populations living in intact native vegetation but it is also capable of surviving in, and even invading highly disturbed landscapes (see section 2.4)

Grevillea juniperina subsp. *juniperina* is known to occur naturally on four substrate types recognised by the Geological Survey of New South Wales. They are:

- Triassic Bringelly Shale (Wianamatta Group);
- Paleogene-Neogene Londonderry Clay;
- Paleogene-Neogene St Marys Formation;
- Paleogene-Neogene Rickabys Creek Gravel.

The intersection of any of the above plant community types with any of the above substrates indicates suitable habitat for *Grevillea juniperina* subsp. *juniperina*.

4.5.2 Species polygons

My species polygons for *Grevillea juniperina* subsp. *juniperina* (figure 7) include all patches of PCTs 724, 725, 833, 835 and 849 growing on Londonderry Clay, Rickabys Creek Gravel or Bringelly Shale in the study area. They were prepared with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by Biosis Pty Ltd. A shape file for these polygons is held by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment. My arguments justifying these polygons have been set out in sections 2.3, 2.4, 4.1, 4.3, 4.4 and 4.5.1.

4.5.3 Estimate of area of habitat

The areas estimated to represent suitable habitat for *Grevillea juniperina* subsp. *juniperina* in figure 7 are as follows:

- Greater Penrith to Eastern Creek Area Urban Release Investigation Area
    - Habitat mapped – 1989.8 ha
    - Habitat impacted by development footprint – 93.4 ha
- Western Sydney Aerotropolis Growth Area
    - Habitat mapped – 683.5 ha
    - Habitat impacted by development footprint – 310.4 ha

These estimates were calculated with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by Biosis Pty Ltd. My arguments justifying the polygons from which these estimates were calculated have been set out in sections 2.3, 2.4, 4.1, 4.3, 4.4 and 4.5.1.

5. Information used in this assessment

My assessment was based on information obtained from a diversity of sources:

- Databases of observational and vouchered specimen records of *Grevillea juniperina* subsp. *juniperina*:
    - National Herbarium of New South Wales specimen database;
    - Bionet Wildlfie Atlas;
- Interviews with collectors, observers, propagators and scientists of *Grevillea juniperina* subsp. *juniperina* (see section 6, acknowledgements);
- Fieldwork at 42 sites (see Appendix 1):
    - Five sites at which *P. saxicola* had previously been collected;
    - 14 sites in or near the study area that had potentially suitable habitat;
- The scientific and scholarly literature (see section 7, references);
- A GIS map of the study area with layers representing the boundaries, plant community types, development footprint, and the results of flora and fauna surveys, prepared by Biosis Pty Ltd, provided through the Biosis spatial viewer;
- Background information on the study area provided by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment;

- My personal knowledge and experience, gained from 40 years as a professional botanist specialising in the systematics and ecology of the Proteaceae.

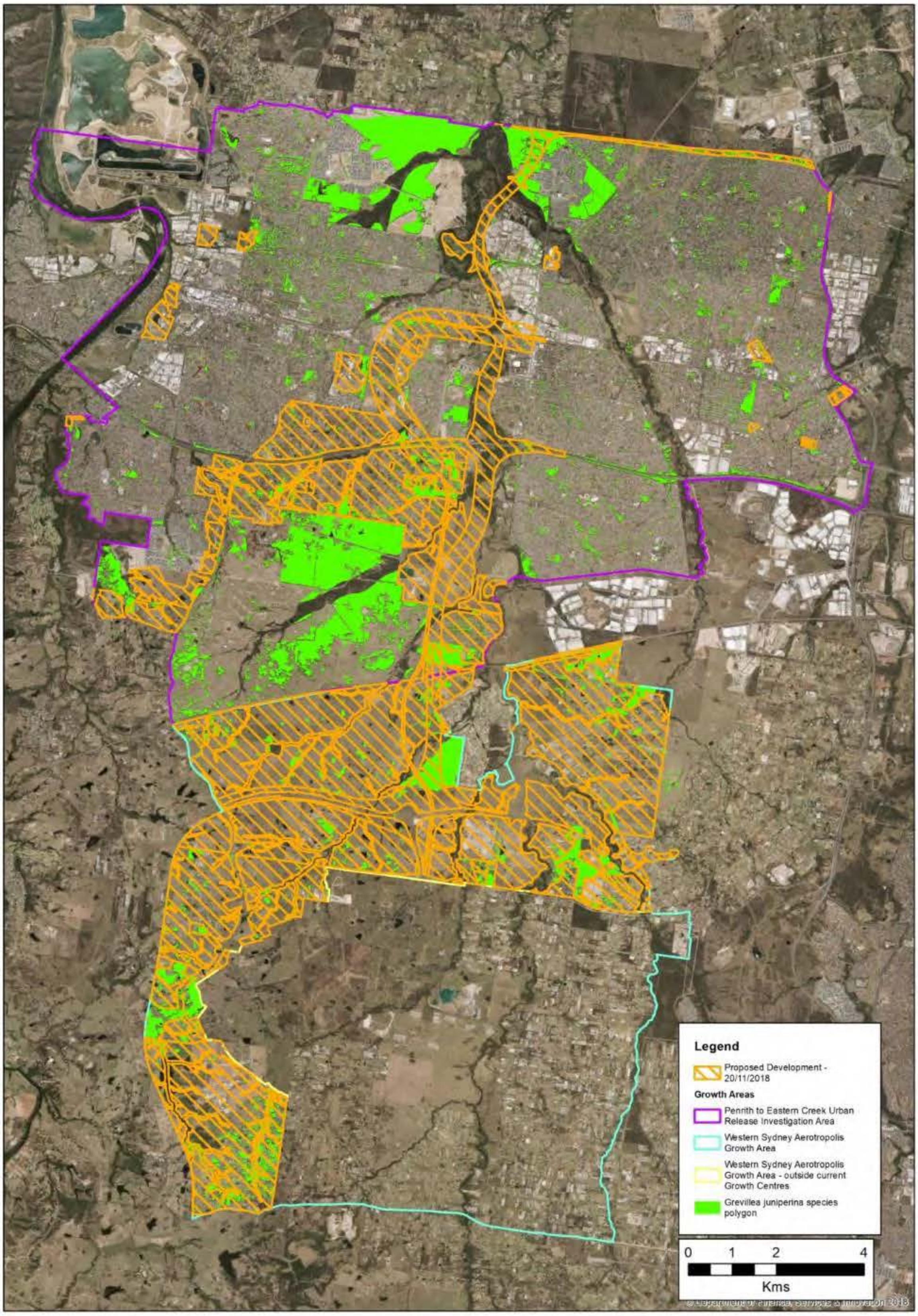

Figure 7. Polygons of suitable habitat for *Grevillea juniperina* subsp. *juniperina* across its whole distribution.

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8. Appendices

8.1 Appendix 1: Characterisation of habitat at selected sites

The tables on following pages record data that I collected at sites both within and outside the study area. Each site was centred on an arbitrarily selected plant of *Grevillea juniperina* subsp. *juniperina*, or at an arbitrarily chosen point where the focal taxon was absent from the site. At each site the precise latitude and longitude, altitude, substrate, soil description, slope and aspect were also recorded. Also, at each site all plant species that could be reliably identified were recorded within a radius of 30 metres.

Site	Gjj present?	Location	Latitude	Longitude	Altitude (m)	substrate
GJ1	y	Southern end of Park Rd, E side, Marsden Park	33°41'22.6"S	150°50'03.1"E	25	St Marys Formation
GJ3	y	Castlereagh Nature Reserve, Northern Rd, Londonderry	33°40'44.9"S	150°44'37.3"E	45	Londonderry Clay
GJ4	y	Junction of Palmyra Ave and Stony Creek Rd, Shanes Park	33°43'09.1"S	150°46'52.7"E	25	Londonderry Clay
GJ5	y	Richmond Road, Marsden Park	33°41'03.3"S	150°49'12.4"E	25	Londonderry Clay
GJ7	n	Bill Anderson Reserve, Kemps Creek site 2	33°52'53.2"S	150°47'19.0"E	65	Bringelly Shale
GJ9	y	Gundungarra Reserve, Spring Farm	34°03'38.8"S	150°44'15.5"E	130	Bringelly Shale
GJ10	y	Pennard Crescent, Luddenham	33°50'37.1"S	150°45'41.9"E	50	Bringelly Shale
PEC1	y	Wianamtta Regional Park, 50 m S of Palmyra Ave, Ropes Crossing	33°43'10.7"S	150°46'34.6"E	30	Londonderry Clay
PEC2	y	Wianamtta Regional Park, S boundary, Ropes Crossing	33°43'52.6"S	150°46'27.5"E	30	Londonderry Clay
PEC3	n	Tregear Reserve, Tregear	33°44'45.0"S	150°47'15.0"E	25	Quarternary alluvium
PEC4	n	Ropes Crossing Boulevard 60 m N of Ropes Creek, Ropes Crossing	33°44'22.3"S	150°46'43.2"E	20	Quarternary alluvium
PEC5	y	Ropes Crossing Boulevard 350 m N of Ropes Creek, Ropes Crossing	33°44'13.0"S	150°46'43.8"E	30	Londonderry Clay
PEC6	y	Links Road, St Marys	33°44'15.7"S	150°45'57.0"E	20	Londonderry Clay
PEC7	y	Embankment, east of entrance to Dunheved Golf Course, St Marys	33°44'44.1"S	150°45'52.5"E	25	Londonderry Clay
PEC8	y	Embankment, south of abandoned railway line, St Marys	33°44'46.8"S	150°46'03.1"E	25	Londonderry Clay
PEC9	y	Bushland between Christie St and abandoned railway line, St Marys	33°44'48.9"S	150°46'08.4"E	25	Londonderry Clay
PEC10	y	Abandoned railway land N of 73A Christie St, St Marys	33°44'46.3"S	150°45'59.4"E	25	Londonderry Clay
PEC11	y	Southern side of abandoned railway station, St Marys	33°44'48.4"S	150°46'14.2"E	30	Londonderry Clay
PEC12	n	Between Dunheved Rd and John Oxley Avenue, Werrington County	33°45'09.1"S	150°44'59.4"E	20	Quarternary alluvium
PEC13	n	Between Dunheved Rd and Dunheved Golf Course, Werrington County	33°44'49.2"S	150°45'08.4"E	30	Quarternary alluvium
PEC14	y	Sinclair Parade, Jordans Springs	33°42'53.3"S	150°43'44.6"E	50	Bringelly Shale

Appendix 1a: Environmental data for sites visited as part of this study (continued on next page)

Site	soil description	Vegetation structure (canopy)	Vegetation structure (understorey)	PCT (my identification)
GJ1	brown sandy loam	dry sclerophyll forest-woodland	sparse shrubby understorey	849
GJ3	brown, gravelly clay-loam	dry sclerophyll forest	sparse shrubby understorey	883
GJ4	brown , gravelly clay-loam	dry sclerophyll woodland	dense shrubby understorey	725
GJ5	gravelly brown clay	Regenerating Dry sclerophyll woodland	sparse shrubby understorey	725
GJ7	red-brown sandy loam	disturbed dry sclerophyll woodland to forest	moderately dense shrubby understorey	883
GJ9	red-brown loam	remnant dry sclerophyll woodland	Grassy, sparsely to densely shrubby understorey	unidentifiable
GJ10	red-brown gravelly loam	dry sclerophyll woodland	sparse shrubby understorey	724
PEC1	brown , gravelly clay-loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC2	brown , gravelly clay-loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC3	brown clay loam	dry sclerophyll woodland	grassy understory with scattered shrubs	1800
PEC4	brown clay loam	dry sclerophyll forest	dense shrubby understorey	1800
PEC5	red-brown gravelly loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC6	red-brown gravelly clay	remnant dry sclerophyll woodland	grassy understorey with scattered shrubs	849
PEC7	red-brown gravelly clay	dry sclerophyll forest	grassy, moderately dense shrubby understorey	725
PEC8	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	725
PEC9	red-brown gravelly clay	dry sclerophyll woodland	grassy, shrubby understorey	849
PEC10	red-brown gravelly clay	dry sclerophyll woodland	grassy, shrubby understorey	725
PEC11	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	849
PEC12	ochre brown clay	dry sclerophyll forest	grassy, shrubby understorey	849
PEC13	ochre brown clay	dry sclerophyll forest	grassy, shrubby understorey	850
PEC14	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	725

Appendix 1a (continued): Environmental data for sites visited as part of this study

Site	Gjj present?	Location	Latitude	Longitude	Altitude (m)	substrate
PEC15	n	Putland Street, Claremont Meadows	33°46'12.8"S	150°45'21.9"E	30	Bringelly Shale
PEC16	n	Corner of Caulfield Road and Equestrian Circuit, Claremont Meadows	33°46'42.3"S	150°45'16.8"E	40	Bringelly Shale
PEC17	n	Caddens Road east, Claremont Meadows	33°46'48.9"S	150°45'36.6"E	25	Quarternary alluvium
PEC18	n	Heaton Avenue, Claremont Meadows	33°46'49.0"S	150°44'28.7"E	35	Quarternary alluvium
PEC19	y	Pandorea Street, Claremont Meadows	33°46'55.1"S	150°44'35.4"E	40	Bringelly Shale
PEC20	y	Pandorea Street, Claremont Meadows	33°46'57.1"S	150°44'35.4"E	40	Bringelly Shale
PEC21	n	Flinders Lane, Orchard Hills	33°47'21.7"S	150°45'28.7"E	25	Quarternary alluvium
PEC22	n	Samuel Marsden Reserve, Orchard Hills	33°47'08.5"S	150°45'40.5"E	25	Quarternary alluvium
PEC23	n	34-64 Wentworth Rd, Orchard Hills	33°47'56.9"S	150°44'17.1"E	50	Bringelly Shale
PEC24	n	Opposite 121 Wentworth Rd, Orchard Hills	33°47'52.7"S	150°43'45.5"E	60	Bringelly Shale
PEC25	y	327 Luddenham Rd, Orchard Hills	33°49'43.2"S	150°45'30.7"E	40	Bringelly Shale
PEC26	y	Plumpton Park, Plumpton	33°45'10.3"S	150°50'05.9"E	50	Bringelly Shale
PEC27	y	Dr Charles Mackay Reserve, Mt Druitt	33°46'29.8"S	150°49'39.1"E	70	Bringelly Shale
PEC28	y	Kestrel Crescent Reserve, Erskine Park	33°47'34.6"S	150°48'34.5"E	45	Bringelly Shale
PEC29	n	Apple Gum Reserve, Glenmore Park	33°47'00.9"S	150°39'51.0"E	40	Ashfield Shale
PEC30	n	Forest Redgum Reserve, Glenmore Park	33°46'43.5"S	150°39'44.7"E	50	Rickabys Creek Gravel
WSA1	n	Sales Park, Luddenham	33°52'55.5"S	150°41'26.3"E	90	Bringelly Shale
WSA2	n	Between Cosgrove Creek and Halmstad Boulevard, Luddenham	33°50'58.9"S	150°44'52.6"E	55	Bringelly Shale

Appendix 1a (continued): Environmental data for sites visited as part of this study

Site	soil description	Vegetation structure (canopy)	Vegetation structure (understorey)	PCT (my identification)
PEC15	dark brown loam	dry sclerophyll forest	grassy, moderately dense shrubby understorey	849
PEC16	gravelly dark brown loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC17	brown clay	dry sclerophyll forest	moderately dense shrubby understorey	1800
PEC18	brown clay	dry sclerophyll forest	moderately dense shrubby understorey	849
PEC19	dark brown loam	dry sclerophyll forest	moderately dense shrubby understorey	849
PEC20	dark brown loam	dry sclerophyll woodland	dense shrubby understorey	849
PEC21	grey-brown loam	dry sclerophyll forest	dense shrubby understorey	849
PEC22	pale brown loam	dry sclerophyll forest	sparse shrubby understorey	849
PEC23	Red-brown clay with lateritic pebbles	dry sclerophyll forest	dense shrubby understorey	849
PEC24	mid-brown clay	dry sclerophyll forest	dense shrubby understorey	850
PEC25	mid-brown clay	dry sclerophyll forest	dense shrubby understorey	849
PEC26	grey-brown loam	dry sclerophyll woodland	grassy understory with scattered shrubs	849
PEC27	grey-brown loam	dry sclerophyll woodland to forest	grassy understorey with sparse to dense shrub stratum	849
PEC28	mid-brown loam	dry sclerophyll woodland	grassy understorey with sparse to dense shrub stratum	849
PEC29	mid-brown loam	dry sclerophyll forest	shrubby, grassy understorey	849
PEC30	ochre brown grevelly loam with abundant, large rounded stones	dry sclerophyll forest	Grassy, sparsely to densely shrubby understorey	849
WSA1	mid-brown loam	dry sclerophyll forest	grassy, shrubby understorey	849
WSA2	red-brown gravelly loam	dry sclerophyll woodland	shrubby grassland	725

Appendix 1a (continued): Environmental data for sites visited as part of this study

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Acacia binervia	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Acacia brownii	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Acacia decurrens	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0
Acacia elongata	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Acacia falcata	1	1	0	1	0	0	0	1	1	0	0	0	0	1	0
Acacia fimbriata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia floribunda	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Acacia implexa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia longifolia	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Acacia parramattensis	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0
Acacia parvipinnula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia terminalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga australis	?	?	?	?	?	0	0	0	0	0	0	0	0	0	0
Allocasuarina glareicola	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	0	1	0	1	1	0	0	1	1	0	0	0	0	0	1
Angophora bakeri	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora floribunda	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1
Angophora subvelutina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aristida ramosa	?	?	?	?	?	0	0	?	?	?	?	?	?	?	?
Aristida vagans	?	?	?	?	?	0	0	?	?	?	?	?	?	?	?
Arthropodium milleflorum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b: Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >													
Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Asperula conferta	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Astroloma humifusum	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Austrostipa verticillata	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Banksia spinulosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Billardiera scandens	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Bossiaea obcordata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea rhombifolia	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brunoniella australis	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Bursaria spinosa subsp. *spinosa*	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1
Caesia vittata	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Callistemon salignus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Calotis cuneifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Carex inversa	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?
Casuarina glauca	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Cheilanthes sieberi	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0
Chrysocephalum apiculatum	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Clematis aristata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis glycinoides	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
Commelina ensifolia	?	?	?	?	?	0	0	0	0	0	0	0	0	0	0
Cryptandra amara	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Cryptandra spinescens	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Daviesia ulicifolia subsp. *ulicifolia*	0	1	1	1	1	0	1	0	0	0	0	1	0	1	1
Desmodium brachypodum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium varians	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dianella caerulea var. *producta*	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *longifolia*	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *stenophylla*	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dianella revoluta var. *revoluta*	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dichondra repens	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Dichopogon fimbriatus	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Dillwynia sieberi	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Dillwynia tenuifolia	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0
Dipodium punctatum	?	?	?	?	?	?	?	0	0	0	0	0	0	0	0
Dodonaea falcata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Echinopogon caespitosus	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?
Einadia hastata	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Enchylaena tomentosa	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Entolasia stricta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eremophila debilis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypts amplifolia	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Eucalyptus baueriana	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

Sites >

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Eucalyptus crebra	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0
Eucalyptus eugenioides	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus fibrosa	1	0	0	0	0	0	1	1	1	0	0	1	0	0	0
Eucalyptus globoidea	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Eucalyptus moluccana	1	0	0	0	0	1	0	0	1	1	0	1	1	0	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sclerophylla	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Eucalyptus tereticornis	1	0	1	1	0	1	0	0	1	1	0	1	1	0	1
Exocarpos cupressiformis	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geitonoplesium cymosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycine tabacina	?	?	?	?	?	?	1	0	0	0	0	0	0	0	0
Glycine clandestina	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Goodenia hederacea	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea juniperina subsp. *juniperina*	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1
Grevillea mucronulata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea sphacelata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea laevipes	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea sericea	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0
Hardenbergia violacea	0	1	0	1	0	0	0	0	0	1	1	0	1	1	0
Hibbertia diffusa	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Hypoxis hygrometrica	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Indigofera australis	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Isopogon anemonifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonia scoparia	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Kunzea ambigua	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0
Lagenifera stipitata	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laxmannia gracilis	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Lepidosperma laterale	0	0	0	1	0	0	0	1	1	0	0	1	1	0	0
Leptospermum parvifolium	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum marginale	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Lissanthe strigosa	0	0	1	0	1	0	1	1	0	0	0	1	0	0	1
Lobelia purpurascens	?	?	?	?	?	?	1	0	0	0	0	0	0	0	0
Lomandra filiformis	?	?	?	?	?	?	1	0	0	0	0	0	0	0	0
Lomandra longifolia	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Lomandra multiflora	?	?	?	?	?	?	1	0	0	0	0	0	0	0	1
Lomandra obliqua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus australis	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Melaleuca decora	1	1	1	0	1	0	1	1	1	1	0	0	1	0	1
Melaleuca linariifolia	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Melaleuca nodosa	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
Melaleuca styphelioides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melia azedarach	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Microlaena stipoides	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?
Micromyrtus minutiflora	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Murdannia graminea	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Opercularia aspera	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Opercularia diphylla	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Oxalis perennans	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Ozothamnus diosmifolius	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1
Patersonia sericea	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia linearis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Persoonia nutans	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus hirtellus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus virgatus	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Pimelea glauca	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pimelea linifolia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Plantago debilis	?	?	?	?	?	?	?	0	0	0	0	0	0	0	0
Plantago gaudichaudii	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala japonica	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Pterostylis saxicola	?	?	?	?	?	?	?	0	0	0	0	0	0	0	0
Pultenaea microphylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea parviflora	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	GJ1	GJ3	GJ4	GJ5	GJ7	GJ9	GJ10	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8
Ranunculus lappaceus	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Styphelia laeta	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Themeda triandra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tricoryne elatior	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Viola hederacea	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Wahlenbergia communis	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Wahlenbergia gracilis	?	?	?	?	?	?	0	0	0	0	0	0	0	0	0
Xanthorrhoea media	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea minor	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Acacia binervia	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Acacia brownii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	0	0	0	0	0	1	1	1	0	1	1	0	0
Acacia elongata	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Acacia falcata	1	0	1	0	0	0	0	0	0	0	1	1	0	0
Acacia fimbriata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia floribunda	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia implexa	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia longifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia parramattensis	1	0	1	1	0	1	1	0	1	1	1	0	0	0
Acacia parvipinnula	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia terminalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocasuarina glareicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	1	1	1	0	0	0	0	0	0	0	0	0	1	0
Angophora bakeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora floribunda	1	1	1	1	1	0	0	0	1	0	0	1	0	0
Angophora subvelutina	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aristida ramosa	?	?	?	?	?	?	?	?	?	?	?	?	0	0
Aristida vagans	?	?	?	?	?	?	?	?	?	?	?	?	0	0
Arthropodium milleflorum	0	0	0	0	0	0	1	1	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Asperula conferta	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Astroloma humifusum	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Austrostipa verticillata	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Banksia spinulosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Billardiera scandens	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea obcordata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea rhombifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Brunoniella australis	1	0	1	1	0	0	1	1	0	0	1	1	1	1
Bursaria spinosa subsp. *spinosa*	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Caesia vittata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistemon salignus	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Calotis cuneifolia	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Carex inversa	?	?	?	?	?	?	?	?	?	?	?	?	0	0
Casuarina glauca	0	0	0	1	0	0	0	0	1	0	1	0	0	0
Cheilanthes sieberi	0	0	0	0	1	0	1	1	0	0	1	1	1	1
Chrysocephalum apiculatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis aristata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis glycinoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commelina ensifolia	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Cryptandra amara	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Cryptandra spinescens	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Daviesia ulicifolia subsp. *ulicifolia*	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Desmodium brachypodum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium varians	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella caerulea var. *producta*	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Dianella longifolia var. *longifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *stenophylla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella revoluta var. *revoluta*	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Dichondra repens	1	0	1	1	0	0	1	0	0	0	1	1	1	1
Dichopogon fimbriatus	0	0	0	0	0	0	0	0	0	0	0	0	1	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Dillwynia sieberi	0	1	1	0	0	1	0	0	0	0	0	0	0	0
Dillwynia tenuifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dipodium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea falcata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Echinopogon caespitosus	?	?	?	?	?	?	?	?	?	?	?	?	0	0
Einadia hastata	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Enchylaena tomentosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Entolasia stricta	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Eremophila debilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypts amplifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus baueriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >													
Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Eucalyptus crebra	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Eucalyptus eugenioides	0	0	0	0	1	0	0	1	0	0	1	0	0	0
Eucalyptus fibrosa	1	0	1	0	0	1	1	1	0	0	0	0	0	0
Eucalyptus globoidea	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Eucalyptus moluccana	1	0	0	1	1	1	1	1	0	1	1	1	1	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sclerophylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus tereticornis	1	0	1	1	1	0	1	1	1	1	1	1	1	1
Exocarpos cupressiformis	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Geitonoplesium cymosum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycine tabacina	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Glycine clandestina	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Goodenia hederacea	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Grevillea juniperina subsp. *juniperina*	1	1	1	0	0	1	0	0	0	0	1	1	0	0
Grevillea mucronulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea sphacelata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea laevipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea sericea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardenbergia violacea	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hibbertia diffusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypoxis hygrometrica	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Indigofera australis	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Isopogon anemonifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonia scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunzea ambigua	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lagenifera stipitata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laxmannia gracilis	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Lepidosperma laterale	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptospermum parvifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum marginale	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lissanthe strigosa	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Lobelia purpurascens	0	0	0	0	0	0	1	0	0	0	1	0	1	0
Lomandra filiformis	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lomandra longifolia	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Lomandra multiflora	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Lomandra obliqua	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca decora	0	0	0	1	0	0	1	0	0	0	1	0	0	0
Melaleuca linariifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Melaleuca nodosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca styphelioides	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Melia azedarach	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Microlaena stipoides	?	?	?	?	?	?	?	?	?	?	?	?	0	0
Micromyrtus minutiflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Murdannia graminea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia aspera	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia diphylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis perennans	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Ozothamnus diosmifolius	0	0	0	0	0	1	1	1	1	0	0	0	0	1
Patersonia sericea	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia linearis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia nutans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus hirtellus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus virgatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pimelea glauca	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pimelea linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago debilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago gaudichaudii	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterostylis saxicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea microphylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea parviflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC9	PEC10	PEC11	PEC12	PEC13	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22
Ranunculus lappaceus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Styphelia laeta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Themeda triandra	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Tricoryne elatior	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola hederacea	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Wahlenbergia communis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahlenbergia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Acacia binervia	0	0	0	0	0	0	0	0	0	0
Acacia brownii	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	0	1	1	0	0	0	0	0	0
Acacia elongata	0	0	0	0	0	0	0	0	0	0
Acacia falcata	0	0	0	0	1	0	1	1	0	0
Acacia fimbriata	0	0	0	1	0	0	0	0	0	0
Acacia floribunda	0	0	0	0	0	0	0	0	0	0
Acacia implexa	0	0	0	0	1	0	0	1	1	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0
Acacia longifolia	0	0	0	0	0	0	0	0	0	0
Acacia parramattensis	0	0	0	0	0	0	1	1	0	0
Acacia parvipinnula	0	0	0	0	0	0	0	0	0	0
Acacia terminalis	0	0	0	0	0	0	0	0	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0
Ajuga australis	0	1	0	0	0	0	0	0	0	0
Allocasuarina glareicola	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	0	0	0	0	0	0	1	1	0	1
Angophora bakeri	0	0	0	0	0	0	0	0	0	0
Angophora floribunda	0	0	0	0	0	0	0	0	0	0
Angophora subvelutina	0	0	0	0	0	0	1	0	0	0
Aristida ramosa	0	0	0	0	0	0	1	1	0	0
Aristida vagans	0	0	0	1	1	0	1	1	1	0
Arthropodium milleflorum	1	0	0	1	0	0	0	0	1	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Asperula conferta	0	1	0	0	1	0	0	0	1	0
Astroloma humifusum	0	0	0	0	0	0	0	0	0	1
Austrostipa verticillata	0	0	0	0	0	1	0	0	0	0
Banksia spinulosa	0	0	0	0	0	0	0	0	0	0
Billardiera scandens	0	0	0	0	0	0	0	0	0	0
Bossiaea obcordata	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	0	0	0	0	1	0	0	0	0	0
Bossiaea rhombifolia	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	0	0	0	0	1	0	0
Brunoniella australis	1	0	1	1	1	1	1	1	1	0
Bursaria spinosa subsp. *spinosa*	1	1	1	1	1	1	1	1	1	1
Caesia vittata	0	1	0	0	0	0	1	0	1	0
Callistemon salignus	0	0	0	0	0	0	0	0	0	0
Calotis cuneifolia	0	0	0	1	0	0	0	0	0	0
Carex inversa	0	0	0	0	0	0	1	0	1	0
Casuarina glauca	0	0	0	0	0	0	0	0	0	0
Cheilanthes sieberi	1	0	1	0	1	0	1	1	1	0
Chrysocephalum apiculatum	0	0	0	0	0	0	1	0	0	0
Clematis aristata	0	0	0	0	0	1	0	0	0	0
Clematis glycinoides	0	0	0	0	0	0	0	1	0	0
Commelina ensifolia	0	0	0	1	0	1	1	1	0	0
Cryptandra amara	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >										
Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Cryptandra spinescens	0	0	0	0	0	0	0	0	0	0
Daviesia ulicifolia subsp. *ulicifolia*	0	0	1	0	0	0	1	0	0	0
Desmodium brachypodum	0	0	0	0	1	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0
Desmodium varians	1	0	0	0	0	0	0	0	0	0
Dianella caerulea var. *producta*	0	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *longifolia*	0	0	0	0	0	0	0	0	1	0
Dianella longifolia var. *stenophylla*	1	0	0	1	1	0	1	1	0	0
Dianella revoluta var. *revoluta*	0	0	0	1	0	0	0	0	0	0
Dichondra repens	1	0	0	1	1	1	1	0	1	0
Dichopogon fimbriatus	0	0	0	1	0	0	0	0	0	0
Dillwynia sieberi	0	0	1	1	1	0	0	0	0	0
Dillwynia tenuifolia	0	0	0	0	0	0	0	0	0	0
Dipodium punctatum	0	0	0	0	0	0	0	1	0	0
Dodonaea falcata	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	0	0	0	0	0
Echinopogon caespitosus	0	0	0	0	0	0	0	1	0	0
Einadia hastata	0	0	1	0	0	1	1	0	0	0
Enchylaena tomentosa	0	0	0	0	0	0	0	0	0	0
Entolasia stricta	0	0	0	0	0	0	0	0	0	0
Eremophila debilis	0	0	0	0	1	0	0	0	0	0
Eucalypts amplifolia	0	0	0	0	0	0	0	0	0	0
Eucalyptus baueriana	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Eucalyptus crebra	0	0	0	0	1	0	0	1	1	0
Eucalyptus eugenioides	0	0	0	0	0	0	0	0	0	0
Eucalyptus fibrosa	0	0	0	1	1	1	0	1	0	0
Eucalyptus globoidea	0	0	0	0	0	0	0	1	0	0
Eucalyptus moluccana	1	1	0	1	0	1	1	0	1	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	0	0
Eucalyptus sclerophylla	0	0	0	0	0	0	0	0	0	0
Eucalyptus tereticornis	1	1	1	1	1	1	1	1	1	0
Exocarpos cupressiformis	0	0	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	0	0	0	0	1	0	0	0
Geitonoplesium cymosum	0	0	0	0	0	0	0	0	1	0
Glycine tabacina	1	0	1	1	1	1	1	1	1	0
Glycine clandestina	0	0	0	0	1	0	1	1	0	0
Goodenia hederacea	0	0	0	0	1	0	1	1	0	0
Grevillea juniperina subsp. *juniperina*	0	0	1	1	1	1	0	0	0	0
Grevillea mucronulata	0	0	0	0	0	0	0	0	0	0
Grevillea sphacelata	0	0	0	0	0	0	0	0	0	0
Hakea laevipes	0	0	0	0	0	0	0	0	0	0
Hakea sericea	0	0	0	0	0	0	0	0	0	1
Hardenbergia violacea	0	0	0	0	1	0	1	0	0	0
Hibbertia diffusa	0	0	0	0	0	0	1	1	0	0
Hypoxis hygrometrica	1	0	0	1	1	0	0	0	0	0
Indigofera australis	0	1	0	0	0	0	0	0	1	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Isopogon anemonifolius	0	0	0	0	0	0	0	0	0	0
Jacksonia scoparia	0	0	0	0	0	0	0	0	0	0
Kunzea ambigua	0	0	0	0	0	0	0	0	0	1
Lagenifera stipitata	0	0	0	0	0	0	0	0	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0
Laxmannia gracilis	0	0	0	0	1	0	0	0	0	0
Lepidosperma laterale	0	0	0	0	0	0	0	0	0	0
Leptospermum parvifolium	0	0	0	0	0	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	0	0	0
Linum marginale	1	0	0	0	0	0	0	0	0	0
Lissanthe strigosa	0	0	0	0	0	0	0	0	0	0
Lobelia purpurascens	0	0	0	0	0	1	0	1	1	0
Lomandra filiformis	0	0	1	0	1	0	0	0	0	0
Lomandra longifolia	0	0	0	0	0	0	1	0	0	0
Lomandra multiflora	0	0	0	0	1	0	0	0	0	0
Lomandra obliqua	0	0	0	0	0	0	0	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0
Lotus australis	0	1	0	0	0	0	0	0	0	0
Melaleuca decora	0	0	1	0	0	1	0	0	0	1
Melaleuca linariifolia	0	0	0	0	0	0	0	0	0	0
Melaleuca nodosa	0	0	0	0	0	0	0	0	0	0
Melaleuca styphelioides	0	0	0	1	0	0	0	0	0	0
Melia azedarach	0	1	0	0	0	0	1	1	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Microlaena stipoides	0	0	0	1	0	0	1	1	0	0
Micromyrtus minutiflora	0	0	0	0	0	0	0	0	0	0
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0
Murdannia graminea	0	0	0	1	0	0	0	0	0	0
Opercularia aspera	0	0	0	0	0	0	0	0	1	0
Opercularia diphylla	0	0	0	1	1	0	1	1	0	0
Oxalis perennans	0	0	0	0	0	0	0	1	1	0
Ozothamnus diosmifolius	0	0	0	0	0	0	0	1	0	0
Patersonia sericea	0	0	0	0	0	0	0	0	0	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0
Persoonia linearis	0	0	0	0	0	0	0	0	0	0
Persoonia nutans	0	0	0	0	0	0	0	0	0	0
Phyllanthus hirtellus	0	0	0	0	0	0	0	0	0	0
Phyllanthus virgatus	0	0	0	1	0	0	0	0	0	0
Pimelea glauca	0	0	0	0	0	0	0	0	0	0
Pimelea linifolia	0	0	0	0	0	0	0	0	0	0
Plantago debilis	0	0	0	0	0	0	0	0	0	0
Plantago gaudichaudii	1	0	0	0	0	0	0	0	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	0	0	0	1	0
Pterostylis saxicola	0	0	0	0	0	0	0	0	0	0
Pultenaea microphylla	0	0	0	1	1	0	0	0	0	0
Pultenaea parviflora	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC23	PEC24	PEC25	PEC26	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2
Ranunculus lappaceus	0	1	0	0	0	0	0	0	0	0
Solanum prinophyllum	0	0	0	0	0	1	0	0	1	0
Styphelia laeta	0	0	0	0	0	0	0	0	0	0
Themeda triandra	1	0	0	1	0	0	1	1	1	0
Tricoryne elatior	0	0	0	0	1	1	1	1	1	1
Viola hederacea	0	0	0	0	0	0	0	0	0	0
Wahlenbergia communis	0	1	0	0	1	0	0	0	0	0
Wahlenbergia gracilis	0	0	0	0	0	1	0	0	0	0
Xanthorrhoea media	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea minor	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

8.2 Appendix 2: Peter Weston's curriculum vitae

Personal details

Name: Peter Henry Weston.

Address: 18 Lyle Avenue, Lindfield, New South Wales 2070, Australia.

Date and place of birth: 22 October 1956, Lower Hutt, New Zealand.

Immediate family: wife (Susan) and three children (Timothy 34, Caitlin 32, Nicholas 29).

Nationality: Australian.

Interests: soccer, reading, guitar, orchid growing, cross-country skiing, bush walking.

Academic Qualifications

i) **B.Sc.** (first class honours; equal first in order of merit) School of Biological Sciences, University of Sydney; 1975-78, conferred 7 April 1979.
Thesis title: "The evolution and classification of *Boronia* Sm."

ii) **Ph.D.**, School of Biological Sciences, University of Sydney, 1979-83; conferred 18 May 1985.
Thesis title: "Systematics and biogeography of the Persooniinae (Proteaceae)".

Awards, Fellowships and Scholarships

2014	Nancy Burbidge Medal (awarded by the Australasian Systematic Botany Society to a person who has made a longstanding and significant contribution to Australasian systematic botany. It is the foremost award that can be conferred by ASBS).
2014	Australian Biological Resources Study-sponsored Winston Churchill Fellowship for an established career researcher in taxonomy.
2009	Grady L. Webster Structural Botany Publication Award for 2008 and 2009 from the Botanical Society of America. The BSA component of the award (it is awarded in alternate years by the BSA and the American Society of Plant Taxonomists) recognizes the most outstanding paper published in the *American Journal of Botany* in the field of structural and developmental botany (i.e., anatomy and morphology) over a two-year period. It was awarded to Gregory J. Jordan, Peter H. Weston, Raymond J. Carpenter, Rebecca A. Dillon and Timothy J. Brodribb for: "The evolutionary relations of sunken, covered, and encrypted stomata to dry habitats in Proteaceae," American Journal of Botany, Volume 95, Issue 5; May 2008.
2006	Carrick Award for Australian University Teaching from the Australian Learning and Teaching Council (one of five members of a teaching team from the University of New England cited for Outstanding Contributions to Student Learning).
1992-93	Posting to Royal Botanic Gardens, Kew, as Australian Botanical Liaison Officer.
1982	Charles Gilbert Heydon Travelling Fellowship for the biological sciences (not taken up).
1980-82	University of Sydney Postgraduate Scholarship.

1979-82	Commonwealth Postgraduate Award.
1977	G.S. Caird Scholarship for Third Year Botany, University of Sydney.
1976	Slade Prize for Practical Plant Biology, University of Sydney.

Employment

Present Position: Honorary Research Associate, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney and independent botanical consultant.

Previous positions held:
2008-2016 Senior Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

2000-2008 Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1994-2000 Senior Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1989-1994 Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1982-1989 Scientific Officer, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1979-82 Part-time demonstrator, School of Biological Sciences, University of Sydney.

Adjunct and visiting university appointments

2013-	Adjunct Associate Professor, La Trobe University.
2011-2016	Adjunct Associate Professor, University of New South Wales.
2006	Visiting Lecturer, Rhodes University, Grahamstown, South Africa.
2004-2009	Adjunct Associate Professor, University of New England.
2000-2004	Adjunct Senior Lecturer, University of New England.

Administrative/management experience

2009	Acting Manager Plant Diversity
2002-2003	Member, Plant Diversity Research Program Leaders Committee
1998-99	Systematics Liaison Officer
1997-98	Member RBGS Market testing working party
1997	Member, RBGS advisory committee for restructuring senior management
1990-91	Systematics Co-ordinator
1996-98	Member, RBGS Joint Consultative Committee

Membership of Learned Societies

1996-	Society of Australian Systematic Biologists
1984-	Willi Hennig Society (Elected Fellow, 1992-, Council member, 1998-2000)
1979-	Society of Systematic Biologists (member, Editorial Board 1993-95)

1978- Australasian Systematic Botany Society (formerly Australian Systematic Botany Society: President, 2009-2012, Vice President, 2008-2009, Chairman, Hansjörg Eichler Research Fund Committee, 1998-2002, Council member, 1996-2002)

Membership of External Committees

2015- Financial Grants Standing Committee (formerly the Grants Policy Standing Committee) of the Australasian Systematic Botany Society

2012-2013 Conference Organising Committee of *Systematics Without Borders*, a joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, University of Sydney (Chairman)

2011- Editorial Board, *Phytotaxa*

2008-2009 Corresponding Member, Editorial Advisory Committee, *Australian Systematic Botany*

2006-2014 Ira Butler Memorial Trophy Committee (a joint committee of the Australasian Native Orchid Society and the Orchid Society of New South Wales) (Chairman)

2004- Editorial Advisory Board, *Kew Bulletin*

2001-2006 Panel of Judges, Eureka Prize for Biodiversity Research

2000-2012 Bushland Management Advisory Committee, Lane Cove Council (Chairman, 2008-2010)

1999-2004 Editorial Advisory Committee, *Australian Systematic Botany*

Spoken presentations at conferences (not including presentations delivered by others)

2015 Building Our Botanical Capital, annual conference of the Australasian Systematic Botany Society: “A database of variation in floral characters in the Proteaceae, and implications for key questions in floral evolution”.

2014 Next Generation Systematics, annual conference of the Australasian Systematic Botany Society: Nancy Burbidge Memorial Lecture: “Problems and progress in plant systematics since Nancy Burbidge”

2013 Genetics Society of Australasia conference, Sydney *Genetics in the Harbour City*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2013 Joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, Sydney, *Systematics Without Borders*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2012 Australasian Systematic Botany Society conference, Perth, *Local knowledge, global delivery*: “Contested, Uncontested and Potentially Controversial Taxonomic Changes in the Proteaceae: How Do They Differ?”

2011 37th annual conference of the South African Association of Botanists, *Plants in a Changing World* and 9th conference of the South African Society of Systematic Biologists, *Biodiversity Matters*; plenary address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

2011 XVIII International Botanical Congress, Melbourne: “Floral evolution in animal-pollinated Australian angiosperm clades: patterns and potential explanations”.

2010 VI Southern Connection Congress, Bariloche: “Cladistic biogeography, molecular dating, fossils and the Proteaceae”

2010 VI Southern Connection Congress, Bariloche: “Diversification of the Proteaceae in Mediterranean hotspots of the Southern Hemisphere and in tropical rainforests”

2010 Australian Systematic Botany Society conference *Systematic Botany Across the Ditch: Links Between Australia and New Zealand*; Keynote address: “Cenozoic environmental change and the systematics of southern hemisphere plants”
1999 XVI International Botanical Congress, Saint Louis: “Historical biogeography of Proteaceae”.
1997 II Southern Connection Congress, Valdivia: “Cladistic biogeography of a key woody group: Proteaceae”.
1997 First Biennial International Conference of the Systematic Association, Oxford: “Rolf Sattler’s Plant Morphology and Cladistic Analysis”.
1996 *An International Symposium on the Biology of Proteaceae*, Melbourne: “ITS squence variation in the Proteaceae and what it tells us about phylogeny”.
1993 Joint conference of The Systematics Associations and The Linnean Society on *Models in Phylogeny Reconstruction*, London: “Direct methods for polarising character transformation series”.
1990 IXth meeting of the Willi Hennig Society, Canberra: “Transoceanic cladistic patterns in the Proteaceae”.
2003 The Third International Conference on *the Comparative Biology of the Monocotyledons*, Ontario: “Co-evolution of *Chiloglottis* (Orchidaceae) and its Thynnine wasp pollinators”.
2005 XVII International Botanical Congress, Vienna: “Food is good but sex is better: the evolution of deceptive pollination in the tribe Diurideae (Orchidaceae)”.
2006 Australian Systematic Botany Society conference, Cairns, *Plant Diversity in the Tropics*: “A new suprageneric classification of the Proteaceae”.
2007 5th Southern Connection Congress, Adelaide: “‘I’m not dead yet’ – Gondwana (the Proteaceae are at least partially congruent with Gondwanic fragmentation)”.
1989 Australian Systematic Botany Society symposium, on *Gondwanan Elements in the Australian Flora*, Sydney: “Transpacific cladistic patterns in the Proteaceae and Elaeocarpaceae”.
1988 Symposium on *Panbiogeography of New Zealand*, Wellington: “Problems with the statistical testing of panbiogeographic hypotheses”.
1985 Australian Flora Foundation Symposium on *Waratahs*, Canberra: “Drifting waratahs or continents?”
1984 Australian Systematic Botany Society symposium on *Cladistics, Systematics and Phylogeny*, Canberra: “A reappraisal of Nelson's direct method of character analysis”.

Refereeing manuscripts, grant applications, reports and examining postgraduate theses (last five years)

2018: *Candollea*; *Flora of the Hunter Region*; *Journal of Biogeography.*
2017: *Australian Systematic Botany*; *Evolution*; *New Zealand Journal of Botany*; *Nuytsia*; *South African Journal of Botany.*
2016: *Australian Systematic Botany*; *Botanical Journal of the Linnean Society*, *National Research Foundation* (South Africa).
2015: *American Journal of Botany*; Australian Research Council (4); *Australian Systematic Botany*; *Muelleria*; *Nuytsia*; *Phytotaxa*; *PLOS One*; *Telopea* (6).
2014: Australian Research Council (3); *Australian Systematic Botany* (2); *Cunninghamia*; *Journal of Biogeography* (2); *Muelleria*; National Research Foundation (South Africa); *Orchadian*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Plant Systematics and Evolution*; *Telopea* (3).

Research

My research has been in the theoretical and practical aspects of systematic botany, with emphasis on the theory and practice of phylogenetic analysis, and the broader uses to which phylogenetic knowledge may be applied. I have phylogenetically analysed groups in the plant families Proteaceae, Fabaceae, Orchidaceae, Rutaceae, Winteraceae and Lauraceae, contributed to more general analyses of angiosperm phylogeny, and used the results of these analyses to improve biological classification and to test theories of historical biogeography, trait evolution, co-evolution and adaptation. I have earned an international reputation for my contributions to both theoretical and empirical developments in this field.

Herbarium curation and collections

My curatorial responsibilities at the National Herbarium of New South Wales have included the families Rutaceae (1982-1998), Proteaceae (1982-2016), Orchidaceae (1986-2016) and Fabaceae subfamily Faboideae (1986-2016). I have collected plant specimens (mostly angiosperms) in Australia, England, New Zealand, New Caledonia, Chile, South Africa, and Argentina, mostly for the herbarium and living collections of the Royal Botanic Gardens and Domain Trust, Sydney. Duplicates of my collections have been distributed to over 20 herbaria in 8 different countries.

Teaching

I have been actively involved in the preparation and teaching of four third year undergraduate courses in biosystematics:
Western Sydney University (2015-2018): “Principles of Evolution” (unit 300980), “Botany” (unit 300836).
University of New South Wales (2010-2016): “Assembling the Tree of Life” (BIOS3221)
University of New England (2000-2010): Biosystematics (Biosyst 301, Biosyst 302, Evol 301/501).
Botany Department, Rhodes University, Grahamstown, South Africa (February-March 2006): “Plant Biodiversity” course in collaboration with Associate Professor Nigel Barker.

I am currently co-supervising one postgraduate student:
Nanette Thomas (Ph.D., University of New England): Systematics of *Tasmannia* informs Biogeography of Winteraceae.

Postgraduate and honours students I have previously co-supervised include:
Margaret Stimpson (Ph.D., University of New England): Systematics, evolution and ecology of the *Banksia spinulosa* complex (graduated 2017).
Melita Milner (Ph.D., Australian National University): Phylogeography of *Lomatia and Telopea* (Proteaceae) in south eastern Australia (graduated 2015).
Samanta Oon (B.Sc. Honours, University of New South Wales): *Lomatia* likes it both ways: rampant bidirectional introgression of chloroplast genomes between two morphologically distinct species of Lomatia (Proteaceae) (graduated 2015).
Zoe Reynolds (B.Sc. Honours, Australian National University): Phylogenetic, taxonomic and functional turnover in Proteaceae assemblages (graduated 2013).
Emma McIntosh (B.Sc. Honours, University of Sydney): Hybridization and introgression between *Lomatia myricoides* and *L. silaifolia* (Proteaceae) (graduated 2011).
Margaret Stimpson (M.Sc.Stud., University of New England): Review of the *Banksia spinulosa* species complex (Proteaceae) (graduated 2011).
James Indsto (M.Sc., University of Wollongong): Pollination Ecology and Molecular Systematics of *Diuris* (Orchidaceae) of the Sydney Region (graduated 2010).
Nanette Thomas (Grad.Dip.Sci., University of New England): Phylogenetic analysis of Winteraceae (graduated 2009).

David McKenna (Ph.D., University of Wollongong: Demographic and ecological indicators for rarity in obligate-seeding *Persoonia* (Proteaceae) shrubs of the Sydney region, graduated 2007).
Paul Rymer (Ph.D., University of Wollongong: Plant rarity: species distributional patterns, population genetics, pollination biology and seed dispersal in *Persoonia* (Proteaceae), graduated, 2006).
Georgina Lloyd (B.Sc. Honours, University of Sydney: Pseudocopulation in two species of *Cryptostylis*: Implications for maintaining species integrity, graduated 2004)
Andrew Perkins (Ph.D., University of Sydney: Phylogenetic Systematics of the Genus *Calochilus* (Orchidaceae), graduated 2002).
Jim Mant (Ph.D., Australian National University: Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae), graduated 2002).
Siegfried Krauss (Ph.D., University of Wollongong: Systematic pattern and evolutionary process in the complex species *Persoonia mollis* (Proteaceae), graduated 1995).

I have examined 14 honours and postgraduate theses:
Australian National University (Ph.D., 2003, 2007, 2008)
University of Melbourne (Ph.D., 1995, 2011)
University of Newcastle (M.Phil., 2003)
University of Queensland (Ph.D., 2003)
University of Sydney (Ph.D., 1991, 1994, 1997, 2009)
University of Wollongong (B.Sc. Hons., 2001, 2003)
Victoria University (Ph.D., 2007)

Competitive Research and Infrastructure Grants

Peakall, R., Pichersky, E., Linde, C., Weston, P.H. (2015-2019) The biosynthesis and evolution of novel semiochemicals in orchids. $644,800, Australian Research Council Discovery Grant DP150102762.

Hoebee, S.E., Weston, P.H., & Edwards, T.J. (2015-18) Evolution in action or the demise of iconic Australian flora? $217,700, Australian Research Council Discovery Grant DP150100508.

He, T., Lamont, B., Weston, P.H., & Cowling, R. (2012-2014) Origin and evolution of plant functional traits in relation to fire. $310,000, Australian Research Council Discovery Grant DP120103389.

Rossetto, M., Crayn, D.M. & Weston, P.H. (2008-2010) Integrating molecular and morphological data for generic delimitation and species identification in Lauraceae. $73,333, Australian Biological Resources Study.

Cantrill, D., Murphy, D. & Weston, P.H. (2008-10) Understanding the origins of the Australian flora by integrating molecular phylogenies and fossil data in the Proteaceae. $88,900, Hermon Slade Foundation.

Rossetto, M. & Weston, P.H. (2007-2009) Speciation in the Australian flora: testing explanatory hypotheses in waratahs and their allies. $78,000, Hermon Slade Foundation.

Considine, J.A., Krauss, S.L. & Weston, P.H. (2002-2004) A biological basis for the efficient breeding of native plants for export markets: a case study with the Australian Goodeniaceae. $168,126, ARC – Linkage (Krauss and Weston representing industry partners)

Whelan, R.J., Ayre, D.J., England, P., Auld, T.D., & Weston, P.H. (2000-2002) Ecology and genetics of fire-sensitive *Persoonia* species: threatened species recovery and management. $126,480, Australian Research Council (ARC– SPIRT, Auld and Weston representing industry partners).

Trent, R. *et al.* (2000) Enhancement of DNA sequencing equipment for the Sydney University and Prince Alfred Molecular Analysis Centre. $600,000, Australian Research Council (ARC-REIF).

Weston, P.H. (1999-2001) Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae). $75,000, Hermon Slade Foundation.

Weston, P.H. (1997-2000) Taxonomic revision of *Dillwynia* (Fabaceae: Faboideae: Mirbelieae). $62,836, Australian Biological Resources Study.

Weston, P.H. & Thomson, J.A. (1993) A molecular approach to the evolution and biogeography of the Queensland tree waratahs. $4000, Queensland Wet Tropics Management Authority

Weston, P.H. & Thomson, J.A. (1991-92) A molecular approach to the evolution and biogeography of the waratahs. $80,100, Australian Research Council (large grants scheme).

Weston, P.H. (1984) Establishment of a data bank for eucalypt specimens held by NSW. $20,000, Australian Biological Resources Study.

Scientific Publications

[the numbers in square brackets following a reference indicate: 1. the journal's 2016-17 impact factor according to ISI Web of Knowledge, then the number of literature citations for the paper found by Google Scholar, as of 13 Feb 2019]

H-index = 34, total number of citations = 4081 as of 13 Feb 2019

1. Craw, R.C. & **Weston, P.H.** (1984) Panbiogeography: a progressive research program? *Systematic Zoology* 33: 1-13. [8.917, 90]

2. **Weston, P.H.**, Carolin, R.C., & Armstrong, J.A. (1984) A cladistic analysis of *Boronia* Sm. and *Boronella* Baill. (Rutaceae). *Australian Journal of Botany* 32: 187-203. [0.793, 49]

3. Morrison, D.A. & **Weston, P.H.** (1985) Analysis of morphological variation in a field sample of *Caladenia catenata* (Smith) Druce (Orchidaceae). *Australian Journal of Botany* 33: 185-195. [0.793, 11]

4. Crisp, M.D. & **Weston, P.H.** (1987a) Waratahs - how many species? Pp. 3-15, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 13]

5. Crisp, M.D. & **Weston, P.H.** (1987b) Cladistics and legume systematics, with an analysis of the Bossiaeeae, Brongniartieae and Mirbelieae. Pp. 65-130, in C.H. Stirton (ed.) *Advances in Legume Systematics Part 3* (Royal Botanic Gardens: Kew). [-, 131]

6. **Weston, P.H.** (1987) *Persoonia* (Proteaceae). Pp. 348-350, in N.G. Marchant *et al*. (eds.) *Flora of the Perth Region* (Western Australian Herbarium: Perth). [-, 0]

7. **Weston, P.H.** & Crisp, M.D. (1987) Evolution and biogeography of the Waratahs. Pp. 17-34, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 14]

8. **Weston, P.H.**, Wilson, P.G., & Hill, K.D. (1987) Identification of *Cannabis*. *Department of Agriculture New South Wales Miscellaneous Bulletin* 25: 148-150. [-, 0]

9. **Weston, P.H.** (1988a) A revision of *Hicksbeachia* (Proteaceae). *Telopea* 3: 231-239. [0.6, 3]

10. **Weston, P.H.** (1988b) Indirect and direct methods in systematics. Pp. 27-56, in C.J. Humphries (ed.) *Ontogeny and Systematics* (Columbia Univ. Press: New York). [-, 76]

11. **Weston, P.H.** (1989) Problems with the statistical testing of panbiogeographic hypotheses. *New Zealand Journal of Zoology* 16: 511. [0.811, 7]

12. **Weston, P.H.** (1990) Notes on *Boronia* (Rutaceae) in New South Wales, including descriptions of three new species. *Telopea* 4: 121-128. [0.6, 6]

13. **Weston, P.H.** & Johnson, L.A.S. (1991) Taxonomic changes in *Persoonia* (Proteaceae) in New South Wales. *Telopea* 4: 269-306. [0.6, 9]

14. Crisp, M.D. & **Weston, P.H.** (1991) *Almaleea*, a new genus of Fabaceae from south-eastern Australia. *Telopea* 4: 307-311. [0.6, 10]

15. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae), a new genus from New Guinea and eastern Australia. *Telopea* 4: 497-507. [0.6, 12]

16. **Weston, P.H.** (1991) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium*, *Pultenaea* and *Dillwynia* (Fabaceae). Pp. 2-19, 452-455, 456-461, 481-497, 499-504, in G. Harden (ed.) *Flora of New South Wales* vol. 2 (New South Wales Univ. Press: Sydney). [-, 0]

17. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae) and *Almaleea* (Fabaceae). Pp. 29-30, 497-498, in G. Harden (ed.) *op. cit.* [-, 0]

18. **Weston, P.H.** & Porteners, M.F. (1991) *Boronia*, *Eriostemon* and *Phebalium* (Rutaceae). Pp. 227-236, 250-254, 255-263, in G. Harden (ed.) *op. cit.* [-, 0]

19. Porteners, M.F. & **Weston, P.H.** (1991) *Correa* and *Crowea* (Rutaceae). Pp. 247-249, 254-255, in G. Harden (ed.) *op. cit.* [-, 0]

20. Crisp, M.D. & **Weston, P.H.** (1991) *Telopea*. Pp. 30-31, in G. Harden (ed.) *op. cit.* [0.6, 0]

21. Gross, C.L. & **Weston, P.H.** (1992) *Macadamia jansenii* (Proteaceae), a new species from central Queensland. *Australian Systematic Botany* 5: 725-28. [0.75, 8]

22. Crisp, M.D. & **Weston, P.H.** (1993) Geographic and ontogenetic variation in morphology of Australian waratahs (*Telopea*: Proteaceae). *Systematic Biology* 42: 49-76. [14.387, 76]

23. Gilmore, S., **Weston, P.H.**, & Thomson, J.A. (1993) A simple, rapid, inexpensive and widely applicable technique for purifying plant DNA. *Australian Systematic Botany* 6: 139-148. [0.75, 41]

24. **Weston, P.H.** (1993) Key to genera, *Cyrtostylis*, *Cryptostylis*, *Zeuxine*, *Cheirostylis*, *Pseudovanilla*, *Erythrorchis*, *Epipogium*, *Gastrodia*, *Oberonia*, *Liparis*, *Dendrobium*, *Calanthe*, *Phaius*, *Geodorum*, *Dipodium*, *Cymbidium*, *Sarcochilus*, *Rhinerrhiza*, *Peristeranthus*, *Papillilabium*, *Schistotylus*, *Plectorrhiza*, *Taeniophyllum* (Orchidaceae). Pp. 134-138, 218-219, 219-221, 221-233, 236-247, in G. Harden (ed.) *Flora of New South Wales* vol. 4 (New South Wales Univ. Press: Sydney). [-, 0]

25. **Weston, P.H.** & Hill, K.D. (1993) *Bulbophyllum* (Orchidaceae). Pp. 233-236, in G. Harden (ed.) *op. cit.* [-, 0]

26. **Weston, P.H.** & Crisp, M.D. (1994) Cladistic biogeography of Waratahs and their allies (Embothrieae: Proteaceae) across the Pacific. *Australian Systematic Botany* 7: 225-249. [0.75, 73]

27. **Weston, P.H.** (1994) The Western Australian species of subtribe Persooniinae (Proteaceae: Persoonioideae: Persoonieae). *Telopea* 6: 51-165. [0.6, 19]

28. **Weston, P.H.** & Johnson, L.A.S. (1994) Three new species of *Persoonia* (Proteaceae) from Queensland. *Telopea* 6: 31-37. [0.6, 1]

29. **Weston, P.H.** (1994) Methods for rooting cladistic trees. Pp. 125-155, in D.J. Siebert, R.W. Scotland and D.M. Williams (eds.) *Models in Phylogeny Reconstruction* (Oxford Univ. Press: Oxford). [-, 38]

30. Crisp, M.D. & **Weston, P.H.** (1995) Mirbelieae. Pp. 245-282, in J.J. Doyle and M.D. Crisp (eds.) *Advances in Legume Systematics Part 7: Phylogeny* (Royal Botanic Gardens: Kew). [-, 37]

31. Crisp, M.D. & **Weston, P.H.** (1995) Subtribe Embothriinae (Proteaceae). *Flora of Australia* 16: 382-390. [-, 0]

32. Crisp, M.D., Linder, H.P. & **Weston, P.H.** (1995) Cladistic biogeography of plants in Australia and New Guinea: congruent pattern reveals two endemic tropical tracks. *Systematic Biology* 44: 457-473. [8.917, 121]

33. Thomson, J.A., **Weston, P.H.** & Tan, M.K. (1995) A molecular approach to tracing the major lineages in *Pteridium*. Pp. 21-28, in R.T. Smith and J.A. Taylor (eds.) *Bracken: an Environmental Issue* (University of Leeds: Leeds). [-, 13]

34. **Weston, P.H.** (1995) Key to the genera of Proteaceae in Australia, Subfamily Persoonioideae, Subfamily Bellendenoideae, Subtribe Gevuininae, Subtribe Hicksbeachiinae. *Flora of Australia* 16: 41-46, 47-125, 125-127, 409-410. [-, 0]

35. Bernhardt, P. & **Weston, P.H.** (1996) The pollination ecology of *Persoonia* (Proteaceae) in eastern Australia. *Telopea* 6: 775-804. [0.6, 48]

36. **Weston, P.H.** & Crisp, M.D. (1996) Trans-Pacific biogeographic patterns in the Proteaceae. Pp. 215-232, in A. Keast & S.E. Miller (eds.) *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processes* (SPB Academic Publishing: Amsterdam). [-, 34]

37. **Weston, P.H.** & Johnson, L.A.S. (1997) *Persoonia hindii* (Proteaceae), a new species from the Newnes Plateau, New South Wales. *Telopea* 7: 199-203. [0.6, 6]

38. Jobson, P.C. & **Weston, P.H.** (1998) *Dillwynia glaucula* (Fabaceae: Mirbelieae), a new species from the Southern Tablelands, New South Wales. *Telopea* 8: 1-5. [0.6, 1]

39. **Weston, P.H.** (1999) *Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8: 159-164. [0.6, 5]

40. Crisp, M.D., Gilmore, S.R. & **Weston, P.H.** (1999) The phylogenetic relationships of two anomalous species of *Pultenaea* (Fabaceae: Mirbelieae) from molecular and morphological data, and description of a new genus. *Taxon* 48: 701-714. [2.447, 21]

41. Jobson, P.C. & **Weston, P.H.** (1999) Two new species of *Dillwynia* (Fabaceae: Mirbelieae), from the Southern Tablelands of New South Wales. *Telopea* 8: 363-369. [0.6, 0]

42. Thomson, J.A., **Weston, P.H.** and Tan, M.K. (1999) A molecular approach to tracing major lineages in *Pteridium*: update and amendment. Pp. 35-36 in J.A. Taylor & R.T. Smith (eds.) *Bracken Fern: Toxicity, Biology and Control* (International Bracken Group: Aberystwyth). [-, 1]

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Papers in Preparation

1. Stimpson, M.L., Wright, B.R., **Weston, P.H.**, Whalley, R.D.B., & Bruhl, J.J. (in review) Seedling morphology helps unravel the taxonomic intricacies in the *Banksia spinulosa* complex (Proteaceae). *Botanical Journal of the Linnean Society* [2.523, -]

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Conference Abstracts

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Expert report – *Hibbertia fumana*

Hibbertia fumana – Wilton and GMAC, Robert Miller, September 2018

Hibbertia fumana – WSA and GPEC, Robert Miller, December 2018

Strategic assessment for Cumberland Plain Conservation Plan
Hibbertia fumana

Hibbertia fumana, Moorebank, R. Miller September 2017.

Report prepared for Department of Planning and Environment

By

Cumberland Flora & Fauna Interpretive Services

Robert Miller - September 2018

Executive Summary

Hibbertia fumana is listed as a Critically Endangered Species under the *Biodiversity Conservation Act 2016*. There are two known populations of the species, one at Moorebank and the other at Bankstown Airport. The species is assessed as data-poor.

Survey for this report was limited by time constraints, lack of access to private property, survey outside the species flowering season and years of preceding drought conditions.

Assessment relied on the expected presence of “likely habitat”, based on extant population habitat, and “potential habitat”, based on speculation of historic record habitat.

The probability of the species to occur in the likely habitat is considered low due to site disturbance, however, cannot be ruled out as the Bankstown population survives in highly modified mown derived grassland environment. The probability of the species to occur in potential habitat is considered to be very low. However, a precautionary approach is recommended. Locating and protecting new populations, no matter how small, is significant to the survival of this species.

H. fumana is a small shrub that could be severely affected by anthropogenic impacts resulting from development edge effects, particularly in areas downhill of development.

The assessment identified:

- at Menangle Park an area of approximately 92ha that could contain likely habitat niches within the growth area footprint, and a further 31 ha of land containing likely habitat niches adjacent to the footprint.
- at Kayess and Milton Parks areas of likely habitat that are not affected by the growth area footprints.
- at Bunbury Curran Creek vicinity areas of potential habitat are not affected by the growth area footprints.
- in the Gilead and Appin areas approximately 8ha of land containing potential habitat niches within the growth area footprint and a further 380ha of land containing potential habitat niches adjacent to the footprint.
- in the Wilton growth area, approximately 65ha of land containing potential habitat niches within the footprint and a further 680ha of land containing potential habitat niches adjacent to the footprint.

Note that the likely and potential habitats are niches within the overall landscape, generally associated with localised soil and drainages within transition vegetation.

Although the species occurrence is assessed as low, it is recommended that further survey be carried out in the likely habitat and some of the potential habitat areas during the species’ flowering season.

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Abbreviations

AVH	Australian Virtual Herbarium
BAM	Biodiversity Assessment Method
BC Act	Biodiversity Conservation Act 2016
CFFIS	Cumberland Flora & Fauna Interpretive Services
DPE	NSW Department of Planning and Environment
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GMGA	Greater Macarthur Growth Area
IBRA	Interim Biogeographic Regionalisation for Australia
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
sp./spp.	species (species singular / plural)
s. str.	*sensu stricto* – in the narrow sense
subsp.	subspecies
WGA	Wilton Growth Area

1. Introduction

1.1 PURPOSE

The purpose of this expert report is to determine the potential for future urban development in identified growth areas of Western Sydney to impact on *Hibbertia fumana*, which is listed as a Critically Endangered Species under the *Biodiversity Conservation Act 2016*. This report forms part of the Cumberland Plain Conservation Plan, which will be assessed under the:

- Biodiversity certification under the *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Biodiversity Assessment Method (BAM) sets out the framework and methods to be used for assessment of impacts to biodiversity to provide preferred conservation outcomes while also supporting the development approval process. Under the BAM an expert report can be used when adequate survey is not possible. An expert report can only be used for species to which species credits apply.

The expert report must document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report. The report must set out whether the subject species is likely to be present at the development site, and if present then the report must estimate, in the case of a species such as *Hibbertia fumana*, the area of habitat where the species is likely to be impacted, as well as areas from which it is known to occur in which it will be impacted.

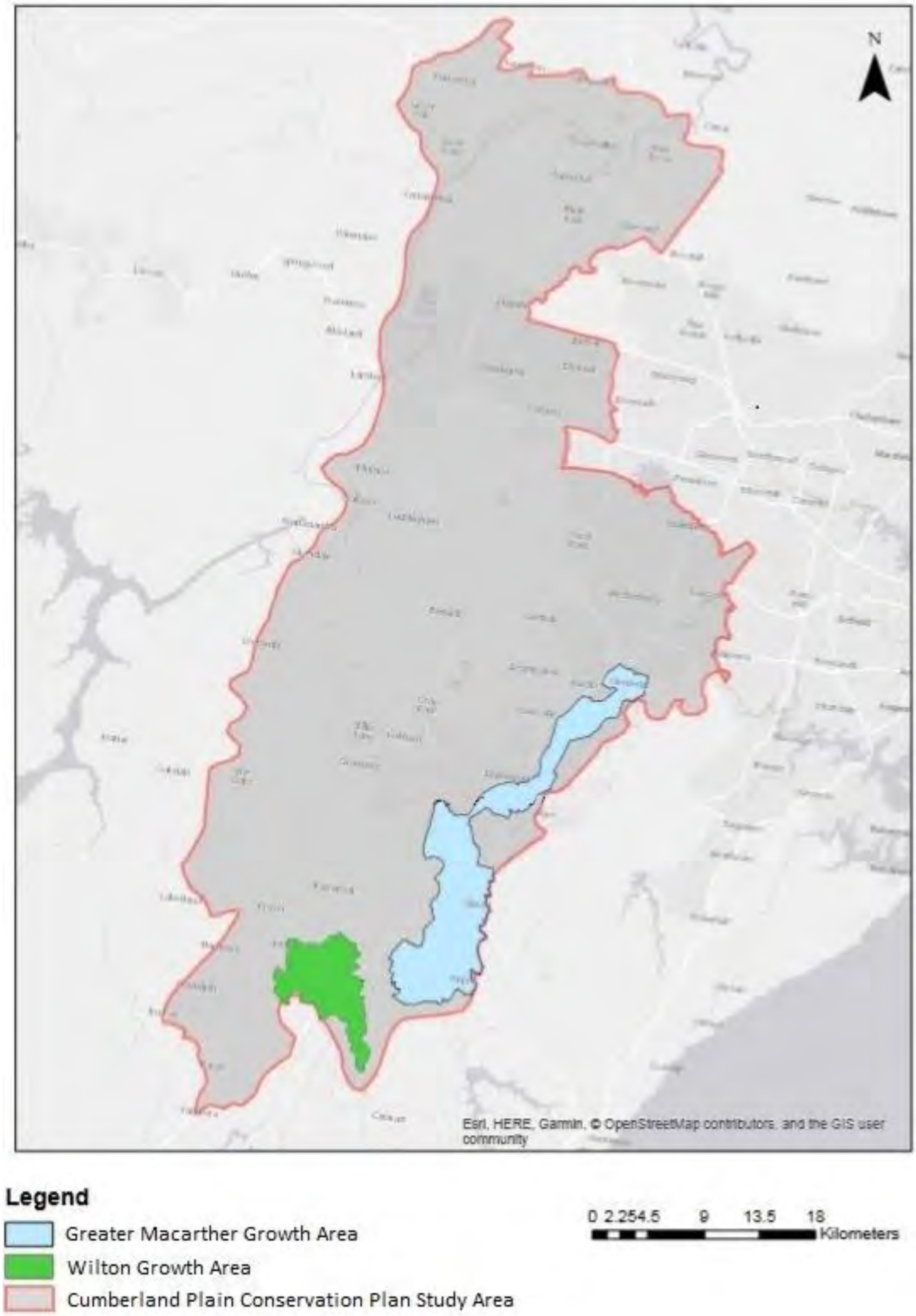
1.2 PROJECT CONTEXT

The NSW Government is planning for future urban development in Western Sydney. Four growth areas have been identified, these are Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These growth areas are all located within the Cumberland Subregion in version 7 of the Interim Biogeographic Regionalisation for Australia (IBRA) (2016).

As part of the planning for this future development, the Department of Planning and Environment (DPE) is preparing the Cumberland Plain Conservation Plan. This is a strategic regional assessment that will lead to the identification of preferred conservation outcomes for the Cumberland subregion.

1.3 STUDY AREA

The Map 1 shows the Cumberland Plain Conservation Plan Study Area and the two growth areas of Greater Macarthur (GMGA) and Wilton (WGA).



Map 1: Cumberland Plain Conservation Study Area and Growth Areas

Map source: NSW Department of Planning and Environment.

1.4 SPECIES SURVEYS

Past collections

This species was first collected by George Caley from “near South Head” in 1802 and was subsequently collected by Robert Brown “in occidental (western) Sydney” in 1804.

The type specimen is a F. W. Sieber collection Australia near Sydney. His expedition was from June until December 1823 when he collected 645 local plant specimens (Council of Heads of Australasian Herbaria Australian National Herbarium Biographical Notes Extracted from: A.E.Orchard (1999)).

One collection by Keith Ingram at Connells Point in 1941 is also thought to be that species but a degree of uncertainty prevails (refer to specimen label notes by Orme in Appendix 3). No precise locality details nor habitat information was recorded on these historic specimens.

Presumed extinct when first published in 2012, the species was re-discovered at the Moorebank Intermodal site in October 2016. It has also been recorded at Bankstown Airport in November 2017 (AVH) as part of environmental assessment of an infrastructure proposal. It is not known to occur at any other locations.

Surveys for this Bio Assessment

Surveys for the biodiversity assessment informing the development of the biocertification were constrained by private lands access issues, time and the overall size of the biocertification area.

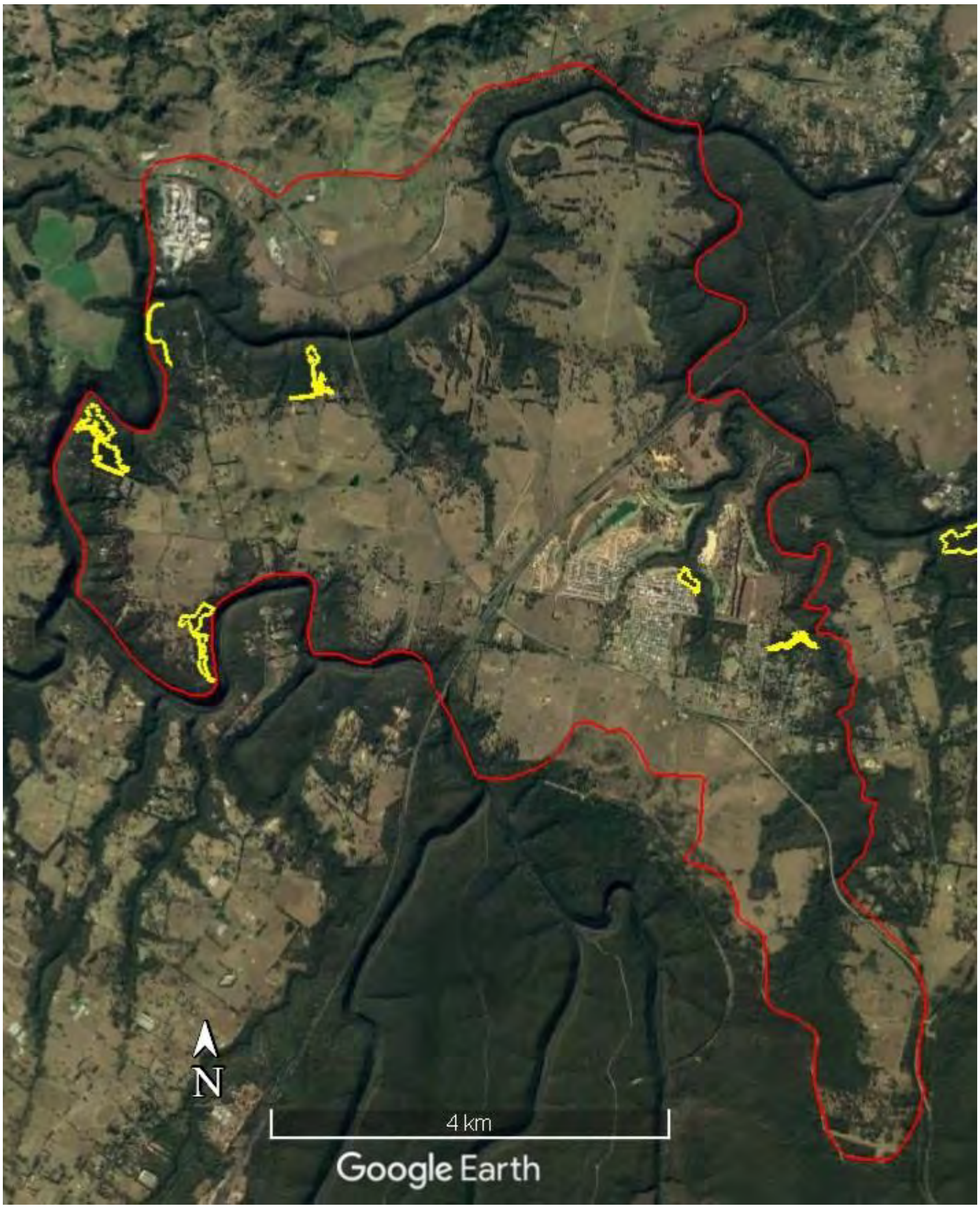
Surveys undertaken by Ecoplanning and Biosis consultancies since 2017 have largely been confined to the deemed “development footprint” and appear to have been undertaken predominantly to comply with the BAM protocols for vegetation sampling for assessment purposes with little survey for threatened species. As such, no new occurrences of threatened *Hibbertia* species including *Hibbertia fumana* were recorded by Biosis or Ecoplanning through their survey efforts.

One site was identified by DPE and Biosis as having potential to support the species, an area mapped as PCT 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain.

Access to a spatial viewer was provided by DPE to assist in the expert assessment. Whilst this tool has been useful in gaining a general overview, the information presented is limited and is acknowledged to “have been acquired and developed from numerous sources of differing dates, accuracy and completeness and may include errors in extent and content”. CFFIS are not aware of any surveys performed specifically for *Hibbertia fumana* by DPE, Ecoplanning or Biosis Consultancies. The broadscale vegetation mapping of PCTs that was provided to assist with this assessment cannot identify the habitat niches that may be present on a localised scale.

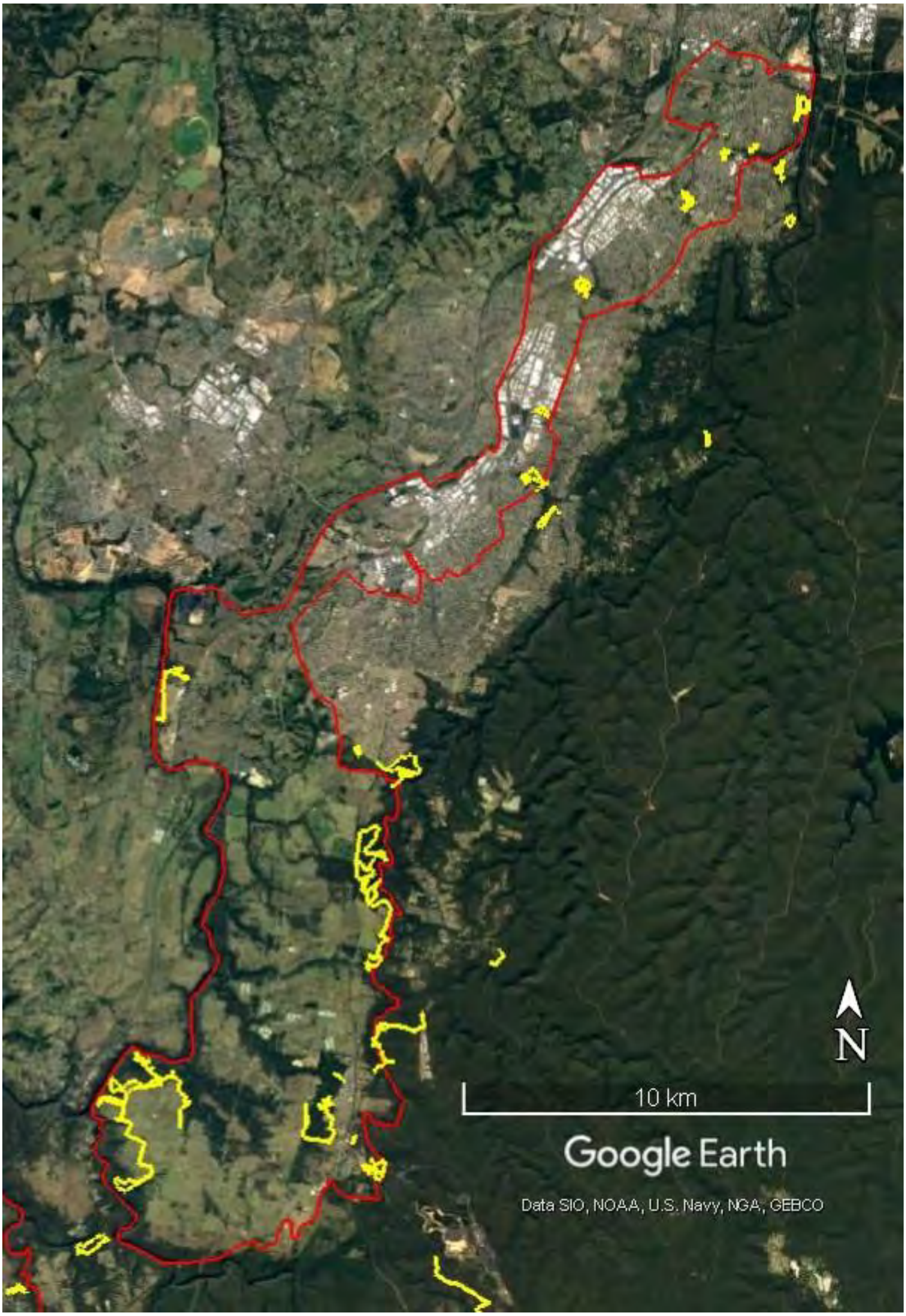
The surveys undertaken by Miller as part of this expert report relied on assessment of known habitat traits of extant sites and, although highly speculative, inferred habitat traits from historic records. PCT mapping and aerial digitised photography were used to select potential habitat areas for targeted surveys. Priority was given to finding the same habitat as occurs at the Moorebank and Bankstown Airport sites, although a variety of vegetation associations that are known habitat of other *Hibbertia* species such as *H. puberula* were surveyed to include inferred habitat from historic records. *Hibbertia puberula* co-occurs with *H. fumana* at the Moorebank site.

Map 2**Error! Reference source not found.** and Map 3 **Error! Reference source not found.**show the sites that were surveyed for this assessment.



Map 2: Google Earth image of Wilton Growth Area showing the tracks of CFFIS survey.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow.



Map 3: Google Earth Image of Greater Macarthur Growth Area and CFFIS survey tracks.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow.

<u>Species identification</u>

If a small-leaved *Hibbertia* was located that had macro morphological features resembling that of *Hibbertia fumana* then a specimen would be retained for later microscopic examination. CFFIS has also assessed the likelihood of *Hibbertia puberula* to occur in the GMGA and the WGA. *Hibbertia puberula* co-occurs with *H. fumana* at Moorebank and as both species are small-leaved, diminutive plants it is possible to misidentify *H. fumana* as *H. puberula* or other small-leaved species without careful examination (refer Photo 2). Selected specimens taken as part of the *Hibbertia puberula* assessment were microscopically examined to ensure that *Hibbertia fumana* was not inadvertently collected and dismissed as *Hibbertia puberula* or another small-leaved species. Due to the time of the year and prevailing drought conditions, plants were not in flower and depauperate, such that any specimens removed consisted of very small fragments (eco-scraps) most only a few cm in length.

The survey during June and July is not the flowering season for this species, so identification relied on stem and leaf characteristics, shown in Figure 1, Figure 2, Appendix 2 and microscopic comparison with voucher specimens. Note that positive identification of the species requires flowering parts, however, some species of *Hibbertia* can be ruled out based on stem and leaf characteristics.

Figure 1 drawing depicts *Hibbertia fumana* in bud where those buds appear +/- sessile. During the Moorebank surveys it was purported by a consultant that pedunculate flowers are a key field identification tool even in bud. This is clearly erroneous and should not be used as the sole identifying feature (refer also to Photo 3**Error! Reference source not found.** R.T. Miller and photo of the Isotype in Figure 3**Error! Reference source not found.**).

Peduncle elongation is clearly related to and is proportional to the developmental progression from buds to seed formation. Anecdotal observation by Miller suggests peduncle development is also related to environmental conditions such as moisture content of the soil and degree of exposure, for example, extended periods of low soil moisture and /or in combination with exposure appears to reduce peduncle length.

The species profile for *Hibbertia fumana* identifies some of the *Hibbertia* species with which it might be confused: "species with which it may be confused include *Hibbertia aspera* (peduncle of *H. fumana* is shorter, especially in flower, the foliage is more persistently hairy, and there are fewer stamens), *H. empetrifolia* (*H. fumana* is much more prominently stellate-hairy) and *H. riparia* (*H. fumana* has much shorter leaves). *Hibbertia superans* is another possible species for confusion, though *H. fumana* has smaller leaves" (OEH 2018).

It is unlikely that an expert would misidentify large / mature flowering plants of the above species with *Hibbertia fumana*. Confusion / unreliability is likely to arise if a population census is undertaken outside of optimal flowering time and/or the survey site is recovering from fire when high proportion of the plants will be small and immature, or if depauperate in drought conditions.

There are several other small leaved diminutive Hibbertias that could be confused including *Hibbertia dispar*, *H. pedunculata*, *H. calycina* s.str. and other undescribed taxa.

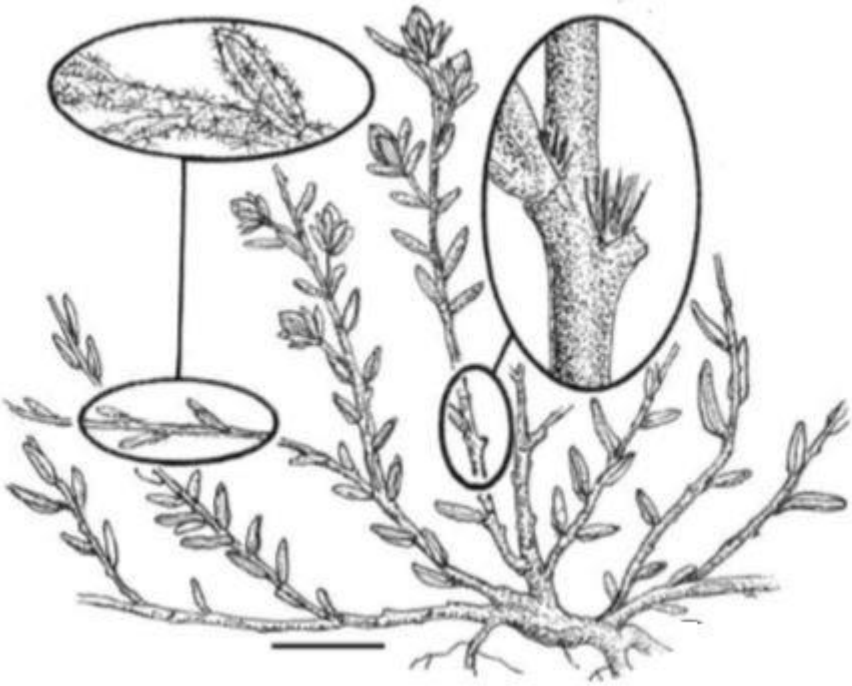


Figure 1: Stem and leaf characteristics of a flowering *Hibbertia fumana* specimen.

F.W. Sieber 147 (MEL 3111616) (Toelken and Miller 2012)

Relying solely on stem and leaf characteristics in field survey can lead to mis-identification. *Hibbertia fumana*, *H*. *aspera* and *H*. *empetrifolia* have discolorous leaves and using this character alone on non-flowering specimens without a high resolution microscopic examination could result in dismissing or mis-identifying a plant to be *H*. *fumana*. The discoloration of the under surface of the leaves in both *Hibbertia fumana* and *H*. *aspera* is due to the presence of a usually dense white/silvery tomentum whilst the leaf under surface of *H*. *empetrifolia* lacks dense tomentum but it is of a similar whitish coloration.

Apparent tomentum density and type on the stems and leaves will vary according to the section of branchlet examined and the prior climatic conditions. New growth is likely to have a higher density and a fuller range of hair types present whereas on older growth much of this tomentum will have "worn off" (Toelken), especially the longer simple hairs. Drought condition will see a marked reduction in new growth. *Hibbertia aspera*, like *H. empetrifolia*, shows much variation in different local populations as well as sometimes on the same plant (Toelken).

Both *Hibbertia aspera* and *H*. *empetrifolia* were frequently observed during the CFFIS survey, whilst *H. ericifolia* subsp. *acutifolia* was noted to be locally common in the south-eastern sector of the GMGA mostly associated with Scribbly Gum Woodland.

Microscope photographs of *H. fumana* characteristic features used during this survey by CFFIS are provided in Appendix 2 and includes comparison photos of *Hibbertia aspera*, *H*. *empetrifolia* and *H*. *dispar*.

<u>Survey assumptions</u>

The survey was carried out in June to August, during the non-flowering period, and it was not possible to access and survey all the many bushland remnants within the Wilton and Greater Macarthur growth areas. As such, the first assumption was:

Assumption 1. *Hibbertia fumana* would not be found growing in bushland that is unlikely to be suitable habitat.

The author is familiar with the type of habitat at the Moorebank Intermodal and Bankstown sites. Using this knowledge of geology, soil and vegetation type that is the known occupied habitat of the species, areas of bushland that would not be suitable habitat were ruled out of the assessment.

Using this knowledge of habitat requirement, the second assumption was:

Assumption 2. *Hibbertia fumana* is likely to be present in areas that are known to be suitable habitat. While surveys in suitable PCTs since the species was described in 2012 have failed to find *H. fumana*, this is a cryptic plant and the precautionary principle should be applied to the potential for the species to occur in suitable habitat.

The survey was carried out following several years of drought in western Sydney, and many shrubs, forbs and grasses were dead. This led to the third assumption:

Assumption 3. In areas of suitable habitat, where *Hibbertia fumana* specimens have not been found, the species could be present in the soil seed bank.

Identification to species of the *Hibbertia* relies on characters of the flowers. The survey was carried out in the non-flowering period which led to the fourth assumption:

Assumption 4. That specimens matching the stem and leaf characteristics of *Hibbertia fumana* could possibly be that species. Small narrow-leaved specimens were examined under the microscope to determine if the stem and leaf characteristics matched those of *Hibbertia fumana.*

1.5 JUSTIFICATION FOR USE OF EXPERT REPORT

The BAM allows for situations where an expert report will be required to replace or complement survey effort at a development site. While there has been some field survey for the Strategic Biocertification assessment, the area covered by the proposed GMGA and WGA are extensive and there have been issues with gaining access to some of the private properties.

An expert report is required to assess potential impact to *Hibbertia fumana* for the following reasons:

Insufficient survey: A large extent of the identified growth areas could not be surveyed because it was on private property and could not be accessed within the project timeframe. Expertise was required to identify and survey potential species habitat and propose additional habitat based on extant and historic records.

Survey out of flowering season: Survey during June and July is at the non-flowering period for the species, so finding cryptic species of *Hibbertia* in the field is difficult even for an expert and more so for someone who is not an expert (refer Photo 1).

1.6 CREDENTIALS OF EXPERT

Robert Miller has over 30 years' experience in field botany. Over this time Robert has identified many rare and endangered plant species and has contributed to the scientific knowledge of native flora distribution and habitat in NSW.

Robert has worked with Hellmut Toelken of the State Herbarium of South Australian, locating, collecting and identifying undescribed or rare species of *Hibbertia*. Some of these taxa were known only from historic records with non-precise locality details and depauperate or non-existent habitat information. Many of the specimens have been used for the taxonomic revision of the genus and are cited in various taxonomic publications including "Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*" published in the *Journal of the Adelaide Botanic Gardens* 26 (2013). Examples of the cited specimens include: *Hibbertia ericifolia* subsp. *acutifolia* Toelken, subsp. nov. Type: New South Wales, Sarahs Knob, R. & J. Miller s.n., 21.x.2006 (holo.: AD; iso.: BRI, CANB, NSW, PERTH) and *Hibbertia dispar* R.T.Miller s.n., 0.5 km S of Penrose Rest area, along western boundary track, Penrose State Forest, 12.x.2010 (AD, NSW).

Robert and Hellmut's paper "Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales", was published in the *Journal of the Adelaide Botanic Gardens* in 2012. The paper describes 13 new taxa including *Hibbertia fumana* Toelken and *Hibbertia puberula* subsp. *puberula,* – subsp. *extensa* R.T.Mill. and – subsp. *glabrescens* Toelken*.*

In 2017 Robert was called as an expert to identify the species of *Hibbertia* on the Moorebank bushland site that is the subject of the Intermodal development proposal.

Robert is also a recognised expert for other threatened taxa including *Pomaderris adnata*, *Solanum celatum*, *Epacris purpurascens* var. *purpurascens*, and the genus *Prostanthera* including the threatened taxa *Prostanthera discolor*, *P. stricta*, *P. densa*, *P. junonis* and has provided expertise to the OEH Saving our Species programs.

Photo 1: Very cryptic by its diminutive nature *Hibbertia fumana.*

H. fumana is difficult to detect even just prior to full petal expansion. Refer Photo 3 for close-up showing morphological features.

<u>Survey during drought</u>

The Western Sydney region has been experiencing dry conditions for several years, which means that the *Hibbertia fumana* plants are likely to be under severe drought stress and partially defoliated making this small and cryptic species more difficult to locate. It requires an expert in the species to locate and identify rare *Hibbertia* under these conditions.

<u>Reliable species identification</u>

Identification of the genus *Hibbertia* to species level requires examination of flower parts in combination with stem and leaf characters, especially tomentum type and density. It is not practical nor reliable to identify small leaved species in the field as many of these morphological features require microscopic examination and comparison to known voucher specimens.

The use of an expert report to complement survey of the growth areas avoids the problems associated with *Hibbertia* misidentifications. *Hibbertia* species can be misidentified in vegetation assessments, frequently being dismissed as “common” species.

The misidentification of both *Hibbertia puberula* and presumably *Hibbertia fumana as Hibbertia riparia* during past surveys raises the possibility that other records of *Hibbertia riparia* may in fact be *Hibbertia fumana*. Searches of the databases revealed prior surveys undertaken for various projects have recorded *Hibbertia riparia* to occur at a number of locales within the GMGA and WGA.

The *Hibbertia riparia / H. calycina / H. hirsuta* groups are currently under further detailed evaluation (Toelken pers. comm.). *Hibbertia riparia* R.Br. s. str. occurs in Tasmania (Toelken) and is unlikely to occur in NSW, the name being misapplied (Toelken pers. comm.). It was therefore anticipated that the identifications of *Hibbertia riparia* would be found to be incorrect.

Two recorded *H. riparia* sites were inspected as part of this report, one at Douglas Park (12 June 2018) and one at Wilton on 17 August 2018. A third Site at Appin was not surveyed due to access constraints.

The *Hibbertia* sp. observed off Douglas Park Drive was found to have vegetative features consistent with *H. puberula*. No plants were noted that resembled *Hibbertia fumana*, however the site inspection was limited by the extreme drought conditions and non-flowering period for the species. It remains unknown if *Hibbertia fumana* co-occurs at the site.

The Wilton locale was inspected in August and it was found that the severity of impact to the bushland from drought had markedly increased. The site was extremely dry following the years of drought, the ground was covered with a thick layer of leaf litter, and many plants were dead including large numbers of *Hibbertia aspera*. No plants resembling *H. riparia* were found at the location, so the correct identification of the species could not be ascertained.

It is considered likely that this species is the same taxon as the proximate occurrence off Douglas Park Drive which has vegetative features consistent with *H. puberula,* however there remains a possibility although low, that the *Hibbertia* may be *H. fumana*.

Photo 2: Five species of Hibbertia, photo taken 30cm above specimens, but which one is which?

Key - A: *Hibbertia aspera*, B: *H. empetrifolia*, C1: *H*. *puberula* (Lucas Heights), C2: *H*. puberula (Moorebank), D*: H*. sp. (morphological vegetative features consistent with *H*. *puberula* (East Gilead), E: *H*. *fumana*, F: *H*. *dispar*.

2. Species information

2.1 SPECIES DESCRIPTION

Hibbertia fumana was described by Toelken and Miller (2012) in their paper "Notes on Hibbertia (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. Hemistemma, mainly from the central coast of New South Wales". At the time of writing, the species was presumed extinct and had not yet been discovered at the Moorebank Intermodal site. The description was based on three herbarium specimens collected in 1802, 1804 and 1823.

The re-discovery of the species provided a broader range of specimens and a revised description which included for the first time fruit and seed, was provided by Duretto, Orme, Rodd, Stables and Toelken (2017). The following is a direct quote from that description.

Hibbertia fumana Sieber ex Toelken, Journal of the Adelaide Botanic Gardens 25: 73 (2012).

Type: Australia, near Sydney, "F.W.Sieber Nov. Holl. No. 147"

Decumbent shrublet, prostrate to weakly ascending to 20 cm high, with many branches from the base, moderately- to much-branched; branches wiry, with raised leaf bases shortly decurrent, shortly fascicled-pubescent. Vestiture persistent, consisting of more or less coarse simple hairs over fine fascicled hairs on tubercles; on branches more or less densely covered with short subequal multiangulate fascicled hairs (4–7 equal arms) and without simple hairs except for intrapetiolar tufts of hairs in leaf axils; on leaves above scattered, short antrorse fine bi- or triforked to simple hairs, sparse becoming denser onto the petiole, few simple hairs along the flanks, all wearing off soon; on leaves below dense, with short subequal multiangulate fascicled hairs (4–12 subequal arms) particularly on central vein, overtopped by few simple hairs on the flanks of the revolute margins; on outer calyx outside moderately dense, with spreading coarse antrorse simple hairs over erect-spreading multiangulate fascicled hairs (8–15 subequal arms), inside dense, with forked to simple antrorse hairs over most of surface; on inner calyx lobes outside dense with spreading multiangular fascicled hairs (2–12 subequal or unequal arms) becoming smaller towards the membranous margins, overtopped by coarse antrorse simple hairs along the central ridge, inside glabrous except for a few simple hairs towards the apex. Leaves with intrapetiolar axillary tuft of hairs to 0.7 mm long; petiole 0.2–0.45 mm long; lamina narrowly oblong, rarely linear-elliptic, (1.9–) 2.1–6.5 × 0.5–1.2 mm, obtuse, with terminal tuft of hairs on a somewhat recurved apex of the central vein, more or less abruptly constricted into petiole, above ± flat and puberulous to glabrescent, below with broadened central vein recessed below the level of revolute margins and protruding into apex, pubescent to puberulous. Flowers single, terminal, commonly on main branches; flower stalk 2–9 mm long, recurved and elongating after flowering, pubescent; bract linear to linear-triangular, 1–1.3 mm long, sometimes leaf-like to 5.5 mm long, fascicled-pubescent, on lower third to half of flower stalk. Calyx distinctly accrescent, with lobes subequally long; outer calyx lobes lanceolate, 3.5–5.7 × 1.3–1.65 mm, enlarging to 6.1 × 2.2 mm with fruit, acute to acuminate, without ridge, outside strigose-pubescent, inside finely strigose with antrorse forked hairs on much of the surface;

inner calyx lobes oblong-ovate, 4.0–5.8 × 3.1–3.5 mm, usually cuspidate, outside strigose along the central vein and tomentose towards the margins, inside glabrous with few forked hairs at the apex. Petals obovate, 4–5.2 mm long, broadly bilobed. Stamens 5 or 6 (7), subequal, clustered on one side of the ovaries; filaments 0.4–0.6 mm long, basally connate; anthers broadly oblong, 1.3–1.4 mm long, ± abruptly constricted above and below. Pistils 2; ovaries obovoid but ± laterally compressed, each with 4 ovules, fascicled-tomentose, with style attached to the centrifugal apex of the ovary then after a short curve downwards straightening up on either side of the stamens with stigmas exposed above the anthers. Fruit puberulous with simple and multiangular hairs. Seeds oblong-obovoid to almost obloid, 1.6–2.0 × 1.4–1.5 mm, smooth, light brown; aril with fleshy base surmounted by one-sided membranous cup covering c. one quarter of one side of seed.

Additional specimens examined: NEW SOUTH WALES: Central Coast: R.Brown [J.J.Bennett 4873], "In occidental Sydney 1804" (BM); G.Caley s.n., "near South Head", viii.1802 (BM); Moorebank in western Sydney, J.Rodd & M.Stables, 19.x.2016 (NSW, 3 specimens); Moorebank in western Sydney, A.E.Orme 1572, 16.xi.2016 (AD, NSW).

Photo 3: *Hibbertia fumana* in pre-flower at Moorebank Intermodal Site

R. Miller September 2017.

Fig. 1. *Hibbertia fumana*. **a**, habit; **b**, branch; **c**, branch detail showing tufts of hairs in leaf axil; **d**, leaf, adaxial surface; **e**, leaf, abaxial surface; **f**, flower; **g**, flower, petals removed; **h**, inner sepal, abaxial surface; **i**, inner sepal, adaxial surface; **j**, outer sepal, abaxial surface; **k**, outer sepal, adaxial surface; **l**, flower with fruit; **m**, seed. Scale bar: **a** = 80 mm; **b** = 15 mm; **c** = 2.5 mm; **d & e** = 4 mm; **f** = 6 mm; **g & l** = 8 mm; **h–k** = 5 mm; **m** = 3 mm. Drawn from *Orme 1572*.

Figure 2: *Hibbertia fumana* Lesley Elkan in *Telopea* 20: 143–146

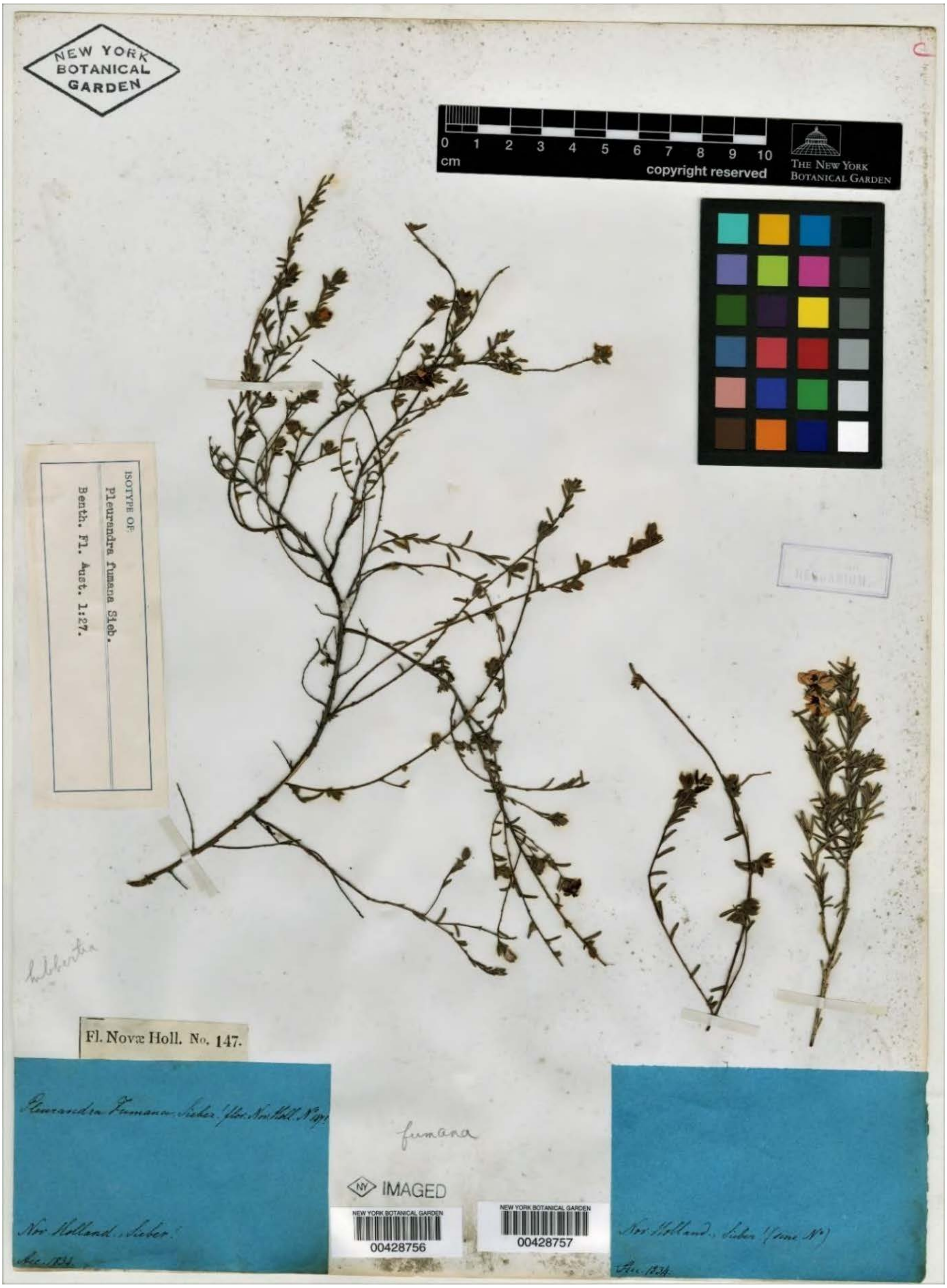


Figure 3: Isotype of *Hibbertia fumana.*

F.W Sieber held within the William and Lynda Steere Herbarium as digitised imagery in the C. V. Starr Virtual Herbarium New York Botanic Gardens showing apparent +/- sessile flower buds.

2.2 LIFE CYCLE

The NSW Threatened Species Scientific Committee Final Determination for listing of *Hibbertia fumana* states that "Little is known about the life history of *Hibbertia fumana*. Seed production and plants of different ages were recorded within the only known population (A. Orme in litt. November 2016). The species does sucker (A. Orme in litt. November 2016) suggesting it may be able to resprout from rootstock following fire."

Peak flowering is recorded as spring to early summer, although the species appears to be capable of minor sporadic flowering at other times of the year as a response to suitable climatic conditions (Miller pers. obs.).

2.3 DISTRIBUTION AND ABUNDANCE

Historically the species was collected by Caley "near South Heads", eastern Sydney, in 1802, by Robert Brown in 1804 "occidental Sydney" and by Sieber 1823 "near Sydney New Holland".

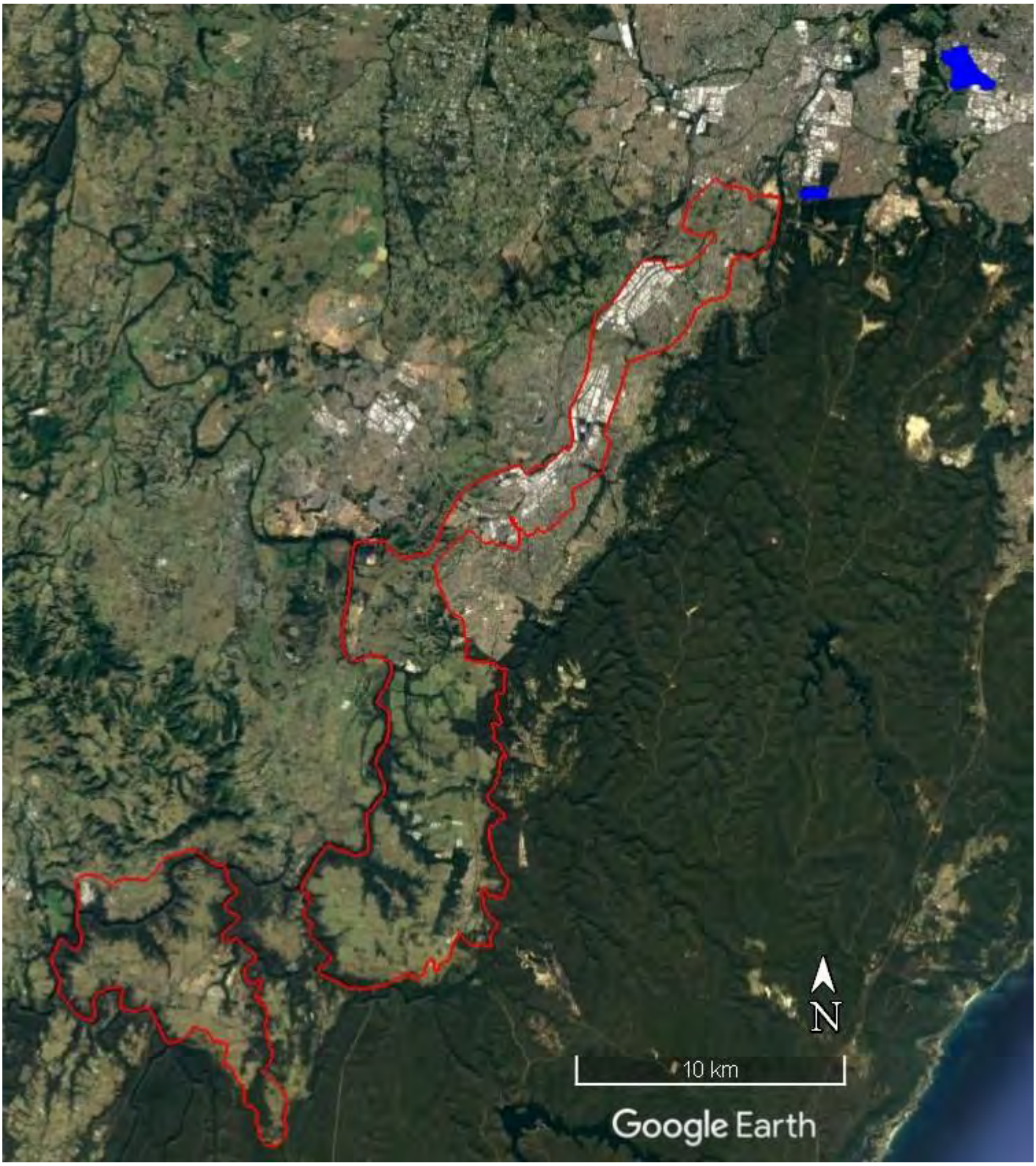
Recently a specimen from the Keith Ingram herbarium collection has been determined as most likely to be that species by Andrew Orme. It was collected at Connells Point in February 1941.

South Head and Connells Point are now highly urbanised environments and as such this diminutive species is unlikely to have persisted at either locale. If the species has persisted it is most likely so in the Connells Point environs. Targeted searches may be warranted in the Poulton Creek vicinity including Poulton Park.

Currently known from one extant population at Moorebank of c. 400 and an unknown number of plants in the Bankstown Airport vicinity.

At the time of the species listing in October-November 2016 (Arcadis and Parsons & Brinckerhoff Australia/New Zealand (WSP)) 370 plants were recorded at Moorebank and a further "approximately 29 plants" were recorded in September 2017 (Arcadis and Cumberland Ecology).

The impact upon the population at the Moorebank site from an intense fire in April 2018 is unknown.



Map 4: Indicative area of *Hibbertia fumana* populations.

Key - Areas of known *H. fumana* populations (blue) and the Wilton and Greater Macarthur growth areas (red).

2.4 HABITAT REQUIREMENTS

Historic collections

The *Hibbertia fumana* profile states: “Habitat of an 1802 Caley collection 'near South Head' are uncertain, with potential communities in that area including coastal shale sandstone communities and open forest or forest communities on lateritised shale lenses. No similar alluvial sand deposits are identified in that area.” (OEH 2018)

It is speculated by Miller that the most likely habitat for the Caley collection is transitional vegetation associated with “Swamps” or wet heath, especially the transition from shale influence communities to heath and/or open woodland. Although unsuitable habitat now, the Woollarah Golf Course site is likely to have consisted of a mosaic of vegetation types including swamp transition to woodland and the original habitat at Centennial Park is well documented “Originally a swamp and then set aside as land for the water source for Sydney, Centennial Park” (Centennial Park Trust). The diverse micro-habitats at Centennial Park supported numerous now locally rare or endangered taxa including *Hibbertia virgata E.Cheel NSW 86014*, Centennial Park, ix.1900 (NSW); and *A.A.Hamilton NSW 86016*, Centennial Park, 23.viii.1912 (AD, NSW) (Toelken in. prep.) and it is likely to have also supported *Hibbertia fumana*.

Extant populations

The OEH website states that *Hibbertia fumana* is known to be associated with the following vegetation formations and classes:

Dry sclerophyll forests (shrub/grass sub-formation) - within the Cumberland Dry Sclerophyll Forests class *Hibbertia fumana* is associated with

- Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain and Sydney Basin Bioregion and
- Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion

Dry sclerophyll forests (shrubby sub-formation) - the Vegetation Types that *Hibbertia fumana* is associated within the Sydney Sand Flats Dry Sclerophyll Forests class include

- Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion and
- Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion

At Bankstown Airport the AVH record states that the “Site is heavily managed and is routinely slashed to a height of about 10cm. Soils are grey heavy clay with ironstone fragments present at surface. Other native species observed indicate a derived form of Cooks River / Castlereagh Ironbark forest community. Main weed observed *Eragrostis curvula*.”

Photo 4: Indicative habitat of *Hibbertia fumana* at Bankstown Airport, regularly slashed.

At the Moorebank site the species is found growing in the transition zone between Castlereagh Ironbark Forest and Castlereagh Scribbly Gum woodland in open forest of *Eucalyptus sideroxylon, E. fibrosa, E. parramattensis, E. sclerophylla* and *Melaleuca decora* with a diverse understorey of shrubs including *Hakea sericea, Callistemon linearis, Bursaria spinosa, Grevillea parviflora* subsp. *parviflora, Acacia brownii, Acacia bynoeana, Pultenaea retusa, Pultenaea villosa, Hibbertia puberula* subsp. *puberula* and *H. aspera* subsp. *aspera*. The herb/grass layer is dominated by *Goodenia hederacea, Dianella revoluta, Thysanotus, Gonocarpus, Poa, Stylidium graminifolium, Patersonia, Themeda, Diuris* and *Microtis* (Telopea 2017).

Prior to the recent fire, the density of the understorey was variable across the site and ranged from sparse to extremely dense especially within the long-unburnt sections of the Castlereagh Scribbly Gum woodland. The variation in density is presumed to be due to the fire history, localised clearance events including recent remediation works, as well as minor changes in topography and drainage especially in swales.

In general, the topography of the land is described as flat although this is disrupted by the passage of Anzac Creek and by numerous minor depressions or swales likely to be remnants of past creek alignments and/or overflow channels that support Castlereagh Swamp Woodland. These swales and minor excavations / scrapings form small ephemeral pondages.

From limited brief inspections *Hibbertia fumana* was observed to be of sporadic occurrence across the site and appeared to be absent from ephemeral pondage locales preferring open slightly higher ground. Soils are described as fine sandy clay loam, grey brown in colour.

2.5 ANTHROPOGENIC THREATS TO THE HABITAT

Threats to the habitat of *Hibbertia fumana* that are relevant to sites within or adjacent to urban development include:

- Loss of habitat. Loss of the existing habitats across much of the distribution has occurred and may occur for as-yet-missed populations of the species.
- The Moorebank population consists of approximately 370 individuals only.
- Development of the adjacent lands at Moorebank for a major transport hub may affect the plants, and there is a rarely-used railway line bisecting the site. At Bankstown airport infrastructure development could impact the population.
- Fire either too frequently (limiting recruitment) or too rarely (allowing midstorey thickening) are likely to impact the species.
- Clearing for fire protection zones and infrastructure works could remove habitat.
- Damage to habitat by trail biking, 4WDs and mountain bikes.
- High densities of weeds and invasive grasses occur at the top of ridgelines; there is significant potential for encroachment into areas where the species occurs.
- A number of weeds are likely to impact on the plant, with particular concern for low shrubs, dense shrubs and smothering grasses.
- Changes to hydrological processes can impact habitat by reducing subsoil infiltration, drying out seepages, or concentrating flow paths through habitat.
- Nutrification can increase weed potential.
- Road maintenance and slashing works.

Field inspection of bushland remnants in the heavily urbanised sectors of GMGA provide irrefutable proof of severe degradation arising from anthropogenic impacts and urbanisation (refer photos 4 through 8). Without exception, all creeks and many of the remnants were heavily weed infested arising from a range of factors not limited to nutrification, stormwater discharge, garden refuse and fill dumping and exotic seed dispersal by various vectors.

Damage to zones adjacent urban development can also be caused by clearing for fire hazard reduction, control burning frequently, and recreation activities such as 4WD vehicle access, mountain bikes and kids' cubby house building.

Photo 5: Control burn at Bunbury Curran Park, Macquarie Fields.

Photo 6: Chronic weed infestations characterise the riparian zone of Bunbury Curran Creek.

The photo above was taken in the southwestern corner of Bunbury Curran Park west of TAFE NSW Macquarie Fields.

Weeds include: Balloon Vine (*Cardiospermum grandiflorum*), Fennel (*Foeniculum vulgare*), African Olive (*Olea europaea* subsp. *africana*), Large-leaved Privet (*Ligustrum lucidum*), Small-leaved Privet (*Ligustrum sinense*) Kikuyu (*Pennisetum clandestinum*), African Lovegrass (*Eragrostis curvula*), Rhodes Grass (*Chloris gayana*), Mothvine (*Araujia hortorum*), Honeysuckle (*Lonicera japonica*), Wild Tobacco (*Solanum mauritianum*) and Blackberry (Rubus fruticosus aggregate).

Hibbertia fumana is a small shrub that would not survive in bushland that is severely weed infested, or that is severely burnt on a regular basis.

Photo 7: Pembroke Park Impacts of urbanisation - invasive weed species dominate the shrub, vine and ground layers.

Photo 8: At Pembroke Park Red Ash (*Alphitonia excelsa*) and Forest Red Gum (*Eucalyptus tereticornis*) cut down to construct bike jumps and cubby houses and the shrub layer cleared.

Photo 9: Smith's Creek Reserve typical condition of bushland adjoining residential properties on the southern side of Smith's Creek, highly weed degraded, cleared for hazard reduction, fill and refuse dumping.

3. Description of the study area

3.1 LAND USE HISTORY

The Cumberland Plain was first occupied by the Aboriginal peoples, who enjoyed a plentiful supply of fresh water and foods including fruit, tubers, fish, animals, birds and honey (Hills District Council website).

With the arrival of Europeans, land-use changed to timber gathering and agriculture, permanently altering the landscape. Particularly since the end of the Second World War urban settlement and industry have expanded west from Sydney into the Cumberland subregion. Over the last 40 years many rural properties have been subdivided as lifestyle and hobby farm properties.

Currently there is great pressure for further residential development to the west of Sydney in the Cumberland subregion.

3.2 LANDSCAPE CONTEXT

The changes in land use have caused the clearing of a large proportion of the natural bushland of the Cumberland subregion. In 2011 the Cumberland Plain Recovery Plan stated “Only 13% of the pre-1750 extent of the region’s vegetation remains as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas (NPWS 2002). Consequently, much of the region’s biodiversity is listed as threatened under State and/or Commonwealth legislation.”

Widespread clearing of the remaining habitat has continued with much of the extant vegetation now being assessed as Critically Endangered. Previously recorded from South Head and Western Sydney, *Hibbertia fumana* appears to have suffered a reduction in range caused by urbanisation.

3.3 NATIVE VEGETATION

Since 2011 there has been further clearing, there are now 15 vegetation communities that are listed as Critically Endangered, Endangered or Vulnerable in the Cumberland Plain.

The Cumberland Plain Recovery Plan states that “there are seven threatened species, four endangered populations and nine threatened ecological communities listed on the NSW *Threatened Species Conservation Act* 1995 that are found only on the Cumberland Plain. Seven of these are also listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.” The remaining bushland is highly fragmented and much of it occurs on private lands.

Within the GMGA and the WGA eleven Plant Community Types (PCTs) are mapped (mapping provided by the NSW Department of Planning and Environment). These PCTs are:

- Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, PCT 830

- Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, PCT 835
- Grey – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion. PCT 849
- Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion. PCT 850
- Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion. PCT 877
- Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 883
- Red Bloodwood – Grey Gum woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 1081
- Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateau of the Sydney Basin Bioregion. PCT 1083
- Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion. PCT 1181
- Water Gum- Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion. PCT 1292
- Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion. PCT 1395

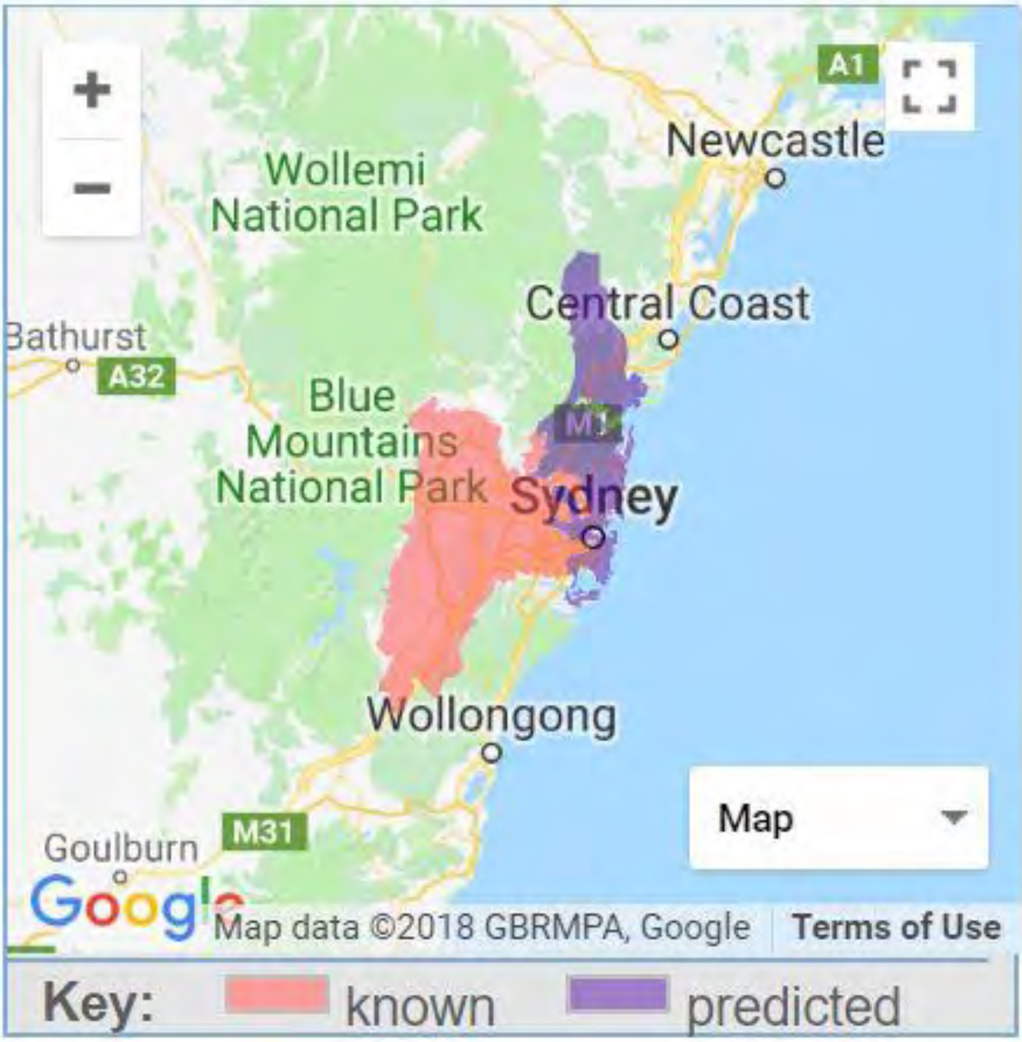
3.4 POTENTIAL HABITAT

Within the Sydney Basin bio-region *Hibbertia fumana* is known from the IBRA subregion of Cumberland and is predicted to occur in the Pittwater IBRA sub-region. No geographic constraints are currently listed for the species. The subregions of known and predicted occurrence are shown in **Error! Reference source not found.**. The areas shown in pink and purple are the sub-regions where the species or community is known or predicted to occur. They may not occur throughout the sub-region but may be restricted to certain areas.

The OEH species profile sheet states: “found in the transition zone between Castlereagh Ironbark Forest and Castlereagh Scribbly Gum woodland in open forest of *Eucalyptus sideroxylon, E. fibrosa, E. parramattensis, E. sclerophylla*”. The species has the potential to occur in similar intergrade alluvial habitats rich in sands and laterite in other parts of western Sydney.

Hibbertia fumana is currently known only from two locations in western Sydney. A single population at Moorebank and a single population in Bankstown (AVH record) but has the potential to occur elsewhere in greater Sydney.

At Moorebank it is found in areas of open woodland in a long intergrade between Castlereagh Scribbly Gum Woodland and Castlereagh Ironbark Forest. The AVH record for *Hibbertia fumana* at Bankstown records “Site is heavily managed and is routinely slashed to a height of about 10cm. Soils are grey heavy clay with ironstone fragments present at surface. Other native species observed indicate a derived form of Cooks River / Castlereagh Ironbark forest community."



Map 5: Known and predicted distribution of *Hibbertia fumana*.

Source OEH website 2018.

The habitat of an 1802 Caley collection 'near South Head' is uncertain, with potential communities in that area including coastal shale sandstone communities and open forest or forest communities on lateritised shale lenses. No similar alluvial sand deposits are identified in that area.

OEH has identified that *Hibbertia fumana* has the potential to occur in the following plant community within the Wilton and Greater Macarthur Growth Areas:

- 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain

4. Assessment of species presence and suitable habitat

4.1 SPECIES RECORDS AND HABITAT ASSESSMENTS

Hibbertia fumana is poorly known and is site managed and assessed as data-poor. There are no records of the species within or adjoining the proposed growth areas. Only two known extant populations exist Moorebank c. 1.6 km to the north-east of the northern boundary of GMGA and approximately 36 km from WGA, and Bankstown Airport 9 km from the northern boundary of GMGA and approximately 41 km from WGA.

The broad scale vegetation assessment that has been carried out across the growth areas does not identify local scale habitat potential.

4.2 PRIOR SPECIES SURVEYS

Private land holdings comprise much of the lands within the GMGA and WGA, restricting access opportunities for botanical surveys and incidental sightings. This is a likely contributing reason for the lack of prior records of threatened *Hibbertia* species including *Hibbertia fumana* within the proposed growth areas.

From the information provided, no prior targeted searches have been undertaken for this species as part of the biocertification assessment process. One small area of mapped potential habitat (PCT 883) at Milton Park, Macquarie Fields was investigated by Biosis. The data provided is limited to that found within the spatial viewer.

The level of data is insufficient to base an assessment of presence/absence for a Critically Endangered species purely as a desktop study.

The Threatened Species Expert Report Overview spreadsheet, provided by DPE, shows that *Hibbertia fumana* was not recorded from the area mapped as PCT 883 in Milton Park based on the records of Bionet and Biosis and Ecoplanning consultant surveys. Nor was it found during surveys of the Greater Macarthur and Wilton Growth areas by these consultants.

CFFIS conducted a site inspection of Milton Park and the adjacent Macquarie Fields Leisure Centre. We found that the regional scale vegetation mapping could not provide the level of detail required to identify potential species habitat.

Local scale variations indicate the need for site-specific survey of the growth areas for *H. fumana* or its habitat.

Photo 10: Milton Park, the majority of the trees are *Eucalyptus tereticornis,* PCT 849 thinned.

Photo 11: Area between Macquarie Fields Leisure Centre and Macquarie Road, site is dominated by Ironbarks.

4.3 ASSESSMENT OF SPECIES PRESENCE

The previous survey data provided by Biosis and Ecoplanning Consultants was insufficient to assess the probability of occurrence of *Hibbertia fumana* from a desk top study. The species has demonstrated an ability to persist within suitable derived habitat, it was therefore appropriate to undertake specific targeted surveys.

The area mapped as PCT 883 and surrounds were surveyed by CFFIS for the species. We also surveyed for habitat appropriate to the species in areas of potential tertiary sediments and shale sandstone interface across the growth areas and adjacent lands, based on geology, soils and landform maps where access was provided.

4.3.1 LIKELIHOOD OF SPECIES PRESENCE

The possibility of *Hibbertia fumana* occurring within the GMGA is assessed as low because potential habitat sites with similar attributes to known extant sites are highly modified and of limited extent. However, the presence of this species cannot be dismissed entirely on disturbance factors because the Bankstown Airport population survives in a highly modified environment. Bannerman and Hazelton (1990) in *Soil Landscapes of the Penrith 1:100,000 Sheet* map the entire site as disturbed terrain, although field observation by Miller and others have identified areas to retain the original soil profile.

There are no habitats similar to the known extant sites mapped as occurring within the WGA. The possibility of those PCT's being undocumented within WGA is assessed as negligible.

Historic occurrence records indicate the species could also be found "in coastal shale sandstone communities and open forest or forest communities on lateritised shale lenses" (OEH Threatened Species Profile). Large tracts of shale sandstone interface exist within the WGA and GMGA. Therefore, the potential for suitable habitat for the species within the WGA, and other areas of the GMGA, although unlikely, cannot be dismissed.

Hibbertia fumana is currently assessed as being Critically Endangered and is data -poor. In this context, a precautionary approach is recommended. Locating and protecting new populations, no matter how small, is significant to the survival of this species.

4.3.2 JUSTIFICATION FOR DETERMINATION

Greater Macarthur Growth Area

Just one small area of known habitat PCT 883 is located in the Milton Park area at Macquarie Fields. This area was surveyed in June and July and the species was not found. Milton Park is intensively managed for recreation, however further survey during the species flowering period would be appropriate.

Hibbertia fumana is reported to occur at Bankstown Airport within a highly modified environment that is “routinely slashed to a height of about 10cm” resulting in a “derived form of Cooks River / Castlereagh Ironbark forest community. Main weed observed *Eragrostis curvula*.” (AVH). This new record demonstrates that the species can be found on differing soils to that of the Moorebank occurrence.

The Bankstown occurrence provides evidence that the species can persist within a suitable derived habitat. It is therefore possible that *H. fumana* could occur within the GMGA. If it does occur, it is most likely in a transitional vegetation zone either between shale / alluvial or shale / sandstone environs. Limited potential habitat areas occur within the GMGA.

Shale alluvial transitional sites may include potentially inadequately surveyed areas in the Menangle Park vicinity and other areas in the northern sector of GMGA, especially those now modified to a derived grassland environment.

Shale / Sandstone transitional vegetation occurs in the middle and southern sectors of GMGA but is mostly confined to above the escarpment edges of the various creeks and rivers. Scattered occurrences of sandstone outcroppings have been noted elsewhere including in the northern sector of the GMGA, for example, at Milton Park and Kayess Park at Ingleburn.

One record of *Hibbertia riparia* (which could potentially be *H. fumana* and/or *H. puberula*) is noted at Appin, the co-ordinates placing the occurrence in Shale / Sandstone transition.

<u>Milton Park environs</u>

The vegetation remnants in Milton Park vicinity are variously mapped as PCT 835 along the unnamed branch of Bunbury Curran Creek and PCT 849 Grey Box – Forest Red Gum grassy woodland elsewhere with the exception of a small area to the north of Macquarie Road and south of Bingara Road which is mapped as PCT 883 Hard-leaved Scribbly Gum – Parramatta Red Gum woodland.

Site inspection revealed that some areas of vegetation in the vicinity of the Macquarie Fields Leisure Centre had Ironbark species dominating the upper canopy. Areas of ironstone gravel were noted. Other species observed included Woollybutt (*Eucalyptus longifolia*), *Cryptandra spinosa*, *Daviesia ulicifolia*, *Bursaria spinosa*, *Lepidosperma laterale*, *Kunzea ambigua*, and *Melaleuca decora*.

The area north of Macquarie Road mapped as PCT 883 and PCT 849 is comprised of a few clumps and scattered remnant trees of both *Eucalyptus sclerophylla* and *E. tereticornis* in a regularly slashed recreation reserve. *Eucalyptus sclerophylla* occurs, on the higher ground to the north on soils observed to have a high quartz content in association with the underlying sandstone plates. Scribbly Gum exists as approximately 1/3 of the areas of remnant trees. Scattered trees of *E. tereticornis* dominate the ephemeral creek / drainage line and are the major tree species in the remainder of the area.

The areas of remnant *Eucalyptus sclerophylla* are characterised by scattered sandstone plate outcroppings and relatively sandy soil. Hard-leaved Scribbly and *Angophora bakeri* / *floribunda* intergrade are likely to have covered much of the site extending to the west to near the sports fields where sandstone outcropping is prominent. Dense mown swathes of *Eragrostis curvula* dominate the ground layer and unmown tussocks the tree bases. Apart from one clump of *Kunzea ambigua* and sapling Eucalypts, few other native species noted had more than one to a few individuals surviving above ground. Twelve native species were observed mostly at the bases of some remnant trees.

Map 6: Image of areas containing likely habitat at Milton Park and Macquarie Road Reserve.

The moister drainage line to the south and the gentle rise to Macquarie Road is dominated by *Pennisetum clandestina*, *Eragrostis curvula* and assorted other weeds, no native understorey species were observed in this mown environment.

It is unknown whether *Eucalyptus parramattensis* exists or existed at this site.

The polygon mapped as 883 is highly disturbed and it is unlikely that this area would now support an occurrence of *Hibbertia fumana.* However, as Ironbark is dominant in the adjoining Macquarie Field Leisure Centre area adjacent Macquarie Road, it is likely that a transitional vegetation type previously existed between the Ironbark, Forest Red Gum and Scribbly Gum Woodland in this vicinity that may have supported *Hibbertia fumana* and/or *H. puberula.*

As a precaution it is recommended that a targeted search be undertaken under non-drought conditions in the species peak flowering season by an experienced *Hibbertia* specialist.

Kayess Park environs

Biosis mapped Kayess Park environs to support Intact PCT 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion and Cumberland Plain Urban Native / Exotic.

Site inspection of the 20 July 2018 determined that PCT 835 mapped along the creek lines was unsuitable habitat for *H. fumana*.

An area of Ironbark occurs in the central area which grades into Grey Box - Forest Red Gum and Ironbark in the western portion. A fire was noted to have impacted much of the site especially the grassland area. This was evidenced by burnt Blackberry canes, bases of many Whisky Grass tussocks and dead *Acacia decurrens*.

The park is cleared and very weedy across much of the location especially on the more fertile shale derived soils. Localised sandstone outcroppings are apparent, and areas of sandy soil also present in the derived grassland. The sandstone influence extends upslope into the Ironbark forest environs but appears absent within areas supporting Grey Box and Forest Red Gum.

In general *Eucalyptus tereticornis* dominates eastern creek slopes. Ironbark species dominate sandstone influenced ridge top, including *Eucalyptus beyeriana*. The northwest corner is dominated by *Eucalyptus tereticornis, E. moluccana* and *E. crebra*?

In the context of its size and location much of the “intact” remnant vegetation is in reasonable condition. Sections of the remnants have a lot of rubbish dumping and weed invasion especially along drainage lines.

Potential threatened *Hibbertia* habitat occurs in the sandy soil at and below sandstone outcroppings including the derived grassland. Prior to clearing the sandy soil may have supported a small localised area of Scribbly Gum woodland as found at Milton Park or a localised variant of Shale Sandstone transitional vegetation.

Map 7: Image of area containing likely habitat at Kayess Park.

Species noted within the burnt derived grassland include: *Centella asiatica, Tricoryne elatior, Drosera hookeri, Goodenia paniculata, Juncus* sp., *Cheilanthes sieberi, Acacia decurrens, Themeda australis, Lomandra filiformis* subsp. *coriacea*, *L. multiflora*, *Microlaena stipoides, Eragrostis brownii*, *E. leptostachya*, *Dianella caerulea, D. revoluta, D. longifolia, Crassula sieberiana., Hibbertia diffusa*, *Opercularia diphylla*, *Helichrysum apiculatum*, *Einadia hastata*, *Bursaria spinosa.*

At the time of inspection, the most prominent weeds were African Lovegrass (*Eragrostis curvula*), Whisky Grass (*Andropogon virginicus*) and Blackberry. A wide variety of other pasture species were noted to have occasional occurrence including Fleabane (*Conyza* sp.), Fire Weed (*Senecio madagascariensis*), Catsear (*Hypochaeris* sp.) and Rambling Dock *(Acetosa sagittata)*.

<u>Menangle Park Paceway environs</u>

From data provided no targeted surveys were undertaken for threatened species within and to the north of Menangle Park Raceway environs. One BAM plot and one fauna survey within the immediate riparian zone of the Nepean River provides the only survey data undertaken for the biocertification assessment for this area.

A brief site inspection of the Menangle Paceway revealed a highly modified environment with some areas of potential habitat for the species. Relictual terraces and associated swales were noted. Native species were observed to exist in a number of locales even in areas routinely slashed and used for activities associated with horse racing. Soils ranged from alluvial to laterised clays.

The area to the north of Fitzpatrick Street was not inspected but viewed from a distance. It is assessed as likely to contain potential habitat, but the species composition of the ground layer remains unknown.

A Klaphake, V. 1992-05-10 record for *Drosera burmannii* describes land to the north in the vicinity of Fitzpatrick street as “Pasture near railway line N, 200 m below Fitzpatrick St, Menangle Park. In swampy pastureland on sloping land with *Eleocharis minuta*, *E. atricha*, *Lipocarpha microcephala*, *Ranunculus inundata*. Growing on the edge of the swamp in damp soil. Soil sand-based.”

Banksia integrifolia is the primary species for the Elderslie Banksia Scrub Forest which is described as “generally associated with alluvium of Tertiary age, on soils which are sandy, with drainage varying from good to poor (Benson 1977). *Banksia integrifolia* is a species component of the sandy tertiary sediments of Bankstown Airport environs especially adjacent to the *Hibbertia puberula* subsp. *glabrescens* population.

The known Bankstown Airport occurrence is reported from soils that are “grey heavy clay with ironstone fragments present at surface” (AVH) and sandy tertiary alluvium is known to be present at some locales.

There is a similarity between the Bankstown Airport environs and the Menangle Park site as both contain alluvial deposits adjacent shale communities.

Map 8: Image of areas containing likely habitat at and adjacent to the Menangle Park Paceway.

Bunbury Curran Creek vicinity

Several areas of Bunbury Curran Creek vicinity have potential habitat for rare *Hibbertia* based on implied habitat derived from historic records.

Map 9: Image of areas containing potential habitat at Bunbury Curran Creek, based on habitat inferred from historic collections.

Wilton Growth Area

The possibility that *Hibbertia fumana* occurs within the WGA sector is uncertain but cannot be ruled out due to the implied habitat derived from historic records. The OEH Threatened Species Profile indicates the species could be found on shale sandstone interface. Shale / Sandstone transitional vegetation is widespread throughout the WGA.

Hibbertia fumana is most unlikely to occur within the proposed urban footprint. The majority of proposed urban footprint is confined to the Wianamatta Shale derived soils which on current knowledge is unsuitable habitat for the species. Much of this land was known, in part, as the Cowpastures and were amongst the first lands to be cleared for agriculture purposes with European occupation. The native ground layer in many of these areas has been replaced by exotic species.

Within the growth area and adjacent the development footprint, we note that the Biosis quadrat Plot B27, near the Georges River at Wilton, records the following species: "Euca punc 15%, Euca fibr 1%, Ango baker 1%, Euca spar 5%, Euca parr 1%, Kunz amb 25%, Call line 1%, Ento stri 15%, Aris vagan2%, Loma fili 1%, Loma mult 0.3%, Aust pube 0.2%". The presence of *Callistemon linearis* and *Eucalyptus parramattensis* indicate a periodically moist environ within the transitional vegetation which may support several threatened taxa such as *Grevillea parviflora* and *Hibbertia puberula*. Both taxa co-occur at the Moorebank site with *H. fumana*. *Epacris purpurascens* is also likely to occur in the vicinity.

A L.A.S Johnson record for *Eucalyptus parramattensis* supports the presence of Parramatta Red Gum in the general area: Douglas Park, 0.75 miles [1.1 km] S of Nepean River, on east rim of gorge. Habitat: Somewhat lateritic soil at edge of shale and sandstone. In regrowth with *Angophora oblonga*, *E. fibrosa*, *Acacia glaucescens*.

It is unknown whether Threatened *Hibbertia* taxa exist in this general locale as access so far has not been granted.

4.4 ASSESSMENT OF SUITABLE HABITAT

The assessment of suitable habitat has been described in section 4.3, assessment of species presence, because the survey during the non-flowering period required the presumption that if suitable habitat were present then the species could also be present.

The species could be present in areas of shale / sandstone transition, in microhabitats such as seepage zones below or above sandstone outcrops. Broad scale vegetation survey and mapping do not identify habitats at this scale. Survey during the flowering season is recommended.

4.4.1 DETERMINATION OF SPECIES POLYGONS

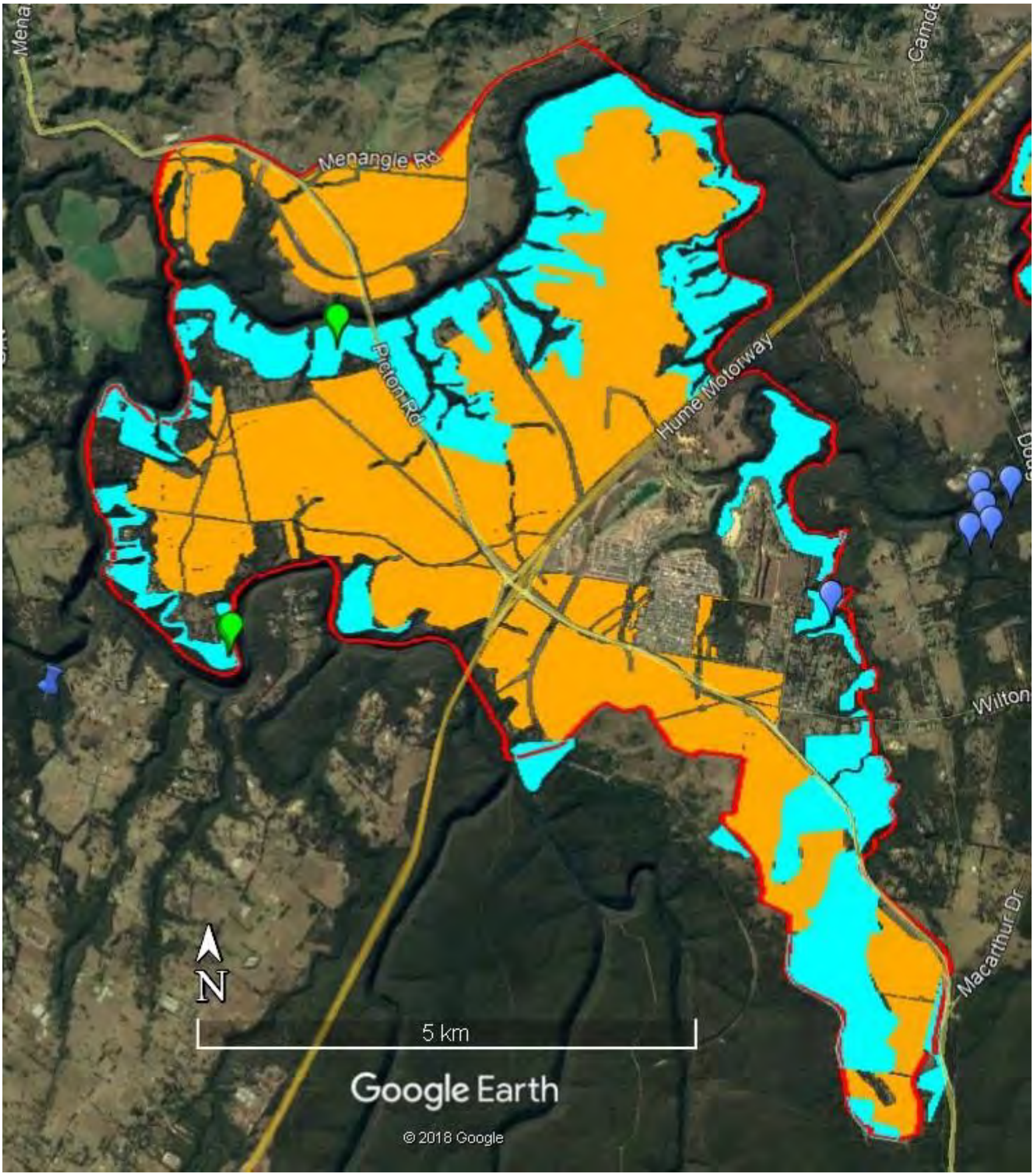
Determination of potential habitat for *Hibbertia fumana* includes areas identified outside but adjacent to the deemed biocertification area. Anthropogenic impacts are well documented to adversely affect vegetation well beyond the direct urban footprint (refer section 2.5).

Maps 10 to 13 show an overview of areas containing likely and potential habitat of *Hibbertia fumana* within the GMGA and WGA. The areas shaded in yellow are habitats assessed as having attributes similar to known extant populations and the entire area should be considered likely habitat. The polygons shaded in blue are based on broad scale mapping units both vegetation and soils and are indicative that potential habitat niches may exist within those areas. The habitat niches are inferred from historic records only.

Mixed native / exotic derived grassland / herbland including *Themeda australis* & *Hibbertia diffusa* that is likely habitat at Menangle Park Paceway vicinity.

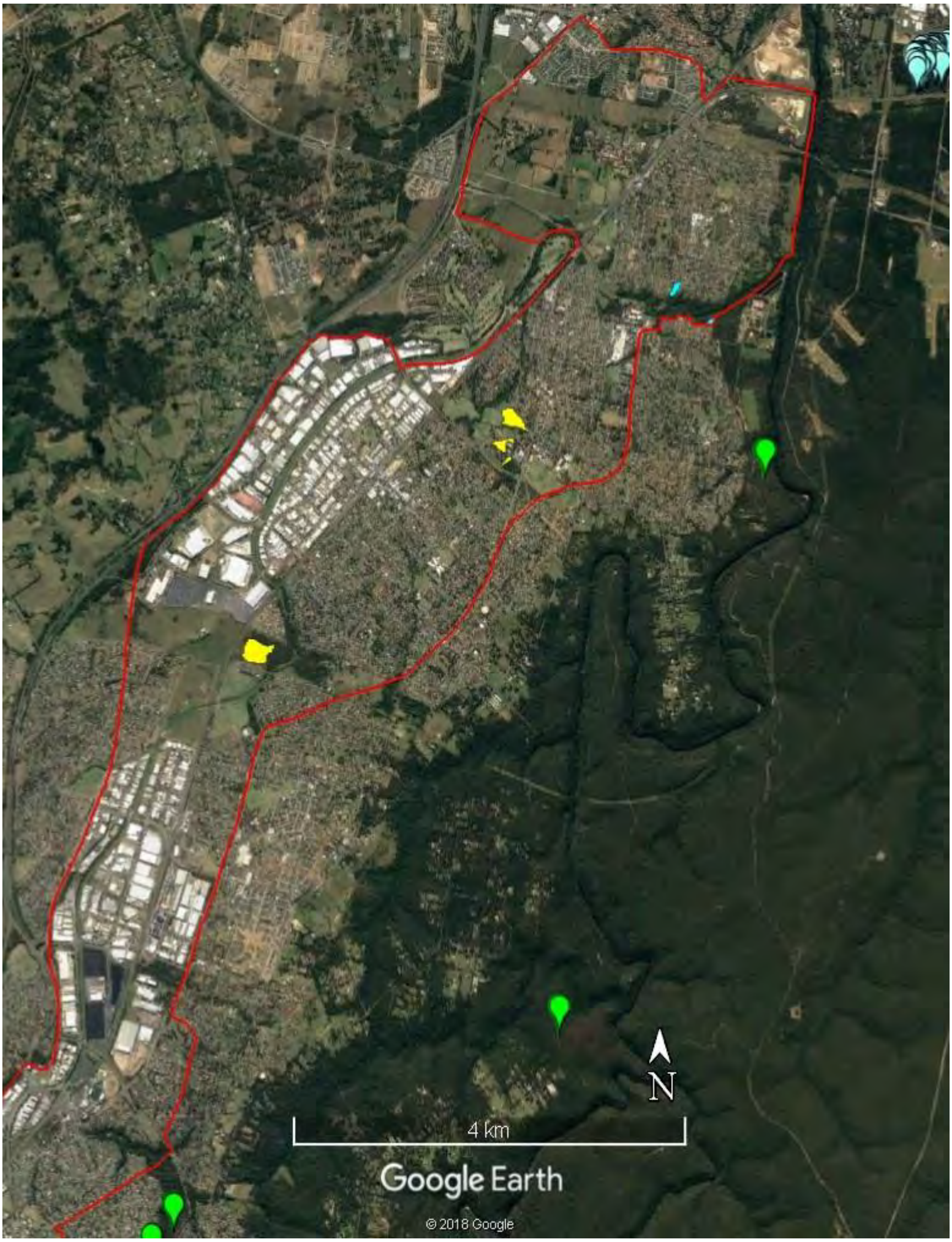
Areas of indigenous shrubs including *Melaleuca erubescens*, *Dillwynia seiberi*, *Pultenaea villosa*, *Daviesia ulicifloia.* This is a habitat that may also support *Hibbertia fumana*.

Photo 12: Indicative of likely habitat in the Manangle Park Paceway vicinity.



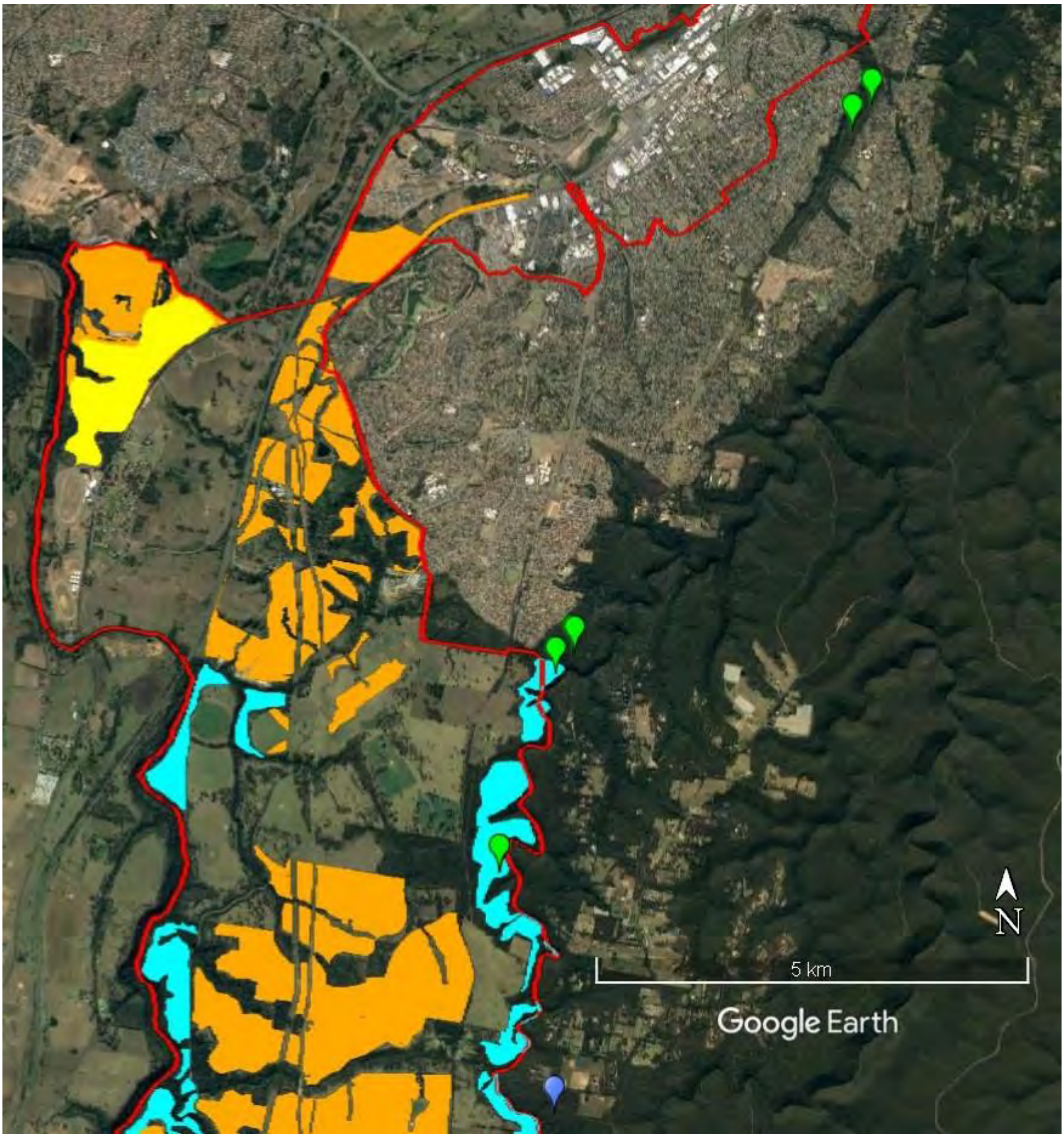
Map 10: Areas containing potential habitat in the Wilton Growth Area.

Key: Red – outline of growth area, blue – areas of potential habitat niches, orange – growth area footprint, green dots – locations of *Hibbertia puberula?* plants, purple dots – records of *Hibbertia riparia*.



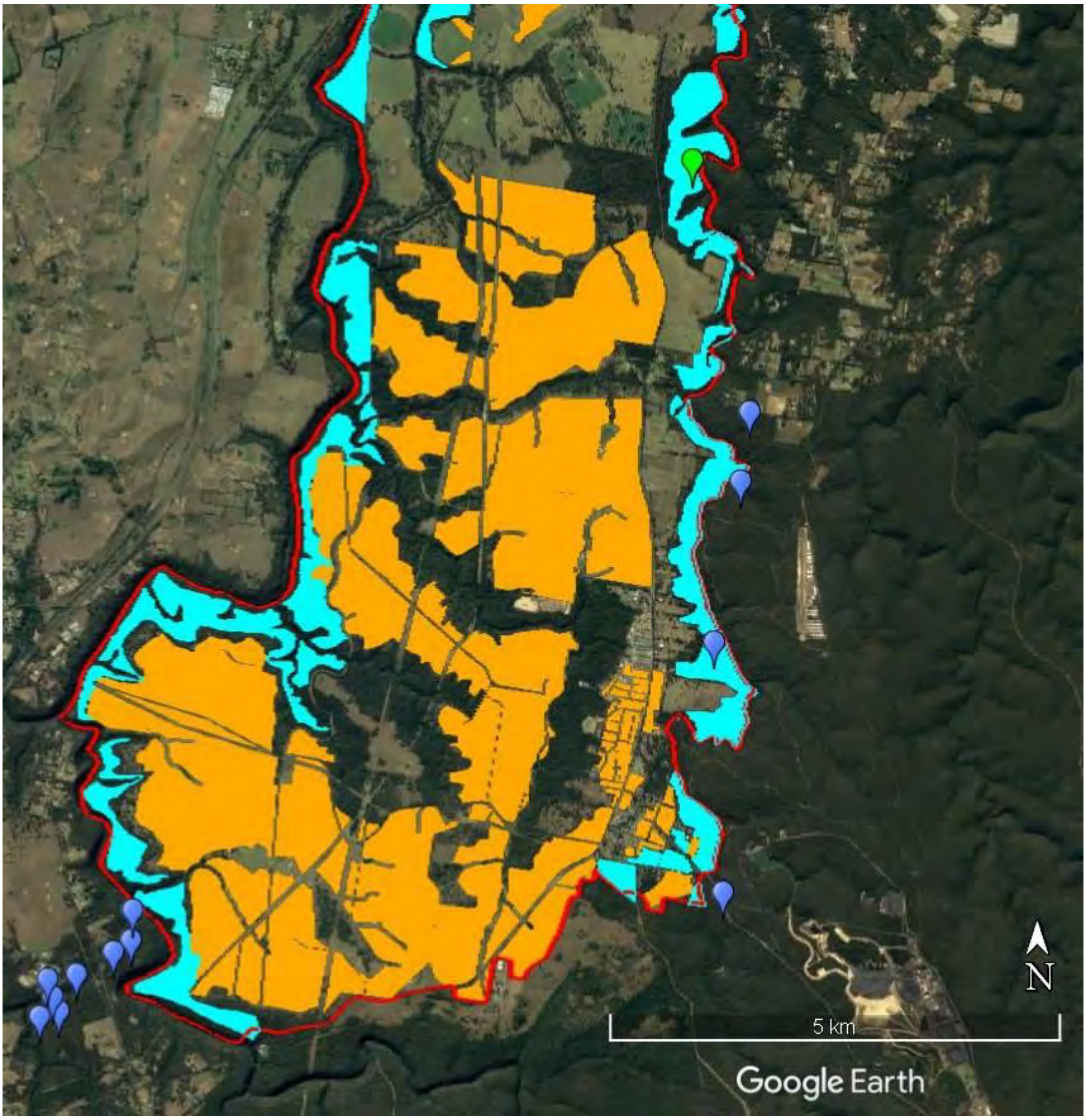
Map 11: Areas of likely habitat, north section of Greater Macarthur Growth Area.

Key: Red –outline of growth area, yellow – areas of likely habitat, blue – areas of potential habitat niches, green dots – locations of *Hibbertia puberula?* plants, blue dots (top right of map at Moorebank) – records of *Hibbertia fumana*.



Map 12: Areas of potential habitat, middle section of Greater Macarthur Growth Area.

Key: Red –outline of growth area, yellow – areas of likely habitat, blue – areas of potential habitat niches, orange – growth area footprint, green dots – locations of *Hibbertia puberula?* plants, purple dots – records of *Hibbertia riparia*.



Map 13: Areas of potential habitat, southern section of the Greater Macarthur Growth Area.

Key: Red – outline of growth area, blue – areas of potential habitat niches, orange – growth area footprint, green dots – locations of *Hibbertia puberula?* plants, purple dots – records of *Hibbertia riparia*.

4.4.2 JUSTIFICATION FOR DETERMINATION

The species likely habitat polygons for Milton Park, Kayess Park and Menangle Park in the GMGA are based on limited field inspections undertaken in adverse environmental conditions outside the flowering period. Therefore, the polygons are indicative only.

The majority of potential habitat polygons for the WGA are based on regional mapping data provided by DPE as access issues limited field inspection. Similar access issues arose with other potential habitat areas within southern and central portions of the GMGA. Unless indicated potential habitat polygons for the southern and central portions of the GMGA are also based on regional mapping data.

4.5 ESTIMATE OF AREA OF HABITAT OR NUMBER OF INDIVIDUALS

4.5.1 ESTIMATES

The assessment provides the following estimates:

- at Menangle Park an area of approximately 92ha that could contain likely habitat niches within the growth area footprint, and a further 31 ha of land containing likely habitat niches adjacent to the footprint.
- at Kayess Park and Milton Park – Macquarie Fields Leisure Centre vicinity areas of likely habitat that are not affected by the growth area footprints. However, Milton Park is managed for recreation and it is very unlikely that the species would survive at that location. Macquarie Fields Leisure Centre vicinity contains remnant bushland some of which may support the species. The derived grassland in the Kayess Park vicinity may support the species.
- at Bunbury Curran Creek vicinity areas of potential habitat are not affected by the growth area footprints.
- in the Gilead and Appin areas approximately 8ha of land containing potential habitat niches within the notional development footprint and a further 380ha of land containing potential habitat niches adjacent to the footprint.
- in the Wilton growth area, approximately 65ha of land containing potential habitat niches within the footprint and a further 680ha of land containing potential habitat niches adjacent to the footprint.

4.5.2 JUSTIFICATION FOR ESTIMATES

Assessment relied on personal knowledge of the species habitat for extant populations and speculation about the habitat of historic records, combined with vegetation mapping and soil and landscape features, to determine “likely habitat” (based on extant population habitat) and "potential habitat" (based on speculation of historic record habitat) locations within and adjacent the growth areas footprints.

The probability of the species to occur in the likely habitat is considered low due to site disturbance, however, cannot be ruled out as the Bankstown population survives in a highly modified mown derived grassland environment refer Photo 12). The probability of the species to occur in potential habitat is considered to be very low. However, a precautionary approach is recommended. Locating and protecting new populations, no matter how small, is significant to the survival of this species.

It was not possible to provide accurate habitat areas or counts due to the following:

- Access was not granted to the majority of development footprint.
- The region has undergone a period of protracted drought and small diminutive species, forbs and even many of the larger resilient shrubs were observed to be in severe drought stress or dead. *Hibbertia puberula* grows in close proximity to *Hibbertia fumana* at both extant sites. At all locations where *Hibbertia* species with vegetative morphological features consistent with *H. puberula* were found only a few individuals were noted, most were almost dead. It is well documented that the above ground populations of many genera including *Hibbertia* species fluctuate widely in response to various conditions such as rainfall and time since last fire.
- Most sites inspected within the WGA and many within GMGA were also noted to have senescing or dead shrubs, high levels of leaf, bark and branch fall and dead understorey an indication of both a long fire interval and severe drought. Apparent diversity and population numbers of many species significantly decline, retreating to the soil seedbank under such conditions. It is inconclusive to undertake population census or estimates under such circumstances.
- The cryptic nature of small-leaved *Hibbertia* when not in flower also make their detection extremely difficult and population count or area calculation unreliable.
- The use of a surrogate site(s), as a base for the estimation, in this case, is deemed not credible. *Hibbertia fumana* is a data-poor species. Insufficient or no reliable data exists in regards to population density and population fluctuation over time at any of the known sites.

5. Information used in the assessment

Information used in this assessment includes taxonomic papers, BioNet and ALA records of the target species, Critically Endangered Listing, online Threatened Species profile and associated documents, personal observations and site inspections, and the spatial viewer including the layers: survey access and coverage, (BAM plots, polygons and transects), PGA layer and geology and soils.

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7. Appendices

Appendix 1. CURRICULUM VITAE

Robert Miller *Curriculum Vitae*

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Current Position:

Principal of Cumberland Flora & Fauna Interpretive Services

Qualifications:

Associate Diploma Horticulture from the University of Western Sydney (formerly Hawkesbury Agricultural College), conferred on 17 April 1982

Journal Articles

H.R. Toelken & R.T. Miller **2012** Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in Journal of the Adelaide Botanic Gardens, Vol. 25.

Miller J and Miller R **2005** Aquatic macroinvertebrates of headwater streams in the south east forests – diversity and conservation management issues, Wetlands (Australia) 23 (1).

Employment Record

1993 – present

Cumberland Flora and Fauna Interpretive Services

Principal - flora surveys, plant identifications, vegetation assessment, project impact assessment, bush regeneration, rehabilitation, habitat enhancement, seed collection and propagation services.

1990 - 1997

Sylvan Grove Native Gardens

Curator of gardens and adjoining bushland - maintenance of and improvement to the plant collection, training and supervision of staff, liaison with other botanic gardens, guided tours, technical advice.

1982 - 1990

Sylvan Grove Native Gardens

Horticulturist Specialising in Australian Flora - collection, propagation, identification, and growing of native plants.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES INFORMATION AND RELEVANT EXPERIENCE

Cumberland Flora and Fauna Interpretive Services have provided technical expertise since 1993 to numerous clients including Local Government, NSW Roads and Maritime, NSW Office Environment Heritage NPWS and community groups.   Following is a list of some of our projects and clients:

REPORT	CLIENT
Expert advice for Conservation Assessment of *Solanum celatum* Eren Delgado1 16/04/2018, Science Division, NSW Office of Environment and Heritage	OEH
Saving our Species (SoS) project for *Pomaderris adnata* a post fire population census Grid D 2018	OEH
Provision of expert advice to update the current ecological data for southern NSW threatened flora species, as part of the review of biodiversity assessments under the Biodiversity Conservation Act 2016.	OEH

REPORT	**CLIENT**
Expert witness in botany Residents Against Intermodal Development Moorebank Incorporated v NSW Minister for Planning and Anor – NSW Land & Environment Court Class 1 Proceedings No. 2017/81889. Review of project documentation, in particular the various biodiversity assessments including the BAM assessment for the project and Individual Expert Witness report of Dr David Robertson 15 October 2017; Site inspections to identify the location of and/or potential habitat for *Hibbertia fumana*, *Hibbertia puberula*, *Grevillea parviflora*, *Persoonia nutans*, *Acacia bynoeana*, provision of an expert report in accordance with Division 2 of Part 31 of the UCPR; confer with the other parties experts at a joint conference and produce a joint expert report; and f appear at the section 34 conciliation conference	EDO
Saving our Species (SoS) project for *Pomaderris adnata* a population census 2017	OEH
Central Coast Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Great Lakes Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2015 – Vegetation Consultant	OEH
Clarence Colliery Discharge Investigation April 2015	OEH
Vegetation Assessment as part of the Lachlan Wetlands Condition Assessment Project October 2013 – May 2014	Lachlan Catchment Management Authority
Field expertise and guidance in the Sydney basin to PhD candidate Karen Muscat studying the molecular phylogenetics and morphology of the genus Dianella with close scrutiny of the variation in the D. *caerulea* group of species in eastern Australia	Volunteer to University of Melbourne
Survey for *Pomaderris adnata* to determine population size, structure, occupancy and threats 2014	NPWS Illawarra Region
Survey of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats. Collection of voucher herbarium material for taxonomic review June 2014	OEH
Survey of the southern populations of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats May 2014	OEH
Investigation of works within the Sublime point precinct Illawarra Escarpment State Conservation Area February 2014.	NPWS Illawarra Region
Identification of Hibbertia species in proposed control burn sites Victoria Road precinct Dharawal National Park.	NPWS Illawarra Region
Assessment of impact of infrastructure upgrade Victoria Road, Dharawal National Park – location of threatened species.	NPWS Illawarra Region
APPEAL IN RESPECT OF PROPERTY AT Lot 1 and 2 DP 224431 Site 2 Sturdee Avenue, Bulli	Roy ‘Dootch’ Kennedy

REPORT	**CLIENT**
Expert Witness Report Relating to Some Environmental Issues Land & Environment Court of New South Wales PROCEEDINGS NO 10982 of 2012	Roy 'Dootch' Kennedy
Field surveys, collection, pressing, curation of botanical specimens and contributions of notes in association with the manuscript "Notes on Hibbertia subgen. Hemistemma (Dilleniaceae) 7. Eight new species, a new combination and four new subspecies from mainly central New South Wales H.R. Toelken & R.T. Miller 2006 - 10 July 2012	Volunteer to Adelaide Botanic Gardens
Vegetation Surveys and assessments & input into the preparation of REF for proposed car-park and amenities Victoria Road Precinct Dharawal National Park November 12.	NPWS Illawarra Region
Office of Environment and Heritage – Priority Action Statement Expert Consultant Interviews June 2012 – January 2013	OEH
Vegetation Surveys and assessments & input into the preparation of REF for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking tracks in Dharawal National Park input into conservation risk assessments 2011 – 12.	NPWS Illawarra Region
Nomination to list Prostanthera saxicola R. Br. S. Str. as an Endangered Species under the NSW TSC Act September 2011	
Field surveys, collection, pressing and curation of botanical specimens of undescribed Kunzea to assist in the taxonomic circumscription of previously presumed extinct, rare and/or poorly known taxa for Dr. H.R. Toelken Honorary Research Associate State Herbarium Science Resource Centre Department of Environment and Natural Resources SA 2011	Volunteer to Adelaide Botanic Gardens
Significant Plant Survey – Maddens Plains Forest Path to Mount Mitchell Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Significant Plant Survey – Wongawillii Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Kembla State Forest Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Site Inspections and Vegetation Survey of Proposed Minor Track Re-Alignments: Forest Path to Woodward Track & Sublime Point to Austinmer Track Maddens Plains To Sublime Point Precinct Illawarra Escarpment State Conservation Area August 2010	NPWS Illawarra Region

REPORT	**CLIENT**
Sandon Point Aboriginal Place and Kuradji Lands Vegetation Management Plan April 2010	Illawarra Aboriginal Land Council, Wollongong Council, Southern Rivers Catchment Management Authority.
Forest Path to Woodward Track Precinct Track-head Realignment Maddens Plains IESCA Vegetation Survey April 2010.	NPWS Illawarra Region
Bushland Conservation Project 95 Glendiver Road, The Oaks 2008	A & S Fitzsimmons / Hawkesbury Nepean Catchment Management Authority
Significant Plant Survey – Maddens Plains Forest Path to Woodward Track Precinct Illawarra Escarpment State Conservation Area June 2007	NPWS Illawarra Region
Nomination of Hibbertia “Bankstown Airport” (R.T. Miller & C.P. Gibson s.n. 18/10/2006) as Critically Endangered under the Environment Protection and Biodiversity Conservation Act	Bankstown Bushland Society
Proposal to Demolish A Derelict Amenities Block at Deepwater Park Webster Street Milperra Environmental Assessment of Impacts	Bankstown City Council
Significant Plant Survey – Sublime Point to Panorama House Precinct Illawarra Escarpment Conservation Area August – September 2006	NPWS Illawarra Region
A Consultant for Priority Action Statement Workshop July 2005	NPWS
PHD research assistance – ‘The Benefits of Riparian Vegetation in Maintaining Water Quality as Assessed Using Biological Indicators”.	UNSW
Plan of Management for Part Lot 11 Dp 1049307 Kurrajong Road Prestons January 2005	Sule College
Preliminary Investigation & Vegetation Survey of Lands At Prestons Bounded By Maxwells Creek, Kurrajong Road, Ash Road & The Western Sydney Orbital December 2003	Sule College
Supply and collection of seed for a research project entitled: Factors Affecting Seed Germination and Microrrihzal Development of the Epacrid: *Woolsia pungens* (2001-2003)	UNSW
Compensatory Habitat Assessment Western Sydney Orbital March 2004	RTA
Compensatory Habitat Assessment Western Sydney Orbital July 2002	RTA
Compensatory Habitat Assessment of Flora at Rouse Hill, Doonside, Cecil Hills & Kemps Creek for The Western Sydney Orbital March 2002	RTA
Compensatory Habitat Assessment Western Sydney Orbital November 2001	RTA
Preliminary Vegetation Survey Between Lawson Rd & Alfords Point Rd, Menai as Part of The Proposed Bangor Bypass 2001	RTA
8-Part Tests for The Proposed Bangor Bypass 2000	RTA
Preliminary Vegetation Survey for The Proposed Bangor Bypass 2000	RTA
Species Impact Statement for the Western Sydney Orbital 2000	Sinclair Knight Mertz

REPORT	**CLIENT**
Review of Environmental Assessments – Proposed Cricket Ground - Louisa Reserve, The Crest of Bankstown 2000	Bankstown Bushland Society
Review of Environmental Assessments – Proposed Olympic Criterium Circuit the Crest Statement of Environmental Effects	Bankstown Bushland Society
Vegetation Survey – 60 Yanderra Road, Yanderra 1999	Mr. Brian Timmis
Review and Comments on Environmental Assessment – Bankstown City Council - Proposed Cricket Ground – 8 – Part Test- The Crest 1999	Bankstown Bushland Society
Vegetation Survey and Review of Proposed Sand Mining Restoration Works – Howard Park, Lansvale 1999	Chipping Norton Lakes Authority
Rare Species Survey – Blue Mountains & Central Western Slopes 1999	National Parks & Wildlife Service
Vegetation Survey - Kookaburra Road and Camden Valley Way Intersection 1999	Roads & Traffic Authority
Chullora Detention Basin Wetlands Habitat Enhancement 1998	Business Land Group DUAP
Vegetation Study Maxwells Creek Trunk Drainage Stage 1 Vegetation Assessment 1998	Bewsher Consulting
Vegetation Study Prestons Urban Release Area Part 3 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 2 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 1 1998	Liverpool City Council
Survey of Remnant Flora for Proposed Nth Liverpool Rd to Edensor Rd Interim Transitway 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management Discussion Paper 1998	Roads & Traffic Authority
Eastern and Western Alignments WSO Cecil Hills Flora Study 1998	Roads & Traffic Authority
Valmay Road Development Vegetation Study 1998	LesryK Pty Ltd
Western Sydney Orbital Prestons To West Baulkham Hills Descriptive Inventory of Remnant Bushland 1998	Roads & Traffic Authority
Vegetation Survey River Road M5 East 1998	Roads & Traffic Authority
Tree Survey, Great Western Highway, Faulconbridge 1998	Roads & Traffic Authority
Eve & Marsh Street Wetlands M5 East 1997	Roads & Traffic Authority
Beverley Grove Bush M5 East 1997	Roads & Traffic Authority
Vegetation Survey - Salt Pan Creek Bridge Duplication M5 East 1997	Roads & Traffic Authority

REPORT	CLIENT
Survey of Flora: Trees and Shrubs, Princes Highway Interchange M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Adjacent to Proposed Exhaust Stack Henderson Avenue, M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Illoura Reserve, Adjacent to Air Intake Vent M5 East 1997	Roads & Traffic Authority
Lansdowne Reserve Survey of Remnant Flora 1997	Bankstown City Council
Villawood Drain Vertebrate Fauna Survey 1997	Bankstown City Council
Kelso Wetlands Survey of Remnant Flora 1997	Bankstown City Council
Deverall Park Survey of Remnant Flora 1997	Bankstown City Council
Louisa & McClean Reserves Bass Hill Survey of Remnant Flora 1997	Bankstown City Council
The Crest of Bankstown Survey of Remnant Flora 1997	Bankstown City Council
Lawson Bridge Roadworks Survey of Remnant Flora 1997	Roads & Traffic Authority
Davidson Street Scrub Survey of Remnant Flora 1997	Strathfield Council
Freshwater Creek Bushland Survey of Remnant Flora 1996	Bankstown Bushland Society for the EPA
Vegetation Survey Forest Lawn Cemetery Roadworks, Leppington 1996	Roads & Traffic Authority
Vegetation Survey Catherine Fields Road Intersection, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Springfields Road Intersection and Camden Valley Way, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Deepfields Road Intersection Camden Valley Way, Catherine Fields 1996	Roads & Traffic Authority
Picnic Point Reserve Vegetation Survey 1996	Bankstown City Council
East Hills Park Vegetation Survey 1996	Bankstown City Council
Monash Reserve Vegetation Survey 1995	Bankstown City Council
Vegetation Consultant on Plan of Management for Cox's Creek for the Endangered Green and Gold Bell Frog 1995	Urban Bushland Management
Smith Park Vegetation Survey 1995	Bankstown City Council
Flora and Fauna Survey, Villawood Stormwater Channel 1995	Bankstown City Council
Virginius Reserve Vegetation Survey 1994	Bankstown City Council
Carysfield Park Vegetation Survey 1993	Bankstown City Council

Ongoing research projects:

Private taxonomic research into the Australian plant genera Prostanthera, Westringia, Dianella, Thelionema, Viola and Hibbertia.

Private research into the invertebrate fauna of the Illawarra with particular emphasis on the Mayfly genus Atalophlebia

Flora of Bankstown" a botanical inventory

Botanical inventories of the Sublime Point and Maddens Plains precincts in the Illawarra Escarpment State Conservation Area

Other Publications & Reports

Miller, R.T. (1984 to 2006) numerous papers for the Prostanthera and Westringia Study Group Newsletters.

Miller, R.T. (1991) Vegetation Consultant on Eloura Nature Reserve Vegetation Survey: Report to Liverpool City Council, Greening Australia.

Miller, R.T. Vegetation Consultant on Salt Pan Creek Stage 1 Vegetation Survey: Report to Bankstown City Council, Ian Olsen.

Gibson, C.P. & Miller, R.T. Plant Species List for Bankstown's Natural Heritage: McLaughlin, L., BCC.

Gibson, C.P. & Miller, R.T. Flora of Bankstown Scientific Inventory of Botanical Heritage: Report to Australian National Parks and Wildlife Service, Gibson, C.P. and Miller, R.T. (in preparation).

Nomination of Prostanthera saxicola R. Br. s. str. As an Endangered Species under the NSW TSC Act November 2011

Special Projects

- "Flora of Bankstown" a botanical inventory
- Founder & Convener Cookson's Landcare Group Bulli (2003 – 2007)
- President, Society for Growing Australian Plants, East Hills Region, 1987-1995.

- Vice President, Society for Growing Australian Plants, East Hills Region, 1996.
- Plant Steward, Society for Growing Australian Plants, East Hills Region, 1987-1996.
- Leader of the Prostanthera Study Group Australian Plant Society, 1992 - 2010.
- Editor and publisher of Prostanthera & Westringia Study Group's Newsletter *The National Mint* and the Study Groups' Journal – *Lasianthos*.
- Vice President and Founding Member, Bankstown Bushland Society.
- Coordinator Grants Application, Bankstown Bushland Society.
- Bushland Regeneration Grants Project Manager, Bankstown Bushland Society:
  - Deverall Park Restoration and Rehabilitation Swamp Woodland ($17,880).
  - The Crest of Bankstown Restoration and Rehabilitation ($27,850).
  - Airport and Ashford Reserves Restoration and Rehabilitation Swamp Woodland ($45,000).
- Co-recipient of Save the Bush grant for Flora of Bankstown by Hon. Ross Kelly, Minister for Arts, Sports and Environment, 1992-93 ($11,050).
- Founding Member of Illawarra Grevillea Park, Bulli.
- Curator, Lamiaceae collection, Illawarra Grevillea Park, Bulli.
- Former Bankstown City Council's Bushfire Taskforce Community Representative.
- Former presenter of an adult education course in gardening at Bankstown Evening College.
- Development and curation of a private regional herbarium.
- Expert Witness for NSW Police murder trial
- Former appointee as Trustee of the Georges River State Recreational Trust by the Minister for the Environment (the Hon. Tim Moore).

Appendix 2. TAXONOMIC DETAILS FOR IDENTIFICATION OF *Hibbertia fumana*

Photo 13: *Hibbertia fumana* indumentum of axillary shoot and +/- sessile flower bud (R.T. Miller)

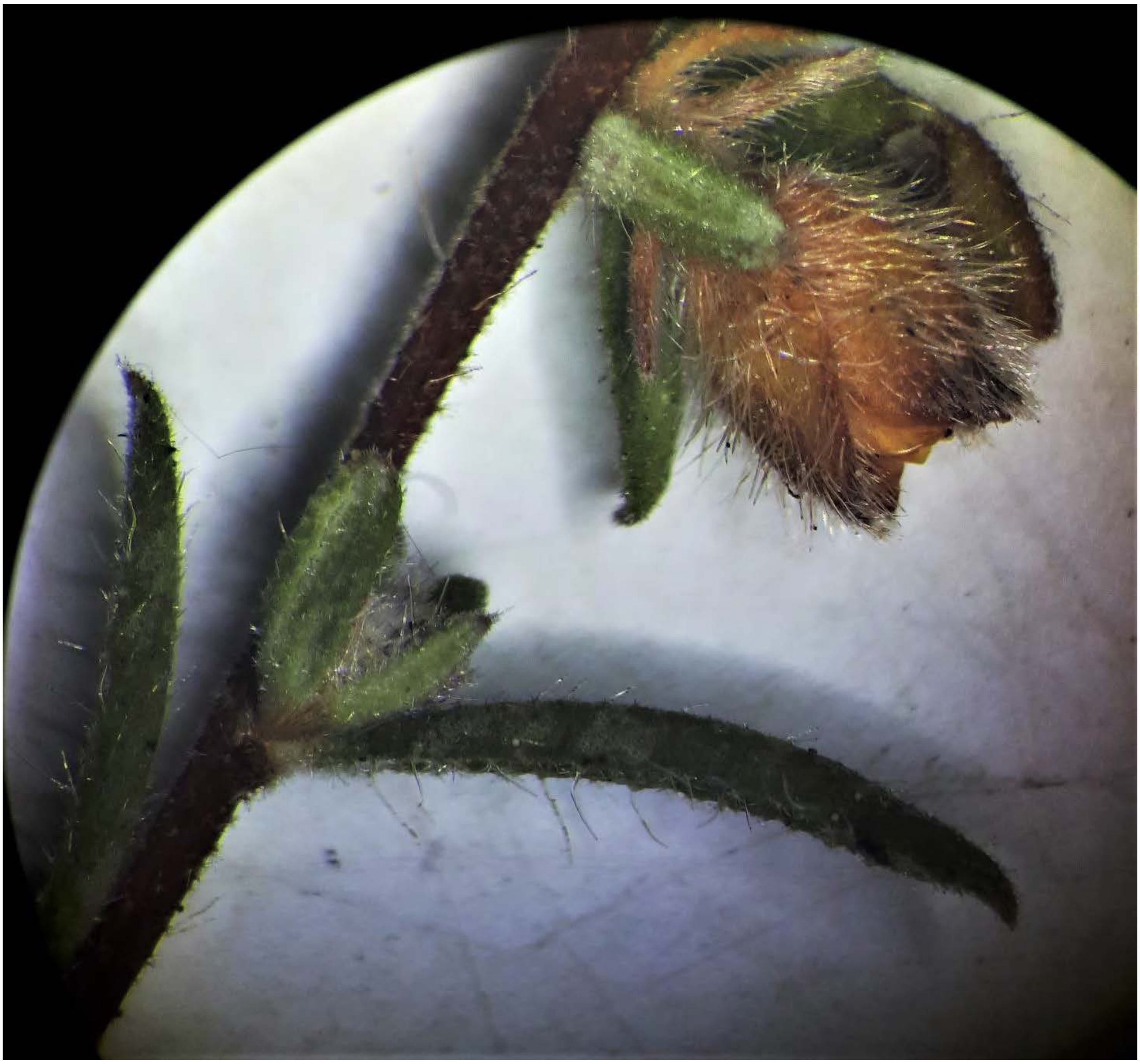


Photo 14: *Hibbertia fumana* indumentum of leaf, axillary shoots and flower buds (R.T. Miller).

Photo 15: *Hibbertia fumana* elongated flower peduncle after petal dehiscence on terminal shoots and indumentum characteristics of leaf undersurface and calyxes. (R.T. Miller).

Photo 16: *Hibbertia fumana* flower morphology (R.T. Miller).

Photo 17: *Hibbertia fumana* interpetiolar tuffs in leaf axils and short subequal multiangulate fascicled hairs characters of the branchlets (Robert T. Miller)

Photo 18: Tomentum characteristics of *Hibbertia fumana* approximate 5 cm from shoot apex. (R.T. Miller).

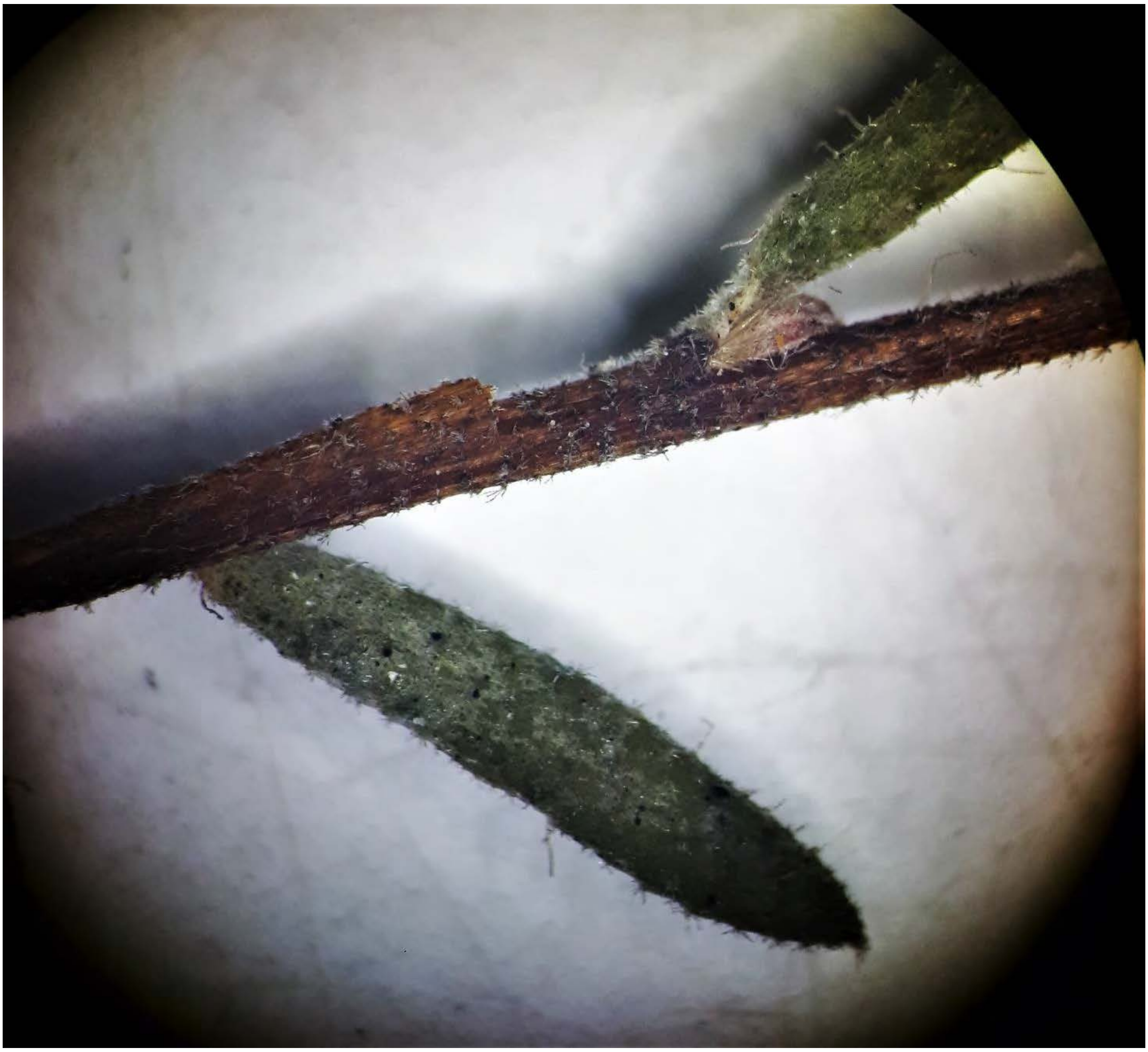


Photo 19: Leaf upper surface showing a reduction in tomentum. Leaf sample is approximately 12cm from tip (R.T. Miller).

Appendix 3. COMPARISON OF TAXONOMIC DETAILS FOR *Hibbertia* SPECIES

Photo 20: Plant of *Hibbertia empetrifolia* (R.T. Miller).

Photo 21: Closeup of leaf undersurface of *Hibbertia empetrifolia* (R.T. Miller).

Photo 22: *Hibbertia aspera* (R.T. Miller).

Photo 23: *Hibbertia aspera* showing tomentum on suckering new growth (R.T. Miller).

Photo 24: *Hibbertia dispar* showing procumbent growth habit, small-leaves and pedunculate flowers (R.T. Miller).

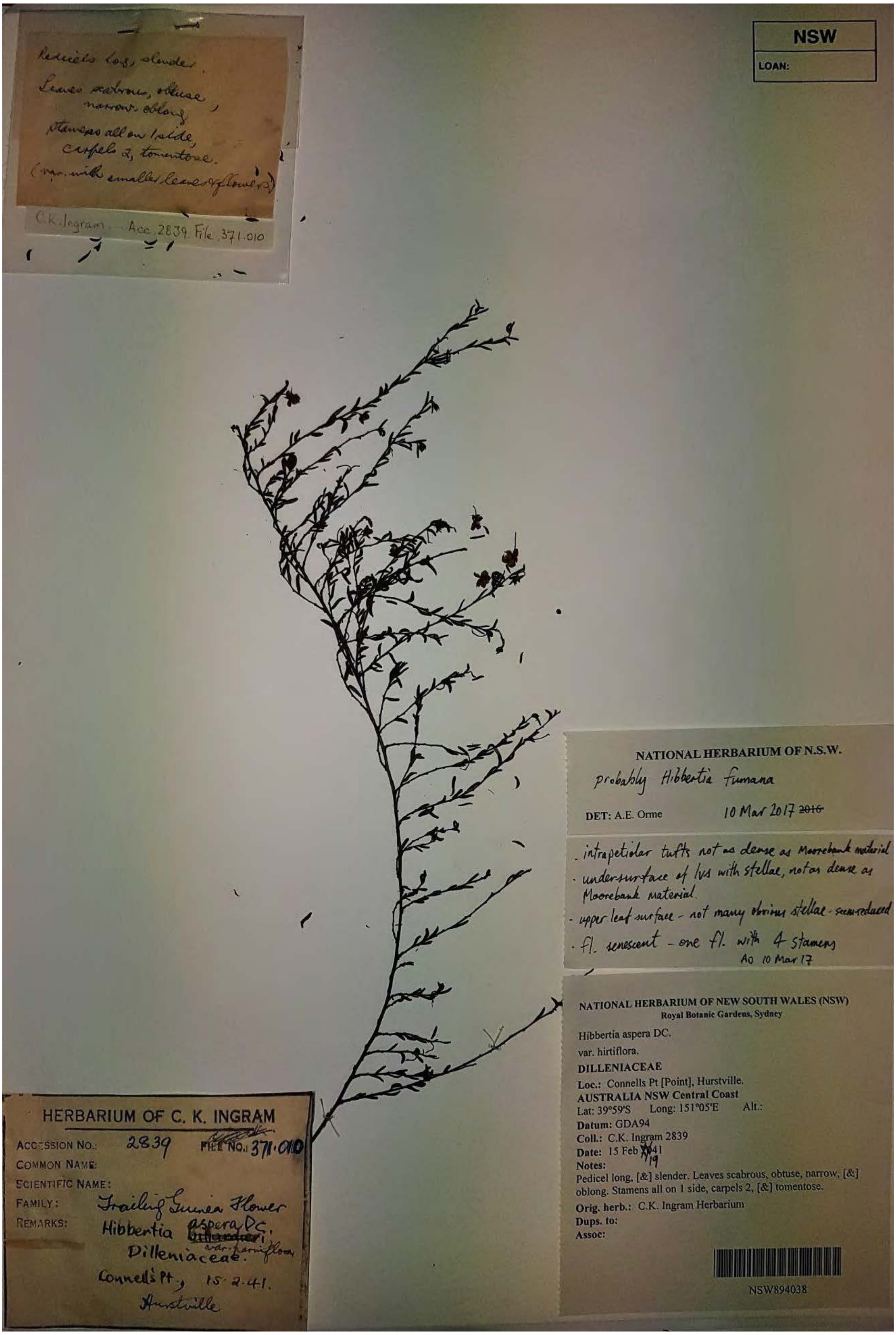
Photo 25: *Hibbertia dispar* showing apparent glabrous leaves and stems and +/- glabrescent floral parts of older growth in which much of the tomentum has "worn off".

Photo 26: *Hibbertia dispar*: closeup of new growth showing tomentum characteristic

Photo 27: *Hibbertia dispar* showing much of the tomentum of the calyxes being “worn off”.

Photo 28: *Hibbertia dispar* showing the tomentum of the calyxes before being “worn off”.

Appendix 4. SPECIMEN OF *Hibbertia fumana* FROM CONELLS POINT 1941



Strategic assessment for Cumberland Plain Conservation Plan
Aerotropolis and Greater Penrith
Hibbertia fumana

Hibbertia fumana, Moorebank, R. Miller September 2017.

Report prepared for Department of Planning and Environment

By

Cumberland Flora & Fauna Interpretive Services

Robert Miller - December 2018

Executive Summary

Hibbertia fumana is listed as a Critically Endangered Species under the *Biodiversity Conservation Act 2016*. There are two known populations of the species, one at Moorebank and the other at Bankstown Airport. There is limited data on the life history and ecology of the species.

Survey for this report was restricted by time constraints, lack of access to private property, and years of preceding drought conditions. Survey targeted areas of suitable habitat identified from the habitat of extant populations and DPE vegetation mapping.

Areas adjacent to the development footprint were included in the survey because *H. fumana* is a small shrub that could be severely affected by anthropogenic impacts.

Outcomes of the assessment:

There were no prior records of the species within or adjoining the proposed growth areas.

There has been just a short period in which the species would have been formally considered in the assessment process as the species was thought to be extinct when described in 2012 and was only recently rediscovered in late 2016. This would be the primary reason for the lack of records.

No plants of *Hibbertia fumana* were found during survey for this assessment.

Non-detection should not be interpreted as the species not being present, but simply as not seen. Survey followed years of drought in Western Sydney and the species could have retreated to the soil seed bank.

The possibility of *Hibbertia fumana* occurring within the GPEC is assessed as low because potential habitat sites found within the biodiversity certification area do not have the same complexity of attributes as known extant sites.

Within the Kemps Creek area of the WSA the likelihood of *H. fumana* occurrence was assessed to range from moderate to low potential adjacent the footprint.

Note that the potential habitats are niches within the overall landscape, generally associated with localised soil and drainages within transition vegetation.

Outcomes of this assessment are that 32 ha of habitat with a low probability of the species occurring are within the development footprint, and that more than 100 ha of habitat with moderate to low probability of species occurrence are outside the footprint but are likely to suffer from anthropogenic impacts caused by the development. More than 10 ha with moderate potential have recently been partly cleared.

As *Hibbertia fumana* is a Critically Endangered species a precautionary approach is recommended. Locating and protecting new populations, no matter how small, is significant to the survival of this species.

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Abbreviations

AVH	Australian Virtual Herbarium
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016*
CFFIS	Cumberland Flora & Fauna Interpretive Services
DPE	NSW Department of Planning and Environment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GPEC	Greater Penrith to Eastern Creek Urban Release Investigation Area
IBRA	Interim Biogeographic Regionalisation for Australia
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
sp./spp.	species (species singular / plural)
s. str.	*sensu stricto* – in the narrow sense
subsp.	subspecies
UBBS	Urban Bushland Biodiversity Survey of Western Sydney NPWS 1997
WSA	Western Sydney Aerotropolis Growth Area

1. Introduction

1.1 PURPOSE

The purpose of this expert report is to determine the potential for future urban development in identified growth areas of Western Sydney to impact on *Hibbertia fumana*, which is listed as a Critically Endangered Species under the *Biodiversity Conservation Act 2016*. This report forms part of the Cumberland Plain Conservation Plan, which will be assessed under the:

- Biodiversity certification under the *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Biodiversity Assessment Method (BAM) sets out the framework and methods to be used for assessment of impacts to biodiversity to provide preferred conservation outcomes while also supporting the development approval process. Under the BAM an expert report can be used when adequate survey is not possible. An expert report can only be used for species to which species credits apply.

The expert report must document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report. The report must set out whether the subject species is likely to be present at the development site, and if present then the report must estimate, in the case of a species such as *Hibbertia fumana*, the area of habitat where the species is likely to be impacted, as well as areas from which it is known to occur in which it will be impacted.

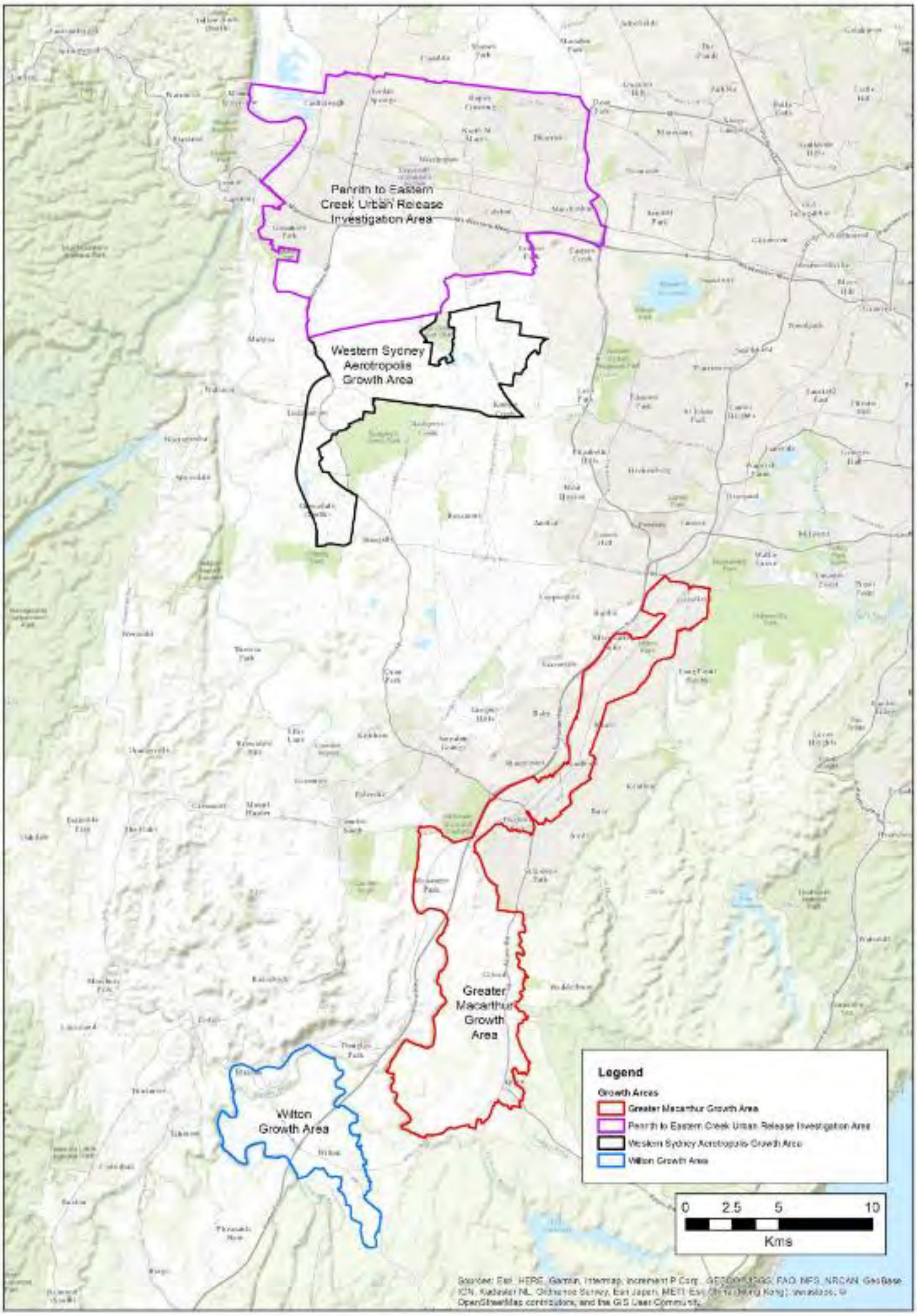
1.2 PROJECT CONTEXT

The NSW Government is planning for future urban development in Western Sydney. Four growth areas have been identified, these are Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These growth areas are all located within the Cumberland Subregion in version 7 of the Interim Biogeographic Regionalisation for Australia (IBRA) (2016).

As part of the planning for this future development, the Department of Planning and Environment (DPE) is preparing the Cumberland Plain Conservation Plan. This is a strategic regional assessment that will lead to the identification of preferred conservation outcomes for the Cumberland subregion.

1.3 STUDY AREA

The Map 1 shows the growth areas of Greater Penrith to Eastern Creek (GPEC) and Western Sydney Aerotropolis (WSA) which are the subject of this report, and the Greater Macarthur and Wilton growth areas which are the subject of a separate report.



Map 1: The four Western Sydney Growth Areas

Map source: NSW Department of Planning and Environment.

1.5 JUSTIFICATION FOR USE OF EXPERT REPORT

The BAM allows for situations where an expert report will be required to replace or complement survey effort at a development site. While there has been some field survey for the Strategic Biodiversity Certification assessment, the area covered by the proposed GPEC and WSA growth areas are extensive and there have been issues with gaining access to some of the private properties.

An expert report is required to assess potential impact to *Hibbertia fumana* for the following reasons:

Insufficient survey: A large extent of the identified growth areas could not be surveyed because it was on private property and could not be accessed within the project timeframe. Expertise was required to identify and survey potential species habitat and propose additional habitat based on extant and historic records.

Survey following extended drought conditions: Western Sydney has been experiencing dry to drought conditions for several years. Numerous usually resilient native trees and shrubs were observed to have experienced severe drought stress causing partial and/or full defoliation and many had died. Although unknown, it is likely that a large proportion of the *Hibbertia fumana* population could be reduced to the soil seed bank in these circumstances. As such, expertise is required to identify potential habitat for the species.

Compounding the effect of reduced soil moisture, following drought many areas have a significant increase in leaf, twig and branch drop making this small and cryptic species more difficult to locate or possibly covering them completely. The discernible population is likely to be significantly reduced from this cause.

Herbivory of a wide range of native species can severely impact small plants during dry conditions.

Rainfall events in months prior to this assessment allowed many *Hibbertia* species to produce new growth and therefore flowers. However, the rainfall was insufficient to replenish subsoil moisture. A dry period and unusually hot conditions prior to, and during, this assessment resulted in moisture stress for many plants. In the case of some *Hibbertia* species this is noticeable by unusually early petal dehiscence making their detection difficult.

It requires an expert in the species to locate and identify rare *Hibbertia* under these conditions.

Reliable species identification: Identification of the genus *Hibbertia* to species level requires examination of flower parts in combination with stem and leaf characters, especially tomentum type and density. It is not practical nor reliable to identify small leaved species in the field as many of these morphological features require microscopic examination and comparison to known voucher specimens. The use of an expert report to complement survey of the growth areas avoids the problems associated with *Hibbertia* misidentifications.

1.6 CREDENTIALS OF EXPERT

Robert Miller has over 30 years' experience in field botany. Over this time Robert has identified many rare and endangered plant species and has contributed to the scientific knowledge of native flora distribution and habitat in NSW.

Robert has been certified as an expert for *Hibbertia fumana* and *H. puberula* under the Biodiversity Assessment Methodology.

Robert has worked with Hellmut Toelken of the State Herbarium of South Australian, locating, collecting and identifying undescribed or rare species of *Hibbertia*. Some of these taxa were known only from historic records with non-precise locality details and depauperate or non-existent habitat information. Many of the specimens have been used for the taxonomic revision of the genus and are cited in various taxonomic publications including "Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*" published in the Journal of the Adelaide Botanic Gardens 26 (2013). Examples of the cited specimens include: *Hibbertia ericifolia* subsp. *acutifolia* Toelken, subsp. nov. Type: New South Wales, Sarahs Knob, R. & J. Miller s.n., 21.x.2006 (holo.: AD; iso.: BRI, CANB, NSW, PERTH) and *Hibbertia dispar* R.T.Miller s.n., 0.5 km S of Penrose Rest area, along western boundary track, Penrose State Forest, 12.x.2010 (AD, NSW).

Robert and Hellmut's paper "Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales", was published in the Journal of the Adelaide Botanic Gardens in 2012. The paper describes 13 new taxa including *Hibbertia fumana* Toelken and *Hibbertia puberula* subsp. *puberula,* – subsp. *extensa* R.T.Mill. and – subsp. *glabrescens* Toelken*.*

In 2017 Robert was called as an expert to identify the species of *Hibbertia* on the Moorebank bushland site that is the subject of the Intermodal development proposal.

Robert has recognised expertise for other threatened taxa including *Pomaderris adnata*, *Solanum celatum*, *Epacris purpurascens* var. *purpurascens*, and the genus *Prostanthera* including the threatened taxa *Prostanthera discolor*, *P. stricta*, *P. densa*, *P. junonis* and has provided expertise to the OEH Saving our Species programs.

2. Species information

2.1 SPECIES DESCRIPTION

Hibbertia fumana was described by Toelken and Miller (2012) in their paper "Notes on Hibbertia (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. Hemistemma, mainly from the central coast of New South Wales". At the time of publishing, the species was presumed extinct and had not yet been discovered at the Moorebank Intermodal site. The description was based on three herbarium specimens collected in 1802, 1804 and 1823.

The re-discovery of the species provided a broader range of specimens and a revised description which included for the first time fruit and seed, was provided by Duretto, Orme, Rodd, Stables and Toelken (2017). The following is a direct quote from that description.

Hibbertia fumana Sieber ex Toelken, Journal of the Adelaide Botanic Gardens 25: 73 (2012).

Type: Australia, near Sydney, "F.W. Sieber Nov. Holl. No. 147"

Decumbent shrublet, prostrate to weakly ascending to 20 cm high, with many branches from the base, moderately- to much-branched; branches wiry, with raised leaf bases shortly decurrent, shortly fascicled-pubescent. Vestiture persistent, consisting of more or less coarse simple hairs over fine fascicled hairs on tubercles; on branches more or less densely covered with short subequal multiangulate fascicled hairs (4–7 equal arms) and without simple hairs except for intrapetiolar tufts of hairs in leaf axils; on leaves above scattered, short antrorse fine bi- or triforked to simple hairs, sparse becoming denser onto the petiole, few simple hairs along the flanks, all wearing off soon; on leaves below dense, with short subequal multiangulate fascicled hairs (4–12 subequal arms) particularly on central vein, overtopped by few simple hairs on the flanks of the revolute margins; on outer calyx outside moderately dense, with spreading coarse antrorse simple hairs over erect-spreading multiangulate fascicled hairs (8–15 subequal arms), inside dense, with forked to simple antrorse hairs over most of surface; on inner calyx lobes outside dense with spreading multiangular fascicled hairs (2–12 subequal or unequal arms) becoming smaller towards the membranous margins, overtopped by coarse antrorse simple hairs along the central ridge, inside glabrous except for a few simple hairs towards the apex. Leaves with intrapetiolar axillary tuft of hairs to 0.7 mm long; petiole 0.2–0.45 mm long; lamina narrowly oblong, rarely linear-elliptic, (1.9–) 2.1–6.5 × 0.5–1.2 mm, obtuse, with terminal tuft of hairs on a somewhat recurved apex of the central vein, more or less abruptly constricted into petiole, above ± flat and puberulous to glabrescent, below with broadened central vein recessed below the level of revolute margins and protruding into apex, pubescent to puberulous. Flowers single, terminal, commonly on main branches; flower stalk 2–9 mm long, recurved and elongating after flowering, pubescent; bract linear to linear-triangular, 1–1.3 mm long, sometimes leaf-like to 5.5 mm long, fascicled-pubescent, on lower third to half of flower stalk. Calyx distinctly accrescent, with lobes subequally long; outer calyx lobes lanceolate, 3.5–5.7 × 1.3–1.65 mm, enlarging to 6.1 × 2.2 mm with fruit, acute to acuminate, without ridge, outside strigose-pubescent, inside finely strigose with antrorse forked hairs on much of the surface;

inner calyx lobes oblong-ovate, 4.0–5.8 × 3.1–3.5 mm, usually cuspidate, outside strigose along the central vein and tomentose towards the margins, inside glabrous with few forked hairs at the apex. Petals obovate, 4–5.2 mm long, broadly bilobed. Stamens 5 or 6 (7), subequal, clustered on one side of the ovaries; filaments 0.4–0.6 mm long, basally connate; anthers broadly oblong, 1.3–1.4 mm long, ± abruptly constricted above and below. Pistils 2; ovaries obovoid but ± laterally compressed, each with 4 ovules, fascicled-tomentose, with style attached to the centrifugal apex of the ovary then after a short curve downwards straightening up on either side of the stamens with stigmas exposed above the anthers. Fruit puberulous with simple and multiangular hairs. Seeds oblong-obovoid to almost obloid, 1.6–2.0 × 1.4–1.5 mm, smooth, light brown; aril with fleshy base surmounted by one-sided membranous cup covering c. one quarter of one side of seed.

Additional specimens examined: NEW SOUTH WALES: Central Coast: R.Brown [J.J.Bennett 4873], “In occidental Sydney 1804” (BM); G.Caley s.n., “near South Head”, viii.1802 (BM); Moorebank in western Sydney, J.Rodd & M.Stables, 19.x.2016 (NSW, 3 specimens); Moorebank in western Sydney, A.E.Orme 1572, 16.xi.2016 (AD, NSW).

Figure 1 shows taxonomic features of *H. fumana*, and Figure 2 shows an image of the species isotoype.

2.2 LIFE CYCLE

The NSW Threatened Species Scientific Committee Final Determination for listing of *Hibbertia fumana* states that “Little is known about the life history of *Hibbertia fumana*. Seed production and plants of different ages were recorded within the only known population (A. Orme in litt. November 2016). The species does sucker (A. Orme in litt. November 2016) suggesting it may be able to resprout from rootstock following fire.”

Peak flowering is recorded as spring to early summer, although the species appears to be capable of minor sporadic flowering at other times of the year as a response to suitable climatic conditions (Miller pers. obs.).

2.3 DISTRIBUTION AND ABUNDANCE

Historically the species was collected by Caley “near South Heads”, eastern Sydney, in 1802, by Robert Brown in 1804 “occidental Sydney” and by Sieber 1823 “near Sydney New Holland”.

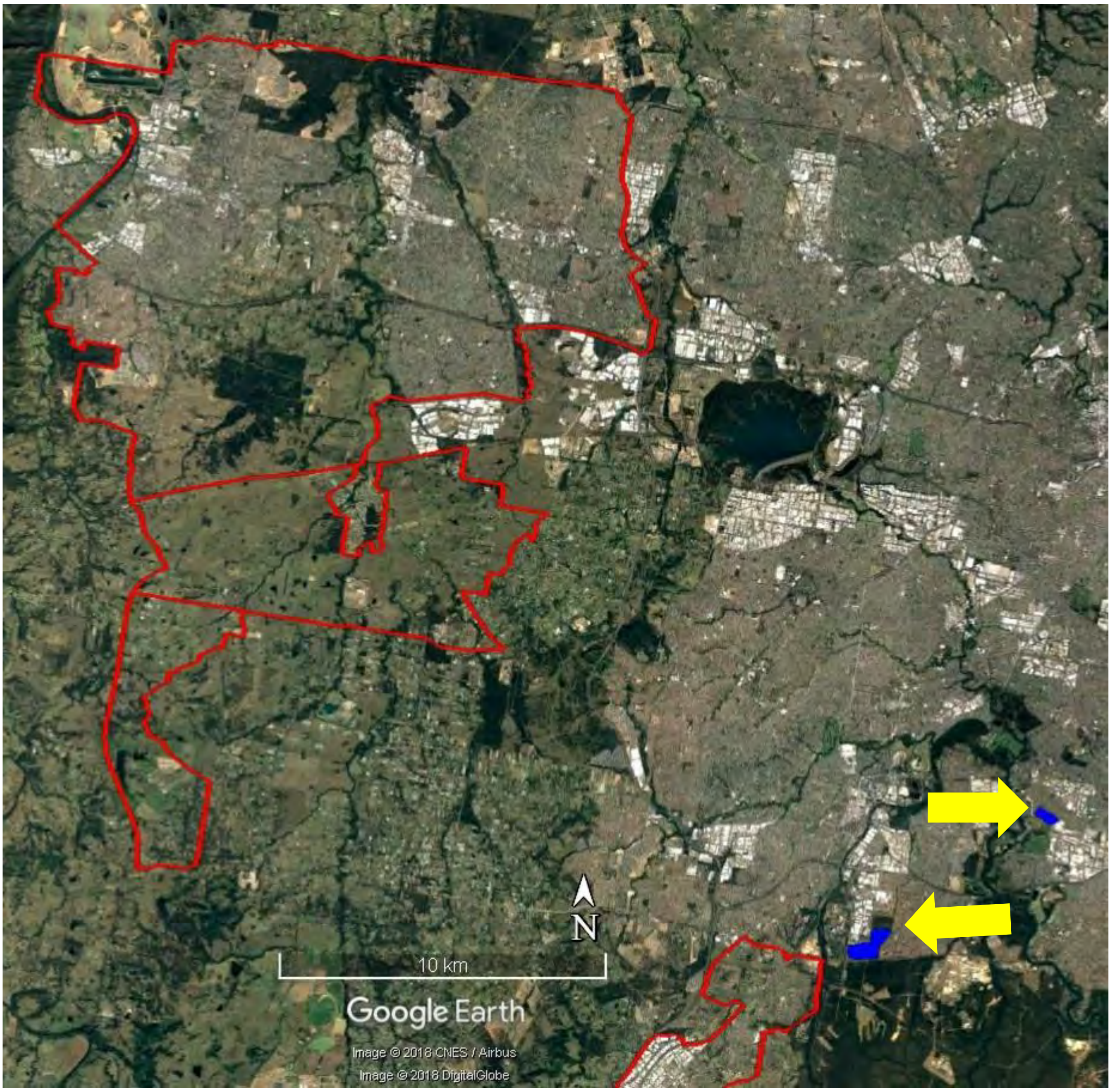
Recently a specimen from the Keith Ingram herbarium collection has been determined as most likely to be that species by Andrew Orme. It was collected at Connells Point in February 1941.

South Head and Connells Point are now highly urbanised environments and as such this diminutive species is unlikely to have persisted at either locale. If the species has persisted it is most likely so in the Connells Point environs. Targeted searches may be warranted in the Poulton Creek vicinity including Poulton Park.

Currently known from one extant population at Moorebank of c. 400 and an unknown number of plants in the Bankstown Airport vicinity.

At the time of the species listing in October-November 2016 (Arcadis and Parsons & Brinckerhoff Australia/New Zealand (WSP)) 370 plants were recorded at Moorebank and a further "approximately 29 plants" were recorded in September 2017 (Arcadis and Cumberland Ecology).

The impact upon the population at the Moorebank site from an intense fire in April 2018 is unknown.



Map 2: Indicative area of known *Hibbertia fumana* populations.

Key - Areas of known *H. fumana* populations (blue) and the Western Sydney growth areas (red).

Fig. 1. *Hibbertia fumana*. **a**, habit; **b**, branch; **c**, branch detail showing tufts of hairs in leaf axil; **d**, leaf, adaxial surface; **e**, leaf, abaxial surface; **f**, flower; **g**, flower, petals removed; **h**, inner sepal, abaxial surface; **i**, inner sepal, adaxial surface; **j**, outer sepal, abaxial surface; **k**, outer sepal, adaxial surface; **l**, flower with fruit; **m**, seed. Scale bar: **a** = 80 mm; **b** = 15 mm; **c** = 2.5 mm; **d & e** = 4 mm; **f** = 6 mm; **g & l** = 8 mm; **h–k** = 5 mm; **m** = 3 mm. Drawn from *Orme 1572*.

Figure 1: *Hibbertia fumana* Lesley Elkan in *Telopea* 20: 143–146

Figure 2: Isotype of *Hibbertia fumana.*

F.W Sieber held within the William and Lynda Steere Herbarium as digitised imagery in the C. V. Starr Virtual Herbarium New York Botanic Gardens showing apparent +/- sessile flower buds.

2.4 HABITAT REQUIREMENTS

Historic collections

The *Hibbertia fumana* profile states: "Habitat of an 1802 Caley collection 'near South Head' are uncertain, with potential communities in that area including coastal shale sandstone communities and open forest or forest communities on lateritised shale lenses. No similar alluvial sand deposits are identified in that area." (OEH 2018)

It is speculated by Miller that the most likely habitat for the Caley collection is transitional vegetation associated with "Swamps" or wet heath, especially the transition from shale influence communities to heath and/or open woodland. Although unsuitable habitat now, the Woollarah Golf Course site is likely to have consisted of a mosaic of vegetation types including swamp transition to woodland and the original habitat at Centennial Park is well documented "Originally a swamp and then set aside as land for the water source for Sydney, Centennial Park" (Centennial Park Trust). The diverse micro-habitats at Centennial Park supported numerous now locally rare or endangered taxa including *Hibbertia virgata* E.Cheel *NSW 86014*, Centennial Park, ix.1900 (NSW); and A.A.Hamilton *NSW 86016*, Centennial Park, 23.viii.1912 (AD, NSW) (Toelken in prep.) and it is likely to have also supported *Hibbertia fumana*.

Extant populations

The OEH website states that *Hibbertia fumana* is known to be associated with the following vegetation formations and classes:

Dry sclerophyll forests (shrub/grass sub-formation) - within the Cumberland Dry Sclerophyll Forests class *Hibbertia fumana* is associated with

- Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain and Sydney Basin Bioregion and
- Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion

Dry sclerophyll forests (shrubby sub-formation) - the Vegetation Types that *Hibbertia fumana* is associated within the Sydney Sand Flats Dry Sclerophyll Forests class include

- Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion and
- Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion

At Bankstown Airport the AVH record states that the "Site is heavily managed and is routinely slashed to a height of about 10cm. Soils are grey heavy clay with ironstone fragments present at surface. Other native species observed indicate a derived form of Cooks River / Castlereagh Ironbark forest community. Main weed observed *Eragrostis curvula*."

Photo 1: Indicative habitat of *Hibbertia fumana* at Bankstown Airport, regularly slashed.

At the Moorebank site the species is found growing in the transition zone between Castlereagh Ironbark Forest and Castlereagh Scribbly Gum woodland in open forest of *Eucalyptus sideroxylon, E. fibrosa, E. parramattensis, E. sclerophylla* and *Melaleuca decora* with a diverse understorey of shrubs including *Hakea sericea, Callistemon linearis, Bursaria spinosa, Grevillea parviflora* subsp. *parviflora, Acacia brownii, Acacia bynoeana, Pultenaea retusa, Pultenaea villosa, Hibbertia puberula* subsp. *puberula* and *H. aspera* subsp. *aspera*. The herb/grass layer is dominated by *Goodenia hederacea, Dianella revoluta, Thysanotus, Gonocarpus, Poa, Stylidium graminifolium, Patersonia, Themeda, Diuris* and *Microtis* (Telopea 2017).

Prior to the recent fire, the density of the understorey was variable across the site and ranged from sparse to extremely dense especially within the long-unburnt sections of the Castlereagh Scribbly Gum woodland. The variation in density is presumed to be due to the fire history, localised clearance events including recent remediation works, as well as minor changes in topography and drainage especially in swales.

In general, the topography of the land is described as flat although this is disrupted by the passage of Anzac Creek and by numerous minor depressions or swales likely to be remnants of past creek alignments and/or overflow channels that support Castlereagh Swamp Woodland. These swales and minor excavations / scrapings form small ephemeral pondages.

From limited brief inspections *Hibbertia fumana* was observed to be of sporadic occurrence across the site and appeared to be absent from ephemeral pondage locales preferring open slightly higher ground. Soils are described as fine sandy clay loam, grey brown in colour.

2.5 ANTHROPOGENIC THREATS TO THE HABITAT

Threats to the habitat of *Hibbertia fumana* that are relevant to sites within or adjacent to urban development include:

- Loss of existing habitats across the growth areas may occur for as-yet-missed unrecorded populations of the species.
- Development of the adjacent lands at Moorebank for a major transport hub may affect the plants, and there is a rarely-used railway line bisecting the site. At Bankstown airport infrastructure development could impact the population.
- Fire either too frequently (limiting recruitment) or too rarely (allowing midstorey thickening) are likely to impact the species.
- Clearing for fire protection zones and infrastructure works could remove habitat.
- Damage to habitat by trail biking, 4WDs, mountain bikes and rubbish dumping.
- High densities of weeds and invasive grasses occur at the top of ridgelines; there is significant potential for encroachment into areas of potential habitat.
- A number of weeds are likely to impact on the plant, with particular concern for low shrubs, dense shrubs and smothering grasses.
- Changes to hydrological processes can impact habitat by reducing subsoil infiltration, drying out seepages, or concentrating flow paths through habitat.
- Nutrification can increase weed potential.
- Road maintenance and slashing works can destroy habitat.

Field inspection of bushland remnants in the heavily urbanised sectors of GPEC growth area provide irrefutable proof of severe degradation caused by anthropogenic impacts and urbanisation (refer photos 2 through 6). Many of the remnants were heavily weed infested arising from a range of factors not limited to nutrification, stormwater discharge, garden refuse and fill dumping and exotic seed dispersal by various vectors.

Damage to zones adjacent urban development are often caused by clearing for fire hazard reduction, frequent control burning, and recreation activities.

Hibbertia fumana is a small shrub that would not survive in bushland that is heavily weed infested, or that is severely burnt on a regular basis. Fencing and on-going maintenance of the fencing around bushland remnants might reduce the severity of some of these impacts.

Photo 2: Indiscriminate access and rubbish dumping threatens the biological integrity of the former Air Services Australia Site.

Photo 3: Garden refuse dumped on top of the endangered species *Pultenaea parvifolia*.

Photo 4: Rubbish dumping in Castlereagh Nature Reserve.

Photo 5: Clearance of understorey for asset protection zones.

Photo 6: Dirt bike tracks and weed invasion in bushland adjacent housing at Shalvey.

3. Description of the study area

3.1 LAND USE HISTORY

The Cumberland Plain was first occupied by the Aboriginal peoples, who enjoyed a plentiful supply of fresh water and foods including fruit, tubers, fish, animals, birds and honey (Hills District Council website).

With the arrival of Europeans, land-use changed to timber gathering and agriculture, permanently altering the landscape. Particularly since the end of the Second World War urban settlement and industry have expanded west from Sydney into the Cumberland subregion. Over the last 40 years many rural properties have been subdivided as lifestyle and hobby farm properties.

Currently there is great pressure for further residential development to the west of Sydney in the Cumberland subregion.

3.2 LANDSCAPE CONTEXT

The changes in land use have caused the clearing of a large proportion of the natural bushland of the Cumberland subregion. In 2011 the Cumberland Plain Recovery Plan stated "Only 13% of the pre-1750 extent of the region's vegetation remains as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas (NPWS 2002). Consequently, much of the region's biodiversity is listed as threatened under State and/or Commonwealth legislation."

Widespread clearing of the remaining habitat has continued with much of the extant vegetation now being assessed as Critically Endangered. Previously recorded from South Head and Western Sydney, *Hibbertia fumana* appears to have suffered a reduction in range caused by urbanisation.

3.3 NATIVE VEGETATION

Since 2011 there has been further clearing, there are now 15 vegetation communities that are listed as Critically Endangered, Endangered or Vulnerable in the Cumberland Plain.

The Cumberland Plain Recovery Plan states that "there are seven threatened species, four endangered populations and nine threatened ecological communities listed on the NSW *Threatened Species Conservation Act* 1995 that are found only on the Cumberland Plain. Seven of these are also listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999." The remaining bushland is highly fragmented and much of it occurs on private lands.

Within the GPEC and the WSA nineteen Plant Community Types (PCTs) are mapped (mapping provided by the NSW Department of Planning and Environment). These PCTs are:

- 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion

- 725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- 774 – Coast Banksia scrub on sand in the Elderslie area, Sydney Basin Bioregion
- 781 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
- 806 - Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)
- 807 – Derived grasslands on shale plains of the Cumberland Plain (<100m asl)
- 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain
- 830 - Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- 850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 877 - Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- 883 - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- 1081 - Red Bloodwood – Grey Gum woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1105 – River oak open forest of major streams, Sydney Basin Bioregion and SE Corner Bioregion
- 1181 - Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- 1253 – Sydney Peppermint – White Stringybark – Smooth Barked Apple Forest on shale outcrops, Sydney Basin Bioregion
- 1292 – Water Gum – Coachwood Riparian Scrub along sandstone streams, Sydney Basin Bioregion
- 1395 - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
- 1800 - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley

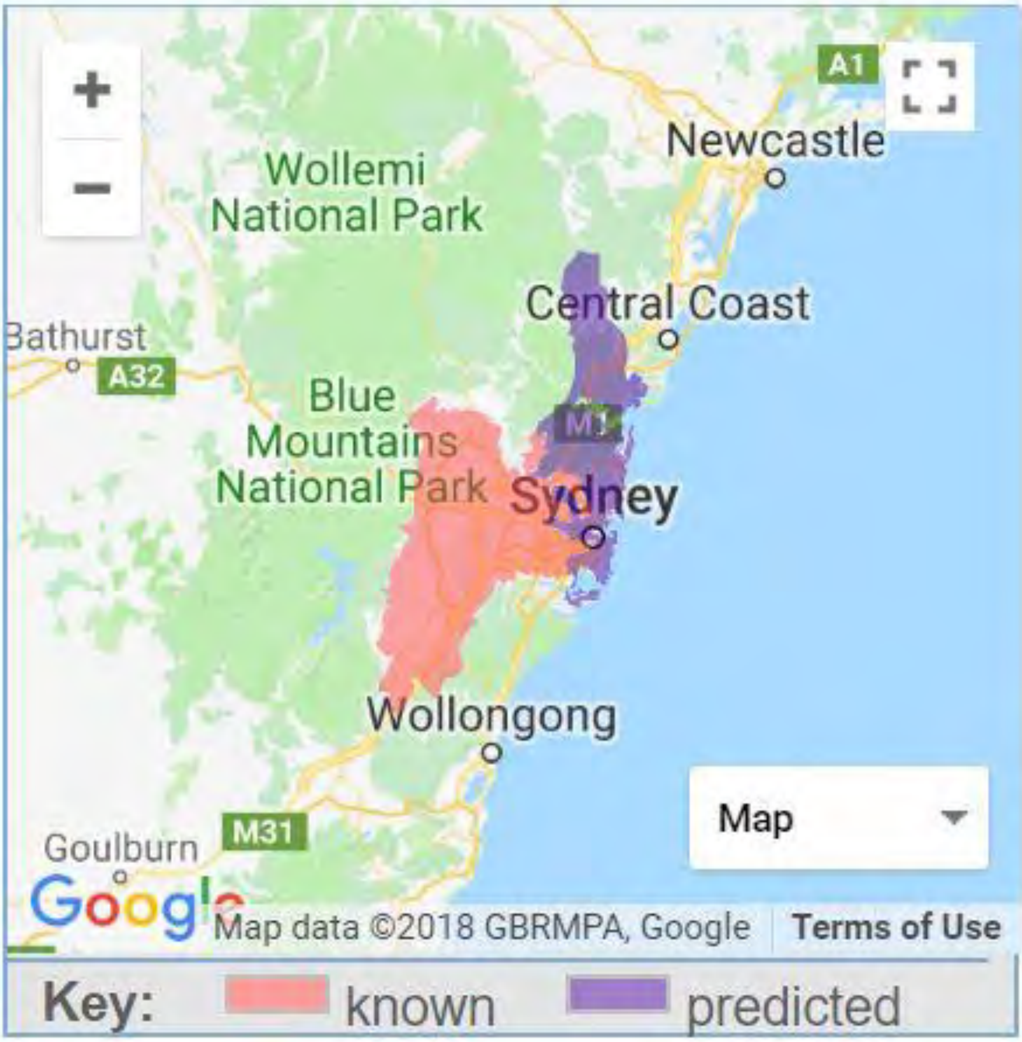
3.4 POTENTIAL HABITAT

Within the Sydney Basin Bioregion *Hibbertia fumana* is known from the IBRA subregion of Cumberland and is predicted to occur in the Pittwater IBRA sub-region (OEH website 2018). No geographic constraints are currently listed for the species. The subregions of known and predicted occurrence are shown in Map 3. The areas shown in pink and purple are the sub-regions where the species or community is known or predicted to occur. They may not occur throughout the sub-region but may be restricted to certain areas.

The OEH species profile sheet states: "found in the transition zone between Castlereagh Ironbark Forest and Castlereagh Scribbly Gum woodland in open forest of *Eucalyptus sideroxylon, E. fibrosa, E. parramattensis, E. sclerophylla*". The species has the potential to occur in similar intergrade alluvial habitats rich in sands and laterite in other parts of western Sydney.

Hibbertia fumana is currently known only from two locations in western Sydney. A single population at Moorebank and a single population in Bankstown (AVH record) but has the potential to occur elsewhere in greater Sydney.

At Moorebank it is found in areas of open woodland in a long intergrade between Castlereagh Scribbly Gum Woodland and Castlereagh Ironbark Forest. The AVH record for *Hibbertia fumana* at Bankstown records "Site is heavily managed and is routinely slashed to a height of about 10cm. Soils are grey heavy clay with ironstone fragments present at surface. Other native species observed indicate a derived form of Cooks River / Castlereagh Ironbark forest community."



Map 3: Known and predicted distribution of *Hibbertia fumana*.

Source OEH website 2018.

The habitat of an 1802 Caley collection 'near South Head' is uncertain, with potential communities in that area including coastal shale sandstone communities and open forest or forest communities on lateritised shale lenses. No similar alluvial sand deposits are identified in that area.

Hibbertia fumana has the potential to occur within the Greater Penrith to Eastern Creek and Western Sydney Aerotropolis Growth Areas in the following PCTs and in transition zones between these PCTs:

- PCT 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- PCT 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain
- PCT 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain
- PCT 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion

Biosis has mapped PCTs 883, 725, and 724 as occurring within the Wianamatta Regional Park/ Ropes Crossing areas and PCTs 725, 724 and 1067 as occurring within the Kemps Creek area.

4. Assessment of species presence and suitable habitat

4.1 EXISTING RECORDS AND SURVEYS

Hibbertia fumana is assessed as site managed. There is limited data on the life history and ecology of the species. There are no records of the species within or adjoining the proposed growth areas. Only two known extant populations exist, at Moorebank approximately 14 km to the south-east of the southern boundary of WSA, and Bankstown Airport 17 km from the southern boundary of WSA.

Private land holdings comprise much of the area within the GPEC and WSA, restricting access opportunities for botanical surveys and incidental sightings. This is a likely contributing reason for the lack of prior records of threatened *Hibbertia* species, possibly including *Hibbertia fumana,* within the proposed growth areas.

There has been just a short period in which the species would have been formally considered in the assessment process as the species was thought to be extinct when described in 2012 and was only recently rediscovered in late 2016.

Even now, it would be likely that the species would not be adequately considered within many assessments as such species are frequently dismissed with statements of “unlikely, no suitable habit present” or “only known from one population” and therefore no targeted searches would be undertaken. As *Hibbertia fumana* was originally misidentified and therefore dismissed at

Moorebank as a common species it is possible this may have occurred at other locales. It was therefore deemed appropriate to consider the possibility of *Hibbertia fumana* being recorded in the data records as another entity. Species of *Hibbertia* with which it might have been confused are discussed in detail in Section 4.3.2.

<u>Potentially misidentified *Hibbertia* within database records</u>

Searches of databases revealed records of *Hibbertia riparia* at a number of locales within and adjacent to the growth areas. The name *Hibbertia riparia* is considered by Toelken to be misapplied to NSW taxa. Prior to the updated taxonomy a number of undescribed species were included within the name *Hibbertia riparia* then considered to be "a variable species complex".

As *Hibbertia fumana* has its stamens on one side of the ovaries it is possible that it may have been captured within the then *H*. *riparia* variable concept. To illustrate this point, Miller has observed that *Hibbertia puberula* is frequently still misidentified as *Hibbertia riparia*.

Reviewing the data set it also became apparent that there were a number of records for *Hibbertia serpyllifolia* in the general Western Sydney area. Recent taxonomic work (Toelken 2013) investigating "The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*", has identified that the name *Hibbertia serpyllifolia* is misapplied to NSW. The species concept is now considered to be confined to coastal forests of mid-northern Queensland. All records from other states are now recognised as new taxa e.g. *Hibbertia ericifolia* group or misidentifications of existing taxa.

As *Hibbertia* are notoriously difficult to identify, and more so if not in flower, it is not surprising to find records of *Hibbertia* sp. within the data set.

The Western Sydney Urban Bushland Biodiversity Survey 1997 undertook the first comprehensive survey of the biota across the region including bushland remnants within the GPEC and WSA area. Although the taxonomy of *Hibbertia* has changed significantly since that time, the records of *Hibbertia* contained within provide additional insight into the potential occurrences of threatened *Hibbertia* species.

The Straede T.M. 1990 "Vegetation of the proposed Londonderry Waste Disposal Site" report for Waste Management Authority, Sydney found *Hibbertia cistiflora* in the Castlereagh – Londonderry Crown Lands. It is unknown if this species occurs in the area or is a misidentification. Like *Hibbertia fumana, H*. *cistiflora* also has its anthers to one side of the ovaries.

The current survey was limited in extent and did not visit the area of the Straede survey which is outside the growth area. The surveys conducted by CFFIS did not locate any specimens of *Hibbertia cistiflora*. There are no other records in the district and most vouchered records in the Sydney Metropolitan area occur north of the Harbour and are associated with sandstone ridges often in proximity to shale caps and Sandstone Shale Transition Forest associations.

It is noted in Toelken & Miller 2012 that subsp. *quadristaminea* is "often wrongly identified in herbaria as *H. serpyllifolia*, but subsp. *quadristaminea* has few stamens only in one dorsal cluster" c.f. *Hibbertia ericifolia* (*H. serpyllifolia* misapplied) possessing usually 8-16 but up to 30 stamens, dependant on the subspecies surrounding and obscuring the ovaries. This highlights that even herbaria have mis-assigned *Hibbertia* specimens. The fact that *H. cistiflora* has its anthers on one side of the ovaries opens the slight possibility that the Straede record could be what is now *Hibbertia fumana*, however it is most likely to be *H. puberula*. It is possible that Straede had another taxon from within the then *H. riparia* variable species complex previously identified, thereby determining it to be *H. cistiflora*. There is also a *Hibbertia riparia* record from the adjacent Castlereagh Nature Reserve which we have determined to be most likely *Hibbertia puberula* as the current CFFIS survey recorded *Hibbertia puberula* within the Nature Reserve.

It is unknown if the *Hibbertia serpyllifolia* UBBS Site (P1) Londonderry – Castlereagh Crown survey by R.S. Lembit & T.A. James - woodland south of Devlin Road & NW end of Nutt Road record was based on field identification of fertile or infertile material. If it was based on fertile material it is most likely to be an unverified record of *Hibbertia ericifolia* group. If it was based on infertile material it is most likely to be *Hibbertia puberula* or possibly *H. fumana.* CFFIS has recorded *Hibbertia puberula* in this vicinity.

Hibbertia pedunculata recorded at Mulgoa (Blue Mountains NP Sydney Sandstone complex) Coveny, R. 1976 – 95 Species lists for Mulgoa (off Fairlight Road – Nepean River) Blue Mountains NP is likely to be that species, however there is a possibility that it could also be potentially be *H. fumana* or *H. puberula* if the Coveny observation was based on field identification of infertile material.

4.2 SURVEYS COMPLETED FOR THE BIOCERTIFICATION

From the information provided, no prior targeted searches have been undertaken for this species as part of the biodiversity certification assessment process.

Surveys undertaken by Ecoplanning and Biosis consultancies since 2017 have largely been confined to the deemed "development footprint" and appear to have been undertaken predominantly to comply with the BAM protocols for vegetation sampling for assessment purposes with little survey for threatened species. As such, no new occurrences of threatened *Hibbertia* species including *Hibbertia fumana* were recorded by Biosis or Ecoplanning through their survey efforts.

Access to a spatial viewer was provided by DPE to assist in the expert assessment. Whilst this tool has been useful in gaining a general overview, the information presented is limited and is acknowledged to "have been acquired and developed from numerous sources of differing dates, accuracy and completeness and may include errors in extent and content". CFFIS are not aware of any surveys performed specifically for *Hibbertia fumana* by DPE, Ecoplanning or Biosis Consultancies. The broadscale vegetation mapping of PCTs that was provided to assist with this assessment cannot identify the habitat niches that may be present on a localised scale.

The level of data available is insufficient to base an assessment of presence/absence for a Critically Endangered species purely as a desktop study.

4.3 SURVEYS COMPLETED FOR THIS ASSESSMENT

Surveys for the biodiversity assessment informing the development of the biodiversity certification were constrained by private lands access issues, time and the overall size of the biodiversity certification area.

4.3.1 SURVEY METHODS

The surveys undertaken by Miller as part of this expert report relied on assessment of known habitat traits of extant sites and, although highly speculative, inferred habitat traits from historic records. PCT mapping and aerial digitised photography were used to select potential habitat areas for targeted surveys. Priority was given to finding the same habitat as occurs at the Moorebank and Bankstown Airport sites, although a variety of vegetation associations that are known habitat of other *Hibbertia* species such as *H. puberula* were surveyed to include inferred habitat from historic records. *Hibbertia puberula* co-occurs with *H. fumana* at the Moorebank site and grows nearby to *H. fumana* site at Bankstown Airport.

Biological data sets were searched for records of *Hibbertia fumana* within the study area. The BioNet and ALA searches failed to find any records of the species in the growth areas. Searches included Urban Bushland Biodiversity Survey of Western Sydney (UBBS) NPWS 1997. *Hibbertia* species are notoriously mis-identified, and as the species was described in 2012 any records prior to that time would be under a different name. Searches were made of all *Hibbertia* records within and adjacent to the growth areas to ascertain if any misidentifications might be included in the data set.

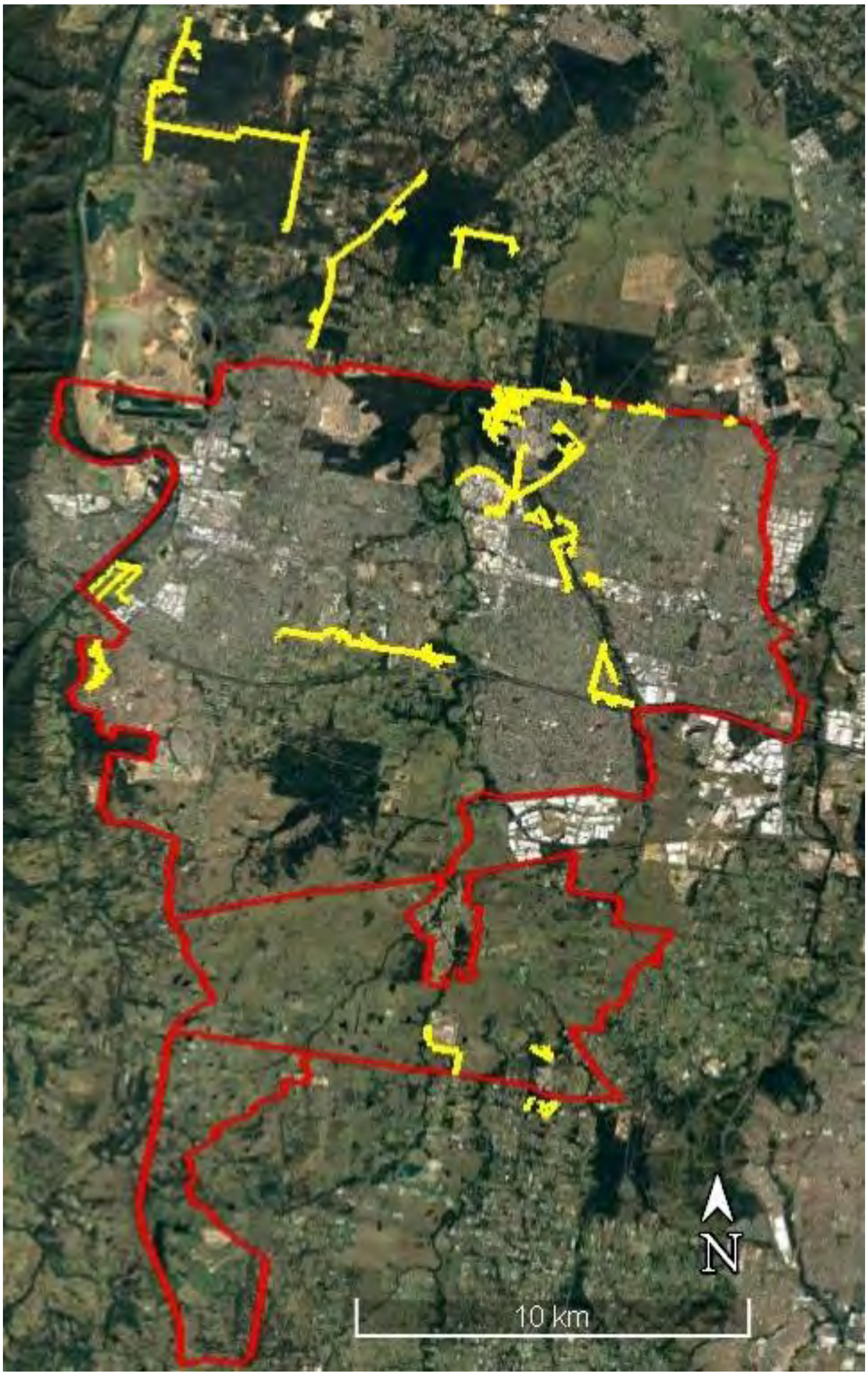
Records of *Hibbertia pedunculata*, *Hibbertia* sp., *Hibbertia* sp. A, *Hibbertia serpyllifolia* and *Hibbertia riparia* were included within the target survey effort where practical and where access had been granted. The large number of entries for *Hibbertia aspera* precluded visiting all known sites.

Searches were also made for indicative co-occurring species other than *Hibbertia* such as *Grevillea parviflora* subsp. *parviflora* to further refine the survey effort.

The prolonged rainfall deficient / drought period prior the survey effort posed significant challenges to the survey. Areas were targeted such as powerline easements where competition for moisture from large trees and shrubs was reduced and the targeted flora may have had greater chance of persisting through the dry period. This strategy was significant in locating one threatened *Hibbertia* adjoining Wianamatta Regional Park, namely *H. puberula*.

The greatest impediment to locating *Hibbertia* species during the survey was early petal drop of some species, thought to be increased due to the dry period and unusually high temperatures. This was most evident on 2nd November where petal drop of *Hibbertia puberula* had commenced before 8.30am (temperature of 30) and was complete by 9.30 am (temperature 32). As such, survey needed to start early in the day. There is no data available for the daily length of flowering times for *Hibbertia fumana*. Casual observations are not possible as access to known sites is restricted.

Map 4 shows the sites that were surveyed for this assessment, using targeted survey, random meander and in some locations of very low probability, drive past.



Map 4: Google Earth image of GPEC and WSA Growth Areas showing the tracks of CFFIS survey.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow.

4.3.2 SPECIES IDENTIFICATION

If a small-leaved *Hibbertia* was located that had macro morphological features resembling that of *Hibbertia fumana* then a specimen would be retained for later microscopic examination. CFFIS has also assessed the likelihood of *Hibbertia puberula* to occur in the GPEC and the WSA. *Hibbertia puberula* co-occurs with *H. fumana* at Moorebank and as both species are small-leaved, diminutive plants it is possible to misidentify *H. fumana* as *H. puberula* or other small-leaved species without careful examination (refer Photo 7). Selected specimens taken as part of the *Hibbertia puberula* assessment were microscopically examined to ensure that *Hibbertia fumana* was not inadvertently collected and dismissed as *Hibbertia puberula* or another small-leaved species. Due to the prevailing drought conditions plants were depauperate, such that any specimens removed consisted of very small fragments (eco-scraps) most only a few cm in length.

Figure 3 drawing depicts *Hibbertia fumana* in bud where those buds appear +/- sessile. During the Moorebank surveys it was purported by a consultant that pedunculate flowers are a key field identification tool even in bud. This is clearly erroneous and should not be used as the sole identifying feature (refer also to photo on the front cover, R.T. Miller and photo of the Isotype in Figure 2).

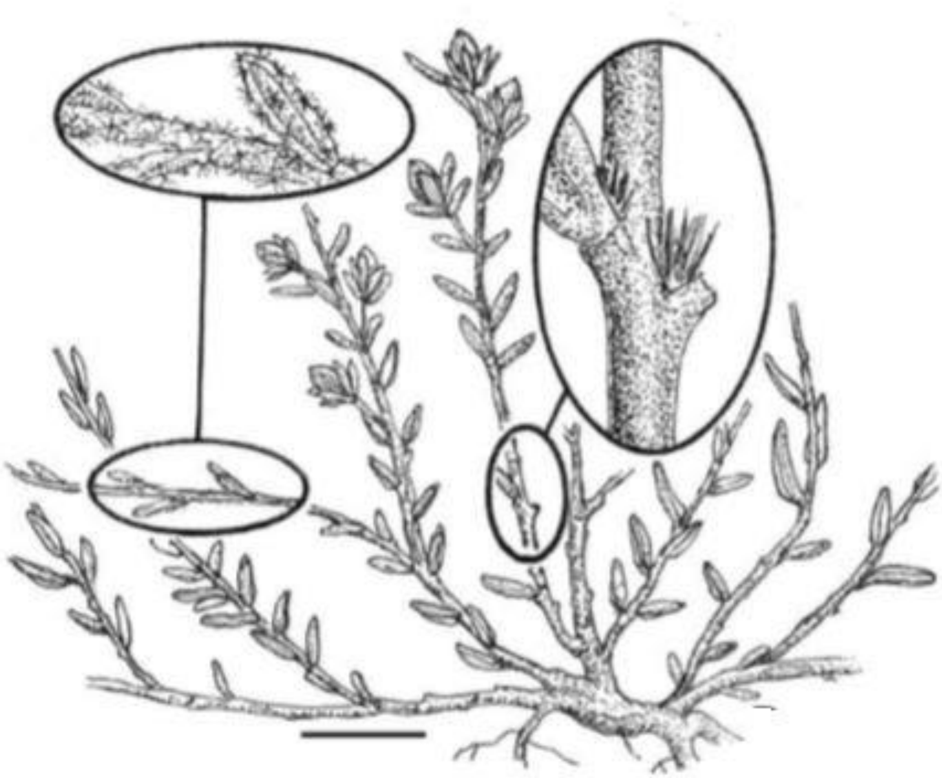


Figure 3: Stem and leaf characteristics of a flowering *Hibbertia fumana* specimen.

F.W. Sieber 147 (MEL 3111616) (Toelken and Miller 2012)

Peduncle elongation is clearly related to and is proportional to the developmental progression from buds to seed formation. Anecdotal observation by Miller suggests peduncle development is also related to environmental conditions such as moisture content of the soil and degree of exposure, for example, extended periods of low soil moisture and /or in combination with exposure appears to reduce peduncle length.

The species profile for *Hibbertia fumana* identifies some of the *Hibbertia* species with which it might be confused: "species with which it may be confused include *Hibbertia aspera* (peduncle of *H. fumana* is shorter, especially in flower, the foliage is more persistently hairy, and there are fewer stamens), *H. empetrifolia* (*H. fumana* is much more prominently stellate-hairy) and *H. riparia* (*H. fumana* has much shorter leaves). *Hibbertia superans* is another possible species for confusion, though *H. fumana* has smaller leaves" (OEH 2018).

It is unlikely that an expert would misidentify large / mature flowering plants of the above species with *Hibbertia fumana*. Confusion / unreliability is likely to arise if a population census is undertaken outside of optimal flowering time and/or the survey site is recovering from fire when a high proportion of the plants will be small and immature, or if depauperate in drought conditions.

There are several other small leaved diminutive Hibbertias that could be confused including *Hibbertia dispar*, *H. pedunculata*, *H. calycina* s.str. and other undescribed taxa.

Relying solely on stem and leaf characteristics in field survey can lead to mis-identification. *Hibbertia fumana*, *H*. *aspera* and *H*. *empetrifolia* have discolorous leaves and using this character alone on non-flowering specimens without a high-resolution microscopic examination could result in dismissing or mis-identifying a plant to be *H*. *fumana*. The discoloration of the under surface of the leaves in both *Hibbertia fumana* and *H*. *aspera* is due to the presence of a usually dense white/silvery tomentum whilst the leaf under surface of *H*. *empetrifolia* lacks dense tomentum but it is of a similar whitish coloration.

Apparent tomentum density and type on the stems and leaves will vary according to the section of branchlet examined and the prior climatic conditions. New growth is likely to have a higher density and a fuller range of hair types present whereas on older growth much of this tomentum will have "worn off" (Toelken), especially the longer simple hairs. Drought condition will see a marked reduction in new growth. *Hibbertia aspera*, like *H. empetrifolia*, shows much variation in different local populations as well as sometimes on the same plant (Toelken).

Hibbertia pedunculata was commonly encountered within suitable habitat. This floriferous species is readily identified in the field provided its flowers are open. It has normally (14-) 18-35 (-43) stamens surrounding the carpels c.f. *H. fumana* which has 5 or 6 (7), subequal stamens, clustered on one side of the ovaries. *Hibbertia fumana* could readily be overlooked as impoverished plants of *H. pedunculata* after petal drop or if surveyed outside the flowering season.

Hibbertia aspera was observed occasionally within potentially suitable habitat for *Hibbertia fumana* during the CFFIS survey but was noted in greater frequency within areas deemed unsuitable habitat such as Shale Plains Woodland.

Microscope photographs of *Hibbertia fumana* characteristic features used for identification during this survey by CFFIS are provided in Appendix 2, and Appendix 3 shows comparison photos of characteristics of *Hibbertia aspera*, *H. dispar, H*. *empetrifolia* and *H*. *pedunculata*.

Photo 7: Five species of Hibbertia, photo taken 30cm above specimens, but which one is which?

Key - A: *Hibbertia fumana* (Moorebank), B: *H. pedunculata* (Wianamatta Regional Park), C: *H*. *empetrifolia* D: *H. puberula* (Powerline easement), and E: *H*. *aspera* (Wianamatta Regional Park).

4.3.3 SURVEY ASSUMPTIONS

It was not possible to access and survey all the many bushland remnants within the Greater Penrith and Western Sydney Aerotropolis growth areas. As such, the first assumption was:

Assumption 1. *Hibbertia fumana* would not be found growing in bushland that is unlikely to be suitable habitat.

The author is familiar with the species type of habitat at the Moorebank Intermodal and Bankstown sites. Using this knowledge of geology, soil and vegetation type that is the known habitat of the species, areas of bushland that would not be suitable habitat were ruled out of the assessment.

Using this knowledge of habitat requirement, the second assumption was:

Assumption 2. *Hibbertia fumana* is likely to be present in areas that are known to be suitable habitat. While surveys in suitable PCTs since the species was described in 2012 have failed to find *H. fumana*, this is a cryptic plant and the precautionary principal should be applied to the potential for the species to occur in suitable habitat.

The survey was carried out following several years of drought in western Sydney, and many shrubs forbs and grasses were dead. This led to the third assumption:

Assumption 3. In areas of suitable habitat, where *Hibbertia fumana* specimens have not been found, the species could be present in the soil seed bank.

4.3.4 *HIBBERTIA* RECORDED BY THIS SURVEY

Six species of Hibbertia were observed whilst undertaking surveys for this report. They are:

Hibbertia puberula: This species is the subject of a separate report (Strategic assessment for Cumberland Plain Conservation Plan, Aerotropolis and Greater Penrith, *Hibbertia puberula* species group, R. Miller 2018).

Hibbertia pedunculata: Very significant populations of this species were observed in the GPEC within and outside the biodiversity certification areas in the Wianamatta Regional Park, also to the north in the former Air Services Australia Site adjoining the north of the GPEC.

Hibbertia diffusa: Widespread, sometimes locally common inside and outside growth areas. Most commonly observed on shale derived or influenced substrates including river-flat forests.

Hibbertia aspera: Widespread, sometimes locally common inside and outside growth areas. Most commonly observed on shale derived or influenced substrates.

Hibbertia acicularis: Noted in two areas outside the growth areas, at Agnes Banks Nature Reserve and Gulguer Nature Reserve.

Hibbertia fasciculata: Noted in one area outside the growth areas in Agnes Banks Nature Reserve, in Scribbly Gum Woodland.

It is a recommendation of this study that *Hibbertia pedunculata* be listed as a Threatened species or an Endangered Population, and taken into consideration as part of this biodiversity certification process.

Toelken (2013) in his revision of the *Hibbertia vestita* group, including *H. pedunculata* and *H. serpyllifolia*, considers *H. pedunculata* to be confined to NSW. Analysis of the cited specimens reveals that the species has two main areas of distribution the Greater Sydney Metro Area and the lower Hunter.

In the Greater Sydney Metropolitan area, the species has suffered a significant reduction in numbers and extant distribution due to urbanisation. Two cited locales occur within the growth area at St Mary's. The Greater St Mary's – Shane Park vicinity is now the only general vicinity that has long term viable habitat remaining for the species, that is, Wianamatta Regional Park including areas within the former ADI site not gazetted and the Former Air Services Australia site.

Of the twenty specimens cited in the Greater Sydney area six only are known to have extant populations, however all are under severe threat due to small population size and anthropogenic impacts. Nine populations are known or highly likely to be extinct.

4.3.5 INCIDENTAL SIGHTINGS OF SIGNIFICANT FLORA DURING THIS SURVEY

The bushland remnants surveyed were observed to support numerous threatened species including but not limited to *Hibbertia puberula*, *Persoonia nutans*, *Pultenaea parviflora*, *Dillwynia tenuifolia*, *Micromyrtus minutiflora* and *Grevillea juniperina*.

Photo 8: Habitat of threatened species recorded by this survey at Kemps Creek.

4.4 ASSESSMENT OF SPECIES PRESENCE

The previous survey data provided by Biosis and Ecoplanning Consultants was insufficient to assess the probability of occurrence of *Hibbertia fumana* from a desk top study. The species has demonstrated an ability to persist within suitable derived habitat, it was therefore appropriate to undertake specific targeted surveys.

A selection of areas mapped as suitable PCTs for *Hibbertia fumana* habitat were surveyed by CFFIS for the assessment. Areas of potential habitat identified as occurring within or adjacent to the biodiversity certification footprint were prioritised. We also surveyed for habitat appropriate to the species in small areas of potential tertiary sediments across the growth areas and adjacent lands, based on geology, soils and landform maps where access was provided.

4.4.1 LIKELIHOOD OF SPECIES PRESENCE

No specimens of *Hibbertia fumana* were observed whilst undertaking surveys for this report.

Non-detection should not be interpreted as the species not being present, but simply as not seen.

The population numbers of ground layer species at many locales were observed to be depauperate in areas of +/- intact canopy cover. A thick layer of detritus was noted to be suppressing the understorey in many places and particularly so if the site had a long fire interval. This was especially apparent within Wianamatta Regional Park and surrounds, including most of the area under the proposed urban footprint.

Similarly, the bushland remnant to the south of Elizabeth Drive, bounded by Western Avenue, and Cross Street, outside the growth area but used as a surrogate site, had significantly suppressed understorey. This included areas where known threatened species had been observed by Miller previously. Species such as *Grevillea parviflora* and *Dillwynia tenuifolia* had a significant retraction in apparent population numbers at that site.

Hibbertia fumana is known only from very few extant and historic records, this data suggests that *H. fumana* may have a very restricted distribution. The species is known only from a narrow band stretching from South Head, Connell's Point, Condell Park to Moorebank.

It is unknown, however, whether factors such as:

- the species only recently being described,
- being extremely cryptic,
- being easily misidentified and/or overlooked as a depauperate version of other species

may have resulted in populations being overlooked by past surveys.

The presence of this species cannot be dismissed on disturbance factors as the Bankstown Airport population survives in a highly modified environment. Bannerman and Hazelton (1990) in *Soil Landscapes of the Penrith 1:100,000 Sheet* map the entire site as disturbed terrain, although field observation by Miller and others have identified areas to retain the original soil profile. Areas of derived habitat have therefore the same probability of occurrence provided the soil profile is intact and anthropogenic factors have not irreversible change the soil chemistry and soil biota.

Hibbertia fumana is currently assessed as being Critically Endangered. There is limited ecological data available for this species. In this context, a precautionary approach is recommended. Locating and protecting new populations, no matter how small, is significant to the survival of this species.

Potential for *Hibbertia fumana* within the GPEC

The possibility of *Hibbertia fumana* occurring within the GPEC is assessed as low because potential habitat sites found within the biodiversity certification area do not have the same complexity of attributes to known extant sites. It is possible however that the species may exist in small habitat niches found within PCTs of the study area.

There is a moderate potential for *Hibbertia fumana* to occur to the north of the biodiversity certification area, not limited to areas such as the former Air Services Australia site, and the tertiary vegetation stretching from Agnes Banks, Berkshire Park, Castlereagh, Llandilo and Cranebrook vicinities. Many of the remnants in these areas are relatively large and support a complex mosaic of transitional vegetation between the various PCTs.

Photo 9: A complex mosaic of vegetation types occurs in this section of Agnes Banks NR.

The habitat depicted in Photo 9 shows PCT 958 Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland interface as it grades into PCT 1067 Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain (occurring in the background). PCT 725 Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain occurs in close proximity. Such areas have a moderate probability of occurrence for *Hibbertia fumana*. No such areas with this complexity were observed within the GPEC growth area.

Of the sites investigated within the growth areas, no significant occurrences of typical PCT 883 were observed where Scribbly Gum grows on a +/- sandy substrate. Some sites adjoining and on the very northern extremity of the biodiversity certification area were recorded to support stands of *Eucalyptus sclerophylla* though the areas observed were on lateritised clays.

The most likely proximate potential habitat site to the GPEC is within the former Air Services Australia site which is immediately adjacent to the northern boundary of the GPEC (Photo 10). The area is mapped to support PCTs 725,724, 883 and 1067, and in combination provide a moderate likelihood of occurrence.

Photo 10: *Eucalyptus sclerophylla* growing on lateritised clay at the northern extremity of the GPEC.

Eucalyptus sclerophylla was noted to occur sporadically within PCTs 725 and 724 in the Wianamatta Regional Park. As PCTs 725 and 724 exist within the biodiversity certification area of the GPEC and Scribbly Gum is found within these communities, the presence of *H. fumana* cannot be dismissed entirely despite no pre-existing records or non-detection during this current survey. If present, *H. fumana* would be confined to very specific habitat niches.

The Bankstown Airport habitat data records “Soils are grey heavy clay with ironstone fragments present at surface. Other native species observed indicate a derived form of Cooks River / Castlereagh Ironbark forest community.”

Lateritised gravel soil and Cooks River / Castlereagh Ironbark forest are common in the northern GPEC, especially within the Wianamatta Regional Park. *Hibbertia puberula* subsp. *puberula* is a co-occurring species at Moorebank and *Hibbertia puberula* subsp. *glabrescens* is proximal (c. 450 m) to the *H. fumana* site at Bankstown. *H. puberula* was located adjacent to the Regional Park by this survey.

It is unknown if Scribbly Gum once occurred as part of the canopy layer at the Bankstown Airport *Hibbertia fumana* site. Remnant Scribbly Gum occurs nearby at the Georges River Golf Course on tertiary sands and a small Scribbly Gum Woodland remnant still exists C. 2.51 km to the south east adjacent Deverall Park.

Photo 11: Lateritised gravel soil substrate within the area of occurrence of *Hibbertia puberula*, east of Ropes Crossing.

No large occurrences of PCT 883 were observed by our survey effort within the Wianamatta Regional Park. The likelihood of the same complexity of habitat found at the Moorebank site to occur within the Regional Park is assessed as negligible. As such a long intergrade between PCT 725 and PCT883 was observed not to exist, however isolated small occurrences of Scribbly Gum were noted. This raises the possibility that localised potential habitat may exist in the area. The discovery of a localised occurrence of *Hibbertia puberula* adjacent to the Regional Park supports this assumption.

Derived habitat areas included in this assessment include the Ropes Creek environs between Ropes Crossing and Oxley Park. Relatively recent BioNet data for the area include records for *Grevillea parviflora* which suggests that potential habitat may exist here despite weed invasion being chronic along the immediate riparian zone and the invasive species *Eragrostis curvula* dominating large swathes of the derived grassland and remnant vegetation.

Large diversity of uncommon and common herbaceous species to the Sydney Metropolitan area including the rarely recorded forb *Murdannia graminea* were noted to be locally common in recently burnt and mown derived grassland under the powerlines. This suggest that other diminutive species such as *Hibbertia fumana* could still persist in the area.

Potential for *Hibbertia fumana* within the WSA

Within the Kemps Creek area of the WSA the likelihood of *H. fumana* occurrence was assessed to range from moderate to low potential adjacent the footprint. Two areas that were adjacent to the footprint and had moderate potential for the species had been mostly cleared in recent times.

The Kemps Creek area is 14 km from known occurrences of *H. fumana* and the complexity of habitat is more appropriate for the species (refer Photo 9). Similarly, a number of co-occurring threatened species have been recorded from the Kemps Creek area including a previously undocumented occurrence of *Hibbertia puberula*. *Grevillea parviflora* subsp. *parviflora* and *Persoonia nutans* are known to be proximate co-occurring species and were recorded by this survey at Kemps Creek.

Only a few remaining areas of remnant bushland exist in the Kemps Creek area. Those that remain are fragmented by development and variously modified and impacted by past and present land use practices. The exact extent of PCT assemblages that occurred in the area is uncertain, however it appears to have been a complex mosaic of various forest types with a diverse assemblage of minor habitat niches within the broader PCT community including heath and open woodland.

Site inspections supports this view with small areas of temporarily wet swales supporting heath/open woodland being observed. These have similarities to the Moorebank site of occurrence.

The Kemps Creek environs is therefore assessed to have potential habitat with a likely occurrence rating ranging from moderately high to low.

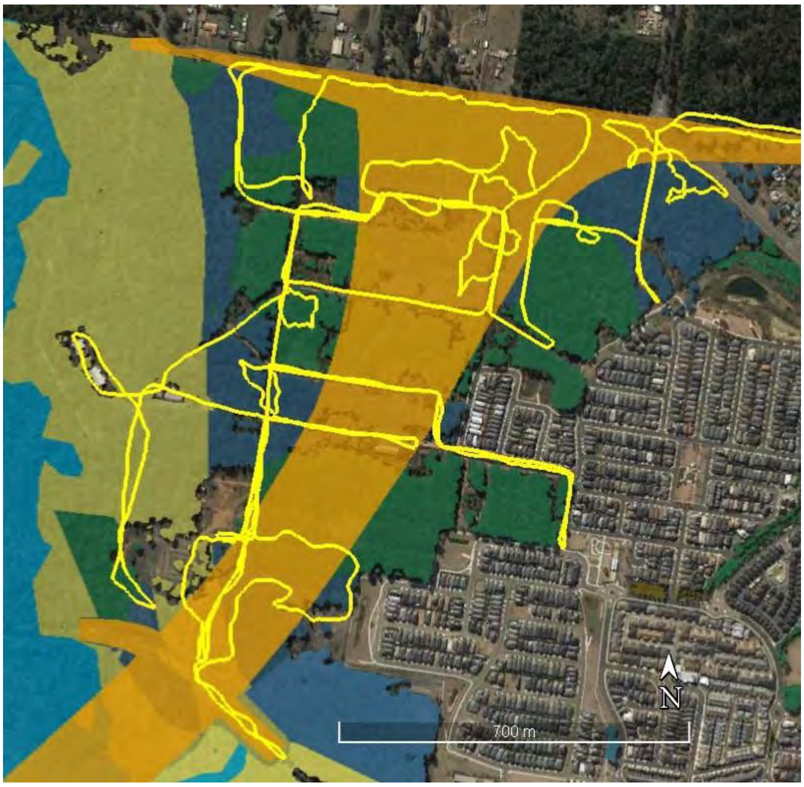
4.4.2 JUSTIFICATION FOR DETERMINATION

The following maps show an overview of areas containing potential habitat of *Hibbertia fumana*, based on vegetation mapping and BioNet records, within the GPEC and WSA. These areas were surveyed by CFFIS for this assessment. Vegetation mapping was provided by DPE.

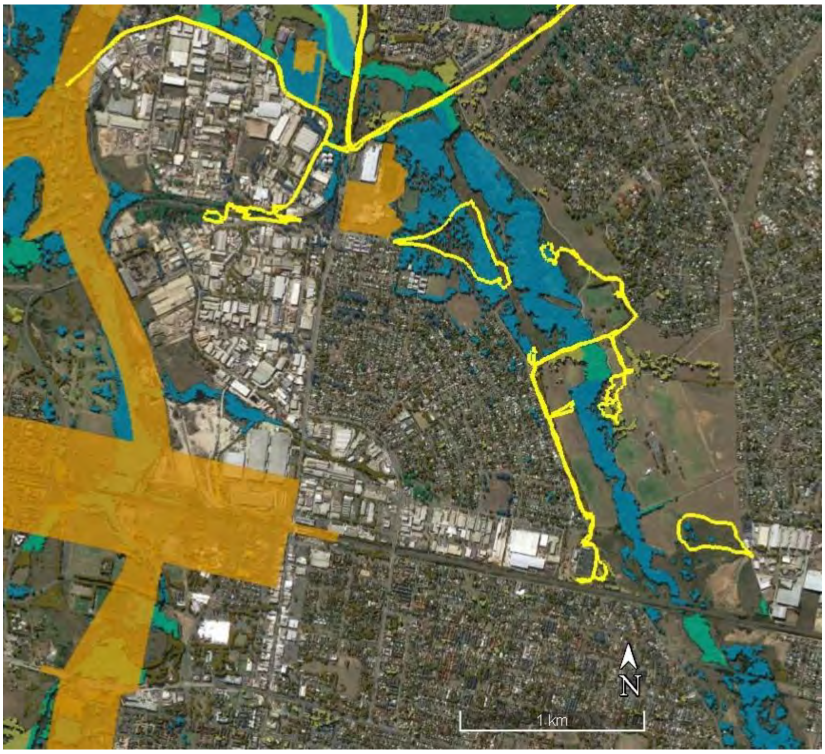
Key to the maps is:

- development footprint – light orange
- CFFIS survey tracks - yellow
- vegetation type PCT 724 – dark blue
- vegetation type PCT 725 - dark green
- vegetation type PCT 835 – light blue
- vegetation type PCT 849 – olive green
- vegetation type PCT 883 – red
- vegetation type PCT 1800 – light green

Map 5: Wianamatta Regional Park south section and powerline easement.



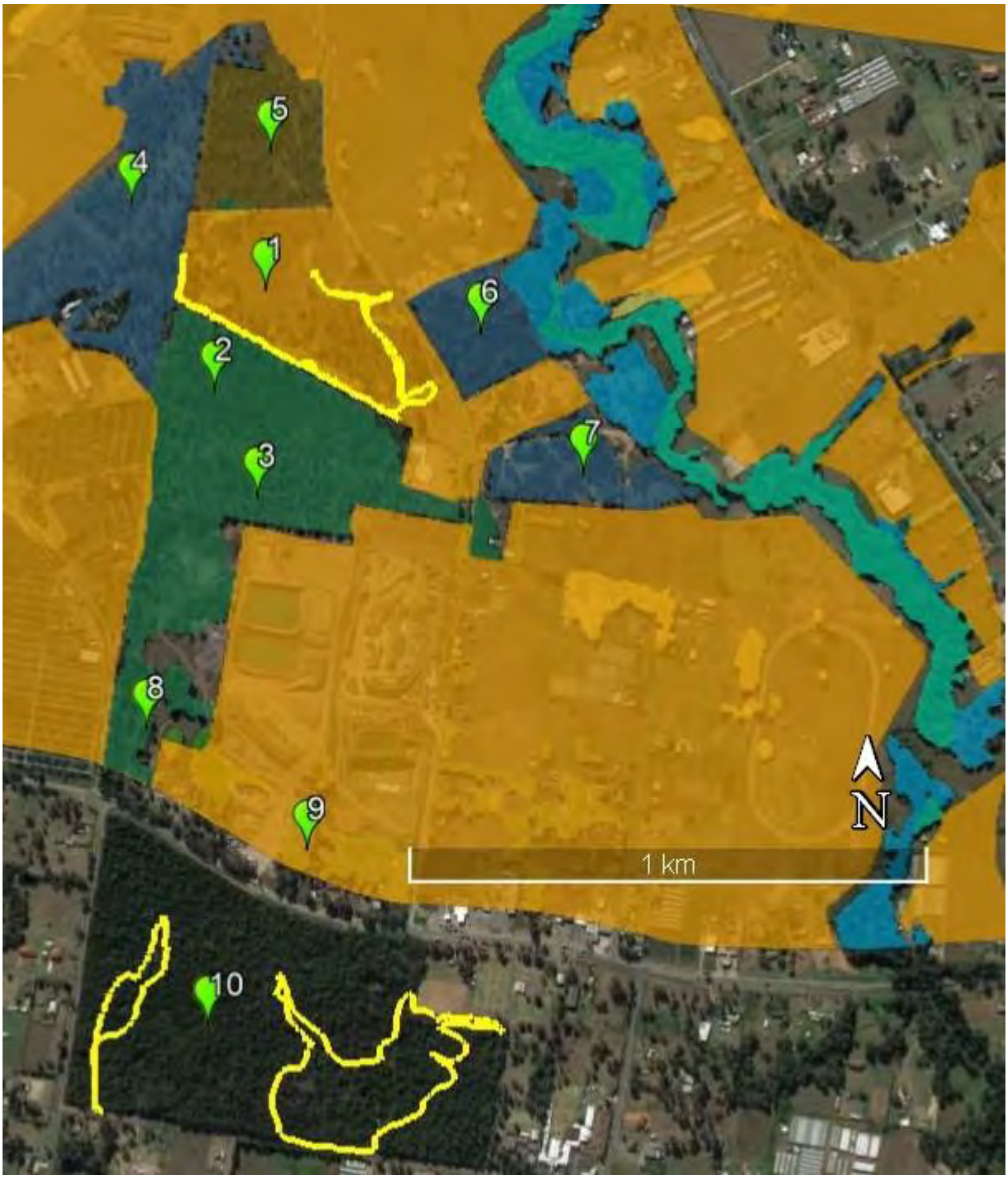
Map 6: Northern section of the Wianamatta Regional Park with road corridor footprint.



Map 7: Ropes Crossing and North St Marys areas of potential habitat, Tregear and Whalan Reserves and development footprint.

Map 8: Boronia Road North St Marys areas of potential habitat.

Map 9: Kemps Creek, south of SUEZ facility, block of land partially cleared.



Map 10: Kemps Creek potential habitat and development footprint.

1. Lot 3 DP812284
2. Lot 2 DP812284
3. Lot 1 DP812284
4. Lot 22 DP60122, Lot 2 DP587135
5. Lot 47 DP734584
6. Lot 6 DP812284
7. Lot 4 DP812284
8. Lot 1 DP716403
9. Lots north of Elizabeth Drive
10. Cross Street bushland

4.5 ASSESSMENT OF SUITABLE HABITAT

4.5.1 SUITABLE HABITAT WITHIN THE GROWTH AREAS

This section provides detail of areas of suitable habitat within the growth areas that have been surveyed by CFFIS, and the outcomes of that survey.

Wianamatta Regional Park area and Outer Sydney Orbital corridor

Within the Regional Park and the Outer Sydney Orbital (OSO) corridor are areas mapped as having PCTs appropriate for *H. fumana* habitat. The potential for the species to occur in these areas is considered to be low.

Survey of the area did not locate the species. Non-detection was not viewed as meaning not present, but rather not observed. The bushland was very dry and had not been burnt for years. It is likely that if the species did occur in the vicinity it's occurrence would be confined to small localised patches that could be easily overlooked. The species is cryptic even in favourable times. Due to the preceding drought conditions the species may have contracted to the soil seed bank.

Hibbertia pedunculata and to a lesser degree *Dillwynia tenuifolia* and *Pultenaea parviflora* were used as surrogate indicator species in determining the likely impact of drought and fire regime on the population densities, within and outside of canopy cover in the assessment of likely occurrence of *Hibbertia fumana*. *Hibbertia pedunculata*, *Dillwynia tenuifolia* and *Pultenaea parviflora* were observed to be locally frequent species within some modified habitat areas.

Photo 12: *Hibbertia pedunculata* within derived habitat away from trees and shrubs.

In areas where these species were noted away from the influence of large trees and shrubs, they were easily discernible, flowering and vigorous. Under the canopy or within the rooting zone of trees and shrubs, flowering was significantly reduced but mostly absent and the apparent population densities low. Visible plants were typically in a late stage of senescence. This was particularly apparent with *Hibbertia pedunculata*.

Other shrub and ground layer species were also noted to be particularly sparse within the areas mapped as PCT 725 and PCT 724 within the Wianamatta Regional Park.

BioNet records the following species for the Regional Park that may indicate localised suitable habitat niches for *Hibbertia fumana*. Species include *Banksia spinulosus*, *Callistemon pinifolius*, *Baeckea diosmifolia*, *Hakea dactyloides*, *Isopogon anemonifolius*, *Leptospermum parvifolium*, *Melaleuca thymifolia*, *Pultenaea tuberculata* and *Xanthorrhoea minor*. The trees *Angophora bakeri*, *Corymbia gummifera*, *E. eugenioides*, *E. parramattensis* and *Eucalyptus sclerophylla* are also listed.

Photo 13: Typical condition of *Hibbertia pedunculata* within “intact” vegetation of the Regional Park.

Note: The *Hibbertia pedunculata* plant is exhibiting extreme water stress and lack of flowers. Detectability of *Hibbertia* in this state is very low.

Many areas were observed to have a particularly high percentage coverage of thick detritus further suppressing the groundcover. BAM plot data for the area records EP GPEC 18 litter cover as 83%, EP GPEC 01 as 93%, EP GPEC 03 as 83%, EP GPEC 12 as 100% and EP GPEC 08 as 72%.

These observations support the conclusion that non-detection of *Hibbertia fumana* within or adjacent to the development footprint (OSO corridor) within the Wianamatta Regional Park is likely to be attributable to a retraction to the soil seed bank rather than non-occurrence.

Photo 14: Typical high levels of detritus under the canopy Wianamatta Regional Park

Photo 15: Many hardy understorey species still show the symptoms of severe drought stress even following recent rains.

Ropes Creek Vicinity

A number of areas were targeted for survey along the Ropes Creek corridor, these were

- Whalan Reserve
- Tregear Reserve
- South of Whalan Reserve
- East of and to the south of St Marys Rugby League Club, Boronia Road North St Marys,
- Electricity Substation vicinity Kurrajong Road and Boronia Road, North St Marys.

The potential habitat sites in the Ropes Creek vicinity were selected based on the PCT mapping, aerial imagery and the following BioNet records:

Grevillea parviflora: 28/01/2015, Ropes Creek, Mt Druitt includes Whalan Reserve and Tregear Reserves, -33.77797 150.80575.

Dillwynia tenuifolia: near corner Roper Rd & Carlisle Ave, Colyton, -33.78435, 150.80540, Ropes Creek, Mt Druitt includes Whalan Reserve and Tregear Reserves -33.78544, 150.80727

Eucalyptus parramattensis subsp. *parramattensis*: Roper Road, St. Marys, -33.78435, 150.80540

Hibbertia pedunculata: Between power station and railway line near Boronia Park, St Marys

Grevillea juniperina: M4 Motorway, Ropes Creek includes Whalan Reserve and Tregear Reserves and near corner Roper Rd & Carlisle Ave, Colyton.

Grevillea parviflora and *Eucalyptus parramattensis* subsp. *parramattensis* are known co-occurring species at Moorebank and at Voyager Point. *Dillwynia tenuifolia* is a known co-occurring species at Kemps Creek and at Ropes Crossing. These species indicate the possibility of potential suitable habitat present in the Ropes Creek vicinity.

The condition of the vegetation and population status of some of the BioNet records remain unknown.

Both *Grevillea parviflora* and *Eucalyptus parramattensis* subsp. *parramattensis* were not located by this survey effort and the GPS points do not align with the descriptors.

The Ropes Creek vicinity was found to be severely impacted by weed invasion displacing most native species in many of the likely potential habitat areas. The majority of the Ropes Creek environs is therefore assessed as unsuitable habitat for *Hibbertia fumana* as no indicative co-occurring habitat species were located within the areas surveyed and these potential habitat areas were acutely degraded.

Further details of the habitat at these sites follows.

Whalan Reserve

Whalan Reserve is primarily developed as a recreational facility including sporting fields, BMX bike jumps, Whalan Model Car Club track, walkway / cycleway and exercise equipment. West of the pathway remnant river-flat forest and supplementary plantings were observed.

In the area surveyed the canopy / subcanopy was variously comprised of *Eucalyptus tereticornis*, *Angophora floribunda*, *Casuarina glauca, Acacia decurrens, A. parramattensis* and *Melaleuca decora*. A stand of Blue Box was noted west of the access road.

Photo 16: Whalan Reserve bushland west of the pathway.

The ground layer was impacted by weeds and dominated by *Eragrostis curvula* in many places. Despite this, numerous areas were observed to support a diverse array of indigenous species including: *Acacia falcata*, *A. elongata*, *Bursaria spinosa*, *Indigofera australis, Ozothamnus diosmifolius*, *Daviesia ulicifolia* var. *stenophylla*, *Tricoryne elatior*, *Phyllanthus virgatus*, *Opercularia diphylla*, *Cyanthillium cinereum*, *Cheilanthes sieberi*, *Glossogyne tannensis*, *Goodenia hederacea*, *G. bellidifolia*, *G. paniculata*, *Brunoniella australis*, *Chorizema parviflora*, *Chrysocephalum apiculatum*, *Centella asiatica*, *Glycine tabacina*, *Desmodium varians*, *Polymeria calycina*, *Zornia dyctiocarpa*, *Dianella longifolia*, *Lomandra longifolia*, *Microlaena stipoides*, *Themeda australis* and *Aristida* *vagans*. *Eucalyptus crebra*, *Melaleuca armillaris*, *Callistemon viminalis*, and *C. salignus* were noted in the plantings.

The river-flat community is atypical of *Hibbertia fumana* habitat as the higher nutrient status of the soils supporting typically a dense grassy /herbaceous layer is unsuitable habitat. However, the presence of minor alluvial terraces in combination with lateritised soil areas with relatively open ground layer provides a low potential for species presence.

Photo 17: Weedy understorey and habitat plantings at Whalan Reserve.

Photo 18: Remnant vegetation at Whalan Reserve severely impacted by *Eragrostis curvula*.

Photo 19: Minor alluvial terrace, potential habitat for *Hibbertia fumana* in Whalan Reserve.

Tregear Reserve

Tregear Reserve is primarily a developed recreational reserve with sporting fields, walkways/ cycleway, exercise facilities and an off-leash dog compound.

Undeveloped portions remain west of the pathway and include riverine remnant vegetation and large areas of unmown exotic grassland / herbland that has predominantly displaced the indigenous vegetation. Habitat enhancement plantings were noted along the bushland verge.

Habitat for *Hibbertia fumana* may have once existed at the interface between the alluvial floodplain and the lateritised rise. The potential habitat is too degraded to now support this species.

In the area surveyed the riparian vegetation was dominated by *Eucalyptus baueriana* with *Casuarina glauca*, *Acacia parramattensis*, *Melaleuca styphelioides*, *Bursaria spinosa* and the native grass *Microlaena stipoides* being relatively common.

Other indicative indigenous species noted included *Carex appressa*, *Scaevola albida*, *Dichondra repens*, *Centella asiatica* and *Alternanthera denticulata*.

The understorey in many locales is heavily weed impacted with species such as: *Eragrostis curvula*, *Chloris gayana*, *Setaria sphacelata*, *Verbena bonariensis*, *Rumex* sp. and *Tradescantia fluminensis*.

Enhancement plantings include: *Eucalyptus crebra*, *Casuarina glauca*, *Melaleuca styphelioides*, *M. decora*, *M. linariifolia* and *Bursaria spinosa*.


Photo 20: Looking across Tregear Reserve to the riparian zone of Ropes Creek


Photo 21: Treagar Reserve chronic weed infestation eliminating potential habitat for the species.

Although very limited in extent, a number of indigenous ground layer species were noted under the canopy of the enhancement plantings and to a lesser degree within the adjoining predominantly exotic weed meadow. Indigenous species noted include: *Wahlenbergia gracilis, W. communis, Centella asiatica, Tricoryne elatior, Microlaena stipoides, Phyllanthus virgatus*, *Rubus parviflorus*, *Glycine tabacina*, *Haloragis heterophylla, Cynodon dactylon* and *Glossogyne tannensis*.

The weed meadow adjoining the plantings was dominated by *Eragrostis curvula, Hypochaeris radicata*, *Plantago lanceolata*, *Melilotus albus* and *Paspalum dilatatum*.

The majority of the potential habitat was blanketed by dense weeds, primarily comprised of: *Eragrostis curvula*, *Cirsium vulgare*, *Verbena bonariensis*, *Melilotus albus*, *Foeniculum vulgare*, *Solanum sisymbriifolium*, *Bidens pilosa*, *Lactuca serriola*, *Plantago lanceolata*, *Chloris gayana*, *Nothoscordum gracile*, *Chenopodium album* and *Sorghum halepense*. No indigenous species were noted in this area.

Treagar Reserve vicinity is assessed as having no potential habitat remaining for *Hibbertia fumana*.

South of Whalan Reserve

The generalised geomorphology of the site is summarised by the intersection of the alluvial floodplain deposits of Ropes Creek with low lateritised rises. It is possible that such conditions once provided localised suitable habitat for *Hibbertia fumana*.

The potential habitat in this section of Ropes Creek is severely impacted by weed invasion and the potential for threatened species to now exist is negligible. A large area is being infilled with road ballast.

A small area of a few square metres was observed to support *Themeda australis* and *Wahlenbergia communis* and colonised by invasive species including *Briza subaristata*, *Eragrostis curvula*, *Hypericum perforatum*, *Lactuca serriola*, *Senecio madagascariensis*, *Verbena bonariensis* and *Hypochaeris radicata*. The site is surrounded by dense exotic vegetation now typical of the area.

No suitable habitat exists for *Hibbertia fumana* in this locale.

Photo 22: Eastern side of Ropes Creek south of Whalan Reserve.

Photo 23: *Eragrostis curvula* smothers potential habitat area of lateritised clay.

Photo 24: Only one small area of supporting *Themeda* was noted to remain.

Photo 25: The density of the grass and herbaceous layer precludes the possibility for the area to now support a viable population of *Hibbertia fumana*.

Boronia Road, North St Marys

A diverse herbaceous layer was observed in recently burnt sections of the powerline easement at North St Marys. Most locales including the adjacent wooded areas and containing PCT 724 were heavily infested with dense *Eragrostis curvula* tussocks, and this was smothering the ground layer.

Flowering species noted in one burnt area included *Murdannia graminea*, *Tricoryne elatior*, *Hypoxis hygrometrica* var. *hygrometrica*, *Isotoma fluviatilis*, *Ophioglossum lusitanicum* and *Hibbertia diffusa*. All of these plants were non-discernible under the adjoining tree cover and within the dense *Eragrostis* tussocks.

In the area inspected no indicative co-occurring species or habitat niches were noted that indicate likely potential habitat for *Hibbertia fumana*. Although the survey was very limited in its extent and duration, this area was assessed as unsuitable habitat for *Hibbertia fumana*.

Photo 26: East of and to the south of Boronia Road North St Marys.

Photo 27: North St Marys electricity easement environs.

Electricity Substation vicinity Kurrajong Road and Boronia Road, North St Marys

The selection of the electricity substation in the vicinity of Kurrajong Road and Boronia Road North St Marys is based on the BioNet records previously mentioned in addition to a BioNet record for *Hibbertia pedunculata* and PCT mapping on the Spatial Viewer. The fact that *Hibbertia pedunculata* was noted at the time of the BioNet entry indicates that the ground layer in that area was sufficiently intact to support diminutive species.

Many of the potential habitat zones along Ropes Creek have been significantly modified leaving a narrow band of vegetation along the immediate riparian zone. The modified areas are managed for various uses including in the Boronia Park vicinity sports fields and at the southern end the North St Marys Off leash Dog Park. These areas can no longer be considered potential habitat.

The riparian zone of Ropes Creek was noted to be particularly impacted by stormwater runoff with the understorey seriously degraded in many of the locales inspected. Where not degraded the PCTs were assessed as unsuitable for *Hibbertia fumana* based on current known ecological requirements.

The invasive *Eragrostis curvula* also dominated extensive areas. The potential for *H. fumana* to occur in Ropes Creek area is therefore considered to be low.

Photo 28: Open areas of lateritised clay soil to the east of the substation and north of railway line west of Ropes Creek support *Hibbertia pedunculata* and provide potential habitat for *H*. *fumana*.

Photo 29: Slashed native vegetation within the powerline easement, a potential habitat area for *Hibbertia fumana*.

Photo 30: An indigenous regrowth area between the substation and western railway line is potential habitat for *Hibbertia fumana*.

Kemps Creek area

The vegetation in the immediate vicinity of Lots 1, 2 and 3 DP812284 has been variously described as PCT 883 by Eco Logical Australia (2013), Ecoplanning (2015) and the Vegetation 100km consolidated layer in the Spatial Viewer, and Shale Gravel Transition Forest by Envirotech (2013). It is currently identified on the spatial viewer as PCT 725 on Lots 1, 2 and 3 DP812284 and PCT 724 as occurring to the east and west.

The vegetation in the Kemps Creek area has been dramatically altered with clearing for agriculture and removal of trees for various uses such as fence posts and firewood. The precise abundance of the various *Eucalyptus* species through the area is difficult to ascertain. *Eucalyptus sclerophylla* is obviously a major component within limited areas with stands still occurring south of Elizabeth Drive adjacent to Bill Anderson Park and the adjacent school. Scribbly Gum also appears to have been a major component of the canopy within Lot 3 DP812284 prior to clearance as documented within the Eco Logical 2013 report, refer Photo 31.

Photo 31: Scribbly Gum was an obvious common component of the site (photo Eco Logical 2013).

The presence of both temporary moist swale habitat niches and a transitional vegetation type comprised of Scribbly Gums, Broad-leaved Ironbark, Thin-leaved Stringybark and Woollybutt in combination with lateritised soil provides moderate to high potential of occurrence of *Hibbertia fumana*.

A periodic moist depression occurring on Lot 3 DP812284 provides habitat for species such as *Xanthorrhoea minor* indicating that before disturbance the area was likely to have supported a relative open small moist heath patch within the broader plant community. Such areas are potential habitat for *Hibbertia fumana*.

Lot 1 & 2 DP812284 Clifton Avenue, Kemps Creek in the Penrith local government area

The remnant vegetation is located at the rear portion of Lot 2 and the adjoining Lot 1. No access was granted therefore site assessment was limited to "through the fence" observation made from the adjoining property, Spatial viewer information and literature review of the Envirotech 2013 assessment.

An assessment by Envirotech 2013 noted a relatively intact flora community and that there was a healthy seed bank evidenced by the regeneration of native vegetation in disturbed portions of the property.

Photo 32: *Xanthorrhoea minor* growing in a periodically moist depression (photo S. Douglas).

Envirotech considered the site to have high species diversity including “well-represented herbaceous, understory and canopy layers that were clearly identifiable”. Weeds were confined to the perimeter of the property.

The “through the fence” inspection noted moderate to high potential habitat for *Hibbertia fumana* as species requiring periodic moist soil were easily detected and minor swales were noted. The habitat is +/- contiguous with the remnant remaining on the adjacent block (Lot 3) being separated only by perimeter trails.

Several undocumented threatened species were observed within the site including *Hibbertia puberula*, *Dillwynia tenuifolia* and *Pultenaea parviflora*. It was considered likely that *Grevillea parviflora* would also exist in the area.

Photo 33: Remnant bushland on Lot 2 DP812284, photo taken through fence.

Note: Subtle variation in elevation and possible substrate consistency providing periodic damp conditions supporting range of species e.g. *Xanthorrhoea minor* and potential habitat for threatened plants such as *Grevillea parviflora* and *Hibbertia fumana*.

Lot 22 DP 60122, 1541A Elizabeth Drive Kemps Creek and Lot 2 DP 587135, 146B Clifton Avenue Kemps Creek

Two blocks in the Kemps Creek area (Lot 22 DP60122 and Lot 2 DP 587135) are assessed as having a low to moderate probability of occurrence for *Hibbertia fumana*.

The majority of the understorey on Lot 2 DP 587135 could not be observed. It is included as potential habitat based on its continuity and close proximity to observed potential habitat areas. The area is mapped as PCT 724 thinned on the spatial viewer. Lot 22 DP60122 was assessed by ''through the fence'' inspection. The area is mapped as PCT 724 thinned on the spatial viewer. Much of the observable portions of the site are disturbed with weeds and fill dumping. Small areas were noted to contain an intact ground layer.

Photo 34: Lot 22 DP 60122, photo through fence taken from the adjoining block.

Note: small areas of regenerating native vegetation and intact ground layer occur within Lot 22 DP 60122. These provide potential habitat for threatened taxa.

Photo 35: View from south western corner of Lot 3 DP812284 into Lot 22 DP 60122.

Note: degradation of habitat by fill dumping and invasion of weeds, notably dense swathes of *Eragrostis curvula.*

Photo 36: Evidence of clearing, fill dumping and weed invasion degrading the habitat potential for threatened species Lot 22 DP 60122.

Lot 47 DP 734584 Kemps Creek

This block of land on Clifton Avenue is cleared and under investigation. It is most likely that similar moist habitat niches also occurred on this block. If so, they may have supported populations of *H. fumana* prior to clearing. From the most recent 31/10/2018 Google Earth imagery no habitat now remains on Lot 47. A narrow strip of very low potential habitat remains roadside.

Photo 37: Street view Google earth November 2016 of block to the north of Lot 3 DP812284.

Photo 38: Street view Google earth November 2016 of block to the north of Lot 3 DP812284.

Photo 39: Location of Lot 47 DP 734584, Lot 3 DP812284, Lot 2 DP587135 and Lot 22 DP601022.

Bushland Remnants Lot 4 DP812284 373 381 Clifton Road and Lot 6 DP812284, 316 Clifton Road, Kemps Creek

There are two blocks on the east side of Clifton Road that both have suitable habitat type although they are disturbed. These blocks have low to moderate probability for the species to occur.

The assessment was made from data shown in the Spatial Viewer from two BAM plots located on Lot 6. Species recorded include:

BIO WSAN 13: *Eucalyptus fibrosa* 15% coverage, *Eucalyptus globoidea* 1%, *Melaleuca decora* 2% and *Melaleuca nodosa* with a 15% coverage. Other species recorded each with a 1% coverage include: *Ozothamnus diosmifolius*, *Dillwynia sieberi*, *Dodonaea viscosa*, *Bursaria spinosa*, *Exocarpos cupressiformis*, *Aristida vagans*, *Lomandra gracilis*, *Daviesia ulicifolia*, *Dillwynia parvifolia*, *Pultenaea microphylla*, *Einadia hastata*, *Phyllanthus hirtellus*, *Pratia purpurascens*, *Eragrostis leptostachya*, *Entolasia stricta*, *Lepidosperma gunnii*, *Lepidosperma laterale*, *Cyathochaeta diandra*, *Lomandra longifolia*, and *L. multiflora*.

The only weed recorded in the BAM data is *Eragrostis curvula* with a 2% coverage.

BIO WSAN 14: *Eucalyptus globoidea* 30%, *Melaleuca decora* 2%, *Bursaria spinosa* 1% and *Cassinia uncata* 1% coverage. Ground layer species recorded cover 45% of the ground layer. They include: *Einadia hastata*, *Lomandra multiflora*, *Entolasia stricta*, *Eragrostis brownii*, *Cynodon dactylon*, *Dichelachne micrantha* and with *Microlaena stipoides* a 40% coverage.

Weeds in total had an 8% coverage, species recorded are: *Axonopus affinis*, *Sporobolus creber*, *Hypochaeris radicata*, *Sida rhombifolia*, *Eragrostis curvula* 1%, *Senecio madagascariensis*, and *Setaria parviflora*.

Photo 40: Google Earth image of Lot 6 DP812284 viewed from Clifton Road.

Remnant Vegetation North of Elizabeth Drive, Kemps Creek

The following Lots contain potential habitat for *Hibbertia fumana*: Lot 1 DP747285 1521 – 1539 Elizabeth Drive, Lot 1 DP1212980 1503 Elizabeth Drive, Lot 10 DP 1087346 1495 Elizabeth Drive Lot 16 DP2566 1491 Elizabeth Drive and Lot 1 DP 1o90754 1481-1489 Elizabeth Drive.

The two vegetation remnants north of Elizabeth Drive and south of Lot 2 DP812284 of land were assessed by ''over the fence'' and ''drive-by'' observation as access was not granted at the time of survey. Both sites were noted to have potential habitat from information contained within the spatial viewer, field observation revealed the small observable areas to be in poor condition and with low habitat suitability. Most of the vegetation was not able to be seen from the roadside.

The majority of the largest remnant Lot 1 DP747285 was not visible from the road. It is a large block extending northward from the road and adjoining the intact remnant on Lot 2 DP812284. Google Earth imagery provides evidence of potential moist swales to be present on the site. There is no BAM Plot data available for this site. The spatial viewer maps two vegetation types PCT 1067 thinned and PCT 725 thinned on the site providing potential likely habitat for the species. The remnant is bordered by a wholesale nursery in the west and a quarry to the east. Numerous site disturbances such as large areas of fill emplacement are observable on Google Earth Imagery providing evidence of degradation of habitat across much of the site.

The smaller remnant is bordered by the quarry on two sides and rural residential properties on Elizabeth Drive, consequently the impact of edge effects is likely to be high. Two BAM plots are located in this remnant and the Spatial viewer maps the site as PCT 725. The information provides some insight into the habitat.

BIO WSAN 10: *Angophora subvelutina* 15%, *Eucalyptus tereticornis* 5%, *Allocasuarina littoralis*, *Acacia decurrens*, *Ozothamnus diosmifolius*, *Acacia elongata*, *Cryptandra spinescens*, *Eragrostis brownii*, *Themeda australis*, *Glycine clandestina*, *Solanum prinophyllum*, *Hibbertia aspera*, *Microlaena stipoides* 50%, *Panicum simile*, *Eragrostis brownii*, *Cynodon dactylon, Lomandra multiflora*, *Juncus usitatus*, *Dichondra repens* and *Lepidosperma laterale*.

Weeds recorded in the BAM Plot include: *Ligustrum lucidum*, *Verbena bonariensis*, *Setaria parviflora*, *Bidens pilosa*, *Sonchus oleraceus*, *Eragrostis curvula*, *Senecio madagascariensis*, *Cyperus eragrostis*, *Ehrharta erecta*, *Anagallis arvensis*, *Araujia sericifera*, *Passiflora subpeltata*, *Chloris gayana*, *Axonopus compressus*, *Conyza* sp., *Sida rhombifolia*, and *Asparagus asparagoides*.

BIO WSAN 9: *Angophora floribunda*, *Eucalyptus tereticornis*, *Melaleuca decora, Acacia decurrens*, *Ozothamnus diosmifolius*, *Bursaria spinosa*, *Dillwynia sieberi*, *Themeda triandra*, *Glycine tabacina*, *Einadia trigonos*, *Opercularia diphylla*, *Brunoniella australis*, *Centella asiatica*, *Pratia puberula*, *Polymeria calycina*, *Microlaena stipoides*, *Aristida vagans*, *Entolasia marginata*, *E. stricta*, *Paspalidium distans*, *Dichelachne crinita*, *Echinopogon caespitosus*, *Cynodon dactylon*, *Lomandra multiflora*, *Carex inversa*, *Dichondra repens*, *Lepidosperma laterale*, *Lomandra filiformis* and *Cheilanthes sieberi*.

Weeds recorded in the BAM Plot include: *Senecio madagascariensis*, *Ehrharta erecta*, *Asparagus asparagoides*, *Cirsium vulgaris*, *Pennisetum clandestina*, *Cuscuta campestris*, *Sida rhombifolia*, *Opuntia stricta*, *Plantago lanceolata*, *Tradescantia fluminensis* and *Hypochaeris radicata*.

The representativeness of the habitat information contained within the BAM plot data is unknown. It is also unknown whether or not localised habitat niches prevail within the broader vegetation type as observed at other locales at Kemps Creek. Accordingly, the presence of *Hibbertia fumana* could not be ruled out though the likelihood of occurrence was assessed as low.

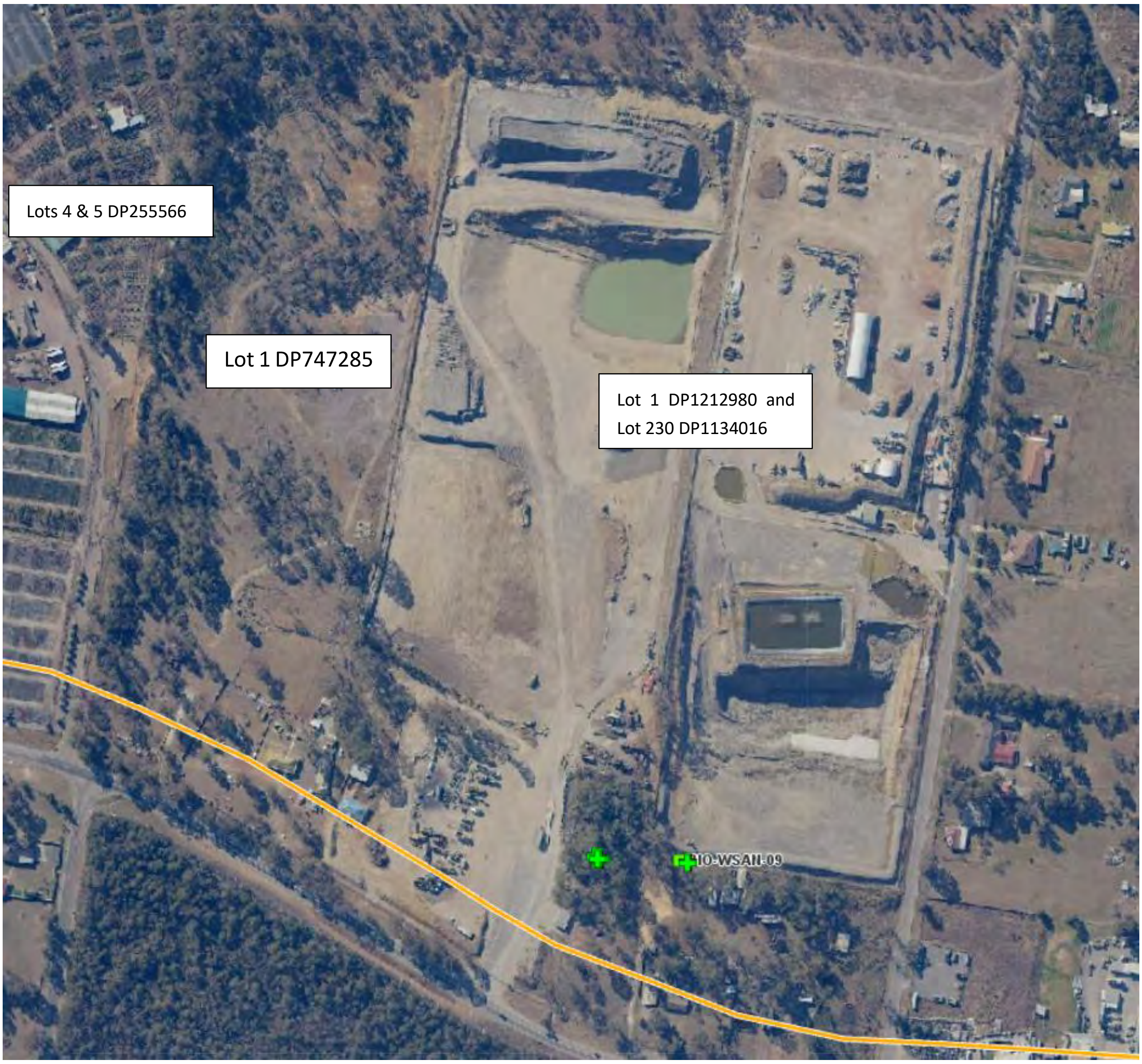


Photo 41: Location of BAM plots BIO WSAN 9 and BIOWSAN 10.

Note: Labels show the location of Lot 1 DP716403, Lots 4 and 5 DP255566, Lot 1 DP1212980 and Lot 230 DP1134016.

Photo 42: Land use practices have impacted upon the biological integrity of the site.

South of the SUEZ landfill site

Lot 4 DP860456, Elizabeth Drive, Kemps Creek.

Inspection of Lot 4 DP860456 was not granted. The area will not be certified due to pending investigation into clearing.

The determination of potential habitat occurring on Lot 4 DP860456 was therefore based on the information contained within the spatial viewer and google earth imagery. Drive by inspection was also constrained by the high volume of trucks entering and exiting the site and the adjoining Suez approved facility. There is a moderate probability that the species occurred in Lot 4 DP860456, as the spatial viewer identifies the area to have contained both PCT 725 and 724. The Google Earth imagery (Photo 43) shows a distinct change in vegetation and two farm dams (the larger on the adjoining property) indicating the presence of a moist depression. Periodically moist depressions in such habitats in the Kemps Creek area are known to support Threatened Species such as *Grevillea parviflora* e.g. at the bushland adjacent Bill Anderson Reserve. *Grevillea parviflora* is a co-occurring species with *Hibbertia fumana* at Moorebank.

Lot 4 is now mostly cleared and under investigation, with high volumes of fill emplacement being observe adjacent Elizabeth drive and the Suez facility 1. A linear band of vegetation remains in the central portion of the site.

Photo 43: Lot 4 DP860456 showing moist swale in the central portion of image prior to clearance and fill emplacement.

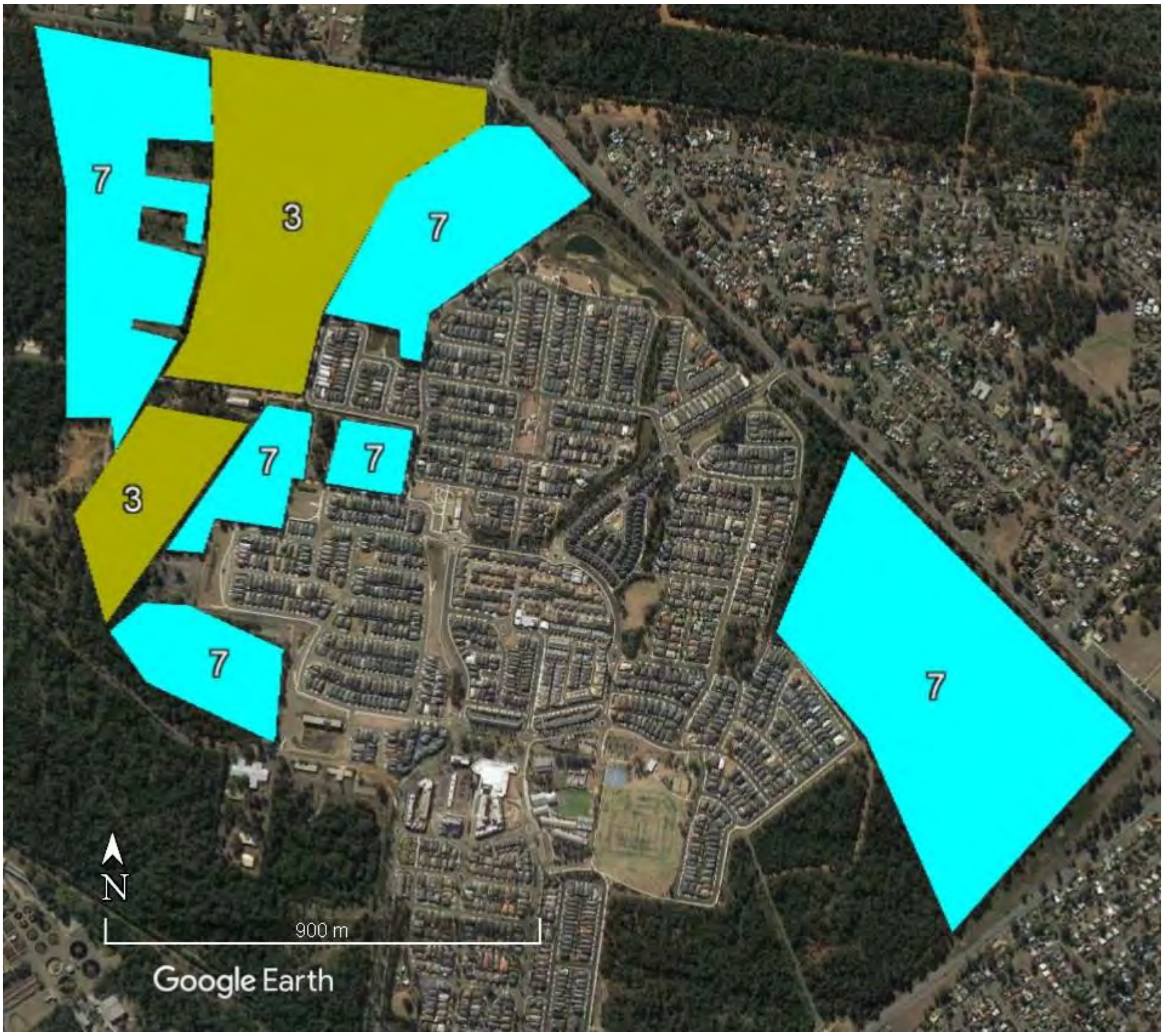
Photo 44: Google Earth Imagery 31/10/2018 Lot 4 DP860456 showing high volume of fill emplacement across most of the site. A small area remains providing some habitat potential.

Photo 45: Fill batter at northern end of Lot DP860456, South of SUEZ facility.

Note: This area is identified as not to be certified on the spatial viewer. Photo taken through fence from the adjoining SUEZ facility.

4.5.2 DETERMINATION OF SPECIES POLYGONS

Based on the available vegetation mapping, site survey and knowledge of the species habitat requirements, the following maps show the polygons of likely habitat and the estimated probability for the species to occur.



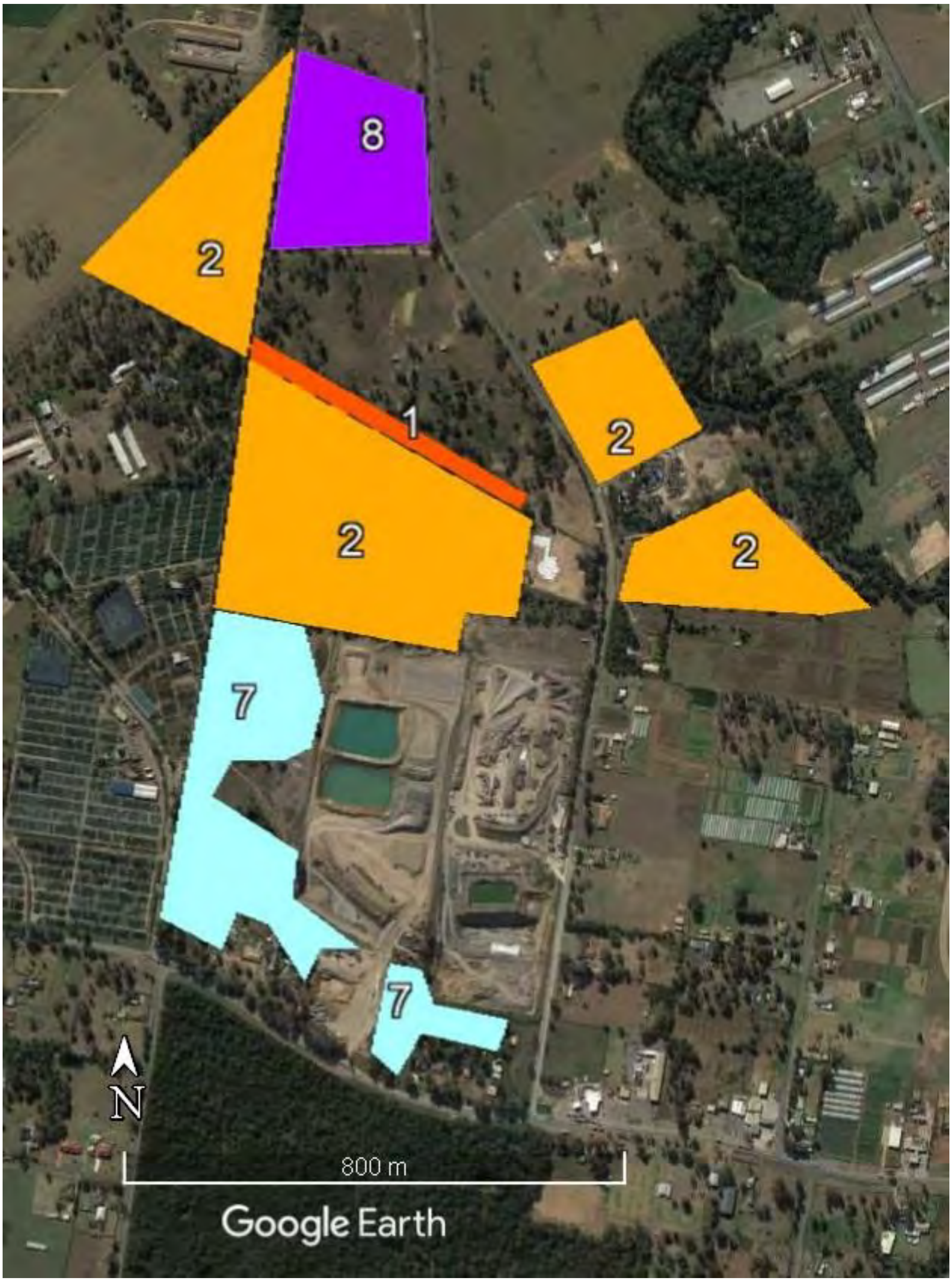
Map 11: Wianamatta Regional Park potential habitat sites.

Key: Within footprint, low probability, olive green - 3.

Proximate to footprint, low probability, light blue - 7

Map 12: Ropes Creek area potential habitat sites.

Key: Outside footprint, low probability, peach - 5



Map 13: Potential habitat sites in the Kemps Creek area

Key to map:

Removed from certification area, moderate probability for the species – dark orange - 1

Adjacent footprint, moderate probability for the species – pale orange - 2

Adjacent footprint, low probability for the species – pale blue - 7

Adjacent footprint, moderate probability for the species prior to clearing – purple - 8

Map 14: Former habitat site south of the SUEZ landfill site.

Key: Adjacent footprint, former moderate probability, purple - 8

4.5.3 ESTIMATE OF AREA OF HABITAT

The following are estimates of the potential habitat for the species. Note that the habitat could be small niches within these areas.

Greater Penrith to Eastern Creek Urban Release Investigation Area

Wianamatta Regional Park

In footprint, low probability, 32 ha.

Adjacent to the footprint, low probability, 77 ha

Ropes Creek vicinity

Adjacent footprint, low probability, 5 ha.

Western Sydney Aerotropolis Growth Area

Kemps Creek area

Removed from certification area, moderate probability, 1.47 ha

Adjacent footprint, moderate to high probability, 14.4 ha

Adjacent footprint, moderate to low probability, 15.6

Adjacent footprint, low probability, 10.25 ha

Adjacent footprint, moderate probability, cleared, 6.25 ha.

South of SUEZ landfill

Adjacent footprint, moderate probability, cleared, 4.4 ha.

In summary, 32ha of habitat with a low probability of the species occurring are within the development footprint, and more than 100 ha of habitat with moderate to low probability of species occurrence are outside the footprint but are likely to suffer from anthropogenic impacts caused by the development. More than 10 ha with moderate potential have recently been partly cleared.

5. Information used in the assessment

Information used in this assessment includes taxonomic papers, BioNet and ALA records of the target species, Critically Endangered Listing, online Threatened Species profile and associated documents, personal observations and site inspections, and the spatial viewer including the layers: survey access and coverage, (BAM plots, polygons and transects), PGA layer and geology and soils. Reference was made to Flora Appendix 2 & 3 of Western Sydney Biodiversity Survey NPWS 1997 for records of *Hibbertia species* observed in that study.

6. References

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7. Appendices

Appendix 1. Curriculum Vitae

Robert Miller *Curriculum Vitae*

Contact Details:

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Current Position:

Principal of Cumberland Flora & Fauna Interpretive Services

Qualifications:

Associate Diploma Horticulture from the University of Western Sydney (formerly Hawkesbury Agricultural College), conferred on 17 April 1982

Journal Articles

H.R. Toelken & R.T. Miller **2012** Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in Journal of the Adelaide Botanic Gardens, Vol. 25.

Miller J and Miller R **2005** Aquatic macroinvertebrates of headwater streams in the south east forests – diversity and conservation management issues, Wetlands (Australia) 23 (1).

Employment Record

1993 – present

Cumberland Flora and Fauna Interpretive Services

Principal - flora surveys, plant identifications, vegetation assessment, project impact assessment, bush regeneration, rehabilitation, habitat enhancement, seed collection and propagation services.

1990 - 1997

Sylvan Grove Native Gardens

Curator of gardens and adjoining bushland - maintenance of and improvement to the plant collection, training and supervision of staff, liaison with other botanic gardens, guided tours, technical advice.

1982 - 1990

Sylvan Grove Native Gardens

Horticulturist Specialising in Australian Flora - collection, propagation, identification, and growing of native plants.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES INFORMATION AND RELEVANT EXPERIENCE

Cumberland Flora and Fauna Interpretive Services have provided technical expertise since 1993 to numerous clients including Local Government, NSW Roads and Maritime, NSW Office Environment Heritage NPWS and community groups. Following is a list of some of our projects and clients:

REPORT	CLIENT
Expert advice for Conservation Assessment of *Solanum celatum* Eren Delgado 16/04/2018, Science Division, NSW Office of Environment and Heritage	OEH
Saving our Species (SoS) project for *Pomaderris adnata* a post fire population census Grid D 2018	OEH
Provision of expert advice to update the current ecological data for southern NSW threatened flora species, as part of the review of biodiversity assessments under the Biodiversity Conservation Act 2016.	OEH

REPORT	**CLIENT**
Expert witness in botany Residents Against Intermodal Development Moorebank Incorporated v NSW Minister for Planning and Anor – NSW Land & Environment Court Class 1 Proceedings No. 2017/81889. Review of project documentation, in particular the various biodiversity assessments including the BAM assessment for the project and Individual Expert Witness report of Dr David Robertson 15 October 2017; Site inspections to identify the location of and/or potential habitat for *Hibbertia fumana*, *Hibbertia puberula*, *Grevillea parviflora*, *Persoonia nutans*, *Acacia bynoeana*, provision of an expert report in accordance with Division 2 of Part 31 of the UCPR; confer with the other parties experts at a joint conference and produce a joint expert report; and f appear at the section 34 conciliation conference	EDO
Saving our Species (SoS) project for *Pomaderris adnata* a population census 2017	OEH
Central Coast Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Great Lakes Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2015 – Vegetation Consultant	OEH
Clarence Colliery Discharge Investigation April 2015	OEH
Vegetation Assessment as part of the Lachlan Wetlands Condition Assessment Project October 2013 – May 2014	Lachlan Catchment Management Authority
Field expertise and guidance in the Sydney basin to PhD candidate Karen Muscat studying the molecular phylogenetics and morphology of the genus Dianella with close scrutiny of the variation in the D. *caerulea* group of species in eastern Australia	Volunteer to University of Melbourne
Survey for *Pomaderris adnata* to determine population size, structure, occupancy and threats 2014	NPWS Illawarra Region
Survey of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats. Collection of voucher herbarium material for taxonomic review June 2014	OEH
Survey of the southern populations of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats May 2014	OEH
Investigation of works within the Sublime point precinct Illawarra Escarpment State Conservation Area February 2014.	NPWS Illawarra Region
Identification of Hibbertia species in proposed control burn sites Victoria Road precinct Dharawal National Park.	NPWS Illawarra Region
Assessment of impact of infrastructure upgrade Victoria Road, Dharawal National Park – location of threatened species.	NPWS Illawarra Region
APPEAL IN RESPECT OF PROPERTY AT Lot 1 and 2 DP 224431 Site 2 Sturdee Avenue, Bulli	Roy ‘Dootch’ Kennedy

REPORT	CLIENT
Expert Witness Report Relating to Some Environmental Issues Land & Environment Court of New South Wales PROCEEDINGS NO 10982 of 2012	Roy 'Dootch' Kennedy
Field surveys, collection, pressing, curation of botanical specimens and contributions of notes in association with the manuscript "Notes on Hibbertia subgen. Hemistemma (Dilleniaceae) 7. Eight new species, a new combination and four new subspecies from mainly central New South Wales H.R. Toelken & R.T. Miller 2006 - 10 July 2012	Volunteer to Adelaide Botanic Gardens
Vegetation Surveys and assessments & input into the preparation of REF for proposed car-park and amenities Victoria Road Precinct Dharawal National Park November 12.	NPWS Illawarra Region
Office of Environment and Heritage – Priority Action Statement Expert Consultant Interviews June 2012 – January 2013	OEH
Vegetation Surveys and assessments & input into the preparation of REF for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking tracks in Dharawal National Park input into conservation risk assessments 2011 – 12.	NPWS Illawarra Region
Nomination to list Prostanthera saxicola R. Br. S. Str. as an Endangered Species under the NSW TSC Act September 2011	
Field surveys, collection, pressing and curation of botanical specimens of undescribed Kunzea to assist in the taxonomic circumscription of previously presumed extinct, rare and/or poorly known taxa for Dr. H.R. Toelken Honorary Research Associate State Herbarium Science Resource Centre Department of Environment and Natural Resources SA 2011	Volunteer to Adelaide Botanic Gardens
Significant Plant Survey – Maddens Plains Forest Path to Mount Mitchell Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Significant Plant Survey – Wongawillii Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Kembla State Forest Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Site Inspections and Vegetation Survey of Proposed Minor Track Re-Alignments: Forest Path to Woodward Track & Sublime Point to Austinmer Track Maddens Plains To Sublime Point Precinct Illawarra Escarpment State Conservation Area August 2010	NPWS Illawarra Region

REPORT	CLIENT
Sandon Point Aboriginal Place and Kuradji Lands Vegetation Management Plan April 2010	Illawarra Aboriginal Land Council, Wollongong Council, Southern Rivers Catchment Management Authority.
Forest Path to Woodward Track Precinct Track-head Realignment Maddens Plains IESCA Vegetation Survey April 2010.	NPWS Illawarra Region
Bushland Conservation Project 95 Glendiver Road, The Oaks 2008	A & S Fitzsimmons / Hawkesbury Nepean Catchment Management Authority
Significant Plant Survey – Maddens Plains Forest Path to Woodward Track Precinct Illawarra Escarpment State Conservation Area June 2007	NPWS Illawarra Region
Nomination of Hibbertia "Bankstown Airport" (R.T. Miller & C.P. Gibson s.n. 18/10/2006) as Critically Endangered under the Environment Protection and Biodiversity Conservation Act	Bankstown Bushland Society
Proposal to Demolish A Derelict Amenities Block at Deepwater Park Webster Street Milperra Environmental Assessment of Impacts	Bankstown City Council
Significant Plant Survey – Sublime Point to Panorama House Precinct Illawarra Escarpment Conservation Area August – September 2006	NPWS Illawarra Region
A Consultant for Priority Action Statement Workshop July 2005	NPWS
PHD research assistance – 'The Benefits of Riparian Vegetation in Maintaining Water Quality as Assessed Using Biological Indicators".	UNSW
Plan of Management for Part Lot 11 Dp 1049307 Kurrajong Road Prestons January 2005	Sule College
Preliminary Investigation & Vegetation Survey of Lands At Prestons Bounded By Maxwells Creek, Kurrajong Road, Ash Road & The Western Sydney Orbital December 2003	Sule College
Supply and collection of seed for a research project entitled: Factors Affecting Seed Germination and Microrrihzal Development of the Epacrid: *Woolsia pungens* (2001-2003)	UNSW
Compensatory Habitat Assessment Western Sydney Orbital March 2004	RTA
Compensatory Habitat Assessment Western Sydney Orbital July 2002	RTA
Compensatory Habitat Assessment of Flora at Rouse Hill, Doonside, Cecil Hills & Kemps Creek for The Western Sydney Orbital March 2002	RTA
Compensatory Habitat Assessment Western Sydney Orbital November 2001	RTA
Preliminary Vegetation Survey Between Lawson Rd & Alfords Point Rd, Menai as Part of The Proposed Bangor Bypass 2001	RTA
8-Part Tests for The Proposed Bangor Bypass 2000	RTA
Preliminary Vegetation Survey for The Proposed Bangor Bypass 2000	RTA
Species Impact Statement for the Western Sydney Orbital 2000	Sinclair Knight Mertz

REPORT	**CLIENT**
Review of Environmental Assessments – Proposed Cricket Ground - Louisa Reserve, The Crest of Bankstown 2000	Bankstown Bushland Society
Review of Environmental Assessments – Proposed Olympic Criterium Circuit the Crest Statement of Environmental Effects	Bankstown Bushland Society
Vegetation Survey – 60 Yanderra Road, Yanderra 1999	Mr. Brian Timmis
Review and Comments on Environmental Assessment – Bankstown City Council - Proposed Cricket Ground – 8 – Part Test- The Crest 1999	Bankstown Bushland Society
Vegetation Survey and Review of Proposed Sand Mining Restoration Works – Howard Park, Lansvale 1999	Chipping Norton Lakes Authority
Rare Species Survey – Blue Mountains & Central Western Slopes 1999	National Parks & Wildlife Service
Vegetation Survey - Kookaburra Road and Camden Valley Way Intersection 1999	Roads & Traffic Authority
Chullora Detention Basin Wetlands Habitat Enhancement 1998	Business Land Group DUAP
Vegetation Study Maxwells Creek Trunk Drainage Stage 1 Vegetation Assessment 1998	Bewsher Consulting
Vegetation Study Prestons Urban Release Area Part 3 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 2 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 1 1998	Liverpool City Council
Survey of Remnant Flora for Proposed Nth Liverpool Rd to Edensor Rd Interim Transitway 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management Discussion Paper 1998	Roads & Traffic Authority
Eastern and Western Alignments WSO Cecil Hills Flora Study 1998	Roads & Traffic Authority
Valmay Road Development Vegetation Study 1998	LesryK Pty Ltd
Western Sydney Orbital Prestons To West Baulkham Hills Descriptive Inventory of Remnant Bushland 1998	Roads & Traffic Authority
Vegetation Survey River Road M5 East 1998	Roads & Traffic Authority
Tree Survey, Great Western Highway, Faulconbridge 1998	Roads & Traffic Authority
Eve & Marsh Street Wetlands M5 East 1997	Roads & Traffic Authority
Beverley Grove Bush M5 East 1997	Roads & Traffic Authority
Vegetation Survey - Salt Pan Creek Bridge Duplication M5 East 1997	Roads & Traffic Authority

REPORT	CLIENT
Survey of Flora: Trees and Shrubs, Princes Highway Interchange M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Adjacent to Proposed Exhaust Stack Henderson Avenue, M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Illoura Reserve, Adjacent to Air Intake Vent M5 East 1997	Roads & Traffic Authority
Lansdowne Reserve Survey of Remnant Flora 1997	Bankstown City Council
Villawood Drain Vertebrate Fauna Survey 1997	Bankstown City Council
Kelso Wetlands Survey of Remnant Flora 1997	Bankstown City Council
Deverall Park Survey of Remnant Flora 1997	Bankstown City Council
Louisa & McClean Reserves Bass Hill Survey of Remnant Flora 1997	Bankstown City Council
The Crest of Bankstown Survey of Remnant Flora 1997	Bankstown City Council
Lawson Bridge Roadworks Survey of Remnant Flora 1997	Roads & Traffic Authority
Davidson Street Scrub Survey of Remnant Flora 1997	Strathfield Council
Freshwater Creek Bushland Survey of Remnant Flora 1996	Bankstown Bushland Society for the EPA
Vegetation Survey Forest Lawn Cemetery Roadworks, Leppington 1996	Roads & Traffic Authority
Vegetation Survey Catherine Fields Road Intersection, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Springfields Road Intersection and Camden Valley Way, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Deepfields Road Intersection Camden Valley Way, Catherine Fields 1996	Roads & Traffic Authority
Picnic Point Reserve Vegetation Survey 1996	Bankstown City Council
East Hills Park Vegetation Survey 1996	Bankstown City Council
Monash Reserve Vegetation Survey 1995	Bankstown City Council
Vegetation Consultant on Plan of Management for Cox's Creek for the Endangered Green and Gold Bell Frog 1995	Urban Bushland Management
Smith Park Vegetation Survey 1995	Bankstown City Council
Flora and Fauna Survey, Villawood Stormwater Channel 1995	Bankstown City Council
Virginius Reserve Vegetation Survey 1994	Bankstown City Council
Carysfield Park Vegetation Survey 1993	Bankstown City Council

Ongoing research projects:

Private taxonomic research into the Australian plant genera Prostanthera, Westringia, Dianella, Thelionema, Viola and Hibbertia.

Private research into the invertebrate fauna of the Illawarra with particular emphasis on the Mayfly genus *Atalophlebia*

Flora of Bankstown" a botanical inventory

Botanical inventories of the Sublime Point and Maddens Plains precincts in the Illawarra Escarpment State Conservation Area

Other Publications & Reports

Miller, R.T. (1984 to 2006) numerous papers for the Prostanthera and Westringia Study Group Newsletters.

Miller, R.T. (1991) Vegetation Consultant on Eloura Nature Reserve Vegetation Survey: Report to Liverpool City Council, Greening Australia.

Miller, R.T. Vegetation Consultant on Salt Pan Creek Stage 1 Vegetation Survey: Report to Bankstown City Council, Ian Olsen.

Gibson, C.P. & Miller, R.T. Plant Species List for Bankstown's Natural Heritage: McLaughlin, L., BCC.

Gibson, C.P. & Miller, R.T. Flora of Bankstown Scientific Inventory of Botanical Heritage: Report to Australian National Parks and Wildlife Service, Gibson, C.P. and Miller, R.T. (in preparation).

Nomination of Prostanthera saxicola R. Br. s. str. As an Endangered Species under the NSW TSC Act November 2011

Special Projects

- "Flora of Bankstown" a botanical inventory
- Founder & Convener Cookson's Landcare Group Bulli (2003 – 2007)
- President, Society for Growing Australian Plants, East Hills Region, 1987-1995.

- Vice President, Society for Growing Australian Plants, East Hills Region, 1996.
- Plant Steward, Society for Growing Australian Plants, East Hills Region, 1987-1996.
- Leader of the Prostanthera Study Group Australian Plant Society, 1992 - 2010.
- Editor and publisher of Prostanthera & Westringia Study Group's Newsletter *The National Mint* and the Study Groups' Journal – *Lasianthos*.
- Vice President and Founding Member, Bankstown Bushland Society.
- Coordinator Grants Application, Bankstown Bushland Society.
- Bushland Regeneration Grants Project Manager, Bankstown Bushland Society:
  - Deverall Park Restoration and Rehabilitation Swamp Woodland ($17,880).
  - The Crest of Bankstown Restoration and Rehabilitation ($27,850).
  - Airport and Ashford Reserves Restoration and Rehabilitation Swamp Woodland ($45,000).
- Co-recipient of Save the Bush grant for Flora of Bankstown by Hon. Ross Kelly, Minister for Arts, Sports and Environment, 1992-93 ($11,050).
- Founding Member of Illawarra Grevillea Park, Bulli.
- Curator, Lamiaceae collection, Illawarra Grevillea Park, Bulli.
- Former Bankstown City Council's Bushfire Taskforce Community Representative.
- Former presenter of an adult education course in gardening at Bankstown Evening College.
- Development and curation of a private regional herbarium.
- Expert Witness for NSW Police murder trial
- Former appointee as Trustee of the Georges River State Recreational Trust by the Minister for the Environment (the Hon. Tim Moore).

Appendix 2. Taxonomic details for identification of *Hibbertia fumana*

Photo 46: *Hibbertia fumana* indumentum of axillary shoot and +/- sessile flower bud (R.T. Miller)

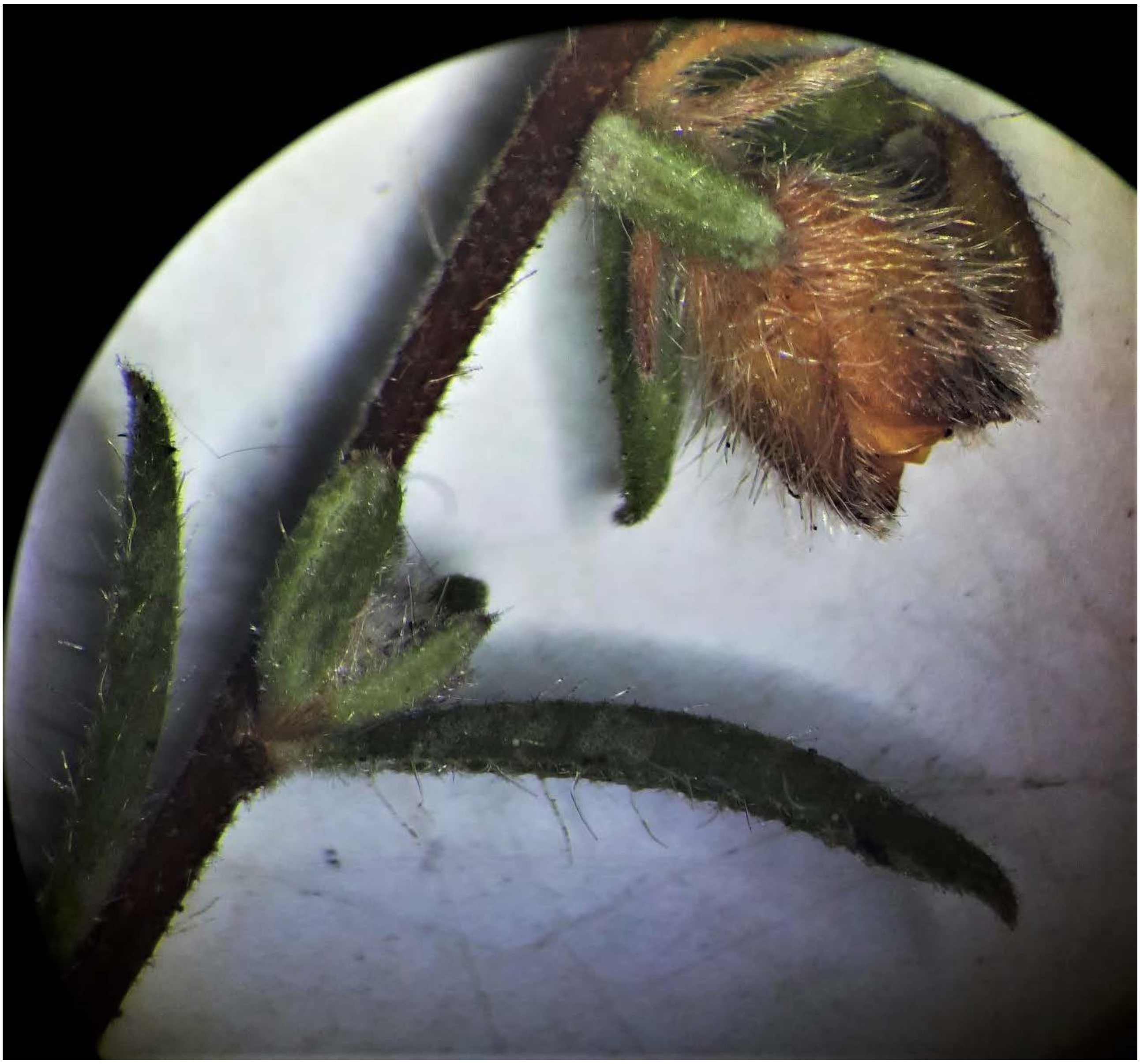


Photo 47: *Hibbertia fumana* indumentum of leaf, axillary shoots and flower buds (R.T. Miller).

Photo 48: *Hibbertia fumana* elongated flower peduncle after petal dehiscence on terminal shoots and indumentum characteristics of leaf undersurface and calyxes. (R.T. Miller).

Photo 49: *Hibbertia fumana* flower morphology (R.T. Miller).

Photo 50: *Hibbertia fumana* interpetiolar tuffs in leaf axils and short subequal multiangulate fascicled hairs characters of the branchlets (Robert T. Miller)

Photo 51: Tomentum characteristics of *Hibbertia fumana* approximate 5 cm from shoot apex. (R.T. Miller)

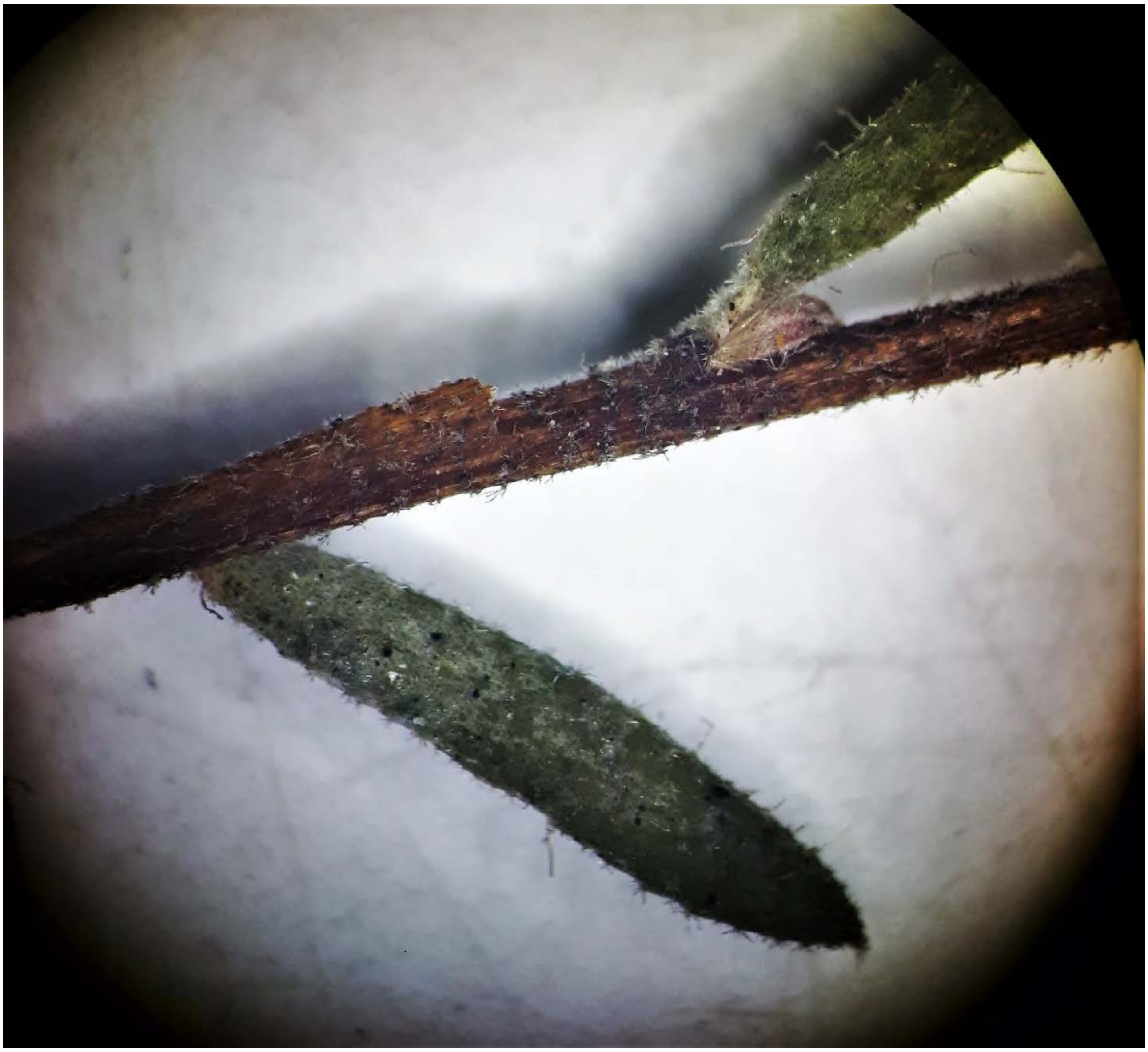


Photo 52: Leaf upper surface showing a reduction in tomentum.

Note: Leaf sample is approximately 12cm from tip (R.T. Miller).

Appendix 3. Comparison of taxonomic details for *Hibbertia* species

Photo 53: *Hibbertia pedunculata*: growing under an electricity easement.

A mature well-developed plant of *Hibbertia pedunculata* free of competition is particularly floriferous and unlikely to be misidentified as *Hibbertia fumana*

Photo 54: *Hibbertia pedunculata* showing flower characteristics noting the 3 styles and large number of anthers surrounding and obscuring the ovaries

Photo 55: *Hibbertia pedunculata* showing leaf, peduncle and calyx characteristics.

Photo 56: Plant of *Hibbertia empetrifolia* (R.T. Miller).

Photo 57: Closeup of leaf undersurface of *Hibbertia empetrifolia* (R.T. Miller).

Photo 58: *Hibbertia aspera* mature plant showing flower, leaf characters and a propensity to have woody branches

Photo 59: *Hibbertia aspera* flower showing distinct arrangement of anthers bent over the ovaries

Photo 60: *Hibbertia aspera* (R.T. Miller).

Photo 61: *Hibbertia aspera* showing tomentum on suckering new growth (R.T. Miller)

Photo 62: *Hibbertia dispar* showing procumbent growth habit, small-leaves and pedunculate flowers (R.T. Miller).

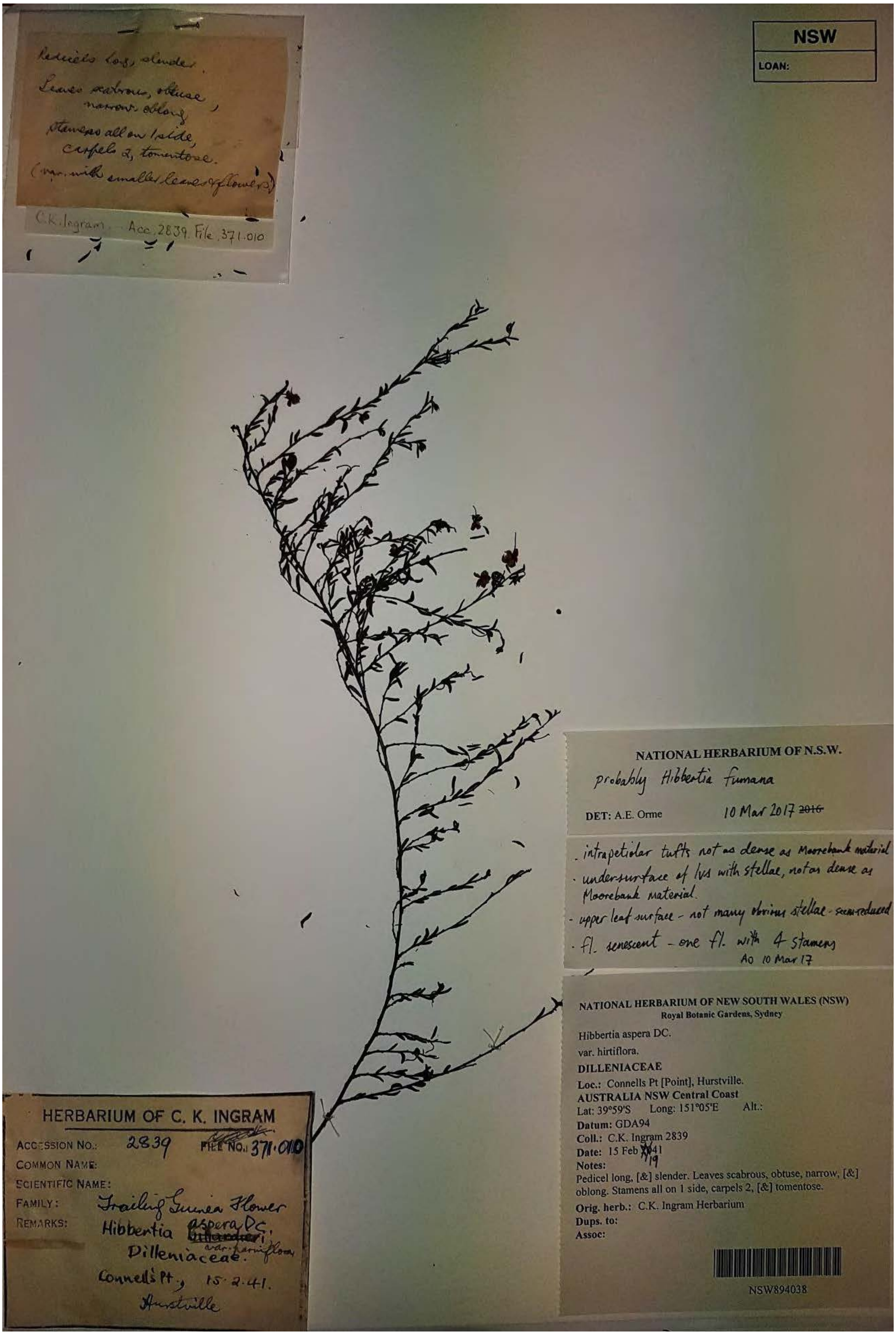
Photo 63: *Hibbertia dispar* showing apparent glabrous leaves and stems and +/- glabrescent floral parts of older growth in which much of the tomentum has “worn off”.

Photo 64: *Hibbertia dispar*: closeup of new growth showing tomentum characteristic

Photo 65: *Hibbertia dispar* showing much of the tomentum of the calyxes being “worn off”.

Photo 66: *Hibbertia dispar* showing the tomentum of the calyxes before being “worn off”.

Appendix 4. Specimen of *Hibbertia fumana* from Connells Point 1941



Expert report – *Hibbertia puberula*

Hibbertia puberula species group – Wilton and GMAC, Robert Miller, August 2018

Hibbertia puberula species group – WSA and GPEC, Robert Miller, December 2018

Strategic assessment for Cumberland Plain Conservation Plan

Hibbertia puberula species group

Hibbertia puberula subsp. *glabrescens* at Bankstown Airport

Report prepared for Department of Planning and Environment

By

Cumberland Flora & Fauna Interpretive Services

Robert Miller - August 2018

Executive Summary

Hibbertia puberula subsp. *extensa* and subsp. *puberula* are listed as an Endangered Species under the *Biodiversity Conservation Act 2016*. *Hibbertia puberula* subsp. *glabrescens* is listed as a Critically Endangered Species, being known from only one population at Bankstown. The species group is assessed as data-poor.

Survey for this report was limited by time constraints, lack of access to private property, survey outside the species' flowering season and years of preceding drought conditions. Assessment of potential habitat area relied on the expected presence of likely habitat, based on habitat of extant populations.

Specific habitat niches of potential occurrence include upper drainage lines, seepages especially those associated with exposed sandstone bedrock or slabs, margins of hanging swamps / wet heath, exposed sandstone rock plates, and large and small occurrences of colluvial or alluvial deposits.

Positive identification to species and subspecies requires flowers, which were not available, so *Hibbertia* that had leaf and stem characteristics consistent with *H. puberula* were considered to be that species. Despite the limitations, survey located three new populations of *Hibbertia* that had leaf and stem characteristics consistent with *H. puberula* within the growth areas and adjacent to the footprint.

H. puberula is a small shrub that could be severely affected by anthropogenic impacts resulting from development edge effects, particularly in areas downhill of development.

The assessment identified:

- Likely habitat for *Hibbertia puberula* subsp. *extensa* occurs within the footprint in the southern part of the WGA, habitat would be small seepages or wet heath within an area of 23ha.
- A further 278ha of land that could contain habitat niches for *H. puberula* subsp. *extensa* is adjacent to the footprint in the southern section of the WGA and the eastern side of the GMGA between Appin and Wedderburn.
- Likely habitat for *Hibbertia puberula* subsp. *glabrescens* occurs at Menangle Park. An area of approximately 92ha could contain likely habitat niches within the growth area footprint, and a further 31 ha of land containing likely habitat niches adjacent to the footprint.
- Likely habitat for *Hibbertia puberula* subsp. *puberula* occurs outside the development footprint at Milton Park, Kayess Park and in the vicinity of Bunbury Curran Creek reserve.
- Likely habitat for subspecies *puberula* within the development footprint occurs at Menangle Park (92ha), Gilead and Appin areas (8ha) and WGA (65ha).
- Likely and known habitat for subspecies *puberula* adjacent to the development footprint occurs at Menangle Park (31ha), Gilead and Appin areas (380ha) and WGA (680ha).

Survey during the flowering period is recommended, to identify the subspecies of *H. puberula* and to locate further populations within and adjacent the growth areas.

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Abbreviations

ALA	Atlas of Living Australia
AVH	The Australasian Virtual Herbarium
BAM	Biodiversity Assessment Method
BC Act	Biodiversity Conservation Act 2016
CFFIS	Cumberland Flora & Fauna Interpretive Services
DPE	NSW Department of Planning and Environment
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GMGA	Greater Macarthur Growth Area
IBRA	Interim Biogeographic Regionalisation for Australia
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
sp./spp.	species (species singular / plural)
s. str.	sensu stricto – in the narrow sense
subsp.	subspecies
WGA	Wilton Growth Area

1. Introduction

1.1 PURPOSE

The purpose of this expert report is to determine the potential for future urban development in identified growth areas of Western Sydney to impact on *Hibbertia puberula*, the subspecies of which are listed as an Endangered or Critically Endangered Species under the *Biodiversity Conservation Act 2016*. This report forms part of the Cumberland Plain Conservation Plan, which will be assessed under the:

- Biodiversity certification under the *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Biodiversity Assessment Method (BAM) sets out the framework and methods to be used for assessment of impacts to biodiversity to provide preferred conservation outcomes while also supporting the development approval process. Under the BAM an expert report can be used when adequate survey is not possible. An expert report can only be used for species to which species credits apply.

The expert report must document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report. The report must set out whether the subject species is likely to be present at the development site, and if present then the report must estimate, in the case of a species such as *Hibbertia puberula*, the area of habitat where the species is likely to be impacted, as well as areas from which it is known to occur in which it will be impacted.

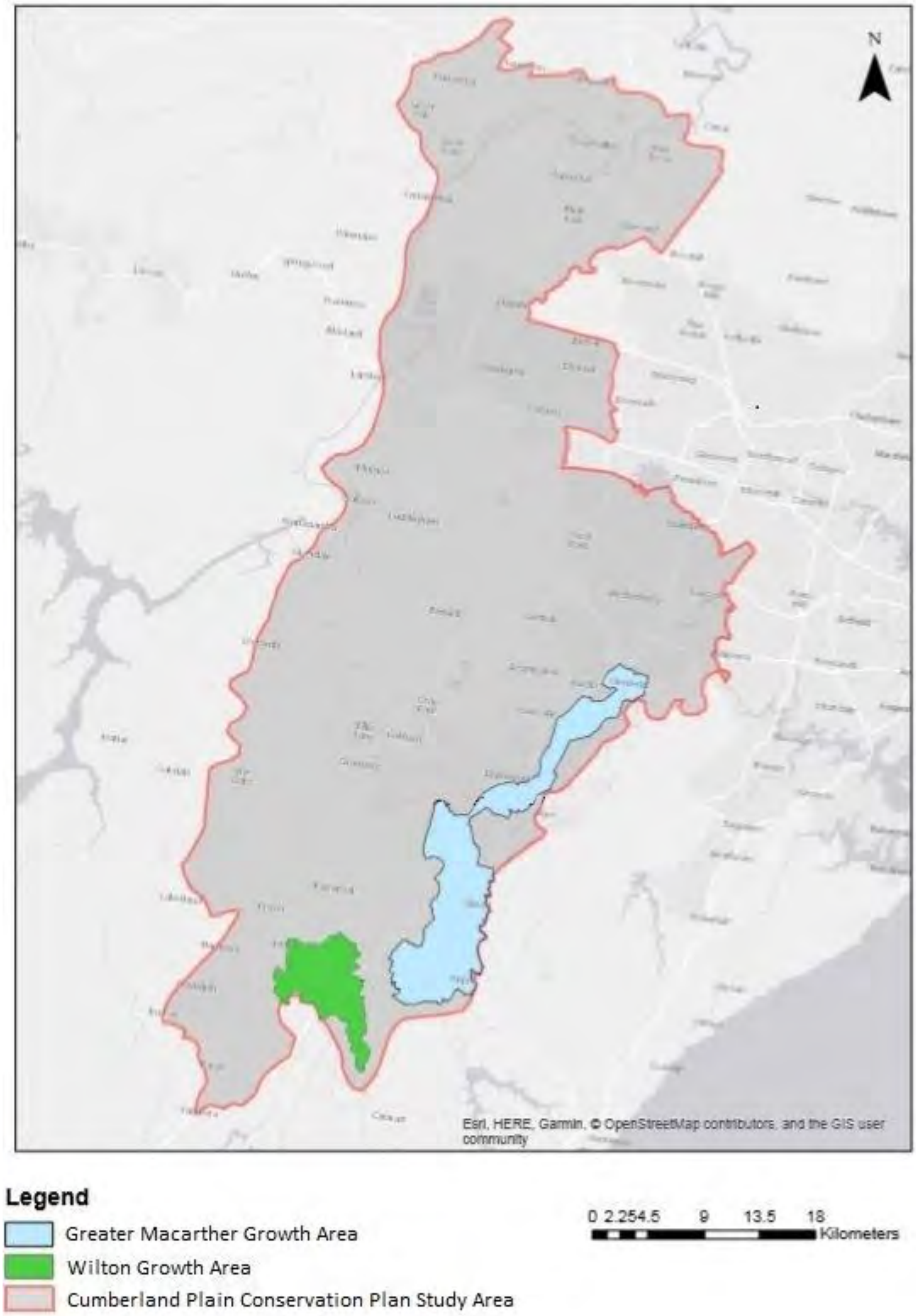
1.2 PROJECT CONTEXT

The NSW Government is planning for future urban development in Western Sydney. Four growth areas have been identified, these are Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These growth areas are all located within the Cumberland Subregion in version 7 of the Interim Biogeographic Regionalisation for Australia (IBRA) (2016).

As part of the planning for this future development, the Department of Planning and Environment (DPE) is preparing the Cumberland Plain Conservation Plan. This is a strategic regional assessment that will lead to the identification of preferred conservation outcomes for the Cumberland subregion.

1.3 STUDY AREA

Map 1 shows the Cumberland Plain Conservation Plan Study Area and the two growth areas of Greater Macarthur (GMGA) and Wilton (WGA).



Map 1: Cumberland Plain Conservation Study Area and Growth Areas

Map source: NSW Department of Planning and Environment.

1.4 SPECIES SURVEYS

<u>Survey timing</u>

Survey for species such as *Hibbertia puberula* are usually carried out during the flowering period of October to December because the plant is a small shrub which can be quite cryptic. The bright yellow flowers, although small c. 10 – 20mm are readily discernible in bushland environs. Surveying in the flowering period makes species counts more reliable and relatively easy. Without flowers the tiny green leaves can hide amongst leaf litter, grasses and other ground covers making species counts near impossible and extremely unreliable.

The survey for this expert report was initially required to be completed within the month of June, when the species is not in flower. Further, the survey follows several very dry years which has caused high levels of leaf fall from trees and retraction of many shrubs to ground level. The following two photos show a close-up view of a *Hibbertia puberula* and the same plant from 2m away. These photos demonstrate the difficult task of finding *Hibbertia puberula* in the field when it is not in flower.

Photo 1: *Hibbertia puberula* plant at Smith's Creek Reserve at Campbelltown.

Photo on the left shows a *Hibbertia puberula* plant, the photo on the right shows the same plant from 2m distance. Scale: individual *Hibbertia* leaves are c.5mm. The photo depicts the largest and most obvious plant found.

<u>Survey methods</u>

To compensate for some of these difficulties the survey for this report followed the following steps:

- Visit known localities of the species, locate some *Hibbertia puberula* plants, and take particular note of the habitat characteristics, plant habit, co-occurring species and population density in the context of the protracted rainfall deficit and;
- Examine the Plant Community Type maps provided by the Department of Planning and Environment;
- Locate potential habitat sites based on the mapping and expert knowledge of the plant habitat requirements;
- Visit as many of these potential habitat sites as possible, considering time and access constraints; and
- Survey these potential habitat sites for the species.

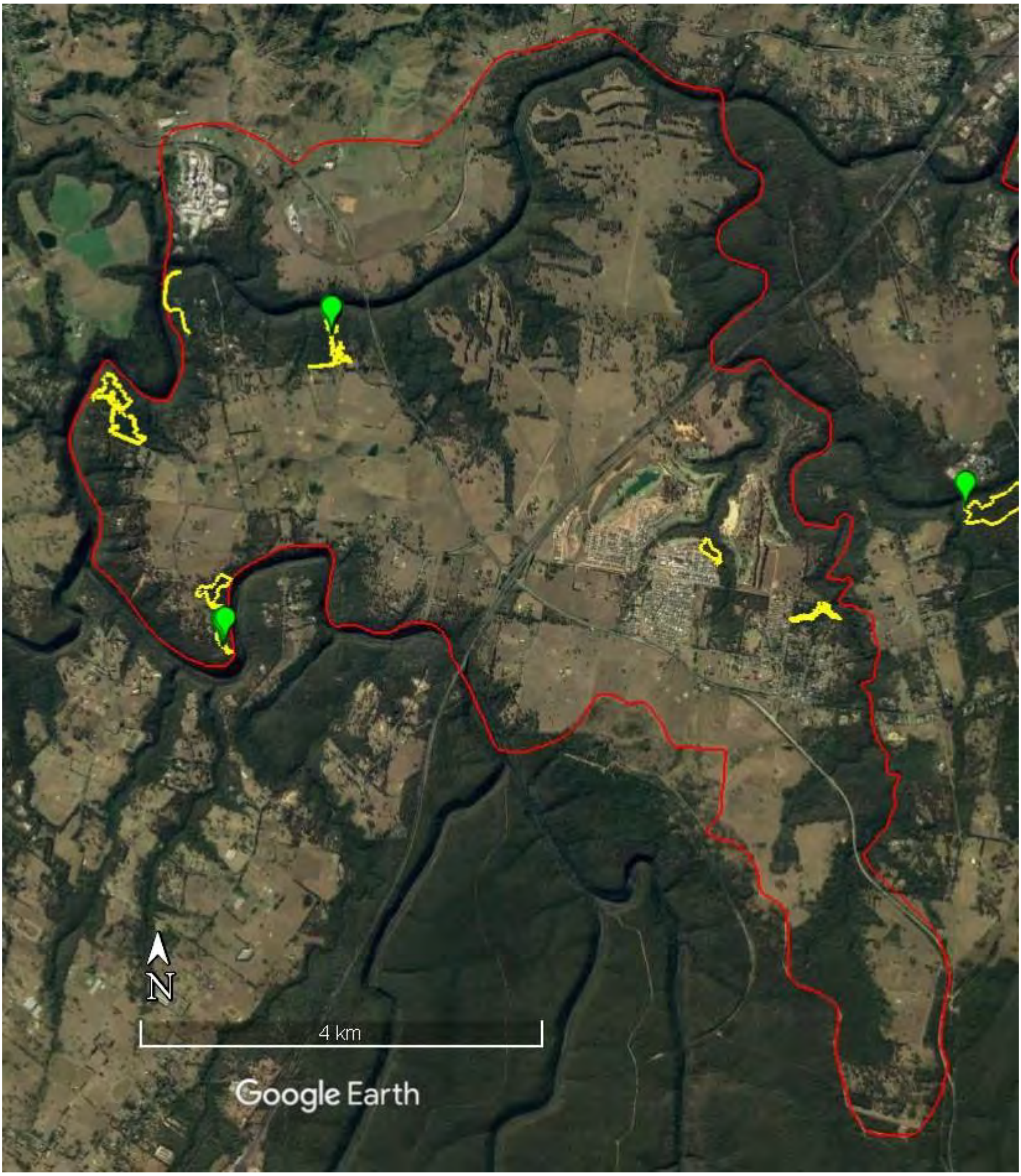
Surveys for the biodiversity assessment informing the development of the biocertification were constrained by private lands access issues, time and the overall size of the biocertification area.

Surveys undertaken by Ecoplanning and Biosis consultancies since 2017 have largely been confined to the deemed “development footprint” and have been undertaken predominantly to comply with the BAM protocols for vegetation sampling for assessment purposes with little survey for threatened species. As such, no new occurrences of threatened *Hibbertia* species including *Hibbertia puberula* were recorded by Biosis or Ecoplanning through their survey efforts.

Access to a spatial viewer was provided by DPE to assist in the expert assessment. Whilst this tool has been useful in gaining a general overview, the information presented is limited and is acknowledged to “have been acquired and developed from numerous sources of differing dates, accuracy and completeness and may include errors in extent and content”. CFFIS are not aware of any surveys performed specifically for *Hibbertia puberula* by DPE, Ecoplanning or Biosis Consultancies in the context of this project. The broadscale mapping of plant community types (PCTs) that was provided to assist with this assessment cannot identify the habitat niches that may be present on a localised scale.

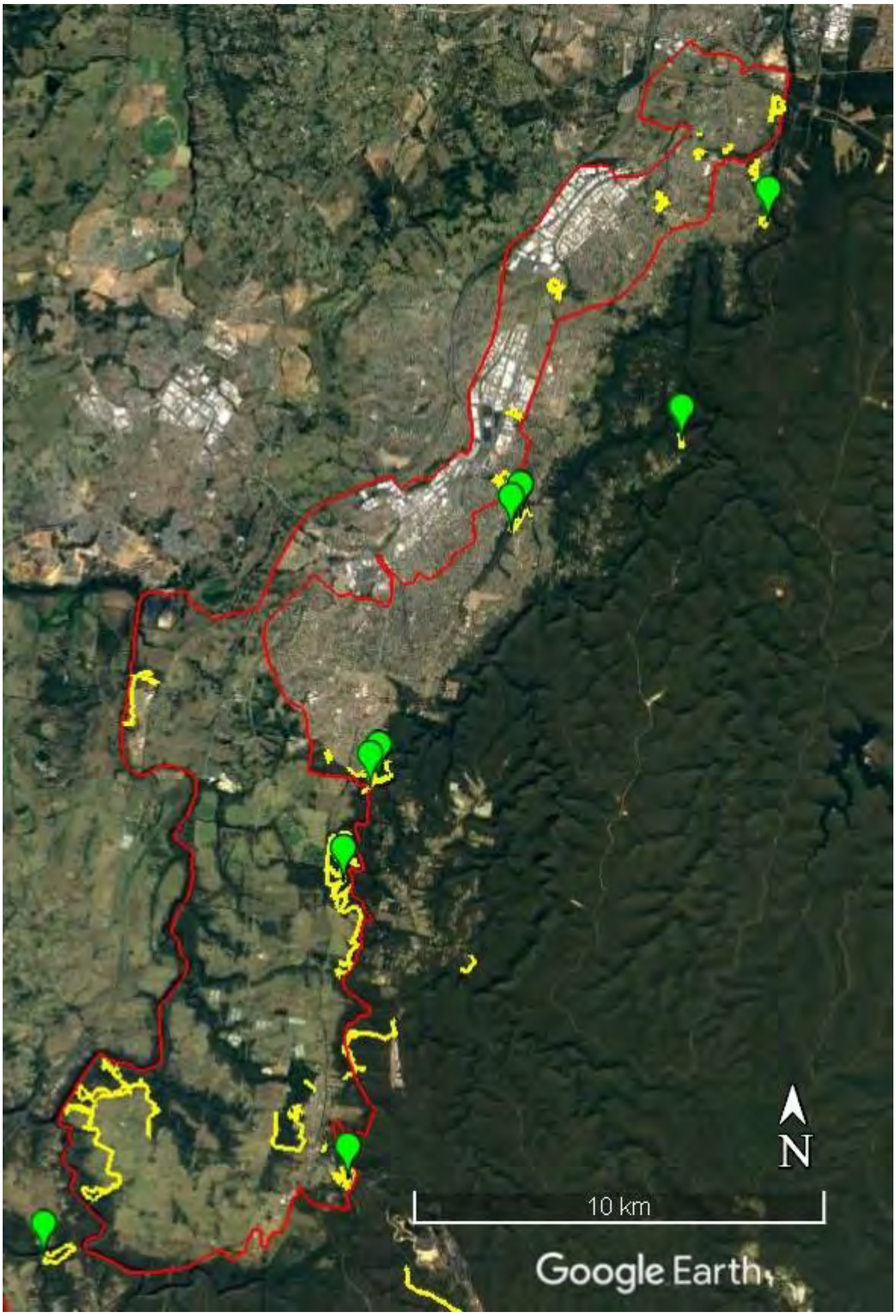
The surveys undertaken by CFFIS as part of this expert report relied on assessment of known habitat traits of extant sites. PCT mapping and aerial digitised photography were used to select potential habitat areas for targeted surveys.

Map 2 and Map 3 show the sites that were surveyed for this assessment.



Map 2: Google Earth map of Wilton Growth Area showing the tracks of CFFIS survey.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow, location of small leaved *Hibbertia* sp. with vegetative morphology +/- consistent with *H*. *puberula* marked in green.



Map 3: Google Earth map showing Greater Macarthur Growth Area and CFFIS survey tracks.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow, location of a small leaved *Hibbertia* sp. with vegetative features consistent with *H. puberula* marked in green.

NOTE: The absence of green dots along the survey route does not equate to the species not being present in that locale, only to the fact that it was not observed.

Species identification

When we located a small-leaved *Hibbertia* specimen that had macro morphological features resembling that of *Hibbertia puberula,* a specimen was retained for later microscopic examination. Selected specimens were taken according to protocols. Due to the time of the year and prevailing drought conditions plants were not in flower and depauperate, such that any specimens removed consisted of very small fragments (eco-scraps) most only a few cm in length.

This is far from ideal, the challenge was to then identify the eco-scraps to species using only stem and leaf characteristics, as shown in the drawing below (Toelken 2000). The small branchlets of each specimen was compared to voucher material of *Hibbertia puberula* under a dissecting microscope. Note that positive identification of the species requires flowering parts, however, some species of *Hibbertia* can be ruled out based on stem and leaf characteristics.

Microscope photographs of *H. puberula* characteristic features used during this survey by CFFIS are provided in Appendix 3.

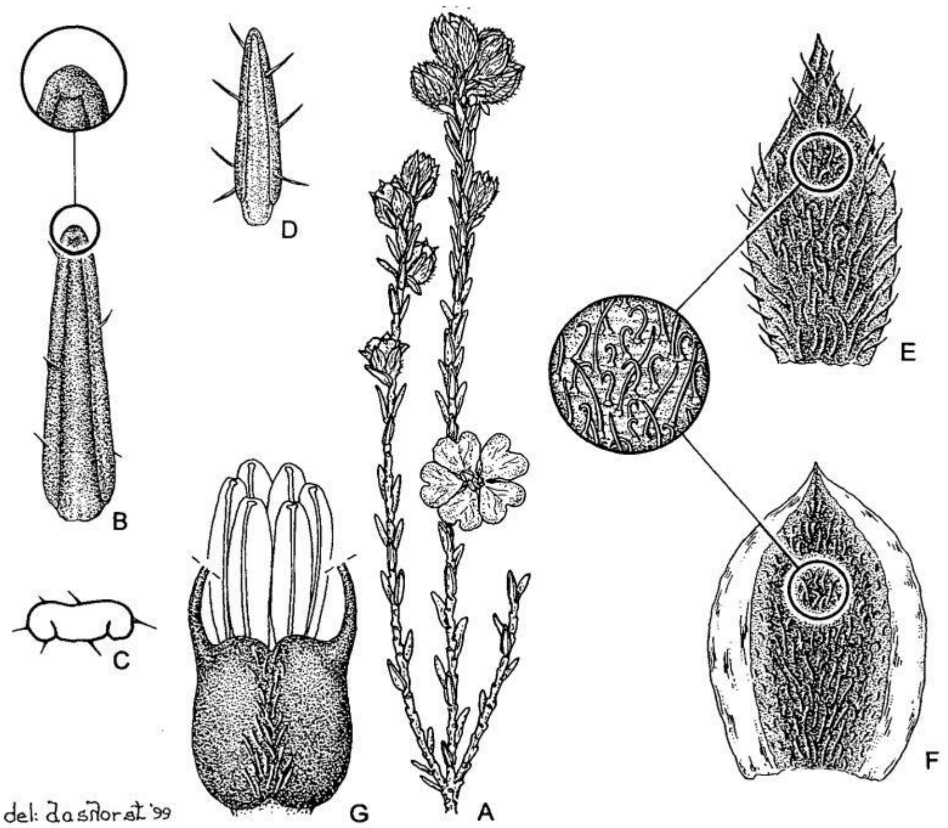


Fig. 7. ***H. puberula***. **A**, Flowering branch; **B**, cauline leaf; **C**, tranverse section; **D**. bract; **E**, outer calyx lobe; **F**, inner calyx lobe; **G**, two glabrescent ovaries. (**A–G**, *J.M.Lindale NSW 101952*; **A** ×1; **B**, **D** ×10; **C** ×15; **E**, **F** ×6; **G** ×20).

Figure 1: Line drawing of *Hibbertia puberula* distinguishing characteristics.

All small narrow leaved *Hibbertia* specimens found during the survey were examined under the microscope to determine if the stem and leaf characteristics matched those of *Hibbertia puberula.* Essential characters considered include leaf dimensions and shape, the leaf undersurface having revolute margins and recessed to bulging broader central vein obscuring the leaf undersurface, and branchlets having interpetiolar tuffs of hairs. Some of these characters are shown on Figure 1Figure 2. Where the majority of characters were a match, the species could not be ruled out of consideration and so was assumed to be the subject species. It should be noted that these characters vary slightly between sub-species, as shown in Figure 2 below, and confident identification to sub-species requires flower characteristics.

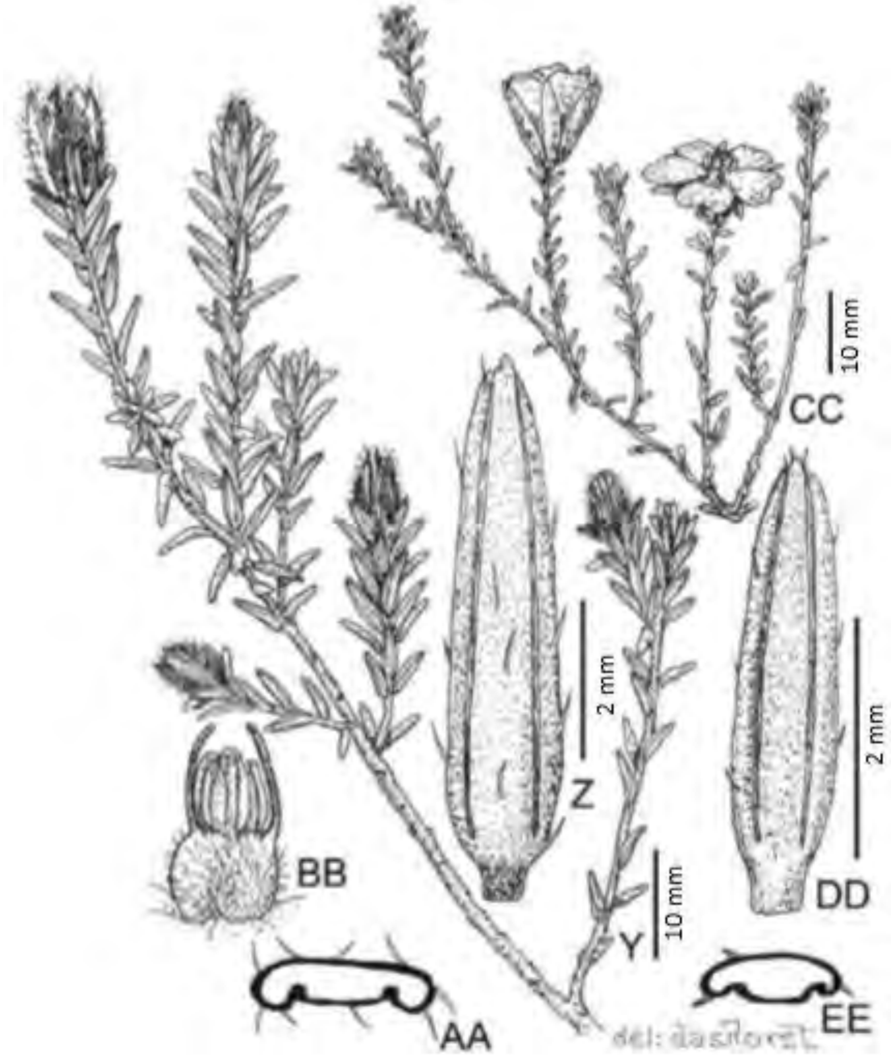


Figure 2: Line drawing of *H. puberula* subs. *extensa* and subsp. *glabrescens*.

Key: *H. puberula* subs. *extensa* Y flowering branch; Z leaf from below; AA transverse section through mid-leaf; BB flowers with petals and calyx removed. *H. puberula* subs. *glabrescens*: CC flowering branch; DD leaf from below; EE transverse section through mid-leaf.

A requisite taxonomic feature is hair types and the specific arrangement on leaf and branchlets. The persistence of the hairs on various parts of *Hibbertia* is variable according to the species. In many species such as *Hibbertia puberula,* hairs on the leaves and stem are notoriously non-persistent and “soon wear off” (Toelken pers. comm.). The full range hair expression is best observed on new and recent growth (Miller pers. obs.). The lack of new or recent growth is a significant limiting factor in the determination of the specimens as at all sites the vegetation was in severe drought stress.

Photo 2: A selection of *Hibbertia* voucher specimens, photo from c. 30cm away.

Key - A: *H. puberula* subsp. *puberula* Moorebank; B: *H. puberula* subsp. *puberula* Smiths Creek Reserve; C: *H.* sp. *puberula?* Round Hill Road, Wilton; D: *H.* sp. *puberula?* Shingle Hill, Wilton; E: *H. puberula*? FT SH1.4 Gilead; F: *H. puberula* subsp. *extensa* juvenile growth, south of Appin Road; G: *H. empetrifolia* Appin; H: *H. puberula* subsp. *extensa* Bonnum Pic vicinity; I: *H. puberula* subsp. *puberula* Lucas Heights and J: *Hibbertia puberula* subsp. *glabrescens*. (Photo by R.T. Miller August 2018). Morphological features are difficult to ascertain without microscopic examination.

Hibbertia sp. *puberula?* is a small leaved *Hibbertia* sp. with vegetative morphology +/- consistent with *H. puberula*.

<u>Survey assumptions</u>

The survey was carried out in June to August, during the non-flowering period, and it was not feasible to survey all the many bushland remnants within the Wilton and Greater Macarthur growth areas. As such, the first assumption was:

Assumption 1. *Hibbertia puberula* would not be found growing in bushland that is not its known habitat.

The author is familiar with the species' types of habitat at Bankstown Airport, the Moorebank Intermodal site, and locations such as Smiths Creek Reserve and Simmo's Beach Reserve. Using this knowledge of geology, soil and vegetation type that is the known habitat of the species, areas of bushland that would not be suitable habitat were ruled out of the assessment.

Using this knowledge of habitat requirement, the second assumption was:

Assumption 2. *Hibbertia puberula* is likely to be present in areas that are known to be suitable habitat.

Although there are occasions where the plant occurs in higher densities, the most common occurrences are rare and scattered throughout suitable habitat or low populations numbers localised to a small habitat niche. Areas of suitable habitat were surveyed using the random meander method. When only one or no individual specimens were located using this method, it was deemed likely that the species would occur scattered throughout these areas of suitable habitat.

The survey was carried out following several years of drought in western Sydney, and many shrubs forbs and grasses were dead. This led to the third assumption:

Assumption 3. In areas of suitable habitat, where *Hibbertia puberula* specimens have not been found, the species could be present in the soil seed bank.

There was a high amount of leaf fall in most locations and most locations have not recently been burnt. In these areas the species is likely to be present in the soil seed bank. An example is the Basin Reserve (outside the growth areas), where the species was previously scattered throughout suitable habitat within the reserve. Since the drought and control burning, the species appears to be very rare at this site but is likely to be still present in the soil seed bank in some of the unburnt habitat.

Identification to species of the *Hibbertia* relies on characters of the flowers. The survey was carried out in the non-flowering period which led to the fourth assumption:

Assumption 4. That specimens matching the stem and leaf characteristics of *Hibbertia puberula* could most likely be that species.

1.5 JUSTIFICATION FOR USE OF EXPERT REPORT

The BAM allows for situations where an expert report will be required to replace or complement survey effort at a development site. While there has been some field survey for the Strategic Biocertification assessment, the area covered by the proposed GMGA and WGA are extensive and there have been issues with gaining access to some of the private properties.

An expert report is required to assess potential impact to *Hibbertia puberula* for the following reasons:

Insufficient survey

A large extent of the identified growth areas could not be surveyed because it was on private property and could not be accessed within the project timeframe. Expertise was required to identify and survey potential species habitat and propose additional habitat based on extant populations and prior knowledge of the species.

Survey out of flowering season

Survey during June and July is at the non-flowering period for the species, so finding cryptic species of *Hibbertia* in the field is difficult even for an expert and more so for someone who is not an expert (refer Photo 13).

Survey during drought

The Western Sydney region has been experiencing dry conditions for several years, which means that the *Hibbertia puberula* plants are likely to be under severe drought stress and partially defoliated making this small and cryptic species more difficult to locate. It requires an expert in the species to locate and identify rare *Hibbertia* under these conditions.

Found in bushland at the end of Roundhill Road, Wilton, this plant shown on the left has vegetative morphological characters +/- consistent with *H*. *puberula*.

Scale reference: leaves are approximately 5mm in length.

Photo 3: A severely drought stressed plant of *Hibbertia* species.

Photo 3 shows the largest specimen of *Hibbertia* species with vegetative features consistent with *H*. *puberula* that was found within the Wilton growth area.

The plant is severely drought stressed, and it is likely that other plants in the area have succumbed to drought. The area had not been burnt for some years, so it is likely that the species apparent population has retracted and survives in numbers in the soil seed bank.

<u>Reliable species identification</u>

Identification of the genus *Hibbertia* to species level requires examination of flower parts in combination with stem and leaf characters, especially tomentum type and density. It is not practical nor reliable to identify small leaved species in the field as many of these morphological features require microscopic examination and comparison to known voucher specimens. This needs to be carried out by an expert in *Hibbertia*.

The use of an expert report to complement survey of the growth areas avoids the problems associated with *Hibbertia* misidentifications. *Hibbertia* species can be misidentified in vegetation assessments, frequently being dismissed as "common" species.

The misidentification of both *Hibbertia puberula* and presumably *Hibbertia fumana as Hibbertia riparia* during past surveys raises the possibility that other records of *Hibbertia riparia* may in fact be *Hibbertia puberula*. Searches of the databases revealed prior surveys undertaken for various projects have recorded *Hibbertia riparia* to occur at a number of locales within and adjacent to the GMGA and WGA (refer Appendix 5).

The *Hibbertia riparia / H. calycina / H. hirsuta* groups are currently under further detailed evaluation (Toelken pers. com.). *Hibbertia riparia* R.Br. s. str. occurs in Tasmania (Toelken) and is unlikely to occur in NSW, the name being misapplied (pers. com. Toelken). It was therefore anticipated that the identifications of *Hibbertia riparia* would be found to be incorrect.

Two recorded *H. riparia* sites were inspected for this assessment, one at Douglas Park (12 June 2018) and one at Wilton (17 August 2018). A third Site at Appin was not surveyed due to access constraints.

The *Hibbertia* sp. observed off Douglas Park Drive was found to have vegetative features consistent with *H. puberula*. The Wilton locale was inspected in August and it was found that the severity of impact to the bushland from drought had markedly increased. The site was extremely dry following the years of drought, the ground was covered with a thick layer of leaf litter, and many plants were dead including large numbers of *Hibbertia aspera*. No plants resembling *H. riparia* were found at the location, so the correct identification of the species could not be ascertained.

It is considered likely that this species is the same taxon as the proximate occurrence off Douglas Park Drive which has vegetative features consistent with *H. puberula*.

1.6 CREDENTIALS OF EXPERT

Robert Miller has over 30 years' experience in field botany. Over this time Robert has identified many rare and endangered plant species and has contributed to the scientific knowledge of native flora distribution and habitat in NSW.

Robert has worked with Hellmut Toelken of the State Herbarium of South Australian, locating, collecting and identifying undescribed or rare species of *Hibbertia*. Some of these taxa were known only from historic records with non-precise locality details and depauperate or non-existent habitat information. Many of the specimens have been used for the taxonomic revision of the genus and are cited in various taxonomic publications including "Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*" published in the Journal of the Adelaide Botanic Gardens 26 (2013). Examples of the cited specimens include: *Hibbertia ericifolia* subsp. *acutifolia* Toelken, subsp. nov. Type: New South Wales, Sarahs Knob, R. & J. Miller s.n., 21.x.2006 (holo.: AD; iso.: BRI, CANB, NSW, PERTH) and *Hibbertia dispar* R.T. Miller s.n., 0.5 km S of Penrose Rest area, along western boundary track, Penrose State Forest, 12.x.2010 (AD, NSW).

Robert and Hellmut's paper "Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales", was published in the Journal of the Adelaide Botanic Gardens in 2012. The paper describes 13 new taxa including *Hibbertia fumana* Toelken and *Hibbertia puberula* subsp. *puberula,* – subsp. extensa *R.T.Mill.* and – subsp. *glabrescens Toelken.*

In 2017 Robert was called as an expert to identify the species of *Hibbertia* on the Moorebank bushland site that is the subject of the Intermodal development proposal.

Robert is also a recognised expert for other threatened taxa including *Pomaderris adnata*, *Solanum celatum*, *Epacris purpurascens* var. *purpurascens*, and the genus *Prostanthera* including the threatened taxa *Prostanthera discolor*, *P. stricta*, *P. densa*, *P. junonis* and has provided expertise to the OEH Saving our Species programs.

2. Species information

2.1 SPECIES DESCRIPTION

There are 3 sub-species of *Hibbertia puberula*. The following descriptions are taken directly from the Toelken and Miller 2012 paper "Notes on Hibbertia (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. Hemistemma, mainly from the central coast of New South Wales".

***Hibbertia puberula* Toelken**

Typus: New South Wales, Yowie Bay, A.A.Hamilton s.n., 14.xi.1908

Description: Shrublets up to 0.25 m tall, decumbent or rarely suberect, much to sparsely branched or spreading; branches wiry to stiff from a woody stem or base, with decurrent leaf bases more or less flanged, pubescent to hirsute mainly between flanges, rarely glabrescent or glabrous. Vestiture often not persistent, with spreading longer over shorter simple hairs on all parts of the plant; on branches with few to many (rarely glabrous) mainly longer hairs (but varying very much in actual length) over much shorter ones, often predominantly in the grooves between flanges of the leaf bases, becoming appressed and wearing off soon; on leaves above with scattered spreading antrorse simple hairs becoming longer towards the margins, often wearing off; on leaves below with few scattered hairs as above on the revolute margins but not on the central vein, wearing off; on bracts with finer but similar hairs to leaves; on outer calyx lobes outside moderate to dense, with erect short hooked hairs overtopped by longer tubercled straight hairs up to 1.3 mm long, often becoming bristle-like particularly on the margins and the base and receptacle, persisting, inside dense, with fine, often silky appressed antrorse hairs; on inner calyx lobes outside and inside usually similar to the outer lobes, but hairs finer and decreasing in number and size towards the glabrous, membranous margins. Leaves usually with dense intrapetiolar tuft spilling over into grooves between flanges; petiole 0–0.6 mm long, ± flattened; lamina linear-lanceolate to oblong-lanceolate or oblong-elliptic, (1.2–) 2.8–5 (–7.6) × (0.5–) 0.7–1 (–1.2) mm, ± abruptly constricted into petiole, acute and usually with a terminal tuft of hairs wearing off soon, often becoming obtuse, above ± flat and sparsely pilose to glabrescent, below revolute margins and recessed to bulging broader central vein obscuring the undersurface, sparsely pilose to glabrous on the margins. Flowers single and terminal, rarely in clusters of up to three from subtending axils; pedicel 0–3 mm long; bracts linear-elliptic to elliptic-lanceolate, (2.9–) 3.2–3.8 (–4.2) × (0.4–) 0.6–0.8 (–0.9) mm, leaf-like but flatted with central vein ± visible, short pilose, rarely glabrous. Calyx distinctly accrescent; outer calyx lobes lanceolate to ovate, (5.3–) 6–8 (–11.7) × (1.6–) 2–3 (–4.2) mm, frequently longer than inner lobes, acute to beaked, usually with raised ridge and recurved distal margins, hirsute, strigose, rarely pubescent to glabrescent; inner calyx lobes oblong-ovate to oblong-elliptic, (4.6–) 5–8 (–11.6) × (2.1–) 2.5–3.5 (–3.7) mm, acute to cuspidate and with lateral membranous margins rarely up to the apex when obtuse and mucronate, hirsute to finely pilose, decreasing towards the margins. Petals broadly obovate to oblanceolate, or rarely oblong-oblanceolate, 5.5–10.6 mm long, ± bilobed. Stamens (4–) 10–14 (–18); filaments (0.6–) 1.4–1.7 (–1.9) mm long, up to one-third connate basally;

anthers obloid, (0.8–) 1.4–1.8 (–2.1) mm long, subequal, rarely unequal, abruptly constricted above and below. Pistils 2; ovaries erect-obloid and usually horizontally truncate, (4–) 6 (–8) ovules, puberulous, rarely shortly pubescent, with style attached apically, rarely laterally, then curved back- and upwards on either side of the anthers with style well above or rarely at the apex of anthers. Fruit puberulous to glabrescent with simple hairs. Seeds oblong-obovoid to almost obloid, 1.6–1.8 × (1.2–) 1.3–1.4 mm, brown; aril with fleshy base surmounted by one-sided membranous cup covering one-third to half of seed.

Notes: The extra specimens now available introduced a much wider range of variation in the *H. puberula* complex. Specimens from the Central Coast can frequently be recognized by almost sessile leaves, broadly ovoid to ellipsoidal buds with apices of the calyx erect to incurved, and often more than one flower is born terminally on branches, while plants from more inland localities have usually petiolate leaves, slender ovoid to ellipsoidal buds with more or less recurved apices of the calyx and a single terminal flower on branches. None of these characters can be decisively used to distinguish these forms. The terminal flower clusters are formed by axillary growth from one or two leaves below the bract of the terminal flower and, in keeping with other species of the H. sericea group with fascicled hairs, immediately develop a terminal flower after usually two nodes with distinct internodes between, so that it becomes a more or less corymbiform cluster. (This is also a distinction from *H. stricta* s.l., which has usually spikiform (pyramidal) terminal clusters). Similar, but loosely branched cymbiform terminal inflorescences have been observed on only one collection (Turpentine Road, Flat Rock Creek, R.T. & J.Miller 22/30.x.2010). The most southern population of *H. puberula*, as represented by this and other mass collections, as well as R.D.Hoogland 11702 and E.Gauba NBG4784, is a particularly interesting extension of the species, as most of the flowers, though large, show a distinct reduction of hairs on the calyx and, more significantly, the styles tend to be laterally attached to the ovaries, similar to those of *H. cistiflora* in the *H. stricta* group. However, this phenomenon, indicative of a convergent development, can be observed in different stages on different plants, varying from an apically attached style curving down- and backwards to being attached laterally. The calyx lobes of most of the specimens identified as belonging to the *H. puberula* complex are hirsute to strigose on the outer surface, but in a few specimens both the shorter hooked hairs as well as the straight overtopping longer ones are very short or absent on plants from a few different localities (cf. variation under subsp. *glabrescens*). Among these, the plants from Bankstown Airport are smaller with thread-like branches and have consistently smaller calyx lobes, which are up to 2.7 mm broad, so that they are here described as subsp. *glabrescens*. The calyx of some flowers of subsp. *puberula* from Voyager Point (R.T.Miller & C.P.Gibson 52/20.x.2006) are of similar size, but hirsute and with a distinct terminal ridge on the outer calyx lobes. Furthermore, the flowering calyx of one plant must always be compared with other specimens at a similar stage, as the calyx (accrescent) elongates after flowering. Specimens from Lucas Heights are an extreme example, as the outer calyx lobes of a flower are 7.2 mm long and those of a fruit on the same specimen (R.T.Miller 3/16.x.2007) are 11.6 mm long. Of all the variation observed, *H. puberula* subsp. *extensa* is very unusual, as its androecium of commonly six stamens was previously unknown in *H. puberula*, which has ten or more stamens. There is a distinct gap between the two types of stamen numbers, as, unlike specimens of the typical subspecies from Simmos Beach Recreation Reserve (R.T.Miller 24–32/2.xi.2007), which has a range of stamens from 15–18, no specimen has as yet been recorded to complete the range from (4–) 6 or 7 stamens of the subsp. *extensa*. However, the wide variation recorded for the typical subspecies suggests this new form should be recognized at subspecific level. The anthers of subsp. *extensa* also tend to be smaller like those of the subsp. *glabrescens*, and their cuneate base into the filaments is rarely observed in the other subspecies.

Key to subspecies of the *H. puberula* complex

1. Stamens (4–) 6 or 7; lateral branches usually spreading up to about right angles to the main axis …………………………………………………………………………………….. *H. puberula* subsp. *extensa*

1: Stamens (9) 10–14 (–18); irregularly and commonly untidily branched

2. Anthers (1.3–) 1.4–2.1 mm long; outer calyx lobes distinctly ridged toward the apex, strigose to hirsute or if pubescent to glabrescent then (2.5–) 2.6–3.0 (–3.8) mm broad when flowering .... ……………………………………………………………… *H. puberula* subsp. *puberula*

2: Anthers 0.9–1.3 mm long; outer calyx lobes 1.6–2.1 mm broad when flowering, scarcely ridged towards the apex, puberulous to glabrescent

……………………………………………………………………….................................. *H. puberula* subsp. *glabrescens*

Hibbertia *puberula* subsp. *puberula*

Description: Branches wiry to stiff-woody from woody stems. Leaf lamina mainly lanceolate. Outer calyx lobes lanceolate to ovate, (7.3–) 7.8–9.3 (–11.6) × (2.5–) 2.6– 3.0 (–3.8) mm, acute to beaked with strongly recurved margins and distinctly raised central ridge towards the apex, strigose or hirsute to rarely puberulous; inner calyx lobes broadly elliptic to oblong-ovate, (6.9–) 7.3– 7.8 (–10.1) × (2.8–) 3.15–3.3 (–3.7) mm, with innermost two acute to ± cuspidate above broad membranous margins, hirsute to strigose, rarely pubescent along the central ridge becoming smaller to glabrous towards the margins. Stamens (9–) 10–14 (–18); anthers (1.3–) 1.4– 2.1 mm long. Flowering: October–December (January).

Variation: The few previous collections available have been disconcertingly variable, but mass collections from a few localities revealed that individual populations are often very variable in the size and number of hairs on various organs. Buds vary from almost spherical to narrow-ellipsoidal to -ovoid with lanceolate to ovate outer calyx lobes, each with an incurved, erect or recurved apex and more or less densely covered with spreading, straight and smaller hooked hairs of varying length. Flowers have usually 12–14 stamens in this subspecies, but the number varies locally from 9 or 10 at Wollemi National Park to 18 in one specimen from Yeramba Lagoon (C.P.Gibson & R.T.Miller 50/14.x.1993). Specimens from Simmos Beach Recreation Reserve show a few flowers with 15 to 17 stamens, while other flowers of similar plants of the same population have 12 to 14 (R.T.Miller 24–32/2. xi.2007). The filaments are up to one-third basally connate. Usually the anthers are described as subequal and forming a range from the slightly smaller to larger ones, but occasionally one or two distinctly larger ones were observed. The typical obloid ovaries are surmounted by a horizontal style base and, while the style is usually attached at the apex, it is sometimes more or less dipping to a lateral position in a number of populations, mainly from Morton National Park. This must not be confused with fruiting specimens, where the bulging developing seeds often displace the position of the style attachment. While the ovaries are usually puberulous, they may vary from pubescent (R.T.Miller 111–113/20.xi.2007) to almost glabrous (R.T.Miller 33–43/12.x.2007).

Hibbertia *puberula* subsp. *extensa* R.T.Mill., subsp. nov.

Typus: New South Wales, south of Appin Road, upper George River catchment, R.T.Miller 102 & A.Henderson, 8.x.2007 (holo.: AD; iso.: NSW).

Description: Branches stiff-woody and lateral ones spreading up to about right angles. Leaf lamina mainly lanceolate. Outer calyx lobes ovate, (6.1–) 66–72 (–7.9) × 3.1–3.5 (–3.8) mm, acute to beaked with ± strongly recurved margins and distinctly raised ridge towards the apex, strigose to hirsute; inner calyx lobes elliptic rarely oblong-ovate, (4.2–) 4.5–4.8 (–5) × 2.9–3.2 (–3.4) mm, with innermost two abruptly constricted into minute terminal point continuous with broad membranous margins, hirsute to strigose with hairs becoming smaller towards the margins. Stamens (4–) 6 (7); anthers 0.8–1.2 mm long. Flowering: October, November (March, April). Fig. 2Y–BB.

Variation: In spite of their often isolated occurrence very little variation was observed in the material examined. The specimens from south of Appin had usually 6 stamens, whereas several flowers from the Wanganderry Tableland had 7. The subspecies has generally very long straight hairs on the calyx and some of them are up to 1.3 mm long. Not only are the stamens shorter in this subspecies, but also the styles are short and robust and often just reach the apex of the anthers. These robust specimens are easily distinguished from superficially very similar plants with spreading branches of the typical subspecies from Lucas Heights (R.T.Miller 111– 113/20.xi.2007) by the number and size of the anthers. While most of the specimens of this subspecies occur in a restricted area from Appin to Wedderburn, a collection from Sackville Road (R.T.Miller 81/23.x.2008) seems to indicate that the taxon has a much wider geographic range. This preceding specimen exhibits in addition to six stamens also the robust spreading branching of the plants from the southern localities in spite of records of more slender forms of the typical subspecies nearby. Etymology. The epithet ‘extensa’, Latin, ‘stretched out, extended’ refers to the impression created by the lateral branches spreading at about right angles to the main branches.

Hibbertia puberula* subsp. *glabrescens Toelken, subsp. nov.

Typus: New South Wales, Bankstown Airport, G.M. Cunningham s.n., 13.xii.2006 (holo.: AD200524; iso.: CANB, K, MEL, NSW). Hibbertia sp. Bankstown (R.T. Miller & C.P. Gibson s.n. 18.x.2006) N.S.W. Herbarium in Australian Plant Census database (2011). Hibbertia sp. nov. (Bankstown Airport) C.P. Gibson, Bushland Bulletin 59: 4, 6 (2009).

Description: Branches thread-like wiry from short stiff-woody stems. Leaf lamina mainly elliptic-oblong. Outer calyx lobes linear-lanceolate, (5.3–) 5.5–6.1 (–6.3) × 1.6–2.1 mm, not beaked and with scarcely recurved margins and faint central ridge towards the apex, glabrescent or sparsely pubescent; inner calyx lobes narrowly oblongovate, (4.6–) 4.8–5.2 (–5.6) × 2.1–2.3 (–2.7) mm, innermost two abruptly constricted into minute terminal mucro continuous with broad membranous margins, glabrous or glabrescent along central ridge. Stamens 12–14; anthers 0.9–1.3 mm long. Flowering: October, November (December).

Variation: The plants at Bankstown Airport are comparatively uniform, as one would expect for such a small and extremely localized population. However, the plants and especially also the calyx lobes are rarely entirely glabrous. Although specimens of some plants of the typical subspecies, especially from nearby Simmos Beach Reserve (R.T. Miller 24–32/2.xi.2007), as well as those from the much further south population along Turpentine Road near Sassafras (e.g. R.T. & J. Miller AD15A–M), show a variation from a hirsute or strigose through to glabrescent tomentum of the calyx lobes, they are always more robust plants and in particular, the calyx lobes are larger and especially broader. Some specimens of the mass collection R.T. Miller 1622/12.x.2007 are very similar to subsp. glabrescens, but can be distinguished by the shape of the calyx or by their strigose to hirsute calyx (C.P. Gibson & R.T. Miller 27/23.x.1990). Furthermore specimens from Bankstown Airport collected in subsequent years (since 2006) have not shown any significant change in morphology. Thus we must assume that a taxon has established itself here that is suited to the unusual ecological conditions artificially maintained by the Bankstown Airport management since about 1940. Etymology. Since all organs of this subspecies have very few small and delicate hairs which usually wear off soon, the epithet ‘glabrescens’, Latin, ‘glabrescent’ seemed appropriate.

2.2 LIFE CYCLE

Peak flowering time is October to December and sometimes into January, and seed is set during this period. Anecdotal evidence (Miller pers. obs.) suggests time of flowering and time to petal dehiscence is variable across subspecies and appears also to be influenced by prevailing climatic conditions. Very limited observations of the flowering times of *Hibbertia puberula* subsp. *extensa* suggest this subspecies has a very short period of flowering each day. Total petal dehiscence has been noted to occur before 1 pm on two occasions in the largest population south of Appin Road. It is not known at what time petal expansion commenced. The subspecies is virtually invisible when not in flower.

Hibbertia puberula and *H. diffusa* at Moorebank were noted to have a window of daily peak flowering (albeit in September, outside its normal recognised peak flower period) being not apparent in early mid-morning and petal senescing by early afternoon. This phenomenon has been observed with several *Hibbertia* species, whilst others appear to have protracted flowering across the day e.g. *Hibbertia dentata*.

Photo 4: *Hibbertia puberula* subsp. *puberula* at Moorebank.

The plants in photos 4 and 5 were not flowering at 8.40 am, the pictures show near total petal dehiscence by early afternoon. (Miller Friday, 29 September 2017 12:05 PM).

Further research is needed to ascertain daily flowering ranges particularly for threatened taxa as this has significant implications for threatened species assessments regarding the reliability of detection.

Flowering time of day may explain, in part, the non-detection of the significant and widespread population of *Hibbertia puberula* at West Menai in the environmental assessment (refer Appendix 4 Indicative distribution of *Hibbertia puberula* at West Menai).

Photo 5: *Hibbertia diffusa* plant at Moorebank.

Plant was not in flower on the way into the site c. 8.40 am, flowered and shed petals by 12.14 pm.

No systematic fire response studies have been undertaken on *Hibbertia puberula*. Anecdotal observations and inferred information from similar species suggest *H. puberula* subsp. *puberula* is killed by fire. In certain circumstances the species may be capable of re-sprouting from near or just below the soil surface as noted at the Keith Longhurst Reserve (formerly the Basin Reserve) in 2007 (R. Miller pers. obs.). At the same site Miller noted in June 2018 the species appears to have mostly been killed by a recent control burn, with limited recruitment from the soil seed bank observed. It is unknown to what degree the protracted dry period has impacted apparent recruitment, but it is thought that the combined impact of fire and drought has been significant.

Since its discovery there has not been a fire in the habitat of *Hibbertia puberula* subsp. *glabrescens*.

The impact of fire upon *Hibbertia puberula* subsp. *extensa* is also poorly known, with only observation by Miller providing a limited insight. The two occurrences south of Appin Road have recently been control burnt. Price *et. al.* (2016) state that "The first fire was 52 ha, lit at 09:45 on 22 August 2015, and targeted patches of forest within the scout camp. The second was 700 ha, lit at 10:15 on 9 October 2015 and burnt the area surrounding the camp in an arc from north through west to south". All pre-existing plants appear to have been killed. Only three tiny plants presumably seedlings were apparent at one site and no plants were detectable at the other.

2.3 DISTRIBUTION AND ABUNDANCE

Limited systematic population surveys have been undertaken for *Hibbertia puberula* s. lat.. The most comprehensive population survey undertaken is for *Hibbertia puberula* subsp. *glabrescens* at Bankstown Airport environs (refer to that subsp.). The population of *Hibbertia puberula* subsp. *puberula* occurring at the Moorebank Intermodal Terminal was, in part, assessed in the environmental assessment for the project.

Hibbertia puberula* subsp. *puberula

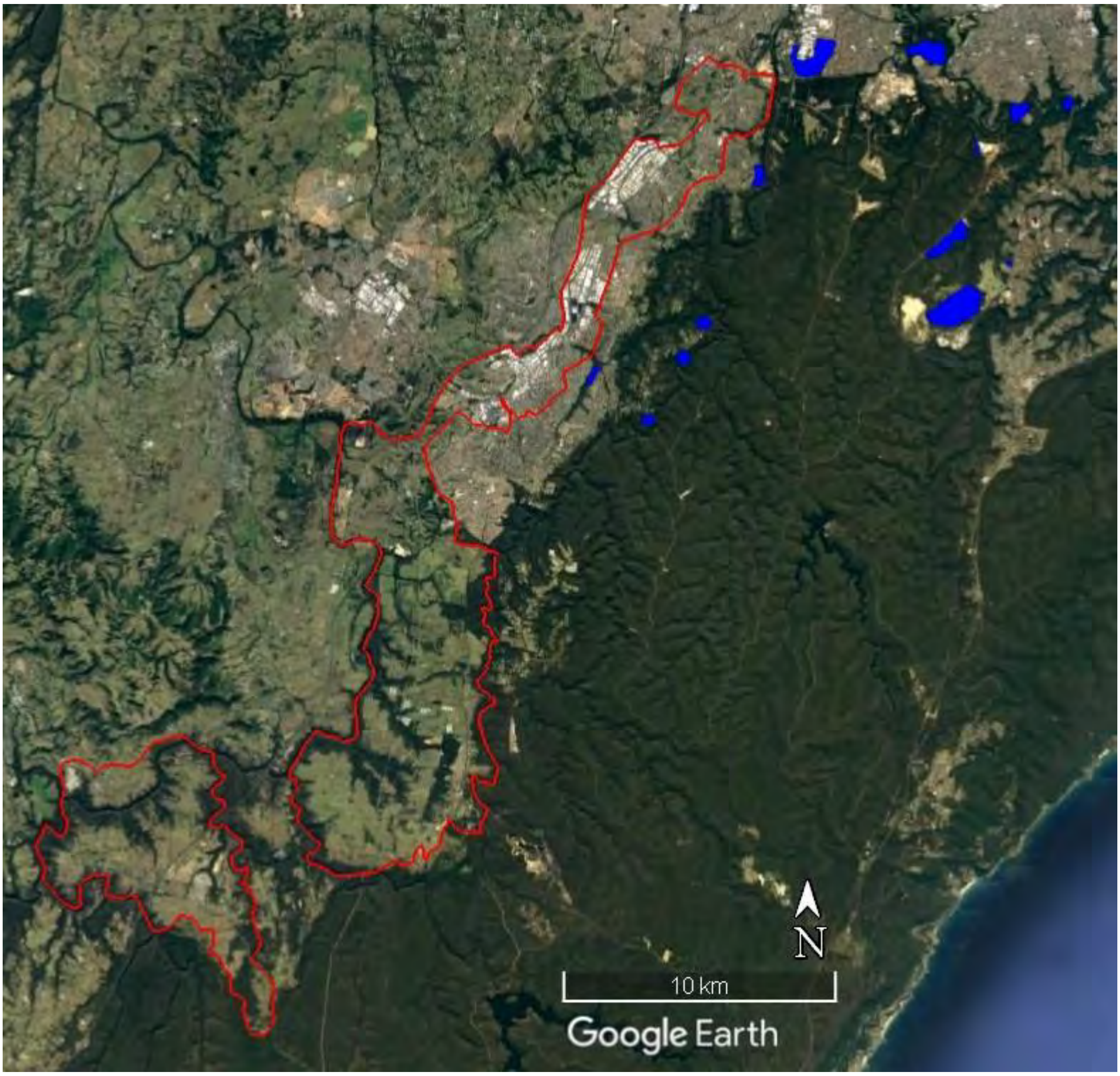
This sub species is known in New South Wales mainly from near Sydney (CC), but also from Wollemi National Park and near Morton National Park (SC, ST).

Of relevance to this study are those sites close to the Wilton and Greater Macarthur growth areas. The sub species has been collected from Smiths Creek Reserve, Moorebank Intermodal site, Simmos Beach Recreation Reserve, Peter Meadows Reserve, the Keith Longhurst Reserve (formerly the Basin Reserve), Kentlyn, Freres Crossing Reserve, Kentlyn, Old Kent Road, Kentlyn, and Lucas Heights. Map 4 shows the areas from which the sub species had been collected prior to this study.

Environmental assessment surveys for the Moorebank Intermodal Terminal have provided some population data on *Hibbertia puberula* subsp. *puberula*. The population data derived cannot be inferred to reflect population density at all recorded sites of its distribution and specifically not within the GMGA or the WGA. The predominant vegetation communities found at the Moorebank Intermodal Terminal where surveys were undertaken are Castlereagh Scribbly Gum Woodland and Cooks River/Castlereagh Ironbark Forest with Shale-Gravel Transition Forest and Castlereagh

Swamp Woodland being recorded in close proximity. Extant examples of these communities in combination are not known to occur in the GMGA or WGA.

The majority of records in proximity to GMGA and WGA occur as small populations in a variety of habitats at the edge of sandstone shale transition or in transition with or in the lower elements of the Mittagong formation. Appendix 4 shows the indicative distribution of *H. puberula* at West Menai, where the species was found to occur as small subpopulations in suitable micro-habitats.



Map 4: Generalised location of *Hibbertia puberula* subsp. *puberula* collections.

Key – Areas of *H. puberula* subsp. *puberula* collections (blue) in relation to the growth areas (red) from surveys prior to this BAM assessment.

A selection of habitat and occurrence notes compiled by Miller in 2007 as herbarium specimen notes are provided below:

- At Lucas Heights the population at a site in Open Woodland / heath – Canopy: *Eucalyptus haemastoma*? and Stringybark species is described as: “Abundance: extremely localised, rare < 12 plants noted”.
- At Lucas Heights Little Forest the population is described as Localised in narrow zone in upper drainage line.
- At Simmos Beach Reserve in Open Woodland of *Eucalyptus sclerophylla*?, *E. punctata, Angophora bakeri* one sub-population is described as “Very localised but locally common c. 20 plants noted”
- At Barden Ridge one population is described as scattered through sedges - relatively rare at edge of wet heath/swamp.

Further details of herbarium specimen collections from Western Sydney in 2007 are provided in Appendix 2.

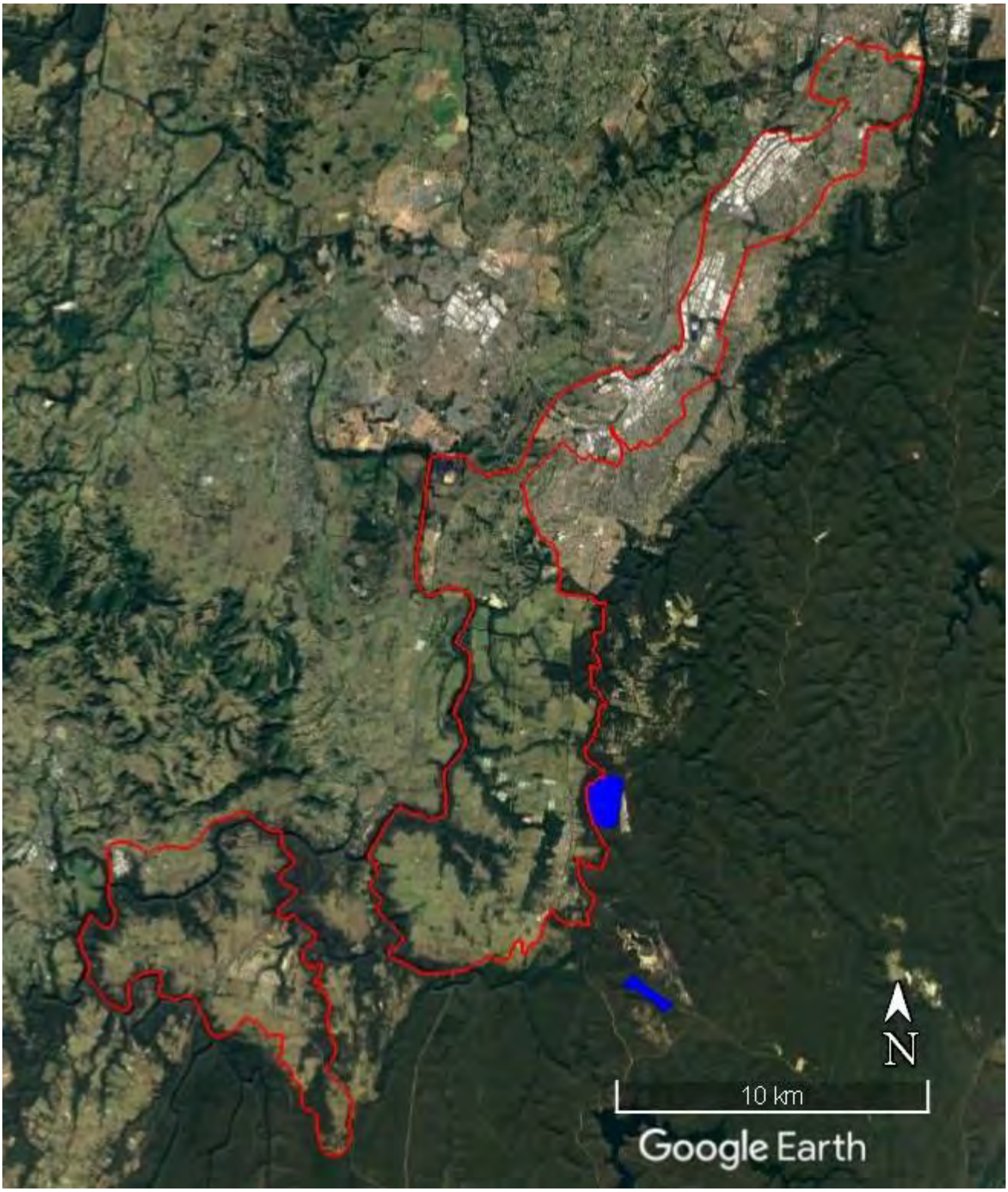
Hibbertia puberula subsp. *extensa*

This subspecies grows with heath on upper headwaters of the Georges River and in rock plate heath on the Wanganderry Tableland, New South Wales (CC).

Collection sites located in the vicinity of the Wilton and Greater Macarthur growth areas are c. 3.5–4 km SE of Appin township, South of Appin Road and Wedderburn, NSW Sports & Aircraft Club, walking tracks, Lysaghts Road vicinity. Map 5 shows the locations of collection sites.

No systematic population surveys have been undertaken for this subspecies. All known populations are thought to be small with most observations noting only a few individuals. One location south of Appin Road was the only population noted as having more than 10 plants. The sightings at Woronora Dam vicinity, Sackville North, the two recorded Wedderburn locations and the Bonnum Pic vicinity all recorded a few individuals only. The known Sackville North occurrence has subsequently been severely impacted by hazard reduction measures and is possibly now extinct at the known site. Similarly, the known occurrence west of Wedderburn Aerodrome has been impacted by grading and fill emplacement and only one specimen could be relocated (Miller pers. obs. July 2018).

A small population of a *Hibbertia* species with vegetative features consistent with *H. puberula* subsp. *extensa* was observed to occur on the verge of a fire trail within the Dharawal National Park at Wedderburn. Only six plants were noted. Positive determination can only be ascertained in combination with floral characters.



Map 5: Generalised location of *Hibbertia puberula* subsp. *extensa* collections.

Key – Areas of past *H. puberula* subsp. *extensa* collections (blue) in relation to the growth areas (red).

Hibbertia puberula* subsp. *glabrescens

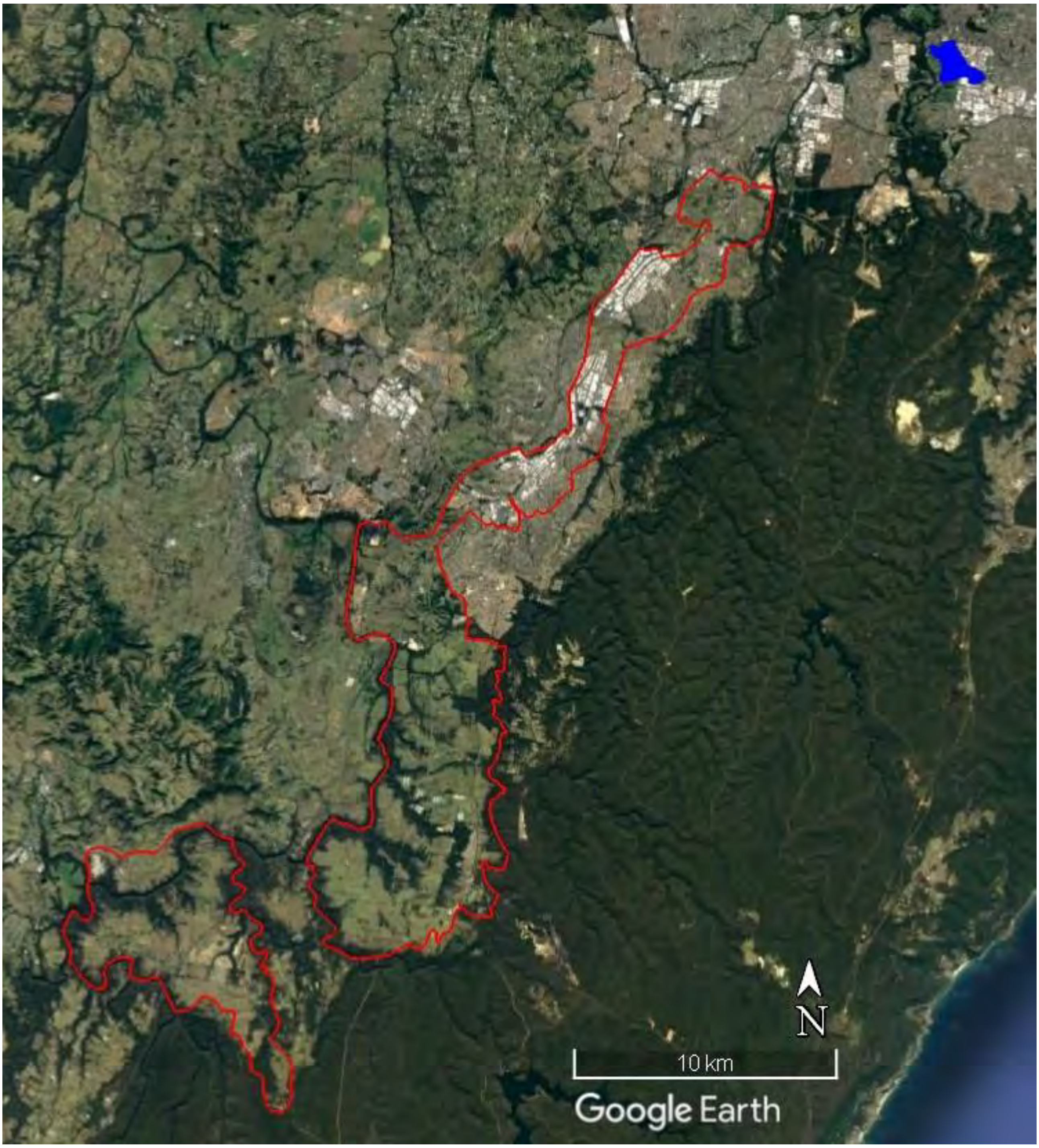
Subspecies *glabrescens* is known only from Bankstown Airport. Map 6 shows the general area where this species has been collected. The population contains between 50 and 100 individuals. Survey by Eco Logical in 2015 could not differentiate individual plants and recorded area of plants only.

The species has a limited area of occupancy. Most of the extant plants are known from one small area to the north of a modified drainage line colloquially referred to as Airport Creek. It was previously recorded by Gibson and Gibson & Miller to occur to the south of Airport Creek. Development and maintenance measures have negatively impacted upon those known occurrences and it had not been observed there again until October 2017 when one plant was observed (Gibson pers. obs.).

Photo 6: *Hibbertia puberula* subsp. *glabrescens* growing in a slashed area of Bankstown Airport.

Top: measure of slashing height, bottom: Airport Area 5. Photos taken by R. Miller 8 October 2014.

Both photographs clearly show the bright yellow flowers of *Hibbertia puberula* subsp. *glabrescens* while vegetative features such as leaves and stems are not discernible. These photographs illustrate the importance of undertaking surveys for small Hibbertia species within the flowering period.



Map 6: Generalised location of past *Hibbertia puberula* subsp. *glabrescens* collections.

Key – Area of *H. puberula* subsp. *glabrescens* collections (blue) and the growth areas (red).

2.4 HABITAT REQUIREMENTS

Hibbertia puberula* subsp. *puberula

Occurs in a wide range of habitats, but usually low heath, on sandy soil or rarely in clay, with or without rocks underneath (Toelken 2000). Proximate populations have been recorded from habitats associated with the Mittagong formation, shale sandstone transitional vegetation and tertiary alluvial deposits. Associated canopy species may include, but not limited to, in combination or isolation: Scribbly Gum spp., Grey Gum (*Eucalyptus punctata*), Scaly Bark (*Eucalyptus squamosa*), Ironbark spp., Narrow-leaved Apple (*Angophora bakeri*), Dwarf Apple (*A. hispida*), and Stringybark spp.

Hibbertia puberula* subsp. *extensa

The habitat requirements of *Hibbertia puberula* subsp. *extensa* are poorly known. The subspecies has only been recorded from five localities: south of Appin Road, Wedderburn vicinity, Woronora Dam vicinity, Sackville North vicinity and Bonnum Pic vicinity Wanganderry Tablelands.

This subspecies appears to have highly specific micro-habitat requirements. The largest known population occurs south of Appin Road, where less than 30 plants of *Hibbertia puberula* subsp. *extensa* have been recorded. Its area of occupancy is small, being noted to occur in a narrow band within a small upland swamp amongst wet heath vegetation. In a larger nearby wet heath site a few specimens of the subspecies were recorded to occur on skeletal soil, in the downslope seepage zone, where the underlying sandstone substrate outcrops. The subspecies has not yet been observed in superficially similar nearby wet heath habitats but as it is very cryptic it may be present. The Woronora, Sackville North and one of the two Wedderburn populations grow in seepage zones of sandstone outcropping in skeletal soil downslope of heathland. In the Bonnum Pic vicinity a few plants were noted growing on rock plate heath.

Hibbertia puberula* subsp. *glabrescens

Subspecies *glabrescens* is known only from Tertiary alluvial soil along Airport Creek on Bankstown Airport and not from areas where subsequent fill has been deposited in between (pers. com. Gibson). The plant assemblage is attributable to “Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion”.

The airport site is very heavily modified from the natural state, lacks canopy species and is currently a low grass/shrub association with many pasture grasses and other introduced herbaceous weeds.

Soil at the site is a sandy (Tertiary) alluvium with a high silt content.

The remnant at the site and soil type are consistent with an inferred pre-settlement cover of Castlereagh Ironbark Forest although some remnant vegetation at and near the site (along the channel in particular) suggests Castlereagh Scribbly Gum Woodland is equally valid.

Hibbertia sp. Bankstown has been observed to flower from October to December, with seed setting from October to January. Most Hibbertia species are primarily pollinated by bees, but many have specialised mechanisms requiring particular bee species, beetles or syrphid flies (OEH Threatened Species Profile).

2.5 ANTHROPOGENIC THREATS TO THE HABITAT

Threats to the habitat of *Hibbertia puberula* that are relevant to sites within or adjacent to urban development include:

- Loss of habitat.
- Damage to habitat by trailbikes, 4WDs and mountain bikes.
- High densities of weeds and invasive grasses occur at the top of ridgelines; there is significant potential for encroachment into areas where the species occurs.
- Altered fire regime, either too frequent or too seldom.
- Potential for widening of major roads to affect populations of the species.
- Road maintenance and slashing works.
- Clearing for fire protection zones.
- One of the subspecies (subsp. *extensa*) occurs in areas subject to underground mining and is known from rock shelves and upland swamps. One site has been destroyed the rock outcropping utilised as a turning circle for hazard reduction purposes and another the habitat has been impacted by fire trail widening and spoil placement.

Photo 7: Smith’s Creek Reserve, clearing and weed invasion adjacent housing.

Field inspection of bushland remnants in the heavily urbanised sectors of GMGA provide irrefutable proof of severe degradation arising from a range of anthropogenic impacts and urbanisation. Without exception, all creeks and many of the remnants were heavily weed infested caused by a range of factors not limited to altered hydrology as well as nutrification and stormwater discharge, garden refuse and fill dumping and exotic seed dispersal by various vectors.

Photo 8: Bunbury Curran Park adjacent Harrow Road Canterbury Road intersection.

The photo shows garden refuse dumping and fire trail maintenance impacting upon the small remnant of potential habitat.

Damage to zones adjacent urban development can also be caused by clearing for fire hazard reduction, control burning frequently, and recreation activities such as 4WD vehicle access, mountain bikes and kids' cubby house building. Changes to hydrology, nutrification, stormwater discharge are of particular concern to this species group as many habitat niches are associated with seepages.

Photo 9: Severe weed infestation at Bunbury Curran Creek vicinity south of Harrow Road.

Photo 10: Severe impact of fire on bushland adjacent Bunbury Curran Creek, potential habitat.

Photo 11: Severe weed degradation of habitat, Pembroke Park, Minto.

Photo 12: Recreational impacts upon habitat, Pembroke Park, Minto.

3. Description of the study area

3.1 LAND USE HISTORY

The Cumberland subregion was first occupied by the Aboriginal peoples, who enjoyed a plentiful supply of fresh water and foods including fruit, tubers, fish, animals, birds and honey (Hills District Council website).

With the arrival of Europeans land use changed to timber gathering and agriculture, permanently altering the landscape. Particularly since the end of the second world war urban settlement and industry have expanded west from Sydney into the Cumberland subregion. Over the last 40 years many rural properties have been subdivided as lifestyle and hobby farm properties.

Currently there is great pressure for further residential development to the west of Sydney in the Cumberland subregion.

3.2 LANDSCAPE CONTEXT

The changes in land use have caused the clearing of a large proportion of the natural bushland of the Cumberland subregion. In 2011 the Cumberland Plain Recovery Plan stated "Only 13% of the pre-1750 extent of the region's vegetation remains as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas (NPWS 2002 in DECCW 2011). Consequently, much of the region's biodiversity is listed as threatened under State and/or Commonwealth legislation."

Widespread clearing of the remaining habitat has continued with much of the extant vegetation now being assessed as Critically Endangered. This widespread clearing has resulted in loss of habitat for endangered species such as *Hibbertia puberula*.

3.3 NATIVE VEGETATION

Since 2011 there has been further clearing, there are now 15 Plant Community Types that are listed as Critically Endangered, Endangered or Vulnerable in the Cumberland subregion.

The Cumberland Plain Recovery Plan states that "there are seven threatened species, four endangered populations and nine threatened ecological communities listed on the NSW *Threatened Species Conservation Act* 1995 that are found only on the Cumberland Plain. Seven of these are also listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999." The remaining bushland is highly fragmented and much of it occurs on private lands.

Within the GMGA and the WGA eleven Plant Community Types (PCTs) are mapped (mapping provided by the NSW Department of Planning and Environment). The PCTs are:

- Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, PCT 830

- Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, PCT 835
- Grey – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion. PCT 849
- Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion. PCT 850
- Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion. PCT 877
- Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 883
- Red Bloodwood – Grey Gum woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 1081
- Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateau of the Sydney Basin Bioregion. PCT 1083
- Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion. PCT 1181
- Water Gum- Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion. PCT 1292
- Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion. PCT 1395

3.4 POTENTIAL HABITAT

Hibbertia puberula has the potential to occur within five Plant Community Types (PCTs) mapped as occurring within the GMGA and the WGA. These community types are:

- Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 883
- Red Bloodwood – Grey Gum woodland of the Cumberland Plain, Sydney Basin Bioregion. PCT 1081
- Red Bloodwood – Scribbly Gum heathy woodland on sandstone plateau of the Sydney Basin Bioregion. PCT 1083
- Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion. PCT 1181
- Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion. PCT 1395

With the exception of PCT 883 at Moorebank, *Hibbertia puberula* has not been recorded to occur uniformly or in substantive numbers across any of the above listed communities. In general, it is usually confined to a variety of specific habitat niches within these regional mapping units. The area of occupancy within and/or the area of the specific habitat niches at any locale may be as small as a few square metres.

Specific habitat niches of potential occurrence may include upper drainage lines, seepages especially those associated with exposed sandstone bedrock or slabs, margins of hanging swamps / wet heath, exposed sandstone rock plates, and large and small occurrences of colluvial or alluvial deposits.

At most locales presence or absence can only be positively determined by intensive targeted surveys that investigate such habitat niches thoroughly within the peak flowering period. Refer to Photo 6 of *Hibbertia puberula* subsp. *glabrescens* that clearly shows the importance of surveying in the flowering period.

Photo 13: *Hibbertia puberula* habitat at Smiths Creek Reserve.

Note that the *Hibbertia* is not discernible. Refer also to the conspicuousness of flowering *Hibbertia puberula* subsp. *glabrescens* in Photo 6.

4. Assessment of species presence and suitable habitat

4.1 SPECIES RECORDS AND HABITAT ASSESSMENTS

Hibbertia puberula including its subspecies are poorly known and assessed as data poor. Apart from Miller (June – August 2018), there have been no other specific targeted surveys for *Hibbertia puberula* within the study area. General vegetation assessments undertaken for various purposes appear also not to have found *Hibbertia puberula* as there are no prior database records of the species within the proposed growth areas.

<u>Prior Records of *Hibbertia puberula*</u>

The nearest known populations of *Hibbertia puberula* subsp. *puberula* to the GMGA boundary are 850m away in West Moorebank and 990m away in Smiths Creek Reserve.

The nearest known population of *Hibbertia puberula* subsp. *puberula* to the northern boundary of WGA is approximately 22km away at Old Kent Road, Kentlyn.

The closest known population of *Hibbertia puberula* subsp. *extensa* occurs just 30 m from the GMGA boundary east of the Georges River Appin. The closest known population to the WGA boundary is c. 7.5km away south of Appin Road.

Hibbertia puberula subsp. *glabrescens* is only known from Bankstown Airport which is situated 9km from the northern boundary of GMGA and approximately 41km from WGA.

Searches of the databases revealed records of *Hibbertia riparia* at a number of locales including a Biobanking site at Douglas Park, just to the north of WGA (refer Appendix 5 *Hibbertia riparia* records in or adjacent GMGA and WGA). The name *Hibbertia riparia* is consider by Toelken to be misapplied to NSW taxa. Miller has observed that *Hibbertia puberula* is sometimes misidentified as *Hibbertia riparia*.

4.2 PRIOR SPECIES SURVEYS

From the information provided, no prior dedicated targeted searches have been undertaken for this species as part of the biocertification process.

4.3 ASSESSMENT OF SPECIES PRESENCE

The previous survey data provided by Biosis and Ecoplanning Consultants was insufficient to assess the probability of occurrence of *Hibbertia puberula* from a desk top study. CFFIS undertook targeted survey of suitable habitat where access was granted.

4.3.1 LIKELIHOOD OF SPECIES PRESENCE

Hibbertia puberula subsp. *extensa*

It is unlikely that suitable habitat for the subspecies occurs within the footprint of the growth areas, with the exception of the area at the southern extent of the WGA where the landscape may contain areas of wet heath or small localised seepages.

It is highly probable that this subspecies occurs within the GMGA and WGA boundaries adjacent to the footprints. Any occurrences would be confined to small populations restricted to very localised habitat niches. Potential habitat areas adjacent to the footprint would be highly susceptible to significant indirect impacts from a range of anthropogenic influences arising from the increase in urbanisation.

Hibbertia puberula subsp. *glabrescens*

Within the GMGA footprint the only location that supports potential habitat for the subspecies is the Menangle Park area. The subspecies may have once existed at Milton Park and Kayess Park vicinities, however, it is now unlikely to occur at those parks. Targeted surveys are recommended within the flowering period at these locales.

The likelihood of occurrence within or adjacent to the WGA is assessed as negligible. From known occurrence data the subspecies does not have the capacity to exist in habitats that occur within the proposed WGA development footprint. No further, specific targeted surveys are warranted for this subspecies in the WGA.

In the unlikely event that this subspecies was to occur it would be picked up in the targeted surveys for the other subspecies.

Hibbertia puberula subsp. *puberula*

Within the development footprint the subspecies is likely to occur at Menangle Park area, Milton Park and Kayess Parks, as well as in areas fringing and adjacent to the footprints (see maps 7 to 9).

From CFFIS limited field surveys, a small-leaved *Hibbertia* sp. has been observed to occur at three sites within the GMGA and WGA boundaries adjacent to the development footprint. Plants were also observed outside but proximate to the GMGA and WGA boundaries. These plants have vegetative morphological features +/- consistent with *Hibbertia puberula*.

It is highly probable that this subspecies occurs at many other locales within the GMGA and WGA boundaries. Any occurrences are likely to be confined to small populations restricted to very localised habitat niches. Potential habitat areas adjacent to the footprint would be highly susceptible to significant indirect impacts from a range of anthropogenic influences arising from the increase in urbanisation.

4.3.2 JUSTIFICATION FOR DETERMINATION

Hibbertia puberula subsp. *extensa*

Occurs in very close proximity to GMGA eastern boundary approximately 30m upslope from the Georges River in seepage zones associated with sandstone outcroppings. Similar outcropping formations were observed within GMGA and WGA that have the potential to support the subspecies. Within the development footprint the only area that may have suitable habitat is at the southern section of the WGA.

No extensive areas of wet heath/swamp areas were noted to occur in the limited sites inspected. Small localised areas supporting species associated with periodically damp soil were observed. There is potential for small localised areas of heath/swamp to occur within WGA in a number of areas where access was not granted.

Hibbertia puberula subsp. *glabrescens*

Sand deposits are noted in the Nepean River floodplain at Menangle Park as evidenced by past and present sand extraction. The alluvial sand deposits may provide suitable habitat.

Hibbertia puberula subsp. *puberula*

Shale – Sandstone geology is widespread around the periphery of both the GMGA and WGA, within this it has been demonstrated from limited field validation that habitat and potential habitat exist. Within the development footprint this habitat occurs at Menangle Park, Kayess Park and Milton Park. Sand deposits are noted in the Nepean River floodplain at Menangle Park as evidenced by past and present sand extraction. The alluvial sand deposits may provide suitable habitat.

4.4 ASSESSMENT OF SUITABLE HABITAT

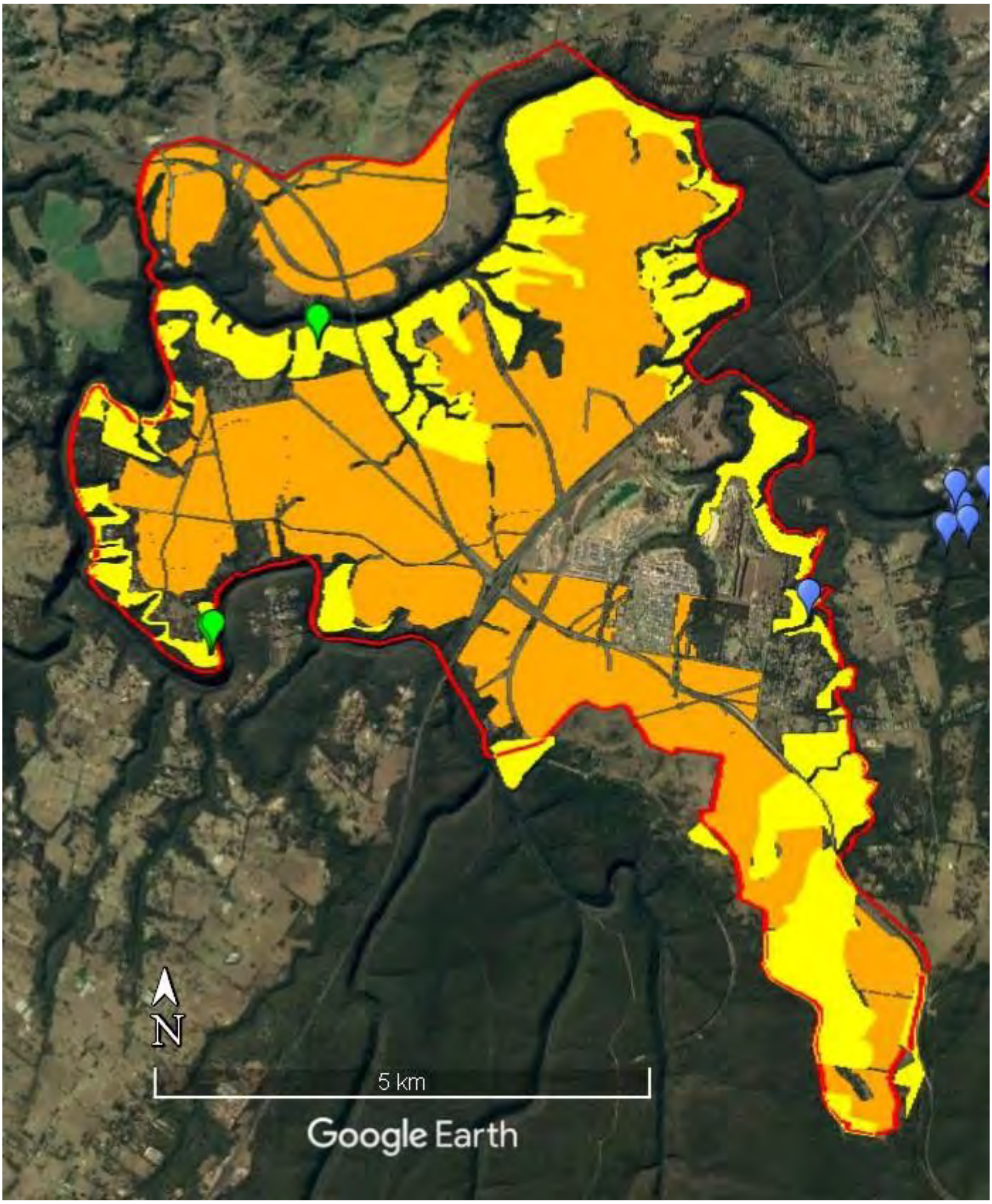
The assessment of suitable habitat has been described in section 4.3, assessment of species presence, because the survey during the non-flowering period required the presumption that if suitable habitat were present then the species could also be present.

The species group could be present in areas of alluvial / colluvial deposition especially adjacent shale and shale / sandstone transition. Within the WGA and GMGA occurrences within and shale / sandstone transition communities are most likely to occur in microhabitats such as seepage zones below or above sandstone outcrops or minor sandy colluvial deposits. Broad scale vegetation survey and mapping do not identify habitats at this scale. Survey during the flowering season is recommended.

4.4.1 DETERMINATION OF SPECIES POLYGONS

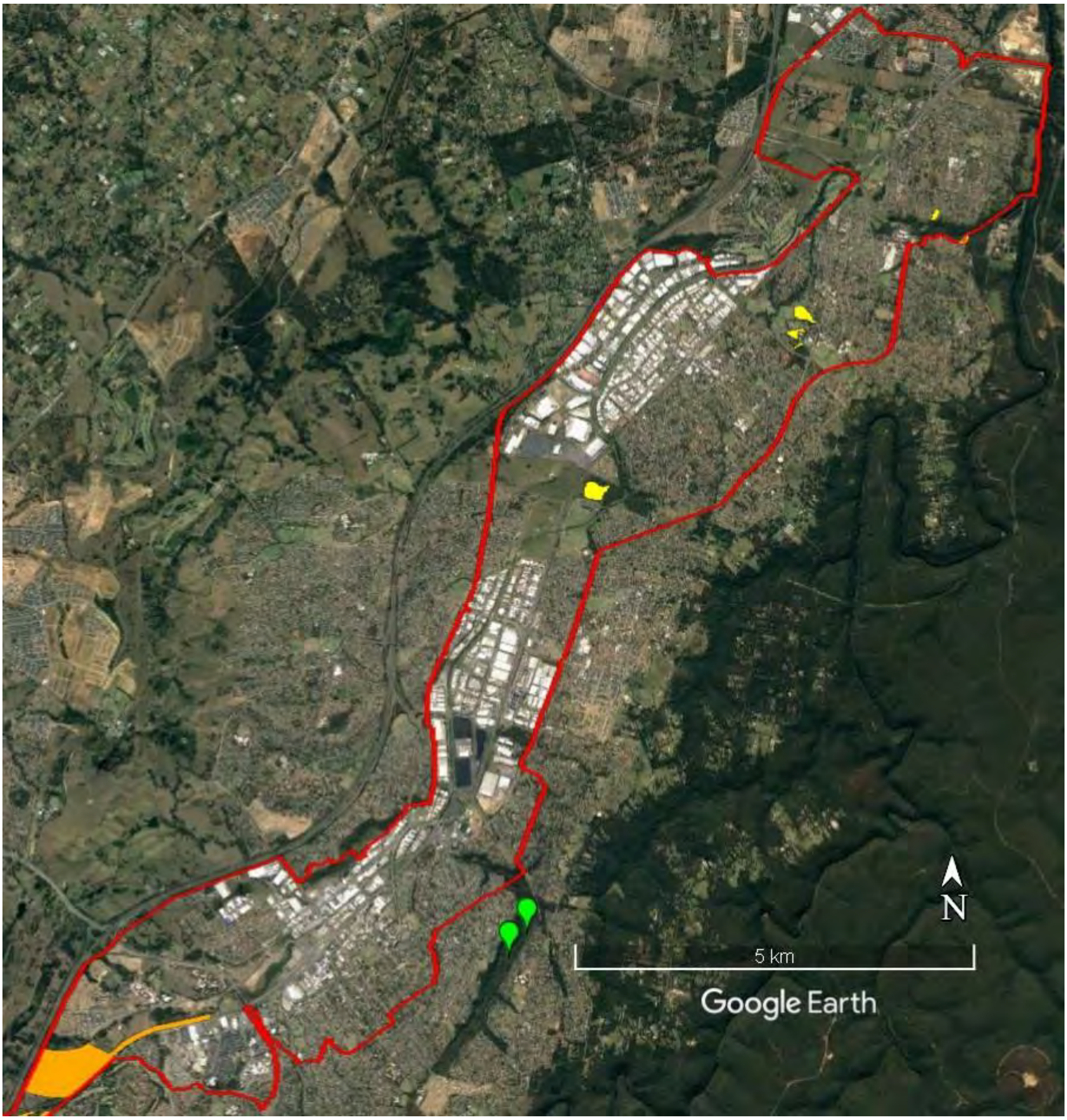
Determination of potential habitat for *Hibbertia puberula* includes areas identified outside the deemed biocertification area. Anthropogenic impacts are well documented to adversely affect vegetation well beyond the direct urban footprint.

The following maps show an overview of areas containing potential habitat of *Hibbertia puberula* group within the GMGA and WGA.



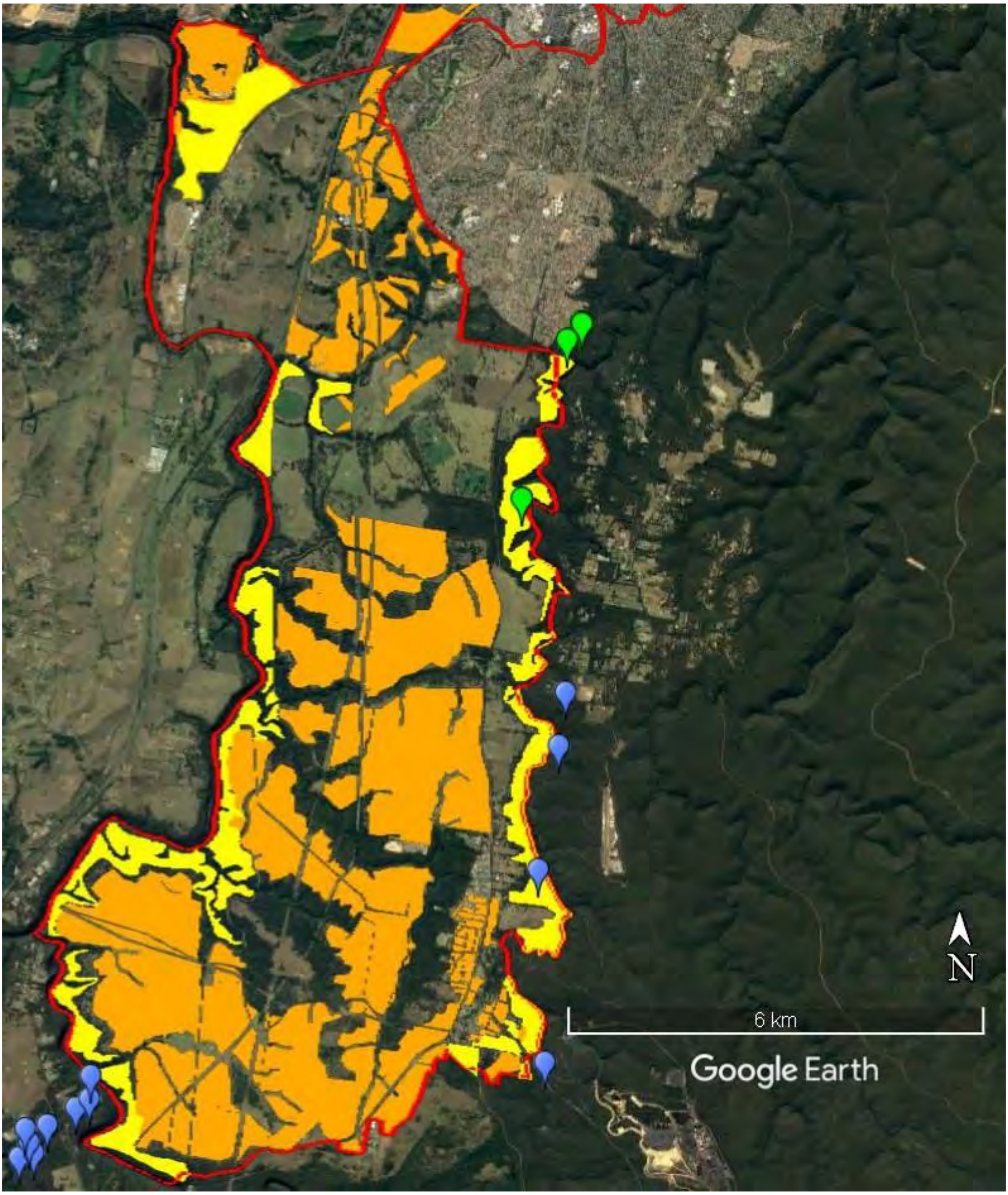
Map 7: Polygons of areas containing potential and known *H. puberula* habitat, WGA.

Key: Red - growth area boundary, orange – growth area footprints, yellow – areas containing known and likely habitat niches, green markers - location of a small leaved *Hibbertia* sp. with vegetative features consistent with *H. puberula*, purple markers – locations of *H. riparia* records.



Map 8: Polygons of areas containing potential *H. puberula* habitat, GMGA northern section.

Key: Red - growth area boundary, orange – growth area footprint, yellow - habitats assessed as having attributes similar to known extant populations, green markers - location of a small leaved *Hibbertia* sp. with vegetative features consistent with *H. puberula*.



Map 9: Polygons of areas containing potential *H. puberula* habitat, GMGA southern section.

Key: Red - growth area boundary, orange – growth area footprint, yellow - habitats assessed as having attributes similar to known populations, green markers - location of a small leaved *Hibbertia* sp. with vegetative features consistent with *H. puberula*, purple markers – location of *H. riparia* records.

4.4.2 JUSTIFICATION FOR DETERMINATION

The species potential habitat polygons for Milton Park, Kayess Park, Bunbury Curran Creek and Menangle Park in the GMGA are based on limited field inspections undertaken in adverse environmental conditions outside the flowering period. Therefore, the polygons are indicative only. The *Hibbertia puberula* group has been recorded from similar habitats.

The majority of potential habitat polygons for the WGA are based on regional mapping data provided by DPE as access issues limited field validation. Similar access issues arose with other potential habitat areas within the southern and central portions of the GMGA. Unless indicated potential habitat polygons for the southern and central portions of the GMGA are also based on regional mapping data.

The *Hibbertia puberula* group has been frequently recorded from Shale /Sandstone transition environs. The polygons are also an extrapolation of habitat characteristics where a small leaved *Hibbertia* sp. was located within or adjacent to the growth areas during survey for this assessment.

4.5 ESTIMATE OF AREA OF HABITAT OR NUMBER OF INDIVIDUALS

4.5.1 ESTIMATES

The assessment provides the following estimates:

- Likely habitat for *Hibbertia puberula* subsp. *extensa* occurs within the footprint in the southern part of the WGA, habitat would be small seepages within an area of 23ha.
- A further 278ha of land that could contain habitat niches for *H. puberula* subsp. *extensa* is adjacent to the footprint in the southern section of the WGA and the eastern side of the GMGA between Appin and Wedderburn.
- Likely habitat for *Hibbertia puberula* subsp. *glabrescens* occurs at Menangle Park. An area of approximately 92ha could contain likely habitat niches within the growth area footprint, and a further 31 ha of land containing likely habitat niches adjacent to the footprint.
- Likely habitat for *Hibbertia puberula* subsp. *puberula* occurs outside the development footprint at Milton Park, Kayess Park and in the vicinity of Bunbury Curran Creek reserve.
- Likely habitat for subspecies *puberula* within the development footprint occurs at Menangle Park (92ha), Gilead and Appin areas (8ha) and WGA (65ha).
- Likely and known habitat for subspecies *puberula* adjacent to the development footprint occurs at Menangle Park (31ha), Gilead and Appin areas (380ha) and WGA (680ha).

4.5.2 JUSTIFICATION FOR ESTIMATES

Assessment relied on personal knowledge of the species habitat for known populations, combined with vegetation mapping and soil and landscape features, to determine likely habitat locations within and adjacent the growth areas footprints.

It was not possible to provide accurate habitat areas or counts due to the following:

- Access was not granted to the majority of development footprint.
- Positive determination of the small leaved Hibbertias found as part of this expert report is not possible even though the vegetative morphological features are assessed to be +/- consistent with *Hibbertia puberula*. Floral characters in combination with vegetative features are essential to confirm identification of many *Hibbertia* species.
- The region has undergone a period of protracted drought and small diminutive species, forbs and even many of the larger resilient shrubs were observed to be in severe drought stress or dead. At all locations only a few *Hibbertia* sp. attributable to *H. puberula* were found, most almost dead. It is well documented that the above ground populations of many genera including *Hibbertia* species fluctuate widely in response to various conditions such as rainfall and time since last fire.
- Most sites inspected within the WGA and many within GMGA were noted to have senescing or dead shrubs, high levels of leaf, bark and branch fall and dead understorey, an indication of both a long fire interval and severe drought. Apparent diversity and population numbers of many species significantly decline, retreating to the soil seedbank under such conditions. It is inconclusive to undertake population census or estimates of occupied area under such circumstances.
- The cryptic nature of small-leaved *Hibbertia* when not in flower also make their detection extremely difficult and population count or area calculation unreliable.
- The use of a surrogate site(s), with the possible exception of *Hibbertia puberula* subsp. *glabrescens*, as a base for the estimation, in this case, is also deemed not credible. *Hibbertia puberula* is a data-poor species group. Insufficient or no reliable data exists with regard to population density across its range of habitat niches and fluctuation in population density over time at any given site.

5. Information used in the assessment

Information used in this assessment includes taxonomic papers, BioNet and ALA records of the target species, Critically Endangered Listing, online Threatened Species profile and associated documents, personal observations and site inspections, and the spatial viewer including the layers: survey access and coverage, (BAM plots, polygons and transects), PGA layer and geology and soils.

6. References

Eco Logical, 2015. *Inspection and review of the Hibbertia sp. Bankstown Population at Bankstown Airport*, report for Bankstown Airport Limited, available at http://www.environment.nsw.gov.au/resources/threatenedspecies/s91ands95/Site_Assessment_ReportA06600-2016.pdf

Hills District Council website, https://webcache.googleusercontent.com/search?q=cache:-vpeh8rPRVEJ:https://www.thehills.nsw.gov.au/files/assets/public/library-documents/local-studies/aborigines-in-the-hills-district.pdf+&cd=3&hl=en&ct=clnk&gl=au

National Parks and Wildlife Service. 2002. *The Native Vegetation of the Cumberland Plain Final Edition*. NSW National Parks and Wildlife Service, Hurstville, available at http://www.environment.nsw.gov.au/resources/nature/cumbPlainMappingInterpguidelines.pdf

NSW Department of Environment, Climate Change and Water, 2010. *Cumberland Plain Recovery Plan*, available at http://www.environment.nsw.gov.au/research-and-publications/publications-search/cumberland-plain-recovery-plan

Price, O. F., Horsey, B. & Jiang, N. (2016). Local and regional smoke impacts from prescribed fires. *Natural Hazards and Earth System Sciences*, 16 (10), 2247-2257, available at http://ro.uow.edu.au/cgi/viewcontent.cgi?article=5192&context=smhpapers

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Toelken, H. R. and Miller, R. T., 2012. Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in *Journal of Adelaide Botanic Gardens* 25 (2012) 71–96 and available at https://data.environment.sa.gov.au/Content/Publications/JABG25P071_Toelken.pdf

Toelken, H. R., 2013. Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia* Journal of the Adelaide Botanic Gardens 26 (2013) 31–69 and available at https://data.environment.sa.gov.au/Content/Publications/JABG26P031_Toelken.pdf

7. Appendices

Appendix 1. CURRICULUM VITAE

Robert Miller *Curriculum Vitae*

Contact Details:

Address	13 Park Road Bulli NSW 2516
Telephone	(02) 42 846768
	0410 244 865
Email	janrob02@gmail.com

Current Position:

Principal of Cumberland Flora & Fauna Interpretive Services

Qualifications:

Associate Diploma Horticulture from the University of Western Sydney (formerly Hawkesbury Agricultural College), conferred on 17 April 1982

Journal Articles

H.R. Toelken & R.T. Miller **2012** Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in Journal of the Adelaide Botanic Gardens, Vol. 25.

Miller J and Miller R **2005** Aquatic macroinvertebrates of headwater streams in the south east forests – diversity and conservation management issues, Wetlands (Australia) 23 (1).

Employment Record

1993 - present

Cumberland Flora and Fauna Interpretive Services

Principal - flora surveys, plant identifications, vegetation assessment, project impact assessment, bush regeneration, rehabilitation, habitat enhancement, seed collection and propagation services.

1990 - 1997 **Sylvan Grove**
Native Gardens

Curator of gardens and adjoining bushland - maintenance of and improvement to the plant collection, training and supervision of staff, liaison with other botanic gardens, guided tours, technical advice.

1982 - 1990 **Sylvan Grove**
Native Gardens

Horticulturist Specialising in Australian Flora - collection, propagation, identification, and growing of native plants.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES INFORMATION AND RELEVANT EXPERIENCE

Cumberland Flora and Fauna Interpretive Services have provided technical expertise since 1993 to numerous clients including Local Government, NSW Roads and Maritime, NSW Office Environment Heritage NPWS and community groups. Following is a list of some of our projects and clients:

REPORT	CLIENT
Expert advice for Conservation Assessment of *Solanum celatum* Eren Delgado1 16/04/2018, Science Division, NSW Office of Environment and Heritage	OEH
Saving our Species (SoS) project for *Pomaderris adnata* a post fire population census Grid D 2018	OEH
Provision of expert advice to update the current ecological data for southern NSW threatened flora species, as part of the review of biodiversity assessments under the Biodiversity Conservation Act 2016.	OEH

REPORT	CLIENT
Expert witness in botany Residents Against Intermodal Development Moorebank Incorporated v NSW Minister for Planning and Anor – NSW Land & Environment Court Class 1 Proceedings No. 2017/81889. Review of project documentation, in particular the various biodiversity assessments including the BAM assessment for the project and Individual Expert Witness report of Dr David Robertson 15 October 2017; Site inspections to identify the location of and/or potential habitat for *Hibbertia fumana*, *Hibbertia puberula*, *Grevillea parviflora*, *Persoonia nutans*, *Acacia bynoeana*, provision of an expert report in accordance with Division 2 of Part 31 of the UCPR; confer with the other parties experts at a joint conference and produce a joint expert report; and f appear at the section 34 conciliation conference	EDO
Saving our Species (SoS) project for *Pomaderris adnata* a population census 2017	OEH
Central Coast Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Great Lakes Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2015 – Vegetation Consultant	OEH
Clarence Colliery Discharge Investigation April 2015	OEH
Vegetation Assessment as part of the Lachlan Wetlands Condition Assessment Project October 2013 – May 2014	Lachlan Catchment Management Authority
Field expertise and guidance in the Sydney basin to PhD candidate Karen Muscat studying the molecular phylogenetics and morphology of the genus Dianella with close scrutiny of the variation in the D. *caerulea* group of species in eastern Australia	Volunteer to University of Melbourne
Survey for *Pomaderris adnata* to determine population size, structure, occupancy and threats 2014	NPWS Illawarra Region
Survey of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species 'Menai') to determine population size, structure, occupancy and threats. Collection of voucher herbarium material for taxonomic review June 2014	OEH
Survey of the southern populations of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species 'Menai') to determine population size, structure, occupancy and threats May 2014	OEH
Investigation of works within the Sublime point precinct Illawarra Escarpment State Conservation Area February 2014.	NPWS Illawarra Region
Identification of Hibbertia species in proposed control burn sites Victoria Road precinct Dharawal National Park.	NPWS Illawarra Region
Assessment of impact of infrastructure upgrade Victoria Road, Dharawal National Park – location of threatened species.	NPWS Illawarra Region
APPEAL IN RESPECT OF PROPERTY AT Lot 1 and 2 DP 224431 Site 2 Sturdee Avenue, Bulli	Roy 'Dootch' Kennedy

REPORT	CLIENT
Expert Witness Report Relating to Some Environmental Issues Land & Environment Court of New South Wales PROCEEDINGS NO 10982 of 2012	Roy 'Dootch' Kennedy
Field surveys, collection, pressing, curation of botanical specimens and contributions of notes in association with the manuscript "Notes on Hibbertia subgen. Hemistemma (Dilleniaceae) 7. Eight new species, a new combination and four new subspecies from mainly central New South Wales H.R. Toelken & R.T. Miller 2006 - 10 July 2012	Volunteer to Adelaide Botanic Gardens
Vegetation Surveys and assessments & input into the preparation of REF for proposed car-park and amenities Victoria Road Precinct Dharawal National Park November 12.	NPWS Illawarra Region
Office of Environment and Heritage – Priority Action Statement Expert Consultant Interviews June 2012 – January 2013	OEH
Vegetation Surveys and assessments & input into the preparation of REF for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking tracks in Dharawal National Park input into conservation risk assessments 2011 – 12.	NPWS Illawarra Region
Nomination to list Prostanthera saxicola R. Br. S. Str. as an Endangered Species under the NSW TSC Act September 2011	
Field surveys, collection, pressing and curation of botanical specimens of undescribed Kunzea to assist in the taxonomic circumscription of previously presumed extinct, rare and/or poorly known taxa for Dr. H.R. Toelken Honorary Research Associate State Herbarium Science Resource Centre Department of Environment and Natural Resources SA 2011	Volunteer to Adelaide Botanic Gardens
Significant Plant Survey – Maddens Plains Forest Path to Mount Mitchell Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Significant Plant Survey – Wongawillii Precinct Illawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Kembla State Forest Precinct Illawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Site Inspections and Vegetation Survey of Proposed Minor Track Re-Alignments: Forest Path to Woodward Track & Sublime Point to Austinmer Track Maddens Plains To Sublime Point Precinct Illawarra Escarpment State Conservation Area August 2010	NPWS Illawarra Region

REPORT	**CLIENT**
Sandon Point Aboriginal Place and Kuradji Lands Vegetation Management Plan April 2010	Illawarra Aboriginal Land Council, Wollongong Council, Southern Rivers Catchment Management Authority.
Forest Path to Woodward Track Precinct Track-head Realignment Maddens Plains IESCA Vegetation Survey April 2010.	NPWS Illawarra Region
Bushland Conservation Project 95 Glendiver Road, The Oaks 2008	A & S Fitzsimmons / Hawkesbury Nepean Catchment Management Authority
Significant Plant Survey – Maddens Plains Forest Path to Woodward Track Precinct Illawarra Escarpment State Conservation Area June 2007	NPWS Illawarra Region
Nomination of Hibbertia "Bankstown Airport" (R.T. Miller & C.P. Gibson s.n. 18/10/2006) as Critically Endangered under the Environment Protection and Biodiversity Conservation Act	Bankstown Bushland Society
Proposal to Demolish A Derelict Amenities Block at Deepwater Park Webster Street Milperra Environmental Assessment of Impacts	Bankstown City Council
Significant Plant Survey – Sublime Point to Panorama House Precinct Illawarra Escarpment Conservation Area August – September 2006	NPWS Illawarra Region
A Consultant for Priority Action Statement Workshop July 2005	NPWS
PHD research assistance – 'The Benefits of Riparian Vegetation in Maintaining Water Quality as Assessed Using Biological Indicators".	UNSW
Plan of Management for Part Lot 11 Dp 1049307 Kurrajong Road Prestons January 2005	Sule College
Preliminary Investigation & Vegetation Survey of Lands At Prestons Bounded By Maxwells Creek, Kurrajong Road, Ash Road & The Western Sydney Orbital December 2003	Sule College
Supply and collection of seed for a research project entitled: Factors Affecting Seed Germination and Mycorrhizal Development of the Epacrid: *Woolsia pungens* (2001-2003)	UNSW
Compensatory Habitat Assessment Western Sydney Orbital March 2004	RTA
Compensatory Habitat Assessment Western Sydney Orbital July 2002	RTA
Compensatory Habitat Assessment of Flora at Rouse Hill, Doonside, Cecil Hills & Kemps Creek for The Western Sydney Orbital March 2002	RTA
Compensatory Habitat Assessment Western Sydney Orbital November 2001	RTA
Preliminary Vegetation Survey Between Lawson Rd & Alfords Point Rd, Menai as Part of The Proposed Bangor Bypass 2001	RTA
8-Part Tests for The Proposed Bangor Bypass 2000	RTA
Preliminary Vegetation Survey for The Proposed Bangor Bypass 2000	RTA
Species Impact Statement for the Western Sydney Orbital 2000	Sinclair Knight Mertz

REPORT	**CLIENT**
Review of Environmental Assessments – Proposed Cricket Ground - Louisa Reserve, The Crest of Bankstown 2000	Bankstown Bushland Society
Review of Environmental Assessments – Proposed Olympic Criterium Circuit the Crest Statement of Environmental Effects	Bankstown Bushland Society
Vegetation Survey – 60 Yanderra Road, Yanderra 1999	Mr. Brian Timmis
Review and Comments on Environmental Assessment – Bankstown City Council - Proposed Cricket Ground – 8 – Part Test- The Crest 1999	Bankstown Bushland Society
Vegetation Survey and Review of Proposed Sand Mining Restoration Works – Howard Park, Lansvale 1999	Chipping Norton Lakes Authority
Rare Species Survey – Blue Mountains & Central Western Slopes 1999	National Parks & Wildlife Service
Vegetation Survey - Kookaburra Road and Camden Valley Way Intersection 1999	Roads & Traffic Authority
Chullora Detention Basin Wetlands Habitat Enhancement 1998	Business Land Group DUAP
Vegetation Study Maxwells Creek Trunk Drainage Stage 1 Vegetation Assessment 1998	Bewsher Consulting
Vegetation Study Prestons Urban Release Area Part 3 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 2 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 1 1998	Liverpool City Council
Survey of Remnant Flora for Proposed Nth Liverpool Rd to Edensor Rd Interim Transitway 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management Discussion Paper 1998	Roads & Traffic Authority
Eastern and Western Alignments WSO Cecil Hills Flora Study 1998	Roads & Traffic Authority
Valmay Road Development Vegetation Study 1998	LesryK Pty Ltd
Western Sydney Orbital Prestons To West Baulkham Hills Descriptive Inventory of Remnant Bushland 1998	Roads & Traffic Authority
Vegetation Survey River Road M5 East 1998	Roads & Traffic Authority
Tree Survey, Great Western Highway, Faulconbridge 1998	Roads & Traffic Authority
Eve & Marsh Street Wetlands M5 East 1997	Roads & Traffic Authority
Beverley Grove Bush M5 East 1997	Roads & Traffic Authority
Vegetation Survey - Salt Pan Creek Bridge Duplication M5 East 1997	Roads & Traffic Authority

REPORT	CLIENT
Survey of Flora: Trees and Shrubs, Princes Highway Interchange M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Adjacent to Proposed Exhaust Stack Henderson Avenue, M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Illoura Reserve, Adjacent to Air Intake Vent M5 East 1997	Roads & Traffic Authority
Lansdowne Reserve Survey of Remnant Flora 1997	Bankstown City Council
Villawood Drain Vertebrate Fauna Survey 1997	Bankstown City Council
Kelso Wetlands Survey of Remnant Flora 1997	Bankstown City Council
Deverall Park Survey of Remnant Flora 1997	Bankstown City Council
Louisa & McClean Reserves Bass Hill Survey of Remnant Flora 1997	Bankstown City Council
The Crest of Bankstown Survey of Remnant Flora 1997	Bankstown City Council
Lawson Bridge Roadworks Survey of Remnant Flora 1997	Roads & Traffic Authority
Davidson Street Scrub Survey of Remnant Flora 1997	Strathfield Council
Freshwater Creek Bushland Survey of Remnant Flora 1996	Bankstown Bushland Society for the EPA
Vegetation Survey Forest Lawn Cemetery Roadworks, Leppington 1996	Roads & Traffic Authority
Vegetation Survey Catherine Fields Road Intersection, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Springfields Road Intersection and Camden Valley Way, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Deepfields Road Intersection Camden Valley Way, Catherine Fields 1996	Roads & Traffic Authority
Picnic Point Reserve Vegetation Survey 1996	Bankstown City Council
East Hills Park Vegetation Survey 1996	Bankstown City Council
Monash Reserve Vegetation Survey 1995	Bankstown City Council
Vegetation Consultant on Plan of Management for Cox's Creek for the Endangered Green and Gold Bell Frog 1995	Urban Bushland Management
Smith Park Vegetation Survey 1995	Bankstown City Council
Flora and Fauna Survey, Villawood Stormwater Channel 1995	Bankstown City Council
Virginius Reserve Vegetation Survey 1994	Bankstown City Council
Carysfield Park Vegetation Survey 1993	Bankstown City Council

Ongoing research projects:

Private taxonomic research into the Australian plant genera Prostanthera, Westringia, Dianella, Thelionema, Viola and Hibbertia.

Private research into the invertebrate fauna of the Illawarra with particular emphasis on the Mayfly genus Atalophlebia

Flora of Bankstown" a botanical inventory

Botanical inventories of the Sublime Point and Maddens Plains precincts in the Illawarra Escarpment State Conservation Area

Other Publications & Reports

Miller, R.T. (1984 to 2006) numerous papers for the Prostanthera and Westringia Study Group Newsletters.

Miller, R.T. (1991) Vegetation Consultant on Eloura Nature Reserve Vegetation Survey: Report to Liverpool City Council, Greening Australia.

Miller, R.T. Vegetation Consultant on Salt Pan Creek Stage 1 Vegetation Survey: Report to Bankstown City Council, Ian Olsen.

Gibson, C.P. & Miller, R.T. Plant Species List for Bankstown's Natural Heritage: McLaughlin, L., BCC.

Gibson, C.P. & Miller, R.T. Flora of Bankstown Scientific Inventory of Botanical Heritage: Report to Australian National Parks and Wildlife Service, Gibson, C.P. and Miller, R.T. (in preparation).

Nomination of Prostanthera saxicola R. Br. s. str. As an Endangered Species under the NSW TSC Act November 2011

Special Projects

- "Flora of Bankstown" a botanical inventory
- Founder & Convener Cookson's Landcare Group Bulli (2003 – 2007)
- President, Society for Growing Australian Plants, East Hills Region, 1987-1995.
- Vice President, Society for Growing Australian Plants, East Hills Region, 1996.

- Plant Steward, Society for Growing Australian Plants, East Hills Region, 1987-1996.
- Leader of the Prostanthera Study Group Australian Plant Society, 1992 - 2010.
- Editor and publisher of Prostanthera & Westringia Study Group's Newsletter *The National Mint* and the Study Groups' Journal – *Lasianthos*.
- Vice President and Founding Member, Bankstown Bushland Society.
- Coordinator Grants Application, Bankstown Bushland Society.
- Bushland Regeneration Grants Project Manager, Bankstown Bushland Society:

- Deverall Park Restoration and Rehabilitation Swamp Woodland ($17,880).
- The Crest of Bankstown Restoration and Rehabilitation ($27,850).
- Airport and Ashford Reserves Restoration and Rehabilitation Swamp Woodland ($45,000).

- Co-recipient of Save the Bush grant for Flora of Bankstown by Hon. Ross Kelly, Minister for Arts, Sports and Environment, 1992-93 ($11,050).
- Founding Member of Illawarra Grevillea Park, Bulli.
- Curator, Lamiaceae collection, Illawarra Grevillea Park, Bulli.
- Former Bankstown City Council's Bushfire Taskforce Community Representative.
- Former presenter of an adult education course in gardening at Bankstown Evening College.
- Development and curation of a private regional herbarium.
- Expert Witness for NSW Police murder trial
- Former appointee as Trustee of the Georges River State Recreational Trust by the Minister for the Environment (the Hon. Tim Moore).

Appendix 2. *Hibbertia puberula* subs. *puberula* COLLECTION RECORDS

Field notes compiled by Miller and Miller & Gibson

Site: Lucas Heights Site 1 16/10/07

Abundance: extremely localised, rare < 12 plants noted.

Field notes: Lucas Heights Soil Landscape, Gentle plateau slope, skeletal soil above first sandstone outcropping +/- intermittent seepage zone. Vegetation sparse and stunted probably from the impact of drought and fire episode > 2 years. All *Hibbertia* appeared to be seedlings at this locale. Open Woodland / heath – Canopy: *Eucalyptus haemastoma*? and Stringybark species. Associated understorey: *Banksia ericifolia, B. oblongifolia, Leptospermum arachnoides, Grevillea sericea, Xanthorrhoea* sp., *Cyathochaeta diandra, Burchardia umbellata, Hypoxis hygrometrica*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 1 Ridgetop Laterite

Field notes: Very disturbed site (past trailbike/FWD and possible laterite extraction but now protected and regenerating. Open Woodland/Laterite Heath: *Eucalyptus punctata.* Associated understorey species: *Exocarpos cupressiformis, Goodenia hederacea, Pomax umbellata, Brachyloma daphnoides, Patersonia sericea, Gompholobium minus, Leptospermum parvifolium, Kunzea ambigua, Persoonia laurina, Micrantheum ericoides.*

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 2 Easterly Plateau slope above Georges River

Abundance: Very localised but locally common c. 20 plants noted.

Field notes: Soil: fine sand with clay component, undisturbed habitat, walking track only. Habit: compact wiry shrub 30-60cm wide with many lax stems arising from a rootstock. In Open Woodland. *Eucalyptus sclerophylla?, E. punctata, Angophora bakeri*. Associated understorey: *Melaleuca nodosa, Lambertia formosa, Leptospermum trinervium, Callistemon linearis, Kunzea ambigua, Kunzea capitata, Helichrysum collinum, Xanthorrhoea sp., Stipa pubescens, Themeda australis*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 3 Upperslope/headwaters of upper drainage line.

Field notes: Undisturbed. *Eucalyptus punctata, E. sclerophylla*? and *Angophora bakeri*. Associated understorey: *Kunzea ambigua, Melaleuca nodosa, Gompholobium minus, Isopogon anemonifolius, Leucopogon, Kunzea capitata, Xanthorrhoea* sp. Dominated by *Kunzea* and *Melaleuca nodosa*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 4 Laterite Ridgetop.

Field notes: *Angophora bakeri. Leptospermum parvifolium* (dominates), *Kunzea ambigua, Petrophile sessilis, Micrantheum ericoides, Kunzea capitata, Lambertia formosa, Pimelea linifolia, Stipa pubescens*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 1: Lateritic Heath

Field notes: *Eucalyptus* sp. (Stringybark), *E. squamosa, Allocasuarina littoralis, Angophora hispida*. Associated understorey*: Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis, Persoonia lanceolata, Isopogon anemonifolius, Hakea laevipes, H. sericea, Grevillea diffusa, Actinotus minor, Cyathochaeta diandra, Entolasia stricta, Caustis flexuous*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 2: Lateritic Heath

Field notes: Soil very fine sandy loam. Habit: low +/- prostrate shrub sprawling through sedges. *Angophora hispida, Corymbia gummifera, Allocasuarina littoralis*. Associated understorey: *Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis, Persoonia lanceolata, Pultenaea elliptica, Isopogon anemonifolius, Banksia spinulosa, Grevillea diffusa, Actinotus minor, Cyathochaeta diandra, Entolasia stricta*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 3

Field notes: Soil sandy loam with small sandstone outcroppings. Open Forest *Eucalyptus punctata*, E. sp. (Stringybark), and *Corymbia gummifera.* Associated understorey: *Hakea laevipes, Leptospermum parvifolium, Isopogon anemonifolius, Lissanthe strigosa, Grevillea diffusa, Hakea sericea, Acacia linifolia, Themeda australis, Lomandra obliqua, Lomandra cylindrica, Cyathochaeta diandra*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 4

Field notes: Soil: fine sandy loam scattered lateritic fragments. Open Forest with grassy and herbaceous understorey comprised of *Eucalyptus punctata*, E. sp. (Stringybark), and *Corymbia gummifera.* Associated understorey: *Leptospermum parvifolium, Isopogon anemonifolius, Lissanthe strigosa, Grevillea diffusa, Goodenia hederacea, Stipa pubescens, Themeda australis, Entolasia stricta, Hypoxis hygrometrica, Hovea linearis, Cryptandra* sp., *Lobelia dentata, Patersonia sericea, Cyathochaeta diandra* and *Xanthorrhoea* sp.

Site: Peter Meadows Reserve Old Kent Road Kentlyn

Field notes: Soil: sandy, lateritic. Lateritic Ridgetop Heath *Eucalyptus sclerophylla, E. squamosa, Angophora hispida* heath. Lateritic Ridgetop Heath /Woodland interface: *Eucalyptus sclerophylla, E. punctata, Angophora hispida*. Associated understorey species: *Petrophile sessilis, Lambertia formosa, Kunzea capitata, Leptospermum arachnoides, Brachyloma daphnoides, Hakea laevipes, Xanthorrhoea sp., Actinotus minor, Pultenaea elliptica, Hakea sericea, Gompholobium minus, Goodenia hederacea* and *Entolasia stricta*.

Site: Freres Crossing Reserve, Freres Road Kentlyn 2/11/07, Ridgetop slopes

Field notes: *Eucalyptus punctata, Syncarpia glomulifera* Associated understorey: *Hakea laevipes, Persoonia linearis, Leptospermum trinervium, Isopogon anemonifolius, Gompholobium minus,* *Acacia terminalis, Gonocarpus tetragynus, Brachyloma daphnoides, Eriostemon australis, Grevillea diffusa, Hibbertia diffusa, Hypoxis hygrometrica, Xanthorrhoea* sp*., Themeda australis, Lomandra obliqua, Entolasia stricta.*

Site: Freres Crossing Reserve, Freres Road Kentlyn 2/11/07, Ridgetop

Field notes: *Eucalyptus punctata, Angophora costata*, Stringybark sp. Associated understorey*: Allocasuarina littoralis, Kunzea ambigua, Acacia terminalis, Brachyloma daphnoides, Hypoxis hygrometrica, Themeda australis* and *Stipa pubescens*.

Site: Ella Avenue Barden Ridge (formerly Lucas Heights) 20/11/07 Below Detention Basin

Field notes: Localised in drainage line. Site impacted by housing development – weed invasion occurring due to urban runoff and sedimentation. *Eucalyptus punctata*, E. sp. (Stringybark), *E. haemastoma, Corymbia gummifera, Angophora hispida*. Associated understorey: *Hakea sericea, Banksia oblongifolia, Leptospermum polygalifolia, L. arachnoides, Lambertia formosa, Kunzea ambigua, Grevillea sericea, Epacris pulchella, Banksia spinulosus, B. marginata, Isopogon anemonifolius, Hakea laevipes, Phyllota phylicoides, Actinotus minor, Patersonia sericea, Xanthorrhoea resinosa, Stipa pubescens, Xanthosia tridentata, Lomandra obliqua, Cyathochaeta diandra, Lepyrodia scariosa, Schoenus brevifolius, Lindsaea linearis*.

Site: Ella Avenue Barden Ridge (formerly Lucas Heights) 20/11/07 Downslope of Detention Basin

Field notes: Scattered through sedges - relatively rare at edge of wet heath/swamp. *Eucalyptus haemastoma*, E. sp. (stringybark), *E. punctata*. Associated understorey: Sedges dominate understorey: *Leptocarpus tenax, Schoenus brevifolius, Xanthorrhoea resinosa, Leptospermum polygalifolia, Banksia oblongifolia, Actinotus minor, Dampiera stricta, Epacris pulchella, Entolasia stricta, Deyeuxia decipiens.*

Site: Little Forest Lucas Heights 20/11/07

Field notes: Soil: fine sandy loam with clay content, +/- impeded drainage, Lucas Heights Soil Landscape, Localised in narrow zone in upper drainage line. *Eucalyptus oblonga, E. haemastoma, Corymbia gummifera, Angophora hispida.* Associated understorey: *Callistemon citrinus, Banksia oblongifolia, Leptospermum polygalifolia, L. arachnoides, Lambertia formosa, Kunzea ambigua, Grevillea diffusa, G. sericea, Melaleuca thymifolia, Callistemon linearis, Hakea sericea, H. teretifolia, Acacia linifolia, Mirbelia rubiifolia, Actinotus minor, Patersonia sericea, Xanthorrhoea resinosa, Stipa pubescens, Xanthosia tridentata, Lomandra obliqua, Cyathochaeta diandra, Schoenus brevifolius*.

Site: Voyager Point Adjacent Old Single Mens Quarters

Field notes: Soil: Fine sand atop of lateritic gravels – Surface layer -Well drained, Aspect: easterly Slope: 0-2. Open Woodland: *Eucalyptus sclerophylla, E. parramattensis, Angophora bakeri*. Understorey diverse open to moderately dense with well-developed ground layer. Dominant Associated Shrub Species: *Melaleuca nodosa, Petrophile sessilis, Leptospermum parvifolium, L.*

trinervium, Banksia spinulosa, Hakea laevipes, Kunzea ambigua, Persoonia lanceolata, Callistemon linearis, Hakea sericea, Acacia brownii, Daviesia acicularis. Dominant Associated Ground Layer Species: *Platysace ericoides, Hovea linearis, Lomandra obliqua, Lepyrodia scariosa, Austrostipa pubescens, Austrodanthonia tenuior, Cyathochaeta diandra*.

Site: Voyager Point adjacent Sirius Drive

Field notes: Soil: Fine sand and laterite – Surface layer -Well drained. Aspect northerly slope 0-2. Open Woodland: *Eucalyptus sclerophylla, Angophora bakeri* and *Eucalyptus oblonga*. Understorey diverse, open to moderately dense with well-developed ground layer. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, Banksia spinulosa, Babingtonia densiflora, Brachyloma daphnoides, Kunzea ambigua, Persoonia levis, Grevillea sericea, Hakea sericea, Isopogon anemonifolius, Melaleuca nodosa, Lambertia formosa, Philotheca scaber, Styphelia laeta.* Dominant Associated Ground Layer Species: *Platysace ericoides, Dianella revoluta, Lomandra obliqua, Lepyrodia scariosa, Austrostipa pubescens, Cyathochaeta diandra*.

Site: Yeramba Lagoon 2/1/07 Ridge slopes 1

Field notes: Shelving sandstone terraces. Soil: Sandy loam. Surface layer: Well drained but drainage impeded by sandstone bedrock. Aspect: westerly slope: 5. Open Woodland: *Eucalyptus racemosa, Corymbia gummifera, Eucalyptus oblonga & Angophora bakeri.* Understorey diverse, open grassy site. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum polygalifolium, Banksia oblongifolia, B. spinulosa, B. marginata, Kunzea ambigua, Persoonia levis, Grevillea sericea, Hakea sericea, Grevillea sericea, Hakea laevipes, Leptospermum arachnoides, Epacris microphylla, Hibbertia stricta.* Dominant Associated Ground Layer Species: *Actinotus minor, Schoenus moorei, Austrostipa pubescens, Themeda australis, Entolasia stricta, Lomandra multiflora.*

Site: Yeramba Lagoon 2/1/07 Ridge slopes 2

Field notes: Ridge slopes – shelving sandstone terraces. Soil: Sandy loam. Surface layer: Well drained. Aspect: northwest. Slope: 5. Interface between Woodland*: Eucalyptus oblonga, Corymbia gummifera, Eucalyptus punctata* Open Woodland: *Eucalyptus racemosa, Corymbia gummifera, Eucalyptus oblonga & Angophora bakeri.* Understorey diverse and well developed moderately dense. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, B. marginata, Hibbertia stricta*, *Leucopogon microphyllus, Lambertia formosa, Callistemon linearis, Melaleuca thymifolia, Gompholobium grandiflora, Epacris microphylla, Lasiopetalum ferrugineum.*

Dominant Associated Ground Layer Species: *Themeda australis, Entolasia stricta, Burchardia umbellata*, *Actinotus minor, Lomandra obliqua, Schoenus moorei, Austrostipa pubescens.*

Site: Blackwall 2/1/07 Ridgetop / Plateau

Field notes: Soil: relatively deep sand. Aspect: Northerly Slope: < 2. Open Woodland: *Corymbia gummifera, Eucalyptus racemosa, E. punctata, and E. oblonga.* Understorey diverse. Dominant Associated Shrub Species: *Brachyloma daphnoides, Banksia spinulosa, Petrophile sessilis, Leptospermum trinervium, L. parvifolium, Isopogon anemonifolius, Babingtonia densifolia, Dillwynia* *retorta, Philotheca scabra, Grevillea sericea, Gompholobium glabratum, Xanthorrhoea media, Kunzea ambigua, Bossiaea heterophylla, Acacia myrtifolia.* Dominant Associated Ground Layer Species: *Phyllanthus hirtellus, Pomax umbellata, Austrostipa pubescens, Themeda australis* and*Cyathochaeta diandra.*

Site: Mickeys Point 2/1/07 Ridgetop / Plateau

Field notes: Soil: lateritic. Aspect: North east Slope: < 2. Open Woodland / Heath: *Eucalyptus racemosa, Angophora hispida,* and *Allocasuarina littoralis.* Understorey diverse. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, Hakea sericea, Persoonia levis, Kunzea ambigua, Styphelia triflora, Isopogon anemonifolius, Brachyloma daphnoides, Babingtonia densifolia, Hemigenia purpurea, Hibbertia stricta*. Dominant Associated Ground Layer Species: *Actinotus minor, Baeckea ramosissima, Poranthera ericoides, Lomandra obliqua, Austrostipa pubescens, Entolasia stricta.*

Appendix 3. *Hibbertia puberula* IDENTIFICATION CHARACTERS

All microscopic photos by Miller 2018.

Photo 14: *Hibbertia puberula* subsp. *puberula* Canoelands.

Photo shows that the hairs are “worn off” on the older growth.

Photo 15: *Hibbertia puberula* subsp. *puberula* Canoelands

Photo shows tomentum characteristics of new shoots, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface.

Photo 16: *Hibbertia puberula* subsp. *puberula* from Lucas Heights.

Photo 17: *Hibbertia puberula* subsp. *puberula* (Lucas Heights)

Photo shows leaf and stem tomentum, revolute margins and bulging broader central vein obscuring the leaf undersurface of new shoot.

Photo 18: *Hibbertia puberula* subsp. *puberula,* Smith's Creek Reserve 4th June 2018.

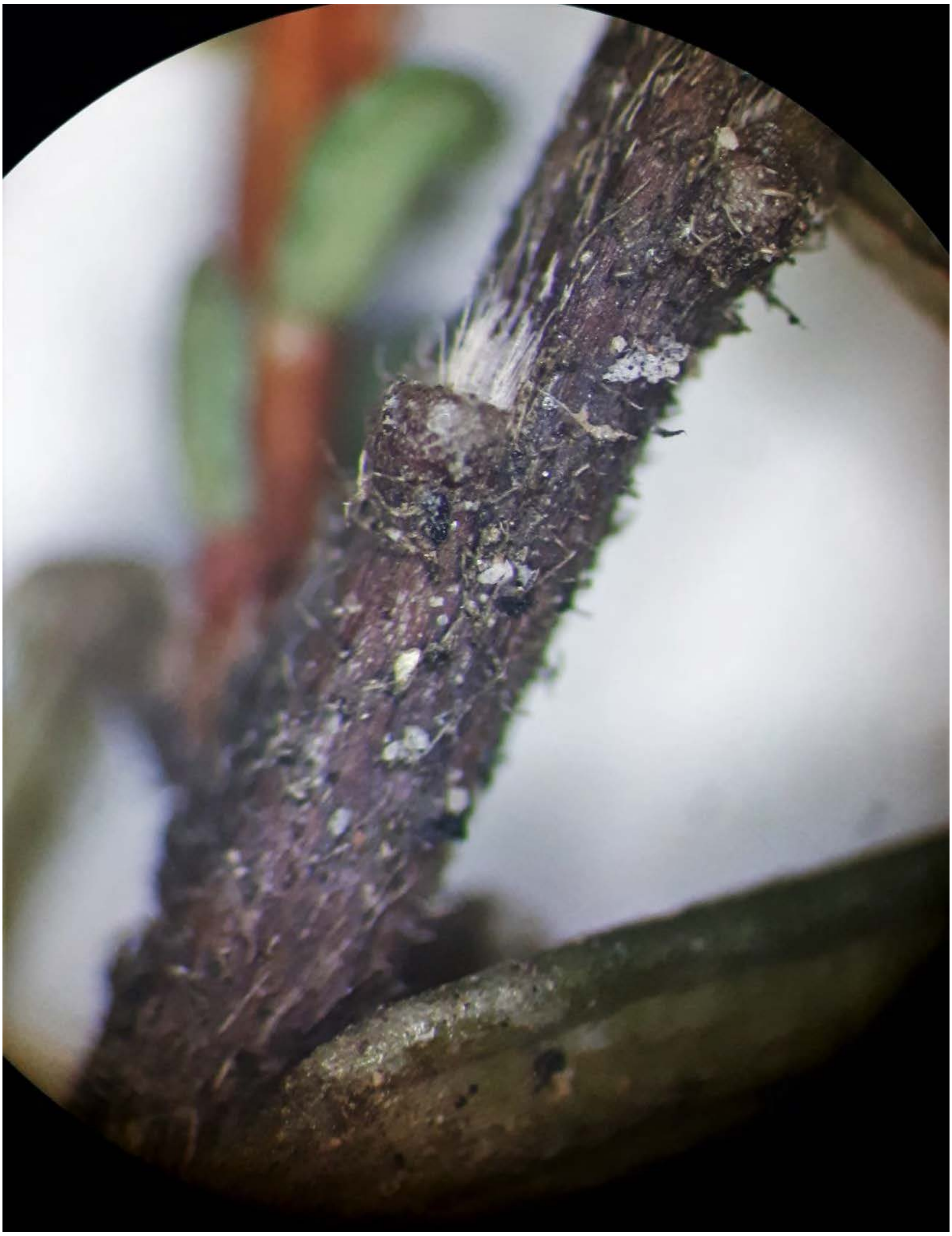


Photo 19: *Hibbertia puberula* subsp. *puberula,* Smith's Creek Reserve 4th June 2018.

Photo 20: *Hibbertia puberula* subsp. *extensa* juvenile shoot.

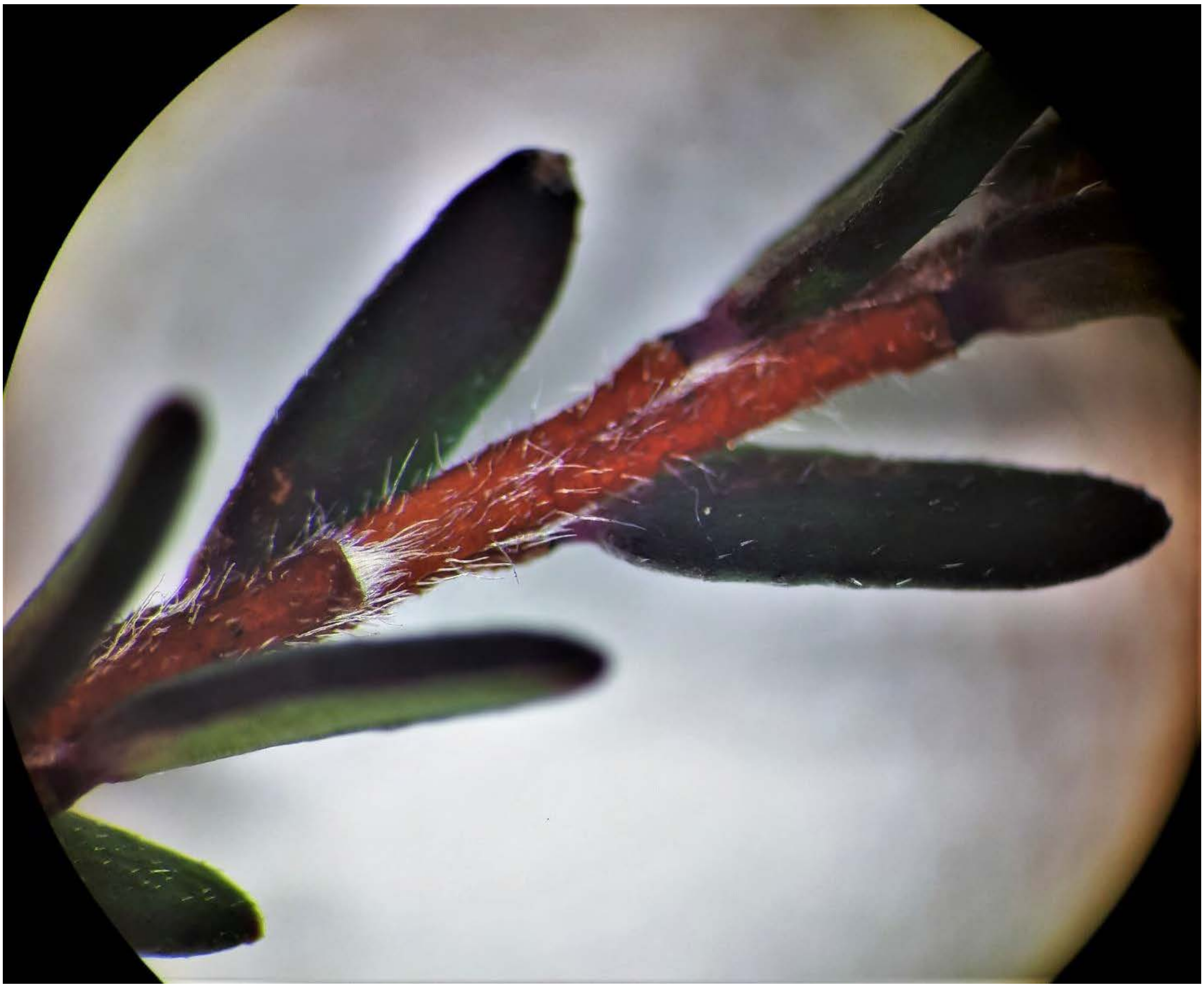


Photo 21: *Hibbertia puberula* subsp. *extensa* juvenile shoot showing tomentum characteristics.

Photo 22: *Hibbertia puberula* subsp. *extensa*

Photo shows typical lateral branching habit and tomentum characteristics of calyxes, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface.

Photo 23: *Hibbertia puberula* subsp. *extensa*

Photo shows tomentum characteristics of stem, revolute leaf margins and bulging broader central vein that obscures the leaf undersurface noting that tomentum has “worn off”.

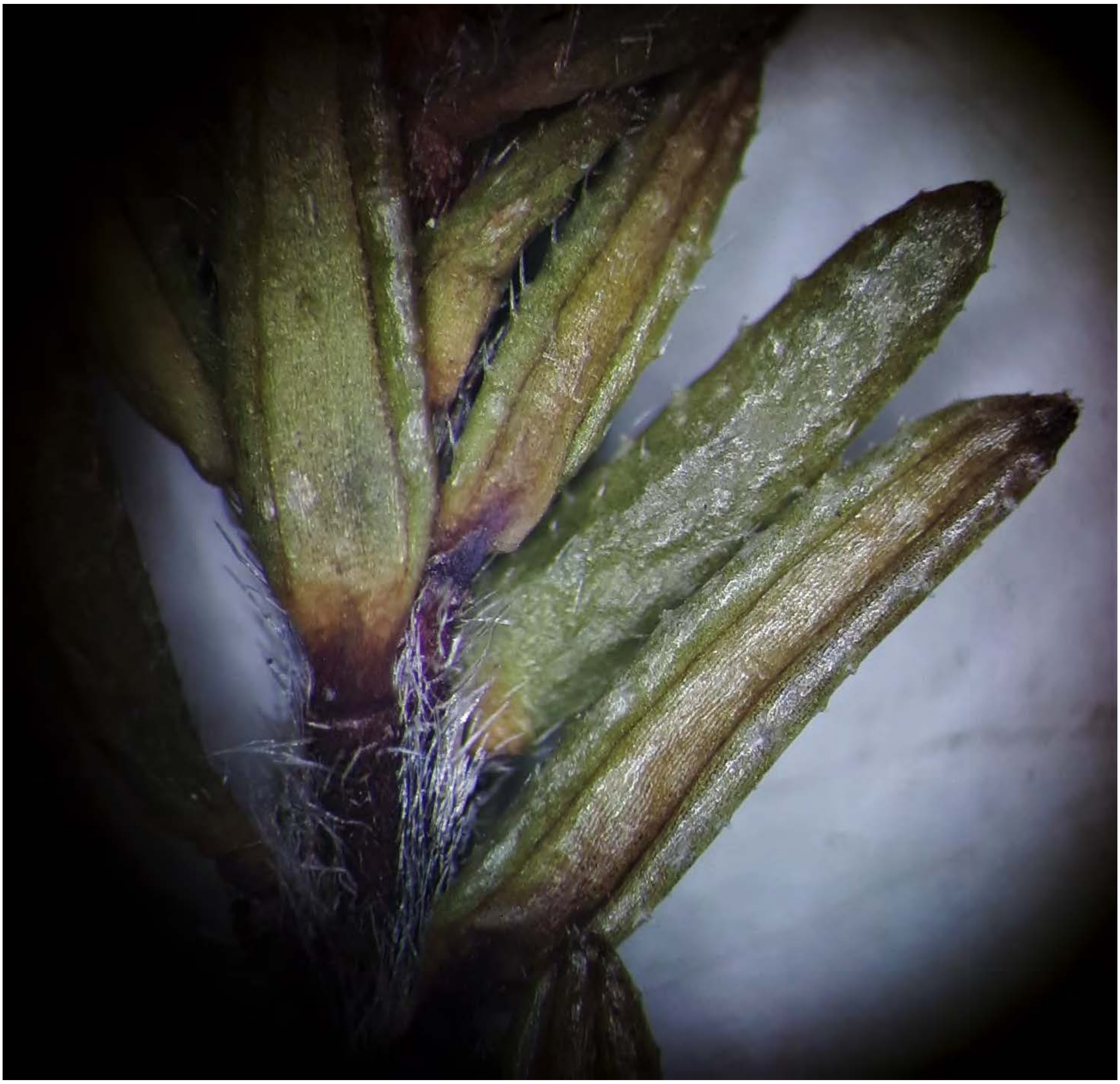


Photo 24: *Hibbertia puberula* subsp. *extensa.*

Photo shows tomentum characteristics of an upper portion of the branchlet, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Note that much of the tomentum has not “worn off”.

Photo 25: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing tomentum characteristics, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 26: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing interpetiolar tuffs, glabrescent tomentum characteristics, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 27: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing interpetiolar tuffs of hair and scattered simple hairs on upper shoot. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 28: *Hibbertia puberula* subsp. *glabrescens.*

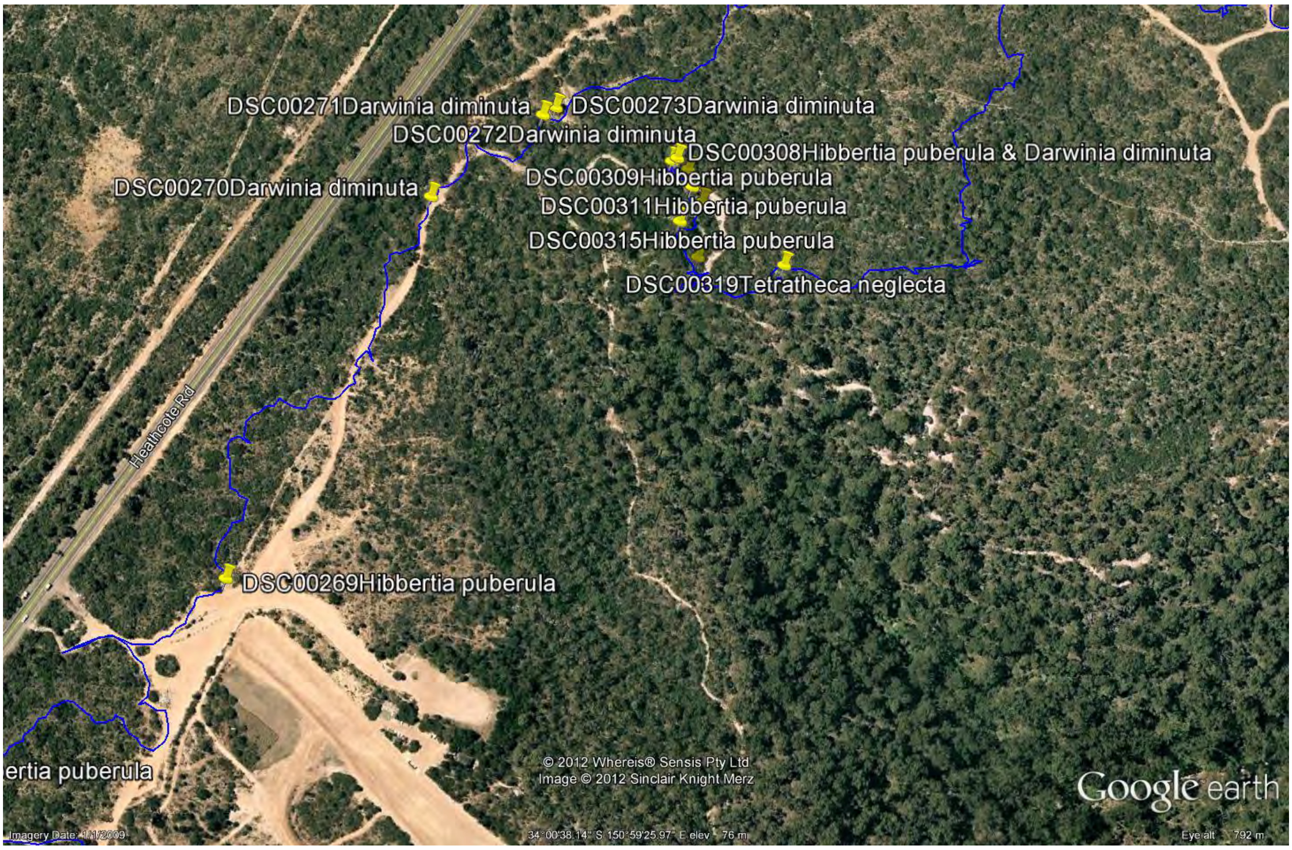
Photo showing glabrescent calyces. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Appendix 4. INDICATIVE DISTRIBUTION OF *Hibbertia puberula* at MENAI.

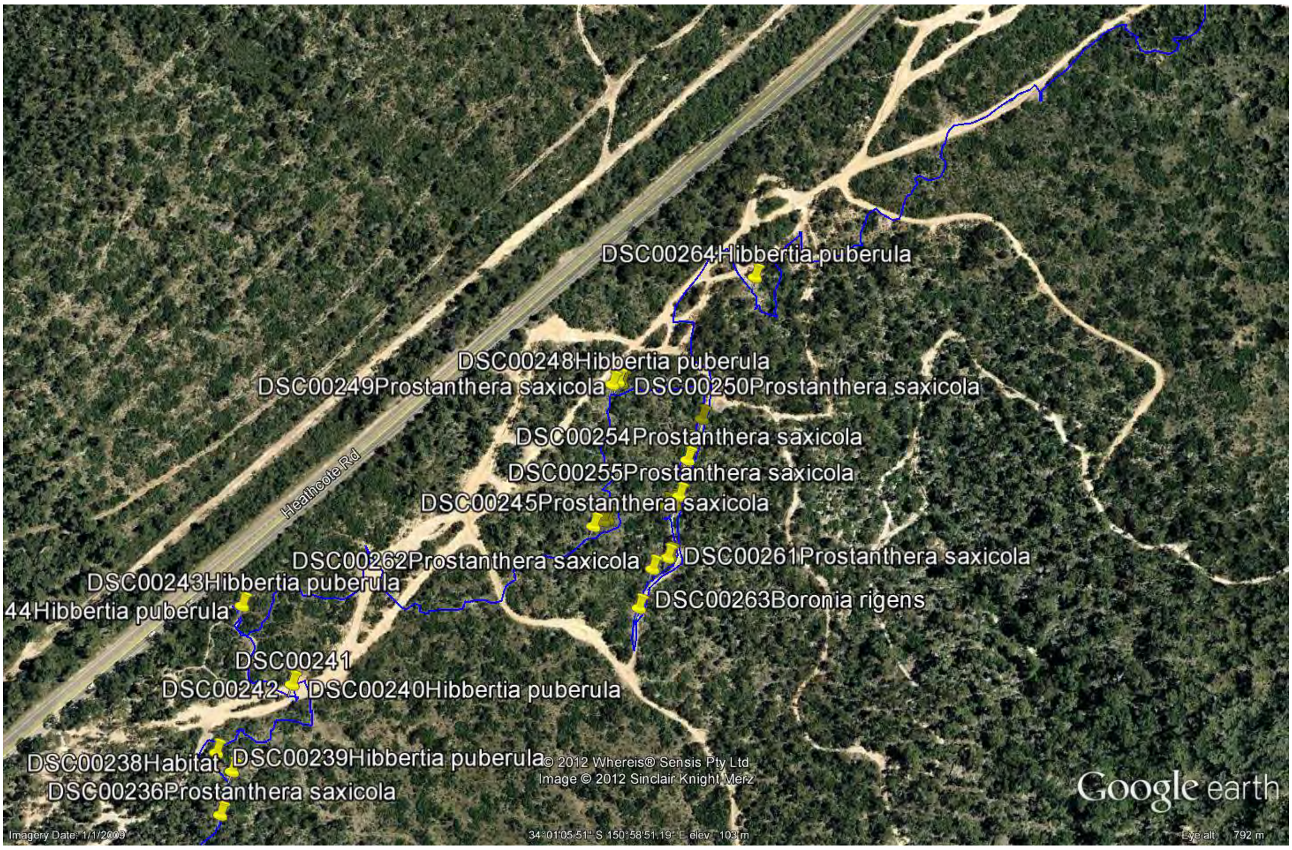
The following Google Earth images show the indicative distribution of threatened taxa east of Heathcote Road within a Menai proposed development footprint, recorded on two brief CFFIS site inspections.

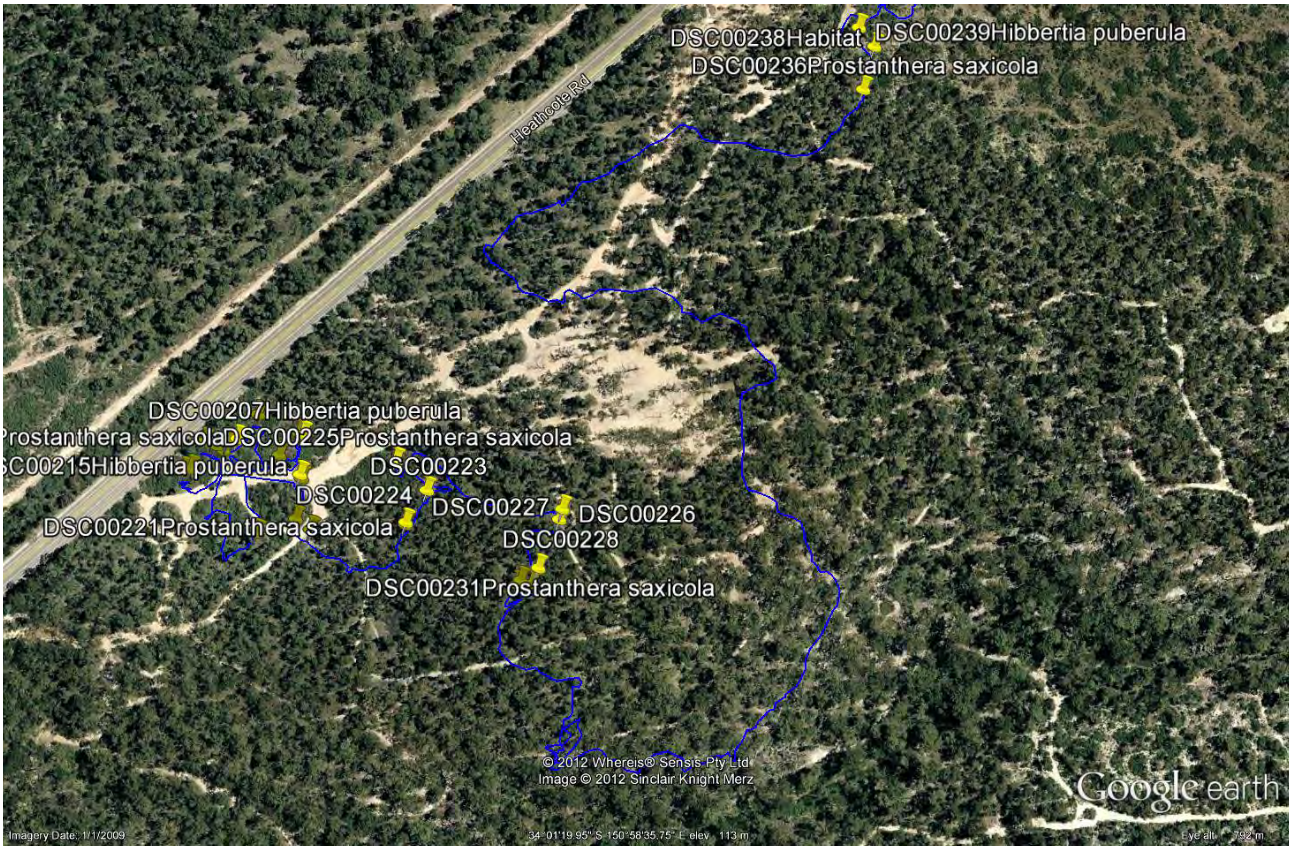

Heathcote Rd
318Acacia bynoeana
319Acacia bynoeana
317Prostanthera saxicola
315Prostanthera saxicola
314Prostanthera saxicola
313Prostanthera saxicola
320Prostanthera saxicola
321Prostanthera saxicola
322Prostanthera saxicola
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth
Imagery Date: 1/1/2009
Eye alt 792 m


311Acacia bynoeana
312Acacia bynoeana
308Hibbertia puberula
310Hibbertia puberula
DSC00321Hibbertia puberula
Survey
DSC00277habitat
DSC00278habitat
DSC00275habitat
DSC00320Acacia bynoeana
DSC00274habitat
DSC00273Darwinia diminuta
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth
Eye alt 792 m


DSC00271Darwinia diminuta
DSC00273Darwinia diminuta
DSC00272Darwinia diminuta
DSC00308Hibbertia puberula & Darwinia diminuta
DSC00270Darwinia diminuta
DSC00309Hibbertia puberula
DSC00311Hibbertia puberula
DSC00315Hibbertia puberula
DSC00319Tetratheca neglecta
Heathcote Rd
DSC00269Hibbertia puberula
ertia puberula
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00268Hibbertia puberula
DSC00267Hibbertia puberula
DSC00265Hibbertia puberula
DSC00266Hibbertia puberula
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00264Hibbertia puberula
DSC00248Hibbertia puberula
DSC00249Prostanthera saxicola
DSC00250Prostanthera saxicola
DSC00254Prostanthera saxicola
DSC00255Prostanthera saxicola
DSC00245Prostanthera saxicola
Heathcote Rd
DSC00262Prostanthera saxicola
DSC00261Prostanthera saxicola
DSC00263Boronia rigens
DSC00243Hibbertia puberula
44Hibbertia puberula
DSC00241
DSC00242
DSC00240Hibbertia puberula
DSC00238Habitat
DSC00239Hibbertia puberula
DSC00236Prostanthera saxicola
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00238Habitat
DSC00239Hibbertia puberula
DSC00236Prostanthera saxicola
Heathcote Rd
DSC00207Hibbertia puberula
rostanthera saxicola
DSC00225Prostanthera saxicola
C00215Hibbertia puberula
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DSC00224
DSC00227
DSC00226
DSC00221Prostanthera saxicola
DSC00228
DSC00231Prostanthera saxicola
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Image © 2012 Sinclair Knight Merz
Google earth

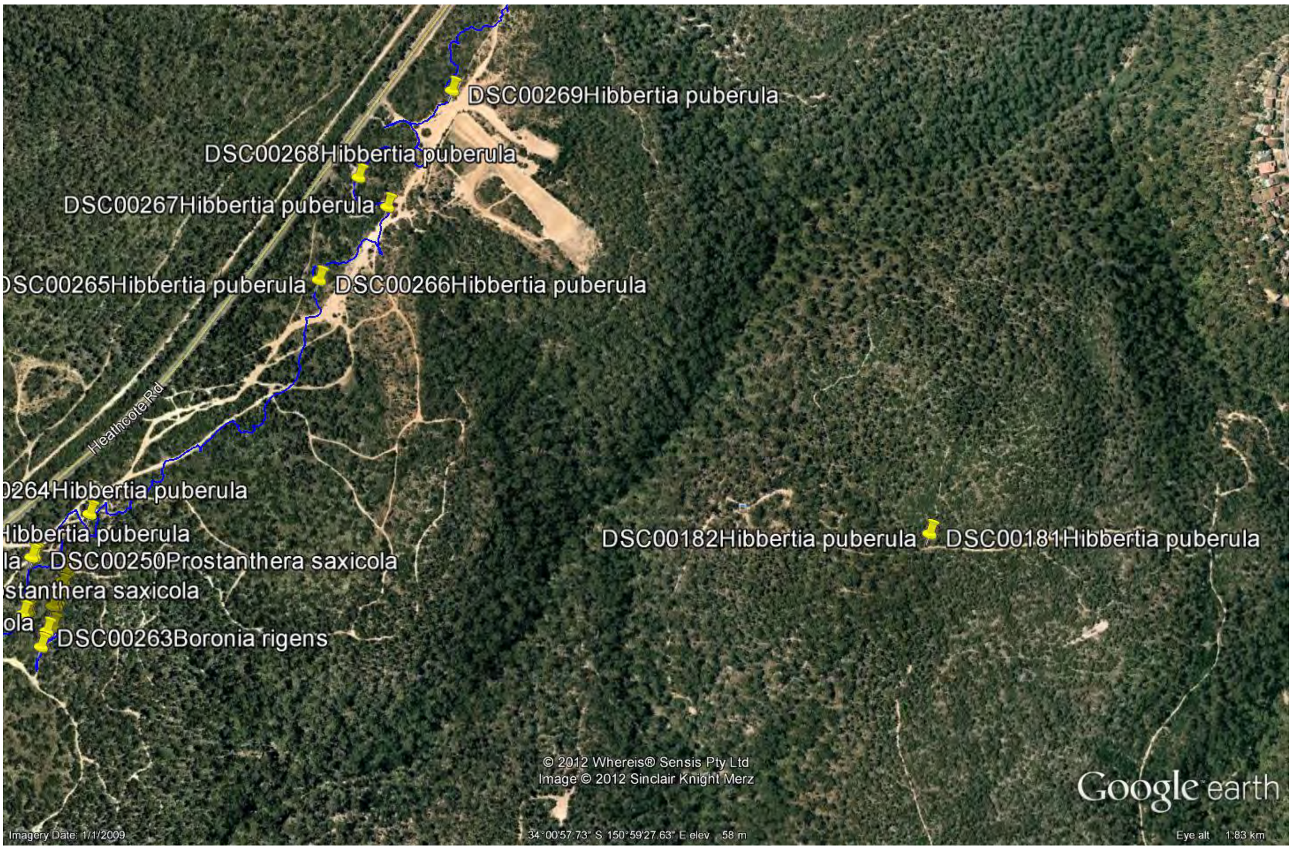
DSC00269Hibbertia puberula
DSC00268Hibbertia puberula
DSC00267Hibbertia puberula
DSC00265Hibbertia puberula
DSC00266Hibbertia puberula
Heathcote Rd
264Hibbertia puberula
Hibbertia puberula
DSC00250Prostanthera saxicola
stanthera saxicola
DSC00263Boronia rigens
DSC00182Hibbertia puberula
DSC00181Hibbertia puberula
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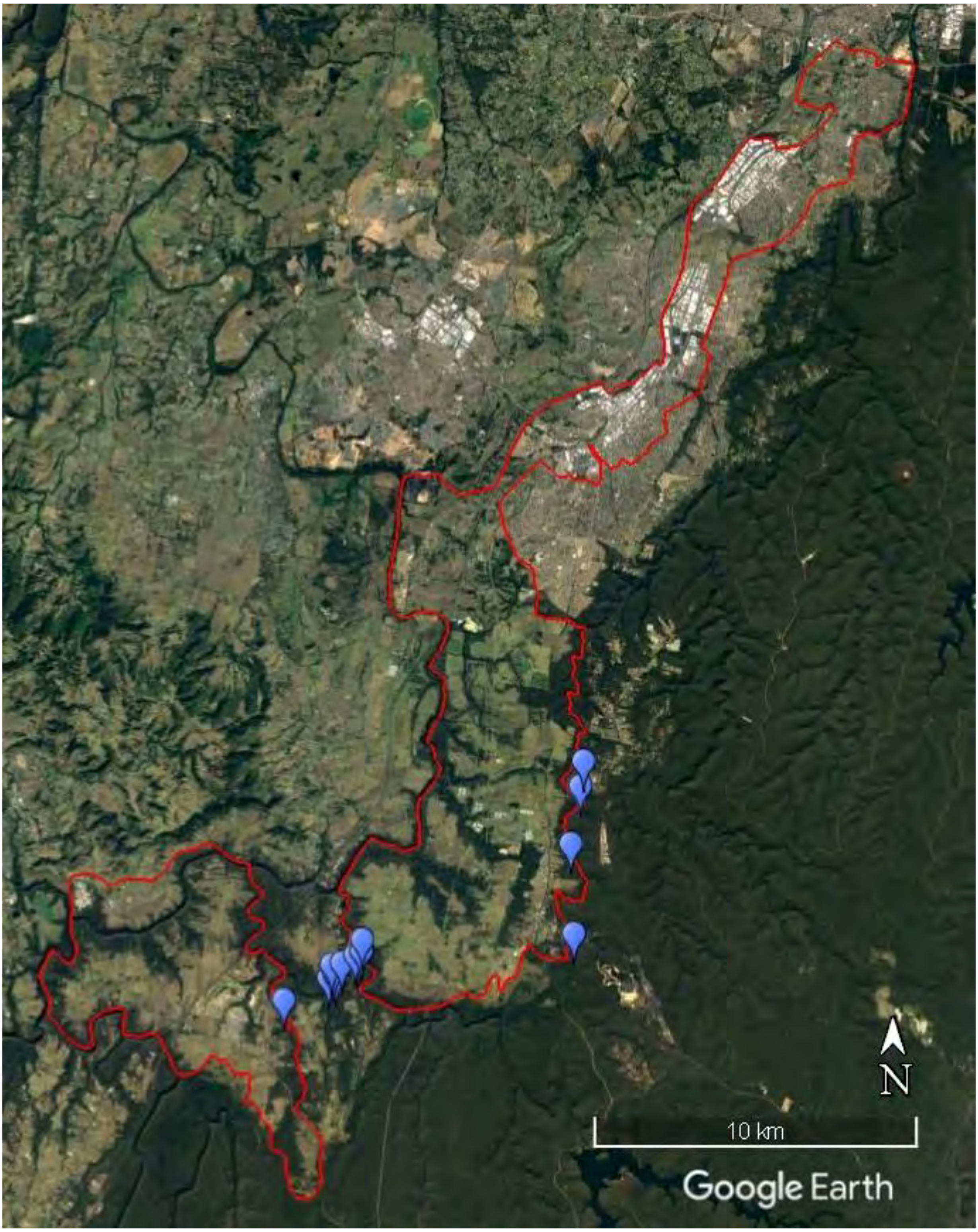
Image © 2012 Sinclair Knight Merz
Google earth

Appendix 5. DISTRIBUTION OF *Hibbertia riparia* IN / CLOSE TO THE GROWTH AREAS.



Map 10: Records of *Hibbertia riparia* in or close to the Growth Areas.

Note that *H. riparia* is unlikely to occur in NSW and these records could be *H. puberula.*

Strategic assessment for Cumberland Plain Conservation Plan Aerotropolis and Greater Penrith,

Hibbertia puberula species group

Hibbertia puberula subsp. *glabrescens* at Bankstown Airport

Report prepared for Department of Planning and Environment

By

Cumberland Flora & Fauna Interpretive Services

Robert Miller - December 2018

Executive Summary

Hibbertia puberula subsp. *extensa* and subsp. *puberula* are listed as Endangered Species under the *Biodiversity Conservation Act 2016*. *Hibbertia puberula* subsp. *glabrescens* is listed as a Critically Endangered Species, being known from only one population at Bankstown. There is limited data on the life history and ecology of the species.

Survey for this report was limited by time constraints, lack of access to private property, and years of preceding drought conditions. Survey targeted areas of suitable habitat identified from the habitat of extant populations and DPE vegetation mapping.

Areas adjacent to the development footprint were included in the survey because *H. puberula* is a small shrub that could be severely affected by anthropogenic impacts, particularly in areas downhill of development. The proposed road corridors will fragment habitat exposing the species to greater edge effects.

Outcomes of the assessment:

<u>*Hibbertia puberula* subsp. *extensa*</u>: It is extremely unlikely that this subspecies exists within the WPEC and WSA growth areas. No suitable habitat is known to occur or is likely to occur within the proposed urban footprint or the growth areas. The likelihood of occurrence is assessed as negligible.

<u>*Hibbertia puberula* subsp. *glabrescens*</u>: The likelihood of occurrence within or adjacent to the GPEC is considered to be low to moderate, and the likelihood of occurrence within or adjacent to the WSA is assessed as low. From known occurrence data the subspecies does not have the capacity to exist in habitats that occur within the proposed WSA development footprint.

<u>*Hibbertia puberula* subsp. *puberula*</u>: Within the development footprint the subspecies is likely to occur within the Wianamatta Regional Park, as well as in areas adjacent to the footprints at Ropes Crossing and Kemps Creek. This study provided 7 new records for *H. puberula* subsp. *puberula*, two within the growth areas and 5 to the north. The species was unknown to occur within or adjacent to the growth areas prior to this survey.

Outcomes of this assessment are that 34 ha of habitat with a high to moderate probability of the species occurring are within the development footprint, and that more than 100 ha of habitat with high to moderate probability of species occurrence are outside the footprint but are likely to suffer from anthropogenic impacts caused by the development.

<u>Recommendations:</u> It is a recommendation of this study to list *Hibbertia pedunculata* as a Threatened species or an Endangered Population, and to take it into consideration as part of this biodiversity certification process as the known populations are likely to be severely impacted by development. It is also a recommendation that all bushland remnants adjacent to development be fenced and maintained to minimise anthropogenic impacts.

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Abbreviations

ALA	Atlas of Living Australia
AVH	Australian Virtual Herbarium
BAM	Biodiversity Assessment Method
BC Act	*Biodiversity Conservation Act 2016*
CFFIS	Cumberland Flora & Fauna Interpretive Services
DPE	NSW Department of Planning and Environment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GPEC	Greater Penrith to Eastern Creek Urban Release Investigation Area
IBRA	Interim Biogeographic Regionalisation for Australia
OEH	NSW Office of Environment and Heritage
PCT	Plant Community Type
sp./spp.	species (species singular / plural)
s. str.	*sensu stricto* – in the narrow sense
subsp.	subspecies
UBBS	Urban Bushland Biodiversity Survey of Western Sydney NPWS 1997
WSA	Western Sydney Aerotropolis Growth Area

1. Introduction

1.1 PURPOSE

The purpose of this expert report is to determine the potential for future urban development in identified growth areas of Western Sydney to impact on *Hibbertia puberula*, the subspecies of which are listed as an Endangered or Critically Endangered Species under the *Biodiversity Conservation Act 2016*. This report forms part of the Cumberland Plain Conservation Plan, which will be assessed for:

- Biodiversity certification under the *Biodiversity Conservation Act 2016* (BC Act)
- Strategic assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Biodiversity Assessment Method (BAM) sets out the framework and methods to be used for assessment of impacts to biodiversity to provide preferred conservation outcomes while also supporting the development approval process. Under the BAM an expert report can be used when adequate survey is not possible. An expert report can only be used for species to which species credits apply.

The expert report must document the information that was considered, and/or rejected as unsuitable for consideration, to reach the determination made in the expert report. The report must set out whether the subject species is likely to be present at the development site, and if present then the report must estimate, in the case of a species such as *Hibbertia puberula*, the area of habitat where the species is likely to be impacted, as well as areas from which it is known to occur in which it will be impacted.

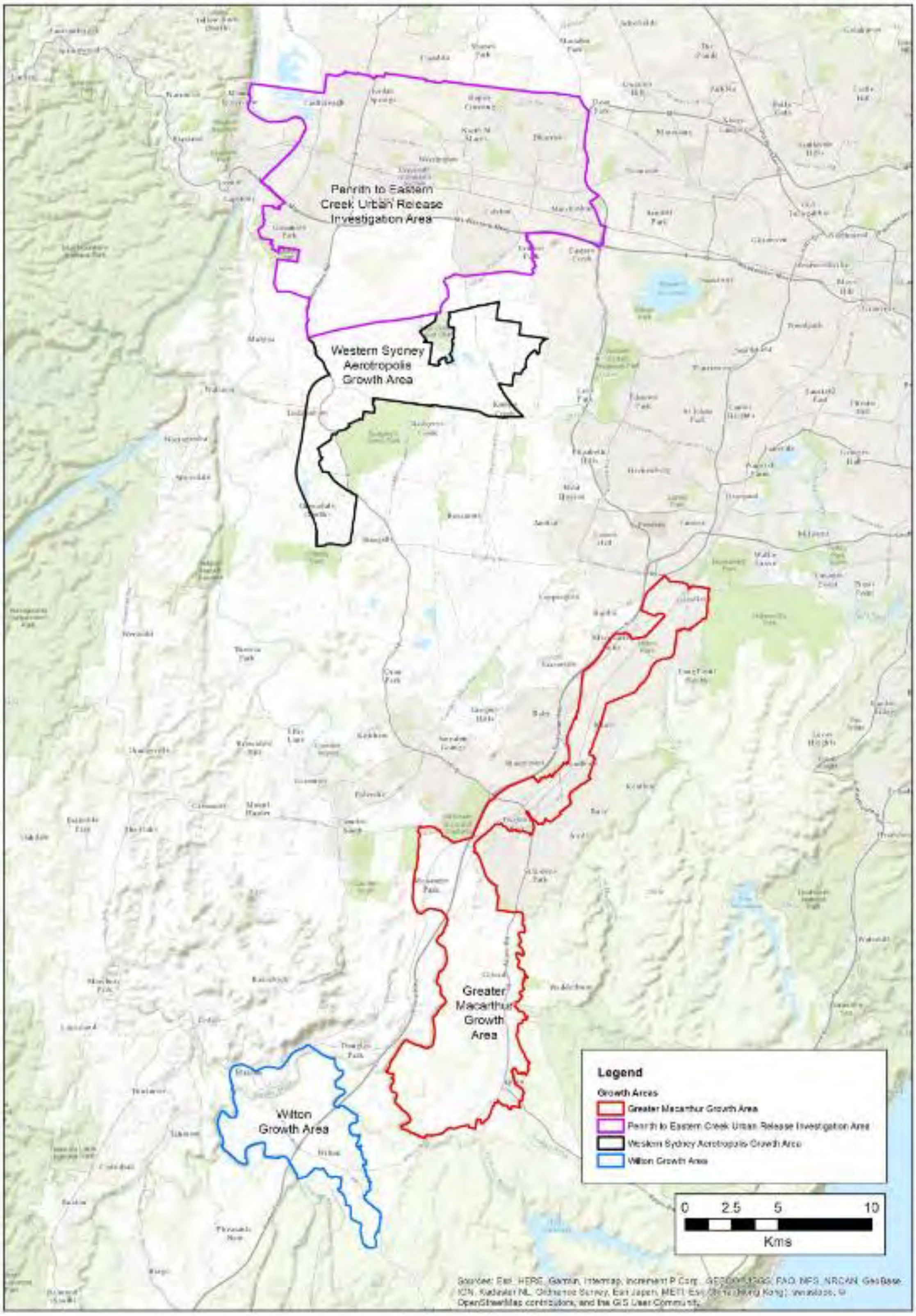
1.2 PROJECT CONTEXT

The NSW Government is planning for future urban development in Western Sydney. Four growth areas have been identified, these are Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Aerotropolis (WSA), and Greater Penrith to Eastern Creek (GPEC). These growth areas are all located within the Cumberland Subregion in version 7 of the Interim Biogeographic Regionalisation for Australia (IBRA) (2016).

As part of the planning for this future development, the Department of Planning and Environment (DPE) is preparing the Cumberland Plain Conservation Plan. This is a strategic regional assessment that will lead to the identification of preferred conservation outcomes for the Cumberland subregion.

1.3 STUDY AREA

Map 1 shows the growth areas of Greater Penrith to Eastern Creek (GPEC) and Western Sydney Aerotropolis (WSA) which are the subject of this report, and the Greater Macarthur and Wilton growth areas which are the subject of a separate report.



Map 1: The four Western Sydney Growth Areas

Map source: NSW Department of Planning and Environment.

1.4 JUSTIFICATION FOR USE OF EXPERT REPORT

The BAM allows for situations where an expert report will be required to replace or complement survey effort at a development site. While there has been some field survey for the Strategic Biodiversity Certification assessment, the area covered by the proposed GPEC and WSA are extensive and there have been issues with gaining access to some of the private properties.

An expert report is required to assess potential impact to *Hibbertia puberula* for the following reasons:

Insufficient survey: A large extent of the identified growth areas could not be surveyed because it was on private property and could not be accessed within the project timeframe. Expertise was required to identify and survey potential species habitat and propose additional habitat based on extant populations and prior knowledge of the species.

Survey following prolonged rainfall deficiency / drought: The Western Sydney region has been experiencing extremely dry conditions for several years, resulting in the *Hibbertia puberula* plants being subject to severe drought stress causing partial and/or full defoliation. In many instances the majority of the population at a particular site may have retracted to the soil seed bank.

Compounding the effect of reduced soil moisture, following drought many areas have a significant increase in leaf, twig and branch drop making this small and cryptic species more difficult to locate or possibly covering them completely.

Herbivory of a wide range of native species can severely impact small plants during dry conditions.

The discernible population was therefore likely to be significantly reduced from these causes.

Rainfall events in months prior to this assessment allowed many *Hibbertia* species to produce new growth and therefore flowers. However, the rainfall was insufficient to replenish subsoil moisture. A dry period and unusually hot conditions prior to, and during, this assessment resulted in moisture stress for many plants. In the case of some *Hibbertia* species this is noticeable by unusually early petal dehiscence making their detection difficult.

It requires an expert in the species to locate and identify rare *Hibbertia* under these conditions.

Reliable species identification: Identification of the genus *Hibbertia* to species level requires examination of flower parts in combination with stem and leaf characters, especially tomentum type and density. It is not practical nor reliable to identify small leaved species in the field as many of these morphological features require microscopic examination and comparison to known voucher specimens. This needs to be carried out by an expert in *Hibbertia*.

The use of an expert report to complement survey of the growth areas avoids the problems associated with *Hibbertia* misidentifications.

1.5 CREDENTIALS OF EXPERT

Robert Miller has over 30 years' experience in field botany. Over this time Robert has identified many rare and endangered plant species and has contributed to the scientific knowledge of native flora distribution and habitat in NSW.

Robert has been certified as an expert for *Hibbertia fumana* and *H. puberula* under the Biodiversity Assessment Methodology.

Robert has worked with Hellmut Toelken of the State Herbarium of South Australian, locating, collecting and identifying undescribed or rare species of *Hibbertia*. Some of these taxa were known only from historic records with non-precise locality details and depauperate or non-existent habitat information. Many of the specimens have been used for the taxonomic revision of the genus and are cited in various taxonomic publications including "Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*" published in the Journal of the Adelaide Botanic Gardens 26 (2013). Examples of the cited specimens include: *Hibbertia ericifolia* subsp. *acutifolia* Toelken, subsp. nov. Type: New South Wales, Sarahs Knob, R. & J. Miller s.n., 21.x.2006 (holo.: AD; iso.: BRI, CANB, NSW, PERTH) and *Hibbertia dispar* R.T. Miller s.n., 0.5 km S of Penrose Rest area, along western boundary track, Penrose State Forest, 12.x.2010 (AD, NSW).

Robert and Hellmut's paper "Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales", was published in the Journal of the Adelaide Botanic Gardens in 2012. The paper describes 13 new taxa including *Hibbertia fumana* Toelken and *Hibbertia puberula* subsp. *puberula,* – subsp. *extensa R.T.Mill.* and – subsp. *glabrescens Toelken.*

In 2017 Robert was called as an expert to identify the species of *Hibbertia* on the Moorebank bushland site that is the subject of the Intermodal development proposal.

Robert has recognised expertise for other threatened taxa including *Pomaderris adnata*, *Solanum celatum*, *Epacris purpurascens* var. *purpurascens*, and the genus *Prostanthera* including the threatened taxa *Prostanthera discolor*, *P. stricta*, *P*. *densa*, *P*. *junonis* and has provided expertise to the OEH Saving our Species programs.

2. Species information

2.1 SPECIES DESCRIPTION

There are 3 sub-species of *Hibbertia puberula*. The following descriptions are taken directly from the Toelken and Miller 2012 paper "Notes on Hibbertia (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. Hemistemma, mainly from the central coast of New South Wales".

***Hibbertia puberula* Toelken**

Typus: New South Wales, Yowie Bay, A.A.Hamilton s.n., 14.xi.1908

Description: Shrublets up to 0.25 m tall, decumbent or rarely suberect, much to sparsely branched or spreading; branches wiry to stiff from a woody stem or base, with decurrent leaf bases more or less flanged, pubescent to hirsute mainly between flanges, rarely glabrescent or glabrous. Vestiture often not persistent, with spreading longer over shorter simple hairs on all parts of the plant; on branches with few to many (rarely glabrous) mainly longer hairs (but varying very much in actual length) over much shorter ones, often predominantly in the grooves between flanges of the leaf bases, becoming appressed and wearing off soon; on leaves above with scattered spreading antrorse simple hairs becoming longer towards the margins, often wearing off; on leaves below with few scattered hairs as above on the revolute margins but not on the central vein, wearing off; on bracts with finer but similar hairs to leaves; on outer calyx lobes outside moderate to dense, with erect short hooked hairs overtopped by longer tubercled straight hairs up to 1.3 mm long, often becoming bristle-like particularly on the margins and the base and receptacle, persisting, inside dense, with fine, often silky appressed antrorse hairs; on inner calyx lobes outside and inside usually similar to the outer lobes, but hairs finer and decreasing in number and size towards the glabrous, membranous margins. Leaves usually with dense intrapetiolar tuft spilling over into grooves between flanges; petiole 0–0.6 mm long, ± flattened; lamina linear-lanceolate to oblong-lanceolate or oblong-elliptic, (1.2–) 2.8–5 (–7.6) × (0.5–) 0.7–1 (–1.2) mm, ± abruptly constricted into petiole, acute and usually with a terminal tuft of hairs wearing off soon, often becoming obtuse, above ± flat and sparsely pilose to glabrescent, below revolute margins and recessed to bulging broader central vein obscuring the undersurface, sparsely pilose to glabrous on the margins. Flowers single and terminal, rarely in clusters of up to three from subtending axils; pedicel 0–3 mm long; bracts linear-elliptic to elliptic-lanceolate, (2.9–) 3.2–3.8 (–4.2) × (0.4–) 0.6–0.8 (–0.9) mm, leaf-like but flatted with central vein ± visible, short pilose, rarely glabrous. Calyx distinctly accrescent; outer calyx lobes lanceolate to ovate, (5.3–) 6–8 (–11.7) × (1.6–) 2–3 (–4.2) mm, frequently longer than inner lobes, acute to beaked, usually with raised ridge and recurved distal margins, hirsute, strigose, rarely pubescent to glabrescent; inner calyx lobes oblong-ovate to oblong-elliptic, (4.6–) 5–8 (–11.6) × (2.1–) 2.5–3.5 (–3.7) mm, acute to cuspidate and with lateral membranous margins rarely up to the apex when obtuse and mucronate, hirsute to finely pilose, decreasing towards the margins. Petals broadly obovate to oblanceolate, or rarely oblong-oblanceolate, 5.5–10.6 mm long, ± bilobed. Stamens (4–) 10–14 (–18); filaments (0.6–) 1.4–1.7 (–1.9) mm long, up to one-third connate basally;

anthers obloid, (0.8–) 1.4–1.8 (–2.1) mm long, subequal, rarely unequal, abruptly constricted above and below. Pistils 2; ovaries erect-obloid and usually horizontally truncate, (4–) 6 (–8) ovules, puberulous, rarely shortly pubescent, with style attached apically, rarely laterally, then curved back- and upwards on either side of the anthers with style well above or rarely at the apex of anthers. Fruit puberulous to glabrescent with simple hairs. Seeds oblong-obovoid to almost obloid, 1.6–1.8 × (1.2–) 1.3–1.4 mm, brown; aril with fleshy base surmounted by one-sided membranous cup covering one-third to half of seed.

Notes: The extra specimens now available introduced a much wider range of variation in the *H. puberula* complex. Specimens from the Central Coast can frequently be recognized by almost sessile leaves, broadly ovoid to ellipsoidal buds with apices of the calyx erect to incurved, and often more than one flower is borne terminally on branches, while plants from more inland localities have usually petiolate leaves, slender ovoid to ellipsoidal buds with more or less recurved apices of the calyx and a single terminal flower on branches. None of these characters can be decisively used to distinguish these forms. The terminal flower clusters are formed by axillary growth from one or two leaves below the bract of the terminal flower and, in keeping with other species of the *H. sericea* group with fascicled hairs, immediately develop a terminal flower after usually two nodes with distinct internodes between, so that it becomes a more or less corymbiform cluster. (This is also a distinction from *H. stricta* s.l., which has usually spikiform (pyramidal) terminal clusters). Similar, but loosely branched cymbiform terminal inflorescences have been observed on only one collection (Turpentine Road, Flat Rock Creek, R.T. & J.Miller 22/30.x.2010). The most southern population of *H. puberula*, as represented by this and other mass collections, as well as R.D.Hoogland 11702 and E.Gauba NBG4784, is a particularly interesting extension of the species, as most of the flowers, though large, show a distinct reduction of hairs on the calyx and, more significantly, the styles tend to be laterally attached to the ovaries, similar to those of *H. cistiflora* in the *H. stricta* group. However, this phenomenon, indicative of a convergent development, can be observed in different stages on different plants, varying from an apically attached style curving down- and backwards to being attached laterally. The calyx lobes of most of the specimens identified as belonging to the *H. puberula* complex are hirsute to strigose on the outer surface, but in a few specimens both the shorter hooked hairs as well as the straight overtopping longer ones are very short or absent on plants from a few different localities (*cf*. variation under subsp. *glabrescens*). Among these, the plants from Bankstown Airport are smaller with thread-like branches and have consistently smaller calyx lobes, which are up to 2.7 mm broad, so that they are here described as subsp. *glabrescens*. The calyx of some flowers of subsp. *puberula* from Voyager Point (R.T.Miller & C.P.Gibson 52/20.x.2006) are of similar size, but hirsute and with a distinct terminal ridge on the outer calyx lobes. Furthermore, the flowering calyx of one plant must always be compared with other specimens at a similar stage, as the calyx (accrescent) elongates after flowering. Specimens from Lucas Heights are an extreme example, as the outer calyx lobes of a flower are 7.2 mm long and those of a fruit on the same specimen (R.T.Miller 3/16.x.2007) are 11.6 mm long. Of all the variation observed, *H. puberula* subsp. *extensa* is very unusual, as its androecium of commonly six stamens was previously unknown in *H. puberula*, which has ten or more stamens. There is a distinct gap between the two types of stamen numbers, as, unlike specimens of the typical subspecies from Simmos Beach Recreation Reserve (R.T.Miller 24–32/2.xi.2007), which has a range of stamens from 15–18, no specimen has as yet been recorded to complete the range from (4–) 6 or 7 stamens of the subsp. *extensa*. However, the wide variation recorded for the typical subspecies suggests this new form should be recognized at subspecific level. The anthers of subsp. *extensa* also tend to be smaller like those of the subsp. *glabrescens*, and their cuneate base into the filaments is rarely observed in the other subspecies.

Key to subspecies of the *H. puberula* complex

1. Stamens (4–) 6 or 7; lateral branches usually spreading up to about right angles to the main axis ……………………………………………………………………………………………………. *H. puberula* subsp. *extensa*

1: Stamens (9) 10–14 (–18); irregularly and commonly untidily branched

2. Anthers (1.3–) 1.4–2.1 mm long; outer calyx lobes distinctly ridged toward the apex, strigose to hirsute or if pubescent to glabrescent then (2.5–) 2.6–3.0 (–3.8) mm broad when flowering .... ……………………………………………………………… *H. puberula* subsp. *puberula*

2: Anthers 0.9–1.3 mm long; outer calyx lobes 1.6–2.1 mm broad when flowering, scarcely ridged towards the apex, puberulous to glabrescent

…………………………………………………………………………………………………… *H. puberula* subsp. *glabrescens*

Hibbertia *puberula* subsp. *puberula*

Description: Branches wiry to stiff-woody from woody stems. Leaf lamina mainly lanceolate. Outer calyx lobes lanceolate to ovate, (7.3–) 7.8–9.3 (–11.6) × (2.5–) 2.6– 3.0 (–3.8) mm, acute to beaked with strongly recurved margins and distinctly raised central ridge towards the apex, strigose or hirsute to rarely puberulous; inner calyx lobes broadly elliptic to oblong-ovate, (6.9–) 7.3– 7.8 (–10.1) × (2.8–) 3.15–3.3 (–3.7) mm, with innermost two acute to ± cuspidate above broad membranous margins, hirsute to strigose, rarely pubescent along the central ridge becoming smaller to glabrous towards the margins. Stamens (9–) 10–14 (–18); anthers (1.3–) 1.4– 2.1 mm long. Flowering: October–December (January).

Variation: The few previous collections available have been disconcertingly variable, but mass collections from a few localities revealed that individual populations are often very variable in the size and number of hairs on various organs. Buds vary from almost spherical to narrow-ellipsoidal to -ovoid with lanceolate to ovate outer calyx lobes, each with an incurved, erect or recurved apex and more or less densely covered with spreading, straight and smaller hooked hairs of varying length. Flowers have usually 12–14 stamens in this subspecies, but the number varies locally from 9 or 10 at Wollemi National Park to 18 in one specimen from Yeramba Lagoon (C.P.Gibson & R.T.Miller 50/14.x.1993). Specimens from Simmos Beach Recreation Reserve show a few flowers with 15 to 17 stamens, while other flowers of similar plants of the same population have 12 to 14 (R.T.Miller 24–32/2. xi.2007). The filaments are up to one-third basally connate. Usually the anthers are described as subequal and forming a range from the slightly smaller to larger ones, but occasionally one or two distinctly larger ones were observed. The typical obloid ovaries are surmounted by a horizontal style base and, while the style is usually attached at the apex, it is sometimes more or less dipping to a lateral position in a number of populations, mainly from Morton National Park. This must not be confused with fruiting specimens, where the bulging developing seeds often displace the position of the style attachment. While the ovaries are usually puberulous, they may vary from pubescent (R.T.Miller 111–113/20.xi.2007) to almost glabrous (R.T.Miller 33–43/12.x.2007).

Hibbertia *puberula* subsp. *extensa* R.T.Mill., subsp. nov.

Typus: New South Wales, south of Appin Road, upper George River catchment, R.T.Miller 102 & A.Henderson, 8.x.2007 (holo.: AD; iso.: NSW).

Description: Branches stiff-woody and lateral ones spreading up to about right angles. Leaf lamina mainly lanceolate. Outer calyx lobes ovate, (6.1–) 66–72 (–7.9) × 3.1–3.5 (–3.8) mm, acute to beaked with ± strongly recurved margins and distinctly raised ridge towards the apex, strigose to hirsute; inner calyx lobes elliptic rarely oblong-ovate, (4.2–) 4.5–4.8 (–5) × 2.9–3.2 (–3.4) mm, with innermost two abruptly constricted into minute terminal point continuous with broad membranous margins, hirsute to strigose with hairs becoming smaller towards the margins. Stamens (4–) 6 (7); anthers 0.8–1.2 mm long. Flowering: October, November (March, April). Fig. 2Y–BB.

Variation: In spite of their often isolated occurrence very little variation was observed in the material examined. The specimens from south of Appin had usually 6 stamens, whereas several flowers from the Wanganderry Tableland had 7. The subspecies has generally very long straight hairs on the calyx and some of them are up to 1.3 mm long. Not only are the stamens shorter in this subspecies, but also the styles are short and robust and often just reach the apex of the anthers. These robust specimens are easily distinguished from superficially very similar plants with spreading branches of the typical subspecies from Lucas Heights (R.T.Miller 111– 113/20.xi.2007) by the number and size of the anthers. While most of the specimens of this subspecies occur in a restricted area from Appin to Wedderburn, a collection from Sackville Road (R.T.Miller 81/23.x.2008) seems to indicate that the taxon has a much wider geographic range. This preceding specimen exhibits in addition to six stamens also the robust spreading branching of the plants from the southern localities in spite of records of more slender forms of the typical subspecies nearby. Etymology. The epithet ‘extensa’, Latin, ‘stretched out, extended’ refers to the impression created by the lateral branches spreading at about right angles to the main branches.

Hibbertia puberula* subsp. *glabrescens Toelken, subsp. nov.

Typus: New South Wales, Bankstown Airport, G.M. Cunningham s.n., 13.xii.2006 (holo.: AD200524; iso.: CANB, K, MEL, NSW). Hibbertia sp. Bankstown (R.T. Miller & C.P. Gibson s.n. 18.x.2006) N.S.W. Herbarium in Australian Plant Census database (2011). Hibbertia sp. nov. (Bankstown Airport) C.P. Gibson, Bushland Bulletin 59: 4, 6 (2009).

Description: Branches thread-like wiry from short stiff-woody stems. Leaf lamina mainly elliptic-oblong. Outer calyx lobes linear-lanceolate, (5.3–) 5.5–6.1 (–6.3) × 1.6–2.1 mm, not beaked and with scarcely recurved margins and faint central ridge towards the apex, glabrescent or sparsely pubescent; inner calyx lobes narrowly oblongovate, (4.6–) 4.8–5.2 (–5.6) × 2.1–2.3 (–2.7) mm, innermost two abruptly constricted into minute terminal mucro continuous with broad membranous margins, glabrous or glabrescent along central ridge. Stamens 12–14; anthers 0.9–1.3 mm long. Flowering: October, November (December).

Variation: The plants at Bankstown Airport are comparatively uniform, as one would expect for such a small and extremely localized population. However, the plants and especially also the calyx lobes are rarely entirely glabrous. Although specimens of some plants of the typical subspecies, especially from nearby Simmos Beach Reserve (R.T. Miller 24–32/2.xi.2007), as well as those from the much further south population along Turpentine Road near Sassafras (e.g. R.T. & J. Miller AD15A–M), show a variation from a hirsute or strigose through to glabrescent tomentum of the calyx lobes, they are always more robust plants and in particular, the calyx lobes are larger and especially broader. Some specimens of the mass collection R.T. Miller 1622/12.x.2007 are very similar to subsp. *glabrescens*, but can be distinguished by the shape of the calyx or by their strigose to hirsute calyx (C.P. Gibson & R.T. Miller 27/23.x.1990). Furthermore, specimens from Bankstown Airport collected in subsequent years (since 2006) have not shown any significant change in morphology. Thus we must assume that a taxon has established itself here that is suited to the unusual ecological conditions artificially maintained by the Bankstown Airport management since about 1940. Etymology. Since all organs of this subspecies have very few small and delicate hairs which usually wear off soon, the epithet ‘glabrescens’, Latin, ‘glabrescent’ seemed appropriate.

2.2 LIFE CYCLE

Flowering time and duration

Peak flowering time is October to December and sometimes into January, and seed is set during this period. Anecdotal evidence (Miller pers. obs.) suggests time of flowering and time to petal dehiscence is variable across subspecies and appears also to be influenced by prevailing climatic conditions.

Very limited observations of the flowering times of *Hibbertia puberula* subsp. *extensa* suggest this subspecies has a very short period of flowering each day. Total petal dehiscence has been noted to occur before 1 pm on two occasions and before 11am on 30 November 2018 in the largest population south of Appin Road. It is not known at what time petal expansion commenced. The subspecies is virtually invisible when not in flower.

Hibbertia puberula and *H. diffusa* at Moorebank were noted to have a window of daily peak flowering (albeit in September, outside its normal recognised peak flower period) being not apparent in early mid-morning (8.40 am) and petal senescing by early afternoon (12:05 PM) on Friday, 29 September 2017.

This phenomenon has been observed with several *Hibbertia* species, whilst others appear to have protracted flowering across the day e.g. *Hibbertia dentata*.

Photo 1: *H. puberula* subsp. *puberula* at Berkshire Park dehiscing petals before our eyes.

Note: Photo 1 shows one of the few plants retaining petals on Friday, 2 November 2018 at 9:14 AM.

Additional information into flowering time and duration has been gained from this biodiversity assessment. On 29 October 2018 petal dehiscence had already commenced by 10 am and was finished before 11am at Ropes Crossing. On the 31 October 2018 total petal dehiscence was recorded to have occurred before 1.15pm but noting many plants of the co-occurring *Hibbertia pedunculata* still retained the majority of their petals though petal drop on those plants had begun.

Conversely, a site inspection of Bankstown Airport by Peter Ridgeway, Paul Bircher, Stephanie Clark, Colin Gibson, Damien Vella and Foster Walker – Environmental Manager Bankstown Airport Limited (BAL) revealed that *Hibbertia puberula* subsp. *glabrescens* was in full flower at 2.50pm and petals were still evident at approximately 4.30pm. It is unknown if the subspecies has a longer flowering duration than the other subspecies or whether the cool overcast conditions with a light shower earlier in the day prolonged flowering.

Photo 2: *H. puberula* subsp. *glabrescens* at Bankstown Airport.

Photo 2 taken on Friday, 16 November 2018 2:54 PM by Stephanie Clark.

Further research is needed to ascertain daily flowering ranges of *Hibbertia,* particularly for threatened taxa, as this has significant implications for reliable detection of threatened species during biodiversity assessments.

<u>Fire response</u>

No systematic fire response studies have been undertaken on *Hibbertia puberula*. Anecdotal observations and inferred information from similar species suggest *H. puberula* subsp. *puberula* is killed by fire in many instances. In certain circumstances the species is capable of re-sprouting from near or just below the soil surface as noted at the Keith Longhurst Reserve (formerly the Basin Reserve) in 2007 (R. Miller pers. obs.). At the same site Miller noted in June 2018 the species appeared to have mostly been killed by a recent control burn, with limited recruitment from the soil seed bank observed. It is unknown to what degree the protracted dry period has impacted apparent recruitment, but it is thought that the combined impact of fire and drought has been significant.

This current survey has noted that the “form” observed at Berkshire Park during this study is capable of resprouting from a thickened rootstock. This form is consistent with J.M. Lindale NSW 101952 shown in Figure 1 Toelken (2000) and reproduced as Figure 2 of this report.

Since its discovery there has not been a fire in the habitat of *Hibbertia puberula* subsp. *glabrescens*.

The impact of fire upon *Hibbertia puberula* subsp. *extensa* is also poorly known, with only observation by Miller providing a limited insight. The two occurrences south of Appin Road have recently been control burnt. Price *et al.* (2016) state that “The first fire was 52 ha, lit at 09:45 on 22 August 2015, and targeted patches of forest within the scout camp. The second was 700 ha, lit at 10:15 on 9 October 2015 and burnt the area surrounding the camp in an arc from north through west to south”. All pre-existing plants appear to have been killed. Only three tiny plants presumably seedlings were apparent at one site and no plants were detectable at the other in a survey by Miller on 1 July 2018. A subsequent survey on 30 November 2018 confirmed the three plants had survived and flowered with 9, 8 and 8 plus 3 aborted and/or mature buds observed. Two plants were located at the second site both with 3 buds only.

Photo 3: *H. puberula* subsp. *extensa* with flower buds 30/11/2018 after the October 2015 fire.

2.3 DISTRIBUTION AND ABUNDANCE

Limited systematic population surveys have been undertaken for *Hibbertia puberula* s. lat.. The most comprehensive population survey undertaken is for *Hibbertia puberula* subsp. *glabrescens* at Bankstown Airport environs (refer to that subsp.). The population of *Hibbertia puberula* subsp. *puberula* occurring at the Moorebank Intermodal Terminal was, in part, surveyed in the environmental assessment for the project.

Hibbertia puberula* subsp. *puberula

This subspecies is known in New South Wales mainly from near Sydney (CC), but also from Wollemi National Park and near Morton National Park (SC, ST). The most significant sites are located at Moorebank and to lesser degree at Voyager Point.

Of most relevance to this study are those locations with similar attributes to those within the two growth areas. Few locations exhibit such habitat characteristics.

With the exception of the Moorebank and Liverpool records, known occurrences within the Sydney Metropolitan area occur in transitional soils adjoining sandstone areas, communities not found within the growth area boundaries. A selection of such sites includes the Georges River environs including The Georges River National Park, Lucas Heights to West Menai area, Simmos Beach Recreation Reserve, Peter Meadows Reserve, the Keith Longhurst Reserve (formerly the Basin Reserve), Kentlyn, Freres Crossing Reserve, Kentlyn, and Old Kent Road, Kentlyn.

Appendix 5 shows the indicative distribution of *H. puberula* at West Menai, where the species was found to occur as small subpopulations in suitable micro-habitats.

The species is also known from the lower Blue Mountains in the Warrimoo vicinity, and scattered occurrences within the Hawkesbury River Catchment including Sackville North, Canoelands, and the McCarrs Creek vicinity.

Historic collections localities include Yowie Bay 1908, Frenchs Forest 1946 and Coogee 1954.

Map 2 shows the areas proximate to the growth areas from which the subspecies had been collected prior to this study as well as new records provided by this biodiversity assessment.

Environmental assessment surveys for the Moorebank Intermodal Terminal have provided some population data on *Hibbertia puberula* subsp. *puberula*. At this site the species is relatively common and is significant in number. The population data derived cannot be inferred to reflect population density at other recorded sites of its distribution and specifically not within the GPEC or the WSA. The predominant vegetation communities found at the Moorebank Intermodal Terminal where surveys were undertaken are Castlereagh Scribbly Gum Woodland and Cooks River/Castlereagh Ironbark Forest with Shale-Gravel Transition Forest and Castlereagh Swamp Woodland being recorded proximally.

Extant examples of these communities are known to occur in and to the north of GPEC. Data obtained from field surveys for this assessment, though extremely limited, have found only small localised occurrences. Within the WSA, only the Kemps Creek area retains small remnants of the Castlereagh communities.

A selection of habitat and occurrence notes compiled by Miller in 2007 for herbarium specimens are:

- At Lucas Heights the population at a site in Open Woodland / heath – Canopy: *Eucalyptus haemastoma*? and Stringybark species is described as: "Abundance: extremely localised, rare < 12 plants noted".
- At Lucas Heights Little Forest the population is described as Localised in narrow zone in upper drainage line.
- At Simmos Beach Reserve in Open Woodland of *Eucalyptus sclerophylla*?, *E. punctata, Angophora bakeri* one sub-population is described as "Very localised but locally common c. 20 plants noted"
- At Barden Ridge one population is described as scattered through sedges - relatively rare at edge of wet heath/swamp.

Further details of herbarium specimen collections from Western Sydney in 2007 are provided in Appendix 3.

<u>Details of prior collections proximate to growth areas</u>

The closest known prior collections to the growth areas are an McBarron, E.J. 1964-11-08 record stating "Glenbrook township", "In open heathland" and Constable, E.F. 1949-10-28 Blaxland with no other collecting information presented on the data base. It is unknown if the species survives in these localities.

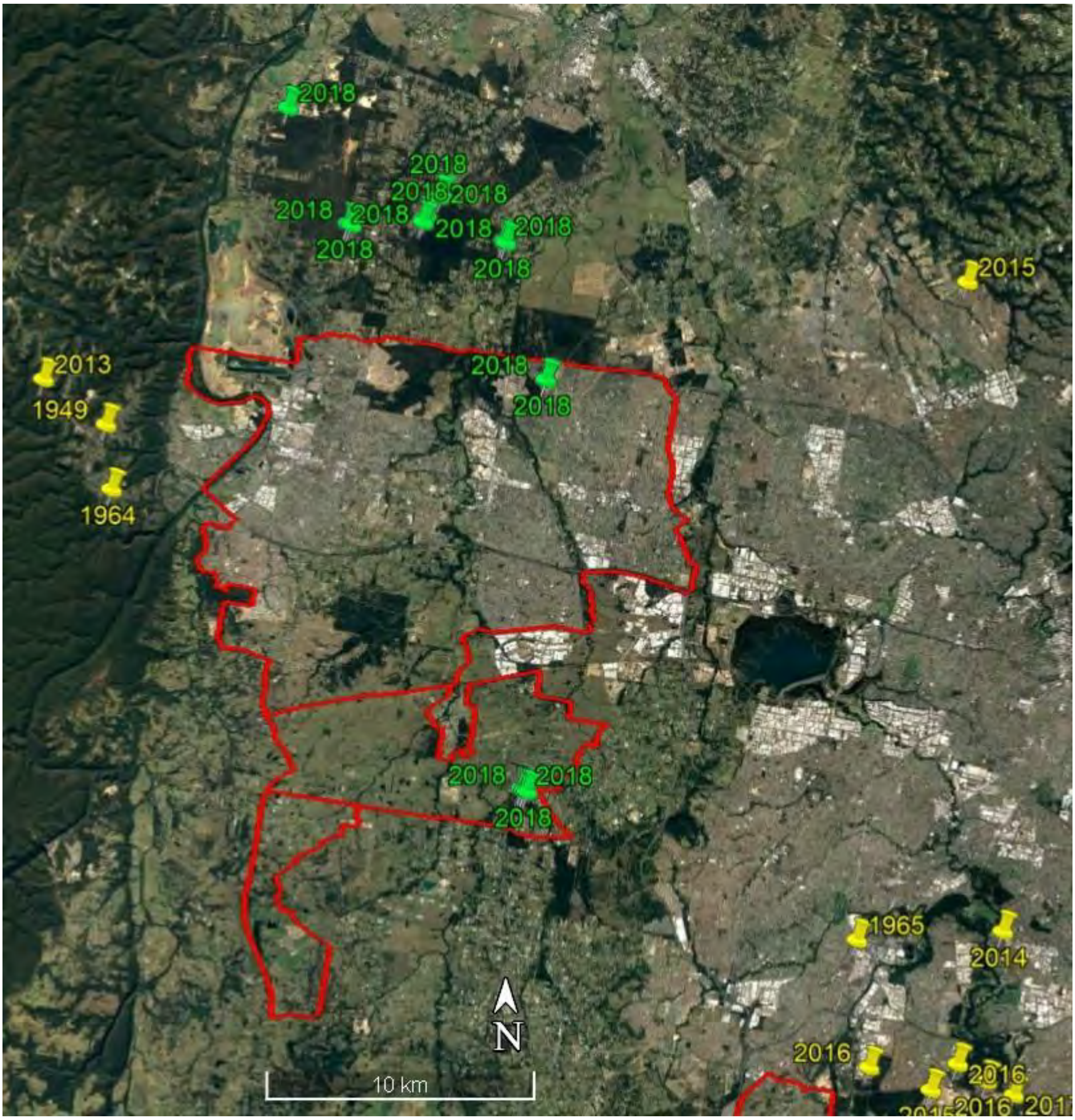
The closest extant population to the growth areas is 5.5 km from the NW corner of the GPEC at Warrimoo (observed and photographed by Greg Steenbeeke in 2018). The original Andrew Orme 2009-11-07 collection records this population as "5 plants noted over a 50m graded fire trail verge". With habitat details "Low open forest of *Eucalyptus notabilis*, *E. consideniana*, *E. sparsifolia*, *Corymbia gummifera*, and *Angophora costata*, with dense understorey of *Leptospermum trinervium*, *Acacia linifolia* co-dominant, also with *Hakea laevipes*, *H. sericea*, *Petrophile pulchella*, *Leptospermum arachnoides*, *Grevillea phylicoides*, *Banksia spinulosa*, *Bossiaea rhombifolia*, *Pultenaea scabra*, *Schoenus imberbis*, *Lepyrodia scariosa*, etc. Gentle easterly slope on sandstone ridge. Shallow yellow sandy soil with some surface laterite over sandstone rock platforms. Disturbed graded fire trail edge".

The closest record to the NE of the growth areas is a Mark Stables 2015-12-01 collection at Kellyville stating the habitat as: "Partially cleared area. Surrounding vegetation sandstone ridgetop woodland with laterite: *Eucalyptus sclerophylla*, *E. squamosa*, *E. sparsifolia*, *Angophora hispida*, *Banksia ericifolia*, *Leptospermum trinervium*, *Grevillea speciosa*, *G. buxifolia* subsp. *buxifolia*, *Calytrix tetragona*, *Boronia ledifolia*, *Phyllota phylicoides*, *Pultenaea tuberculata*, *Cyathochaeta diandra*, *Lepyrodia scariosa*, *Caustis flexuosa*, *Entolasia stricta* & *Austrostipa pubescens*".

The closest record to the south east of the growth areas is a historic record McBarron, E.J. 1965-11-23, Liverpool Cemetery. The species is presumed extinct at this locality.

The closest extent record to the south east occurs at Moorebank 14 km from the WSA.

With the exception of the Moorebank and Liverpool records all other recorded localities occur in close proximity to Sandstone.



Map 2: Location of *Hibbertia puberula* subsp. *puberula* records and year of record.

Key – Historic *H. puberula* subsp. *puberula* records (yellow markers), CFFIS records (green markers) growth areas outlines (red line).

Hibbertia puberula* subsp. *extensa

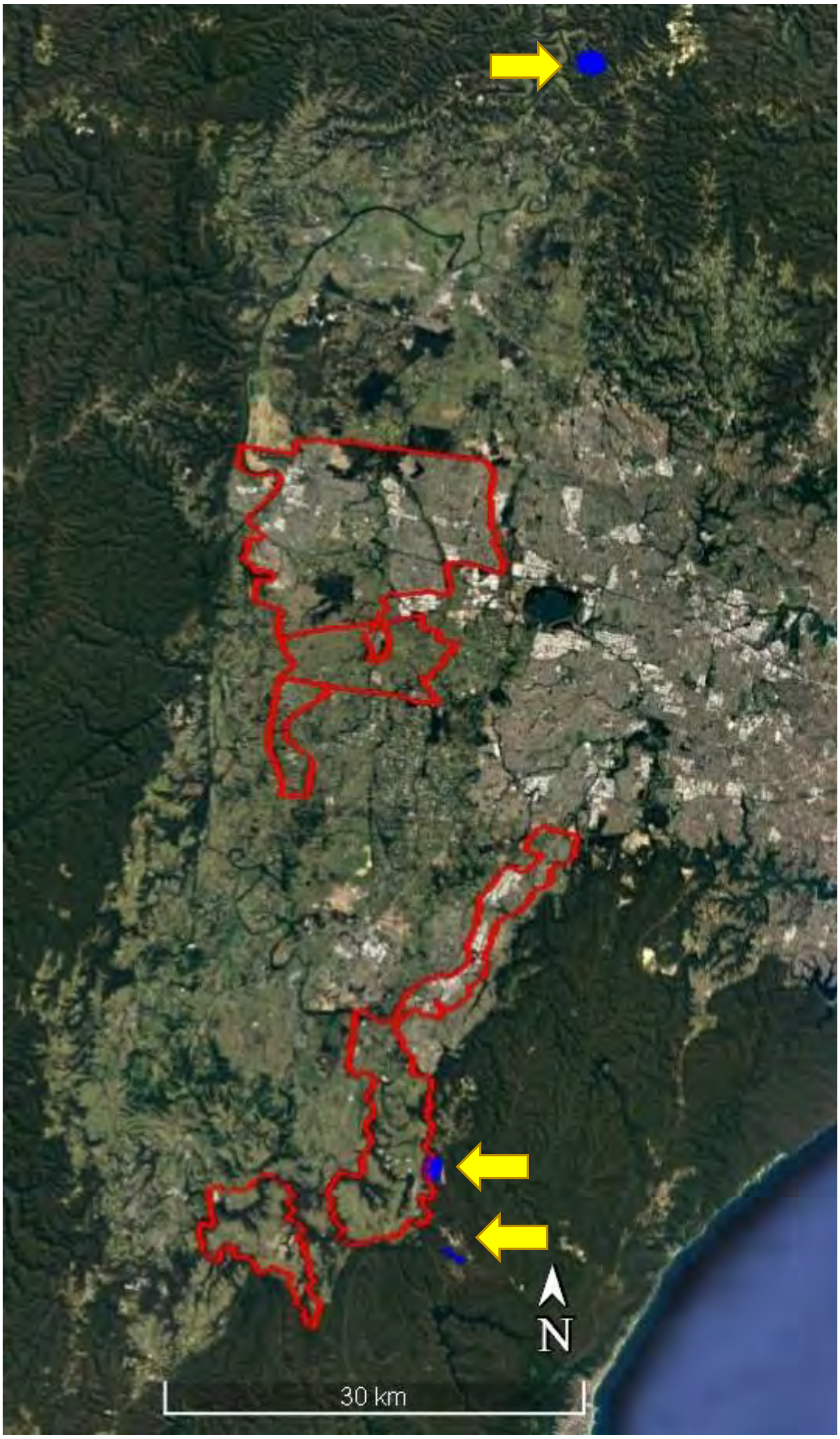
This subspecies grows with heath on upper headwaters of the Georges River and in rock plate heath on the Wanganderry Tableland, New South Wales (CC). Few collections are known of this subspecies.

The closest known extant sites are in the Wedderburn vicinity 27.5 km from the southern border of the WSA. A record cited in Toelken & Miller (2012) in the North Sackville vicinity is 29.5 km from the northern boundary. Map 3 shows the locations of collection sites.

No systematic population surveys have been undertaken for this subspecies. All known populations are thought to be small with most observations noting only a few individuals. One location south of Appin Road was the only population noted as having more than 10 plants. The sightings at Woronora Dam vicinity, Sackville North, the two recorded Wedderburn locations and the Bonnum Pic vicinity all recorded a few individuals only. The known Sackville North occurrence has subsequently been severely impacted by hazard reduction measures and is possibly now extinct at the known site. Similarly, the known occurrence west of Wedderburn Aerodrome has been impacted by grading and fill emplacement and only one specimen could be relocated (Miller pers. obs. July 2018).

A small population of a *Hibbertia* species with vegetative features consistent with *H*. *puberula* subsp. *extensa* was observed to occur on the verge of a fire trail within the Dharawal National Park at Wedderburn. Only six plants were noted. Positive determination can only be ascertained in combination with floral characters. The subject plants were not in flower at the time of observation and their identity remains unconfirmed.

Photo 4: *Hibbertia puberula* subsp. *extensa* habitat south of Appin Road.



Map 3: Generalised location of *Hibbertia puberula* subsp. *extensa* collections.

Key – Areas of past *H. puberula* subsp. *extensa* collections (blue) in relation to the growth areas (red).

Hibbertia puberula **subsp.** ***glabrescens***

Subspecies *glabrescens* is known only from Bankstown Airport which is located approximately 16.5 km from the south eastern corner of WSA. Map 4 shows the general area where this species has been collected. The population contains between 50 and 100 individuals. Survey by Eco Logical in 2015 could not differentiate individual plants and recorded area of plants only.

The species has a limited area of occupancy. Most of the extant plants are known from one small area to the north of a modified drainage line colloquially referred to as Airport Creek. It was previously recorded by Gibson and Gibson & Miller to occur to the south of Airport Creek. Development and maintenance measures have negatively impacted upon those known occurrences and it had not been observed there again until October 2017 when one plant was observed (Gibson pers. obs.).

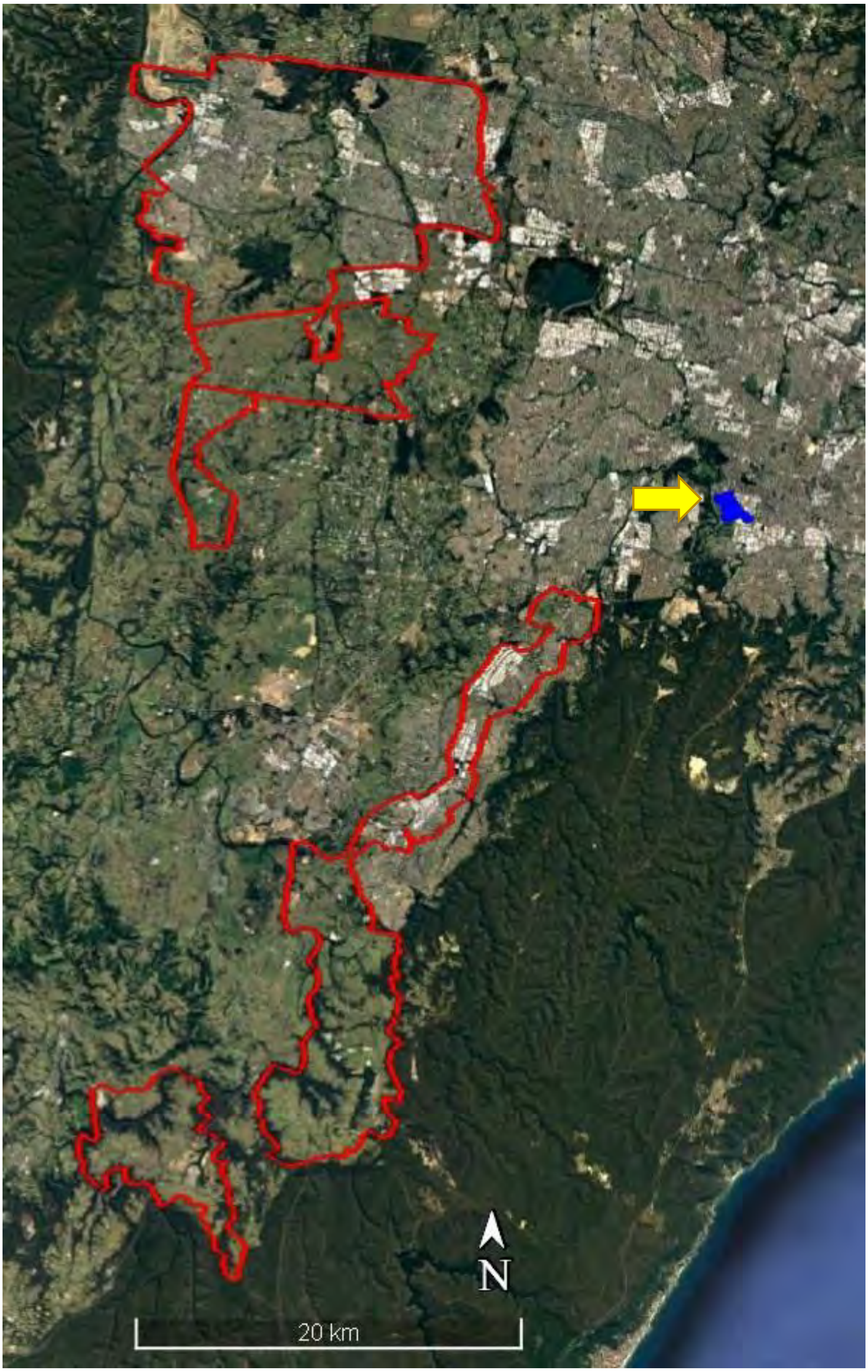
Photo 5: Measure of slashing height, *H. puberula* subsp. *glabrescens* at Bankstown Airport.

Note: See also photo of slashed area on front cover, photos taken by R. Miller 8 October 2014.

A site visit on 16 November 2018 found that creek stabilisation works had negatively impacted upon the site south of the creek, restricting mowing and resulting in dense swathes of *Eragrostis curvula* infesting the location (C.P. Gibson pers. obs.). No plants were detectible at this site despite the main colony being in heavy flower at the time of inspection (C.P. Gibson pers obs.) Site visit was 2.50pm – approximately 4.30 pm (Stephanie Clark pers. com.).

Photo 6: *Hibbertia puberula* subsp. *glabrescens* Bankstown Airport 16/11/2018.

Note: Photo by Stephanie Clark.



Map 4: Generalised location of past *Hibbertia puberula* subsp. *glabrescens* collections.

Key – Area of *H. puberula* subsp. *glabrescens* collections (blue) and the growth areas (red).

2.4 HABITAT REQUIREMENTS

Hibbertia puberula* subsp. *puberula

Occurs in a wide range of habitats, but usually low heath, on sandy soil or rarely in clay, with or without rocks underneath (Toelken 2000). Proximate populations have been recorded from habitats associated with the Mittagong formation, shale sandstone transitional vegetation and tertiary alluvial deposits. Associated canopy species may include, but not limited to, in combination or isolation: Scribbly Gum spp., Grey Gum (*Eucalyptus punctata*), Scaly Bark (*Eucalyptus squamosa*), Ironbark spp., Narrow-leaved Apple (*Angophora bakeri*), Dwarf Apple (*A. hispida*), and Stringybark spp.

Hibbertia puberula* subsp. *extensa

The habitat requirements of *Hibbertia puberula* subsp. *extensa* are poorly known. The subspecies has only been recorded from five localities: south of Appin Road, Wedderburn vicinity, Woronora Dam vicinity, Sackville North vicinity and Bonnum Pic vicinity Wanganderry Tablelands.

This subspecies appears to have highly specific micro-habitat requirements. The largest known population occurs south of Appin Road, where less than 30 plants of *Hibbertia puberula* subsp. *extensa* have been recorded. Its area of occupancy is small, being noted to occur in a narrow band within a small upland swamp amongst wet heath vegetation. In a larger nearby wet heath site a few specimens of the subspecies were recorded to occur on skeletal soil, in the downslope seepage zone, where the underlying sandstone substrate outcrops. The subspecies has not yet been observed in superficially similar nearby wet heath habitats but as it is very cryptic it may be present. The Woronora, Sackville North and one of the two Wedderburn populations grow in seepage zones of sandstone outcropping in skeletal soil downslope of heathland. In the Bonnum Pic vicinity a few plants were noted growing on rock plate heath.

Hibbertia puberula* subsp. *glabrescens

Subspecies *glabrescens* is known only from Tertiary alluvial soil along Airport Creek on Bankstown Airport and not from areas where subsequent fill has been deposited in between (pers. comm. Gibson). The plant assemblage is attributable to “Cooks River/Castlereagh Ironbark Forest in the Sydney Basin Bioregion”.

The airport site is very heavily modified from the natural state, lacks canopy species and is currently a low grass/shrub association with many pasture grasses and other introduced herbaceous weeds.

Soil at the site is a sandy (Tertiary) alluvium with a high silt content.

The remnant at the site and soil type are consistent with an inferred pre-settlement cover of Castlereagh Ironbark Forest although some remnant vegetation at and near the site (along the channel in particular) suggests Castlereagh Scribbly Gum Woodland is equally valid.

Hibbertia sp. Bankstown has been observed to flower from October to December, with seed setting from October to January. Most *Hibbertia* species are primarily pollinated by bees, but many have specialised mechanisms requiring particular bee species, beetles or syrphid flies (OEH Threatened Species Profile).

2.5 ANTHROPOGENIC THREATS TO THE HABITAT

Threats to the habitat of *Hibbertia puberula* that are relevant to sites within or adjacent to urban development include:

- Direct loss of habitat through clearing.
- Reduction in size of habitats predisposing plants to edge effects.
- Fragmentation of habitat reducing the potential seed or gene dispersal across population or subpopulations.
- Damage to habitat by trailbikes, 4WDs and mountain bikes and other recreation activities.
- High densities of weeds and invasive grasses occur at the top of ridgelines; there is significant potential for encroachment into areas where the species occurs.
- Altered fire regime, either too frequent or too seldom.
- Potential for widening of major roads to affect populations of the species.
- Road maintenance and slashing works.
- Clearing for fire protection zones.
- Dumping of garden waste including invasive exotic species.

Field inspection of bushland remnants in the GPEC and WSA growth areas provided irrefutable proof of severe degradation arising from anthropogenic impacts and urbanisation (refer photos 6 through 9). Many of the remnants were heavily weed infested arising from a range of factors not limited to nutrification, stormwater discharge, garden refuse and fill dumping and exotic seed dispersal by various vectors. Environmental degradation was especially evident adjacent to creeks and drainage channels.

Hibbertia puberula is a small shrub that would not survive in bushland that is severely weed infested, or that is severely burnt on a regular basis.

The invasive grass species *Eragrostis curvula* is of significant threat to the species as it was observed to dominate extensive areas of the landscape.

Increased urbanisation is likely to see an upsurge in indiscriminate access into bushland that has not been cleared for development with increased illegal dumping, vehicular access including dumping and arson of stolen cars, and 4WD and trailbike causing serious long-term impacts.

Excluding EECs and Threatened Species habitats from the direct impacts of clearing will not ensure their long-term security without funding for fencing and active management. This funding and management could be a major outcome from the biodiversity certification process.

Photo 7: Dumping of rubbish in the eastern portion of Castlereagh Nature Reserve.

Photo 8: Clearing for asset protection zone, garden refuse dumping and invasive weeds.

Photo 9: Naturalised exotic species in the corridor behind housing.

Photo 10: Frequent fire, Wianamatta Nature Reserve.

3. Description of the study area

3.1 LAND USE HISTORY

The Cumberland subregion was first occupied by the Aboriginal peoples, who enjoyed a plentiful supply of fresh water and foods including fruit, tubers, fish, animals, birds and honey (Hills District Council website).

With the arrival of Europeans land use changed to timber gathering and agriculture, permanently altering the landscape. Particularly since the end of the second world war urban settlement and industry have expanded west from Sydney into the Cumberland subregion. Over the last 40 years many rural properties have been subdivided as lifestyle and hobby farm properties.

Currently there is great pressure for further residential development to the west of Sydney in the Cumberland subregion.

3.2 LANDSCAPE CONTEXT

The changes in land use have caused the clearing of a large proportion of the natural bushland of the Cumberland subregion. In 2011 the Cumberland Plain Recovery Plan stated "Only 13% of the pre-1750 extent of the region's vegetation remains as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas (NPWS 2002 in DECCW 2011). Consequently, much of the region's biodiversity is listed as threatened under State and/or Commonwealth legislation."

Widespread clearing of the remaining habitat has continued with much of the extant vegetation now being assessed as Critically Endangered. This widespread clearing has resulted in loss of habitat for endangered species such as *Hibbertia puberula*.

3.3 NATIVE VEGETATION

Since 2011 there has been further clearing, there are now 15 Plant Community Types that are listed as Critically Endangered, Endangered or Vulnerable in the Cumberland subregion.

The Cumberland Plain Recovery Plan states that "there are seven threatened species, four endangered populations and nine threatened ecological communities listed on the NSW *Threatened Species Conservation Act* 1995 that are found only on the Cumberland Plain. Seven of these are also listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999." The remaining bushland is highly fragmented and much of it occurs on private lands.

Within the GPEC and the WSA nineteen Plant Community Types (PCTs) are mapped (mapping provided by the NSW Department of Planning and Environment). These PCTs are:

- 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion

- 725 - Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion
- 774 – Coast Banksia scrub on sand in the Elderslie area, Sydney Basin Bioregion
- 781 - Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion
- 806 - Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)
- 807 – Derived grasslands on shale plains of the Cumberland Plain (<100m asl)
- 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain
- 830 - Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- 849 - Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- 850 - Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 877 - Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- 883 - Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- 1081 - Red Bloodwood – Grey Gum woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1105 – River oak open forest of major streams, Sydney Basin Bioregion and SE Corner Bioregion
- 1181 - Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- 1253 – Sydney Peppermint – White Stringybark – Smooth Barked Apple Forest on shale outcrops, Sydney Basin Bioregion
- 1292 – Water Gum – Coachwood Riparian Scrub along sandstone streams, Sydney Basin Bioregion
- 1395 - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion
- 1800 - Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley

3.4 POTENTIAL HABITAT

Hibbertia puberula has the potential to occur within seven Plant Community Types (PCTs) mapped as occurring within the GPEC and the WSA. These community types are:

- 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion
- 725 - Cooks River Castlereagh Ironbark Forest

- 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain
- 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- 883 - Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion
- 1395 - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

With the exception of PCT 883 at Moorebank, *Hibbertia puberula* has not been recorded to occur uniformly or in substantive numbers across any of the above listed communities. In general, it is usually confined to a variety of specific habitat niches within these regional mapping units. The area of occupancy within and/or the area of the specific habitat niches at any locale may be as small as a few square metres.

Specific habitat niches of potential occurrence may include upper drainage lines, seepages especially those associated with exposed sandstone bedrock or slabs, margins of hanging swamps / wet heath, exposed sandstone rock plates, and large and small occurrences of colluvial or alluvial deposits. At most locales presence or absence can only be positively determined by intensive targeted surveys that investigate such habitat niches thoroughly within the peak flowering period.

Photo 11: PCT 808 in power easement east of Ropes Crossing.

Note: Large numbers of threatened species survive in the derived habitat.

4. Assessment of species presence and suitable habitat

4.1 EXISTING RECORDS AND SURVEYS

Hibbertia puberula including its subspecies are poorly known and there is limited data on the life history and ecology of the species. Apart from Miller (November 2018), there have been no other specific targeted surveys for *Hibbertia puberula* within the study area. General vegetation assessments undertaken for various purposes appear also not to have found *Hibbertia puberula* as there are no prior database records of the species within the proposed growth areas.

In many instances the species group has not been considered within assessments or dismissed with statements of "unlikely no suitable habit present" and therefore no targeted searches were undertaken.

<u>Potentially misidentified *H. puberula* in the records</u>

Searches of databases revealed records of *Hibbertia riparia* at a number of locales within and adjacent to the growth areas. The name *Hibbertia riparia* is considered by Toelken to be misapplied to NSW taxa. Prior to the updated taxonomy a number of undescribed species were included within the name *Hibbertia riparia* then considered to be "a variable species complex".

Miller has observed that *Hibbertia puberula* is frequently still misidentified as *Hibbertia riparia*.

Reviewing the data set it became apparent that there were a number of records for *Hibbertia serpyllifolia* in the general Western Sydney area. Recent taxonomic work (Toelken 2013) investigating "The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia*", has identified that the name *Hibbertia serpyllifolia* is misapplied to NSW. The species concept is now considered to be confined to coastal forests of mid-northern Queensland. All records from other states are now recognised as new taxa e.g. *Hibbertia ericifolia* group or misidentifications of existing taxa.

As *Hibbertia* are notoriously difficult to identify, and more so if not in flower, it is not surprising to find records of *Hibbertia* sp. within the data set.

The Western Sydney Urban Bushland Biodiversity Survey 1997 undertook the first comprehensive survey of the biota across the region including bushland remnants within the GPEC and WSA area. Although the taxonomy of *Hibbertia* has changed significantly since that time, the records of *Hibbertia* contained within provide additional insight into the potential occurrences of threatened *Hibbertia* species.

The Straede T.M. 1990 "Vegetation of the proposed Londonderry Waste Disposal Site" report for Waste Management Authority, Sydney found *Hibbertia cistiflora* in the Castlereagh – Londonderry Crown Lands. It is unknown if this species occurs in the area or is a misidentification.

The current survey was limited in extent and did not visit the precise area of the Straede survey which is outside the growth area. The surveys conducted by CFFIS did not locate any specimens of *Hibbertia cistiflora*. There are no other records in the district and most vouchered records in the Sydney Metropolitan area occur north of the Harbour and are associated with sandstone ridges often in proximity to shale caps and Sandstone Shale Transition Forest associations.

It is noted in Toelken & Miller 2012 that subsp. *quadristaminea* is "often wrongly identified in herbaria as *H. serpyllifolia*, but subsp. *quadristaminea* has few stamens only in one dorsal cluster" c.f. *Hibbertia ericifolia* (*H. serpyllifolia* misapplied) possessing usually 8-16 but up to 30 stamens, dependant on the subspecies surrounding and obscuring the ovaries. This highlights that even herbaria have mis-assigned *Hibbertia* specimens. The fact that *H. cistiflora* has its anthers on one side of the ovaries opens the possibility that the Straede record could be what is now *Hibbertia puberula*. It is possible that Straede had another taxon from within the then *H. riparia* variable species complex previously identified. The current survey identified *Hibbertia puberula* to be present within the adjacent Castlereagh Nature Reserve.

It is unknown if the *Hibbertia serpyllifolia* UBBS Site (P1) Londonderry – Castlereagh Crown Lands survey by R.S. Lembit & T.A. James - woodland south of Devlin Road & NW end of Nutt Road record was based on field identification of fertile or infertile material. If it was based on fertile material it is most likely to be an unverified record of *Hibbertia ericifolia* group. If it was based on infertile material it is most likely to be *Hibbertia puberula.* CFFIS has recorded *Hibbertia puberula* in this vicinity.

Hibbertia pedunculata recorded at Mulgoa (Blue Mnts NP Sydney Sandstone complex) Coveny, R. 1976 – 95 Species lists for Mulgoa (off Fairlight Road – Nepean River) Blue Mtns National Park is likely to be that species, however there is a possibility that it could also be potentially be *H. fumana* or *H. puberula* if the Coveny observation was based on field identification of infertile material.

A *Hibbertia riparia* record from the Castlereagh Nature Reserve is most likely to be *Hibbertia puberula.* The current CFFIS survey recorded *Hibbertia puberula* within the Nature Reserve.

4.2 SURVEYS COMPLETED FOR THE BIOCERTIFICATION

From the information provided, no prior dedicated targeted searches have been undertaken for this species as part of the biodiversity certification process.

Surveys undertaken by Ecoplanning and Biosis consultancies since 2017 have largely been confined to the deemed "development footprint" and appear to have been undertaken predominantly to comply with the BAM protocols for vegetation sampling for assessment purposes with little survey for threatened species. As such, no new occurrences of threatened *Hibbertia* species including *Hibbertia puberula* were recorded by Biosis or Ecoplanning through their survey efforts.

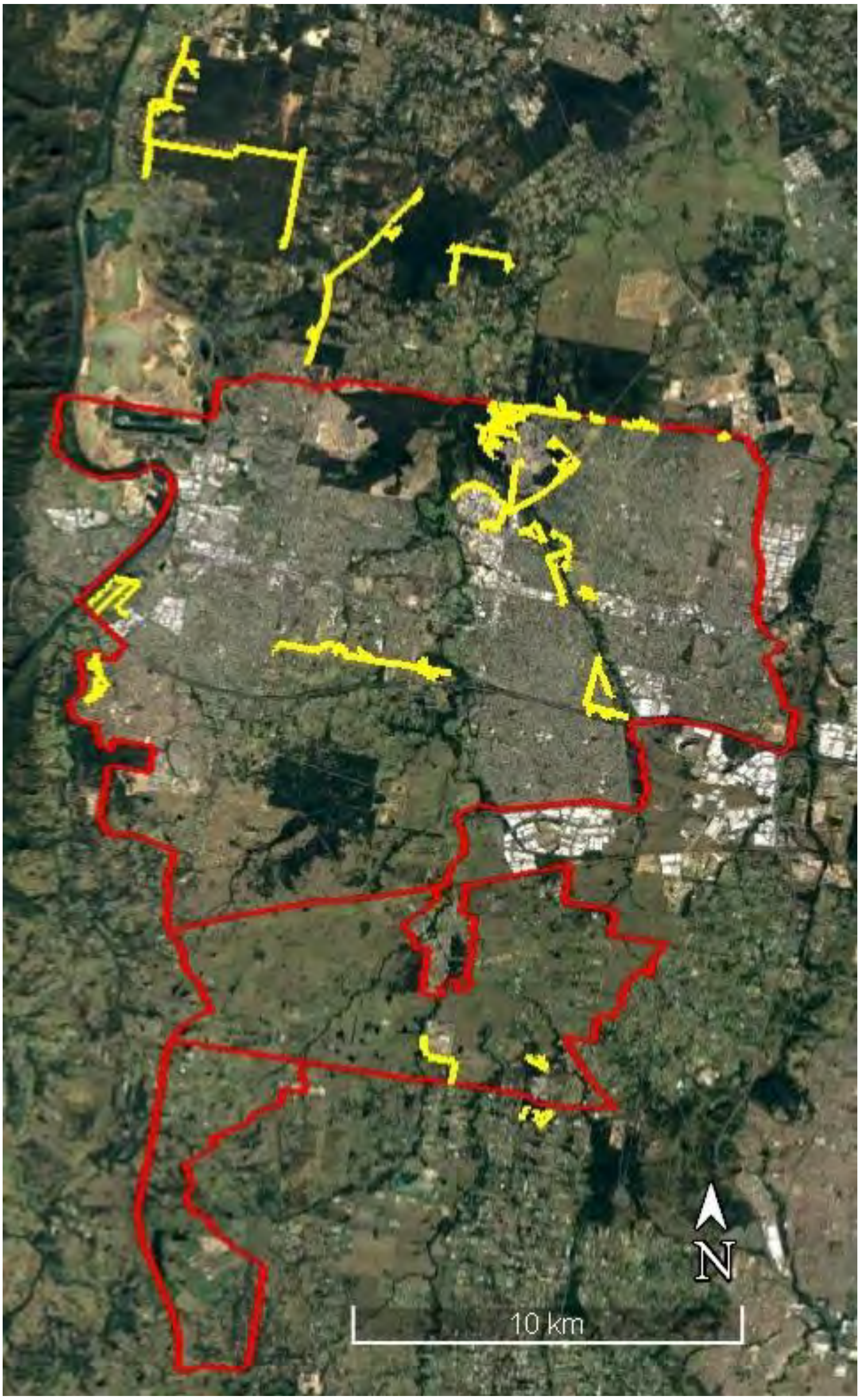
Access to a spatial viewer was provided by DPE to assist in the expert assessment. Whilst this tool has been useful in gaining a general overview, the information presented is limited and is acknowledged to "have been acquired and developed from numerous sources of differing dates, accuracy and completeness and may include errors in extent and content". CFFIS are not aware of any surveys performed specifically for *Hibbertia puberula* by DPE, Ecoplanning or Biosis Consultancies. The broadscale vegetation mapping of PCTs that was provided to assist with this assessment cannot identify the habitat niches that may be present on a localised scale.

The level of data available is insufficient to base an assessment of presence/absence for a Critically Endangered / Endangered species group purely as a desktop study.

4.3 SURVEYS COMPLETED FOR THIS ASSESSMENT

Surveys for the biodiversity assessment informing the development of the biodiversity certification were constrained by private lands access issues, time and the overall size of the biodiversity certification area. Map 4 shows the locations that were surveyed by CFFIS for this assessment.

Photo 12: *H. puberula* subsp. *puberula* located at Ropes Crossing by the CFFIS survey.



Map 5: Google Earth image of GPEC and WSA Growth Areas and tracks of CFFIS survey.

Key: Growth area approximate boundary shown in red, survey tracks shown in yellow.

4.3.1 SURVEY METHODS

Survey for this report followed the following steps:

- Visit a selection of known localities of the species, locate some *Hibbertia puberula* plants, and take particular note of the habitat characteristics, plant habit, co-occurring species and population density in the context of the protracted rainfall deficit.
- Search biological data sets for any records within the study area. The BioNet and ALA searches failed to find any records of the *Hibbertia puberula* group in the growth areas. *Hibbertia* species are notoriously mis-identified. Searches were then made of all *Hibbertia* recorded within and adjacent to the growth areas to ascertain if any misidentification may be included in the data set. Searches included UBBS NPWS 1997. Records stating *Hibbertia pedunculata*, *Hibbertia* sp., *Hibbertia* sp. A, *Hibbertia serpyllifolia*, *Hibbertia cistiflora* and *Hibbertia riparia* were included within the target survey effort where practical and survey access had been granted. The large amount of entries for *Hibbertia aspera* precluded visiting all known sites. An additional rationale for including these records apart from possible mis-identification is the presence of these species may indicate potential suitable habitat for the *Hibbertia puberula* group.
- Search for records of indicative co-occurring species other than *Hibbertia* such as *Grevillea parviflora* subsp. *parviflora* in order to further refine the survey effort.
- Examine the vegetation type maps provided by the Department of Planning and Environment.
- Locate potential habitat sites based on the mapping and expert knowledge of the plant habitat requirements.
- The prolonged rainfall deficient / drought period prior the survey effort posed significant challenges to the survey. Areas were targeted such as powerline easements where competition for moisture from large trees and shrubs may have been reduced and the targeted flora would have had a greater chance of persisting through the dry period. This strategy was significant in locating one new population *Hibbertia puberula* adjoining Wianamatta Regional Park.
- Survey in early to mid-morning. The greatest impediment to detecting *Hibbertia* species during the survey was early petal drop of some species thought to be increased due to the dry period and unusually high temperatures. Early petal dehiscence was most evident on 3 November 2018 where petal drop of *Hibbertia puberula* was noted to have commenced prior to reaching the site at 8.30am (temperature of 30) and was complete by 9 am (temperature 32).
- Visit as many of these potential habitat sites as possible, considering time and access constraints. Conduct drive-by and over-fence survey where habitat is clearly not suitable.
- Survey potential habitat sites for the species.

4.3.2 SPECIES IDENTIFICATION

As there were no prior records of the *Hibbertia puberula* group within or proximate to the growth areas it was deemed appropriate to prepare herbarium voucher specimens for later lodgement with the National Herbariums of NSW and Adelaide to substantiate the records. Selected specimens were taken according to protocols.

If we located a small-leaved *Hibbertia* specimen that was not in flower and it had macro morphological features resembling that of *Hibbertia puberula,* a specimen was retained for later microscopic examination. Due to the antecedent drought conditions many plants were depauperate, such that, in some cases specimens removed consisted of very small fragments (eco-scraps) some only a few cm in length. This is far from ideal, the challenge was to then identify the non-flowering eco-scraps to species using only stem and leaf characteristics, as shown in the drawing below (Toelken 2000).

The small branchlets of each specimen were compared to voucher material of *Hibbertia puberula* under a dissecting microscope. Note that positive identification of the species requires flowering parts, however, some species of *Hibbertia* can be ruled out based on stem and leaf characteristics. Microscope photographs of *H. puberula* characteristic features used during this survey by CFFIS are provided in Appendix 4.

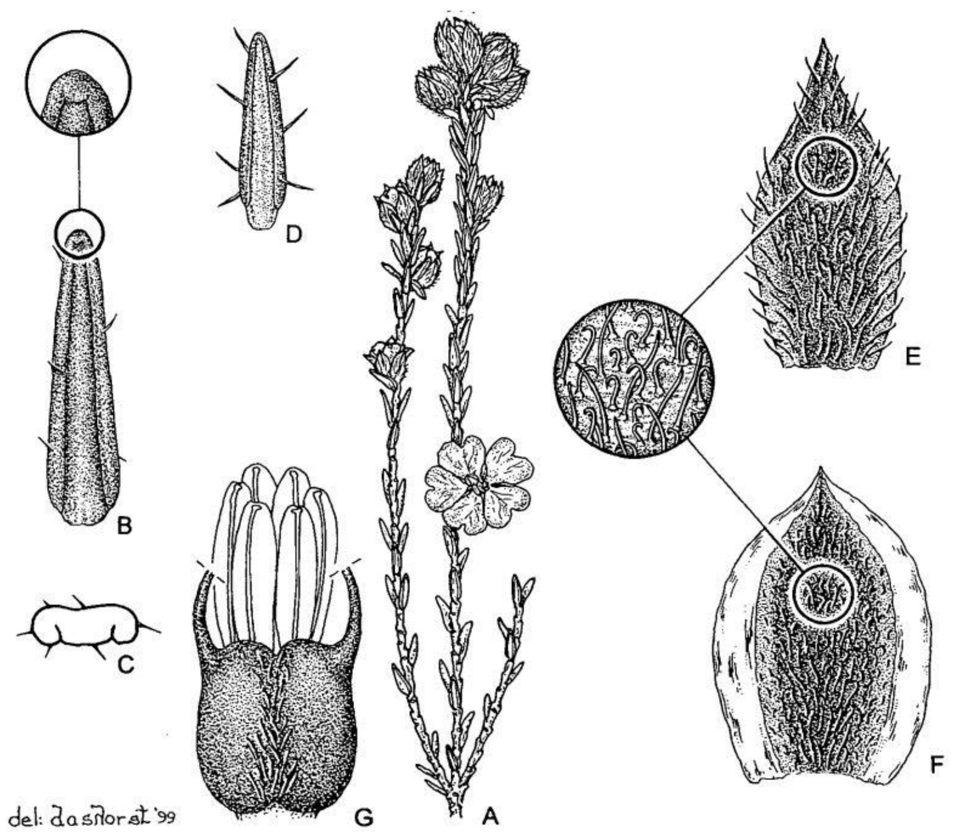


Fig. 7. ***H. puberula***. **A**, Flowering branch; **B**, cauline leaf; **C**, tranverse section; **D**. bract; **E**, outer calyx lobe; **F**, inner calyx lobe; **G**, two glabrescent ovaries. (**A–G**, *J.M.Lindale NSW 101952*; **A** ×1; **B, D** ×10; **C** ×15; **E, F** ×6; **G** ×20).

Figure 1: Line drawing of *Hibbertia puberula* distinguishing characteristics.

All non-flowering small narrow leaved *Hibbertia* specimens found during the survey were examined under the microscope to determine if the stem and leaf characteristics matched those of *Hibbertia puberula.* Essential characters considered include leaf dimensions and shape, the leaf undersurface having revolute margins and recessed to bulging broader central vein obscuring the leaf undersurface, and branchlets having interpetiolar tuffs of hairs. Some of these characters are shown on Figure 1Figure 2. Where the majority of characters were a match, the species could not be ruled out of consideration and so was assumed to be the subject species. It should be noted that these characters vary slightly between sub-species, as shown in Figure 2 below, and confident identification to sub-species requires flower characteristics.

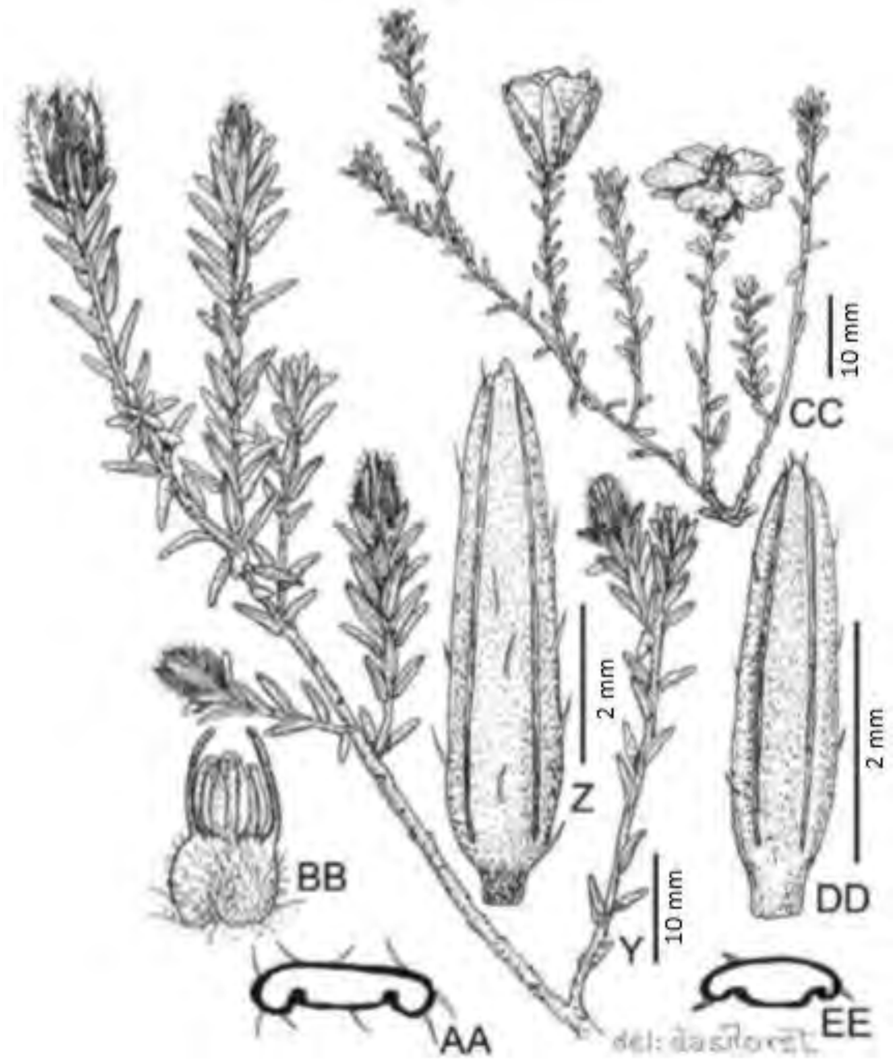


Figure 2: Line drawing of *H. puberula* subs. *extensa* and subsp. *glabrescens*.

Key: *H. puberula* subs. *extensa* Y flowering branch; Z leaf from below; AA transverse section through mid-leaf; BB flowers with petals and calyx removed. *H. puberula* subs. *glabrescens*: CC flowering branch; DD leaf from below; EE transverse section through mid-leaf.

A requisite taxonomic feature is hair types and the specific arrangement on leaf and branchlets. The persistence of the hairs on various parts of *Hibbertia* is variable according to the species. In many species such as *Hibbertia puberula,* hairs on the leaves and stem are notoriously non-persistent and "soon wear off" (Toelken). The full range hair expression is best observed on new and recent growth (Miller pers. obs.). The lack of new or recent growth is a significant limiting factor in the determination of the specimens as at all sites the vegetation was in severe drought stress.

Photo 13: A selection of *Hibbertia* voucher specimens, photo from c. 30cm away.

Key - A: *H. fumana* Moorebank; B: *H. pedunculata* Ropes Crossing; C: *H. empetrifolia* Appin; D: *H. puberula* subsp. *puberula* Ropes Crossing; E: *H. puberula* subsp. *puberula* Belrose; F: *H. puberula* subsp. *puberula* Nutt & Smeeton Roads; G: *H. aspera*

(Photo by R.T. Miller November 2018).

4.3.3 SURVEY ASSUMPTIONS

It was not feasible to survey all the many bushland remnants within the GPEC and WSA growth areas. As such, the first assumption was:

Assumption 1. *Hibbertia puberula* would not be found growing in bushland that is not its known habitat.

The author is familiar with the species' types of habitat across its entire known range. Using this knowledge of geology, soil and vegetation type that is the known habitat of the species, areas of bushland that would not be suitable habitat were ruled out of the assessment.

Using this knowledge of habitat requirement, the second assumption was:

Assumption 2. *Hibbertia puberula* is likely to be present in areas that are known to be suitable habitat.

Although there are occasions where the plant occurs in higher densities, the most common occurrences are rare and scattered throughout suitable habitat or low populations numbers localised to a small habitat niche. Areas of suitable habitat were surveyed using the random meander method. When only one or no individual specimens were located using this method, it was deemed likely that the species would occur scattered throughout these areas of suitable habitat.

The survey was carried out following several years of drought in western Sydney, and many shrubs forbs and grasses were dead. This led to the third assumption:

Assumption 3. In areas of suitable habitat, where *Hibbertia puberula* specimens have not been found, the species could be present in the soil seed bank.

There was a high amount of leaf fall in most locations and most locations have not recently been burnt. In these areas the species is likely to be present in the soil seed bank. An example is the Basin Reserve (outside the growth areas), where the species was previously scattered throughout suitable habitat within the reserve. Since the drought and control burning, the species appears to now be very rare at this site, however it is likely to be present in the soil seed bank.

4.3.4 *HIBBERTIA* RECORDED BY THIS SURVEY

Six species of Hibbertia were observed whilst undertaking surveys for this report. They are:

Hibbertia puberula: First records for the growth areas and to the north of the growth areas. See Appendix 2 for collection notes.

Hibbertia pedunculata: Very significant populations of this species were observed in the GPEC within and outside the biodiversity certification areas in the Wianamatta Regional Park, also to the north in the former Air Services Australia Site adjoining the north of the GPEC.

Hibbertia diffusa: Widespread, sometimes locally common inside and outside growth areas. Most commonly observed on shale derived or influenced substrates.

Hibbertia aspera: Widespread, sometimes locally common inside and outside growth areas. Most commonly observed on shale derived or influenced substrates.

Hibbertia acicularis: Noted in two areas outside the growth areas, at Agnes Banks Nature Reserve and Gulguer Nature Reserve.

Hibbertia fasciculata: Noted in one area outside the growth areas in Agnes Banks Nature Reserve, in Scribbly Gum Woodland only.

It is a recommendation of this study that *Hibbertia pedunculata* be listed as a Threatened species or an Endangered Population and taken into consideration as part of this biodiversity certification process.

Toelken (2013) in his revision of the *Hibbertia vestita* group, including *H. pedunculata* and *H. serpyllifolia*, considers *H. pedunculata* to be confined to NSW. Analysis of the cited specimens reveals that the species has two main areas of distribution the Greater Sydney Metro Area and the lower Hunter.

In the Greater Sydney Metropolitan area the species has suffered a significant reduction in numbers and extant distribution due to urbanisation. Two cited locales occur within the growth area at St Mary's. The Greater St Mary's – Shane Park vicinity is now the only general vicinity that has long term viable habitat remaining for the species, that is, Wianamatta Regional Park including areas within the former ADI site not gazetted and the Former Air Services Australia site.

Of the twenty specimens cited in the Greater Sydney area six only are known to have extant populations, however all are under severe threat due to small population size and anthropogenic impacts. Nine populations are known or highly likely to be extinct (refer to Appendix 6).

Prior to this survey *H. puberula* had not been recorded within or adjoining the growth areas, although potential habitat had been identified. Seven new locations of the *H. puberula* group were confirmed by this study, 2 within the Growth areas and 5 to the north west.

At the time of publishing (Toelken 2000) few collections were known of *H. puberula*. The J. M. Lindale collection was the only known specimen which displayed a predominance of hooked hairs on the calyxes and a reduced number and number of overtopping +/- straight simple hairs. It is a significant outcome of this survey that additional specimens of this "form" have been located. Although from limited sampling these new specimens may indicate a distinct localised form (Toelken pers. comm.) as all specimens of *Hibbertia puberula* identified for this survey appear to +/- consistent with the Lindale NSW 101952.

Further investigation is warranted to ascertain both the morphological trend observed and the abundance at each of the sites of occurrence.

4.3.5 INCIDENTAL SIGHTINGS OF SIGNIFICANT FLORA DURING THIS SURVEY

The bushland remnants surveyed were observed to support numerous threatened species including but not limited to *Hibbertia puberula*, *Persoonia nutans*, *Pultenaea parviflora*, *Dillwynia tenuifolia*, *Micromyrtus minutiflora* and *Grevillea juniperina*.

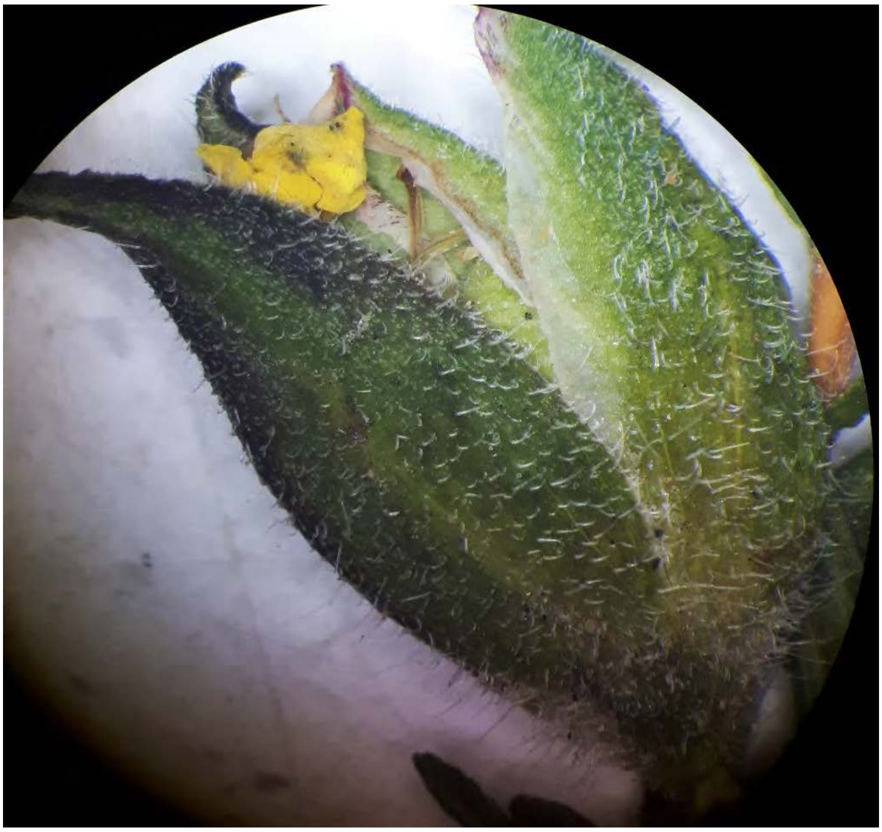


Photo 14: *H. puberula* Kemps Creek showing close similarities to the Lindale NSW 101952

Photo 15: *H. puberula* subsp. *extensa* showing long simple hairs.

4.4 ASSESSMENT OF SPECIES PRESENCE

Within the GPEC and WSA growth areas the species group could be present in the following PCTs:

> 724 - Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin Bioregion,
>
> 725 - Cooks River Castlereagh Ironbark Forest,
>
> 808 – Derived shrubland on Tertiary Gravels of the Cumberland Plain,
>
> 835 - Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, and
>
> 883 - Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion,
>
> 1067 - Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion,
>
> 1395 - Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion.

Occurrences within these broadscale mapping units are most likely to occur in microhabitats. Broad scale vegetation survey and mapping do not identify habitats at this scale. Potential habitat within these PCTs were targeted for survey where access was available.

Determination of potential habitat for *Hibbertia puberula* includes areas identified outside the deemed biodiversity certification area. Anthropogenic impacts are well documented to adversely affect vegetation well beyond the direct urban footprint.

Although there were no pre-existing records of the species within the growth areas, as previously discussed in section 4.1 there are records that could be misidentifications and that could be *H. puberula.* There have been no previous targeted surveys for the species in the growth areas.

4.4.1 LIKELIHOOD OF SPECIES PRESENCE

Hibbertia puberula* subsp. *extensa

It is extremely unlikely that *Hibbertia puberula* subsp. *extensa* exists within the WPEC and WSA growth areas. No suitable habitat for the subspecies is known to occur or is likely to occur within the proposed urban footprint or the growth areas. The likelihood of occurrence is assessed as negligible.

Hibbertia puberula* subsp. *glabrescens

The likelihood of occurrence within or adjacent to the GPEC is considered to be low to moderate, and the likelihood of occurrence within or adjacent to the WSA is assessed as low.

From known occurrence data the subspecies does not have the capacity to exist in habitats that occur within the proposed WSA development footprint. No further, specific targeted surveys are warranted for this subspecies in the WSA footprint. In the unlikely event that this subspecies was to occur it would be picked up in the targeted surveys for *H. puberula* subsp. *puberula*.

Hibbertia puberula* subsp. *puberula

Within the development footprint the subspecies is likely to occur within the Wianamatta Regional Park, as well as in areas adjacent to the footprint at Ropes Crossing and Kemps Creek (see maps 6 to 10).

<u>Within the GPEC</u>

From CFFIS limited field surveys, *Hibbertia puberula* subsp. *puberula* was found to occur at one site immediately adjacent to the Wianamatta Regional Park east of Ropes Crossing. The area of occurrence is a highly modified environment which prior to clearing would have been identified as PCT 725. Mostly now devoid of trees, the derived habitat consists of grassland/herbland/shrubland which is periodically slashed.

It is probable that this subspecies occurs at other locales within the Wianamatta Regional Park and nearby vicinity, especially in the former Air Services Australia Site at Shane Park, the southern border of which is within the biodiversity certification area boundaries. Any occurrences are likely to be confined to small populations restricted to very localised habitat niches. Potential habitat areas adjacent to the footprint would be highly susceptible to significant indirect impacts from a range of anthropogenic influences arising from the increase in urbanisation.

<u>Within the WSA</u>

Whilst undertaking field surveys for this report *Hibbertia puberula* subsp. *puberula* was found to occur at Kemps Creek. The Kemps Creek area is therefore now a known habitat for this species. The likelihood of occurrence within identified suitable habitat within the Kemps Creek vicinity ranges from high (known to be present) to moderate to low depending on location and condition of vegetation. Highly modified environments such as derived shrubland/grassland/herbland cannot be ruled out of consideration and remain assessed as moderate/high as evidenced by the presence of more than 20 *H. puberula* subsp. *puberula* plants observed on Lot 3 DP812284 at Kemps Creek.

A low rating is only justifiable where the soil profile has been significantly altered by fill emplacement or soil chemistry has been significantly altered by past agricultural practices or through urban runoff and where weed invasion is acute.

<u>North of the growth areas</u>

Whilst undertaking field surveys for this report new occurrence records of *Hibbertia puberula* subsp. *puberula* were located in the Agnes Banks, Castlereagh to Berkshire Park vicinities to the north of the GPEC growth area (see Map 2).

4.4.2 JUSTIFICATION FOR DETERMINATION

The following maps show an overview of areas containing potential habitat of *Hibbertia puberula* group, based on vegetation mapping and BioNet records, within the GPEC and WSA. These areas were surveyed by CFFIS for this assessment. Vegetation mapping provided by DPE.

Key to the maps is:

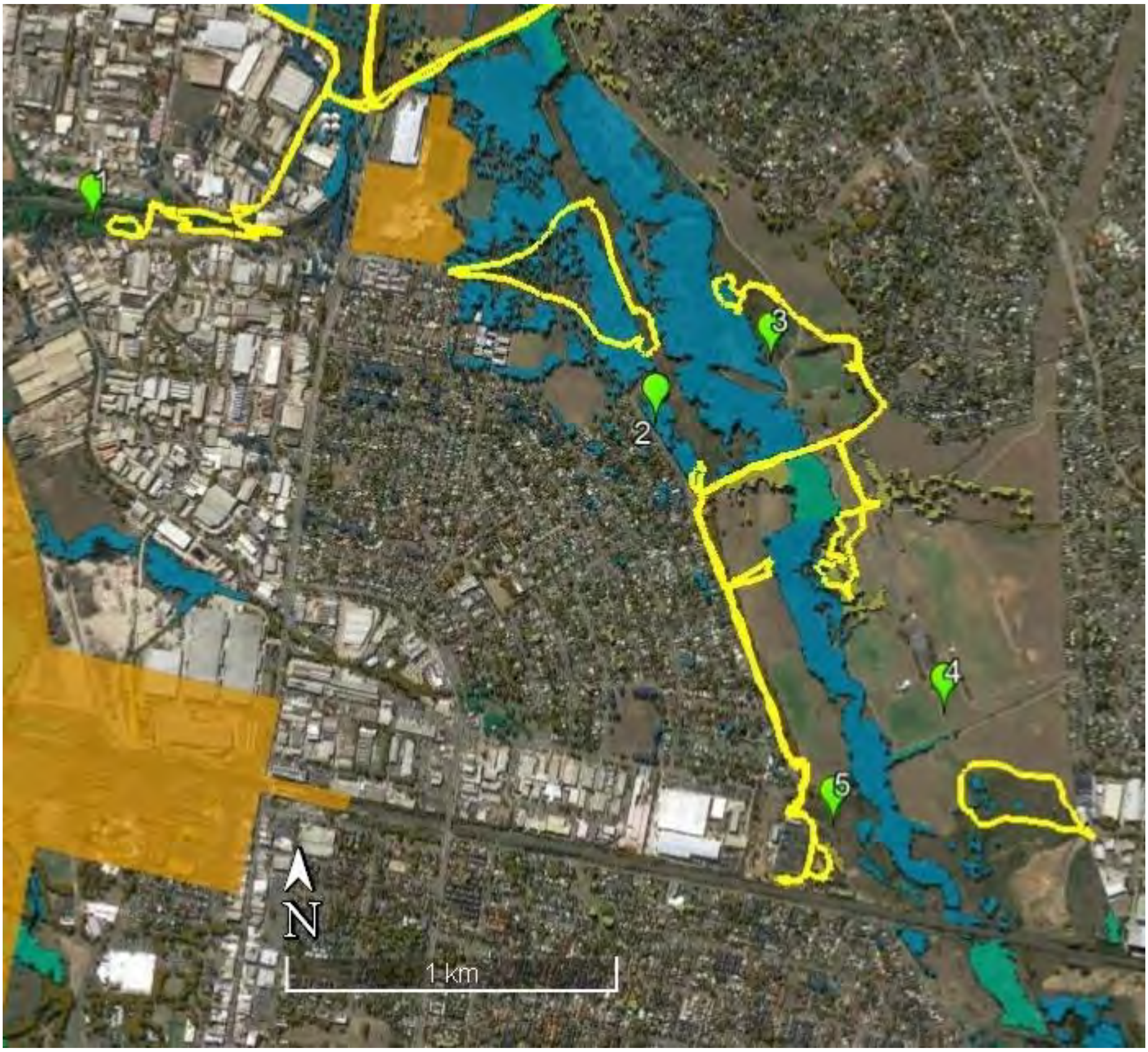
- development footprint – light orange
- CFFIS survey tracks - yellow
- vegetation type PCT 724 – dark blue
- vegetation type PCT 725 - dark green
- vegetation type PCT 835 – light blue
- vegetation type PCT 849 – olive green
- vegetation type PCT 883 – red
- vegetation type PCT 1800 – light green

Map 6: Wianamatta Regional Park south section and powerline easement.

Map 7: Northern section of the Wianamatta Regional Park with road corridor footprint.

Map 8: Bells Line of Road Castlereagh Connection corridor footprint.

Note: former Air Services Australia site is to the north.



Map 9: Ropes Crossing and North St Marys areas of potential habitat and development footprint.

Survey locations:

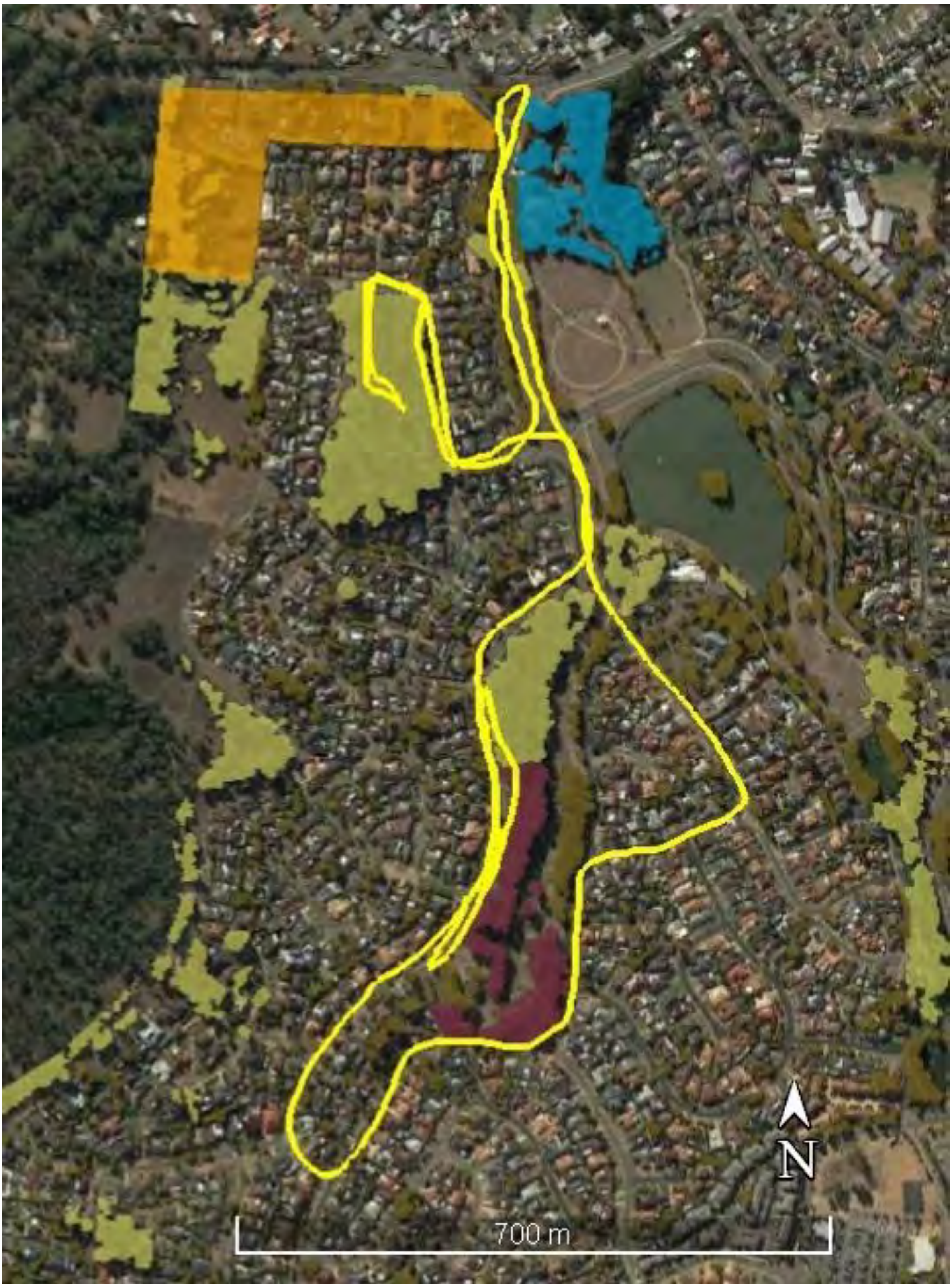
1. Dunheved Estate Reserve
2. Boronia Park
3. Tregear Reserve
4. Whalan Reserve
5. Substation, Kurrajong Road North St Marys

Map 10: Shepherd Street vicinity, St Marys areas of potential habitat.

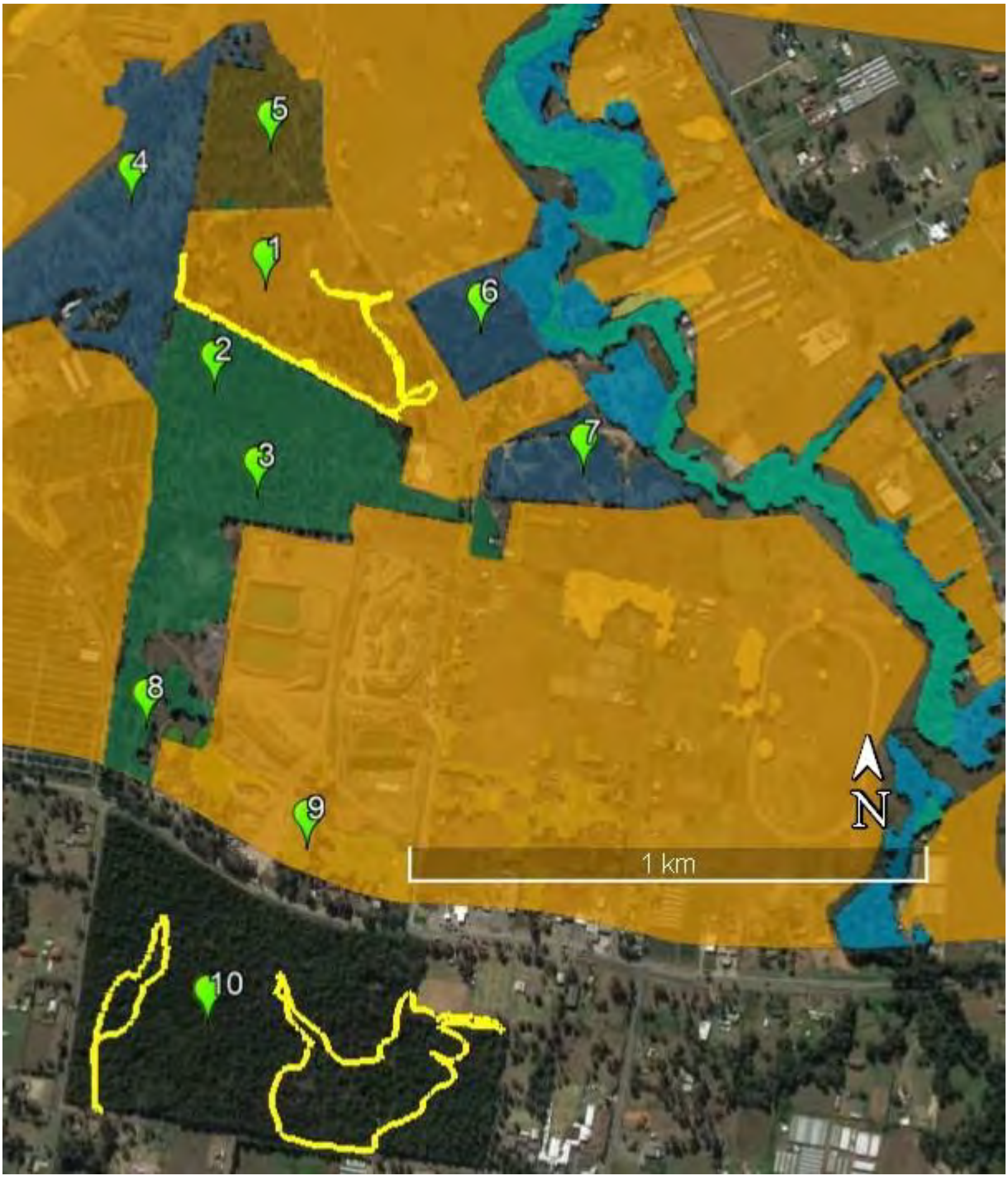
Survey locations:

1. Shepherd Street Park
2. Corner of Motorway bushland remnant

Map 11: Claremont Meadows area of potential habitat and development footprint.



Map 12: Apple Gum Reserve at Glenmore Park, area of potential habitat and development footprint



Map 13: Kemps Creek potential habitat and development footprint.

1. Lot 3 DP812284
2. Lot 2 DP812284
3. Lot 1 DP812284
4. Lot 22 DP60122, Lot 2 DP587135
5. Lot 47 DP734584
6. Lot 6 DP812284
7. Lot 4 DP812284
8. Lot 1 DP716403
9. Lots north of Elizabeth Drive
10. Cross Street bushland

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Map 14: Kemps Creek, south of SUEZ facility, block of land partially cleared.

Map 15: Jamisontown area showing development footprint and potential habitat.

4.5 ASSESSMENT OF SUITABLE HABITAT

4.5.1 SUITABLE HABITAT WITHIN THE GROWTH AREAS

This section provides detail of areas of suitable habitat within the growth areas that have been surveyed by CFFIS, and the outcomes of that survey.

Powerline Easement Adjacent Forrester Road, Ropes Crossing

Vegetation of the powerline easement has not been allocated a PCT despite the area containing high population numbers of threatened taxa.

The Powerline easement is periodically slashed, maintaining a grassland/herbland/shrubland derived habitat. Scattered remnant trees adjacent Forresters Road are mapped as PCT 725 and are mostly *Eucalyptus fibrosa* with a few Stringybarks noted. Along the western portion of the easement the vegetation grades into +/- intact remnants found within the Wianamatta Regional Park and mapped as PCT 725 and PCT 883 (refer Map 6).

The easement supports a high diversity of indigenous flora and has minor incursion of invasive exotic species which are mainly confined to areas adjacent to Forresters and Palmyra Roads. A small upper gullyline, however is weed impacted and a vector source into the regional park.

40 plants of *Hibbertia puberula* subsp. *puberula* were located within the easement and are presumably the same taxon as that assigned as *Hibbertia riparia* in UBBS. The species was only observed in 3 discrete but proximate patches in a limited area. On 29 October 2018 two large plants were noted with petals, approximately 8 other plants with no flowers were scattered amongst plants of *Hibbertia pedunculata.* On 31 October 2018 a further 15 plants were observed at two additional patches. The plants mostly aborted all their petals or were not in flower, so it is likely that more plants are present but were not observed.

Hibbertia pedunculata was observed to be abundant within the easement, the majority of the plants possessing many flowers and easily detectable. This is significant, as virtually no plants of *Hibbertia pedunculata* were noted within the more heavily vegetated western edge of the easement and within the immediate adjoining sector of the regional park.

Similarly, *Pultenaea parviflora* and *Dillwynia tenuifolia* were frequently encountered within the easement but were noticeably infrequently observed within the adjoining intact vegetation.

It is thought that this is attributable to the preceding drought conditions and fire regime. The absence of trees in the easement meant that there was less competition for water allowing smaller plants to thrive.

The power easement is within the GPEC growth area but is not within the development footprint.

Photo 16: Detail of flower structure, *H. puberula* subsp. p*uberula* from powerline easement.

Photo 17: From *H. puberula* site, lush shrub regrowth including large numbers of threatened species.

Photo 18: Photo of powerline easement edge adjacent to trees.

Note that within the sphere of influence of trees the ground layer is sparse and shrubs regrowth stunted.

Photo 19: A large plant of *H. puberula* subsp. *puberula* located in the powerline easement.

Photo 20: *H. pedunculata* within the powerline easement growing with *H. puberula*.

Note: The density of *H. pedunculata* flowers makes detection easy as compared to low-density occurrences under the long-unburnt Cooks River Castlereagh Ironbark Forest.

Photo 21: Lateritised gravel soil substrate within the area of occurrence of *Hibbertia puberula.*

Note: Lateritised gravel soil is common within the Wianamatta Regional Park and the former Air Services Australia site.

Photo 22: Western boundary of the powerline easement.

Note: Few threatened species were detectable, and none were in flower. The population of threatened species is presumed to be reduced to the soil seed bank.

Photo 23: Typical sparse understorey within Wianamatta Regional Park adjacent easement.

Note: no flowering threatened species.

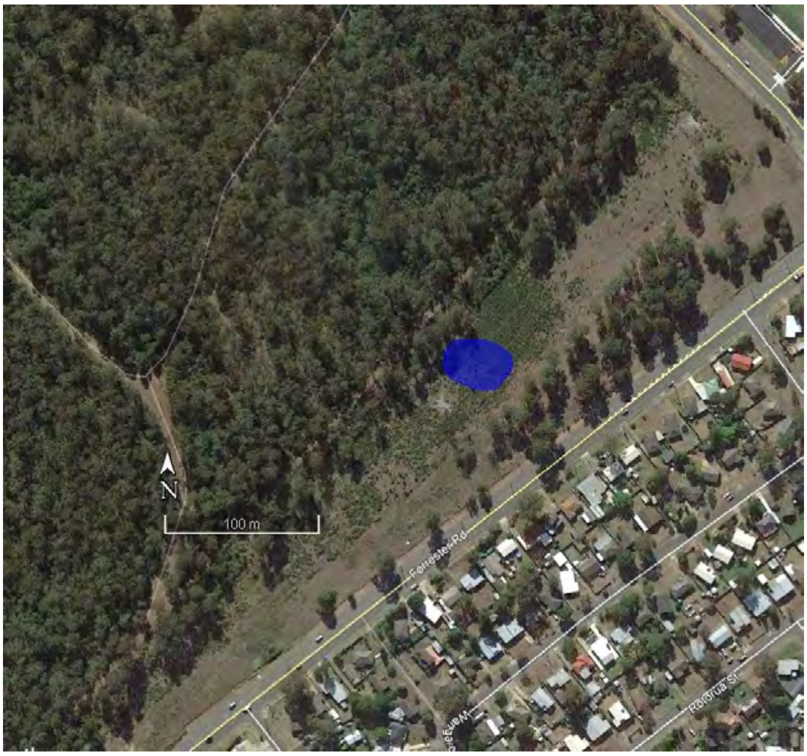


Photo 24: Google image of power easement, location of *H. puberula* subsp. *puberula* in blue.

Wianamatta Regional Park area and Outer Sydney Orbital corridor

Within the Regional Park and the Outer Sydney Orbital (OSO) corridor are areas mapped as having PCTs appropriate for *H. puberula* habitat. The potential for the species to occur in these areas is moderate. Survey of the area did not locate the species, however, the bushland was very dry, had not been burnt for years, and it is likely that the species could be surviving in localised patches in the soil seed bank.

This assessment is based on the proximate record of *Hibbertia puberula* within the electricity easement, the associate species observed there and the presence of lateritised clay soils at both locales.

Hibbertia pedunculata and to a lesser degree *Dillwynia tenuifolia* and *Pultenaea parviflora* were used as surrogate indicator species in determining the likely impact of drought and fire regime on the population densities, within and outside of canopy cover in the assessment of likely occurrence of *Hibbertia puberula*. *Hibbertia pedunculata*, *Dillwynia tenuifolia* and *Pultenaea parviflora* were observed to be locally frequent species within some modified habitat areas.

In areas where these species were noted away from the influence of large trees and shrubs they were easily discernible, flowering and vigorous. Under the canopy or within the sphere of influence of trees and shrubs, flowering was significantly reduced but mostly absent and the apparent population densities low. Visible plants were typically in a late stage of senescence. This was particularly apparent with *Hibbertia pedunculata*.

Photo 25: Typical sparse shrub and ground layer in the regional park.

Other shrub and ground layer species were also noted to be particularly sparse within the areas mapped as PCT 725 and PCT 724 within the Wianamatta Regional Park.

These observations support the conclusion that non-detection of *Hibbertia puberula* within or adjacent to the development footprint (OSO corridor) within the Wianamatta Region Park is likely to be attributable to a retraction to the soil seed bank rather than non-occurrence.

Photo 26: Typical thick detritus suppressing the ground layer in the regional park.

Photo 27: Photo of Wianamatta Regional Park showing depauperate understory.

Note that the extended dry conditions in the Regional Park means that understory species cannot compete with trees for available water. Most of the ground layer has retracted to the soil seedbank.

Photo 28: Sparse shrubs of *Grevillea juniperina*, *Dillwynia tenuifolia* and *Daviesia ulicifolia* subsp. *stenophylla*.

Photo 29: *H. pedunculata* within derived habitat away from trees and shrubs.

Photo 30: Typical condition of *H. pedunculata* within "intact" vegetation of the Regional Park.

Note: The plant is exhibiting extreme water stress and lack of flowers. Detectability of *Hibbertia* in this condition is very low.

The Bells Line of Road Castlereagh Connection Corridor (BLRCCC)

The vegetation within the road corridor can be generalised to consist of PCTs 725 and 724 interspersed with areas of Scribbly Gum Woodland on lateritised clays in the western portion and with PCT 849 more apparent in the eastern sector. Minor and major drainage lines interrupt the generalised vegetation pattern and were noted to be often degraded by urban runoff and weed invasion, at least within and immediately adjacent to the road corridor.

Areas of PCT 1800 - Swamp Oak were noted in the eastern sector. PCT 835 Forest Red Gum - Rough-barked Apple grassy woodland and PCT 1067 Parramatta Red Gum woodland are mapped on the Spatial viewer in the vegetation 100km consolidated layer as occurring adjoining and to the north of the corridor. However, presence or absence of these PCT was not confirmed, as inspection was confined to the road corridor in these locales due to time constraints.

Photo 31: Northern verge of the Bells Line of Road Castlereagh Connection corridor.

Note: A deep trench separates the predominantly intact high-quality remnants from the urban impacted vegetation existing south of the trench adjacent to the cleared sections of the road corridor. The photo foreground has moderate potential habitat and is within the footprint and background has high potential, adjacent to and outside of the growth area boundary. The adjacent highly significant vegetation will be very prone to indirect impacts.

The presence of PCTs 725 and 724 in conjunction with Scribbly Gum Woodland provide potential suitable habitat for *Hibbertia puberula*. Within the growth area boundary, the potential of occurrence is rated as moderate due to disturbance factors.

Adjacent to the northern boundary (the road corridor), being the former Air Services Australia Site, the likelihood of occurrence is rated as moderate to high.

Photo 32: The former Air Services Australia site adjacent to the north of the growth area contains significant populations of *H. pedunculata* and other threatened taxa.

Photo 33: Areas of Scribbly Gum Woodland in the former Air Services Australia site provide likely potential habitat.

Note: Illegal access to the Air Services Australia site by trail bikes and cars has caused impact to vegetation and facilitated rubbish dumping.

The northern edge of the road corridor consists of predominantly intact high-quality remnant vegetation including the edge of the Scribbly Gum Woodland.

A large part of the road corridor is cleared and weed impacted including most of the ground flora which is intermittently slashed. *Eragrostis curvula* dominates much of the disturbed corridor environs.

The following photos show examples of clearing, weed invasion and rubbish dumping along the length of the corridor behind the houses and within the former Air Services Australia site. The photos highlight the significant indirect impacts acting upon remnant vegetation in the region.

Hibbertia puberula is highly unlikely to survive within areas of nutrified mown exotic grasses, dense swathes of *Eragrostis curvula* and thick piles of garden refuse.

Photo 34: Stark contrast in vegetation condition.

Left is highly degraded. Right is intact high quality PCT 725 in part protected from urban runoff and unauthorised access and rubbish/garden refuse dumping by a trench acting as a physical barrier.

Photo 35: Significant species *H. pedunculata* still apparent within disturbance zones.

Photo 36: Anthropogenic impacts along the corridor.

Note: Top left rubbish dumping on verge of high-quality habitat, top right clearing for fire break, mid left acute weed invasion from garden refuse dumping: Mother of Millions, Wandering Jew and *Eragrostis curvula*, mid right commercial scale refuse dumping, bottom left garden refuse dumping facilitating the invasion of *Eragrostis curvula*, bottom right chronic weed invasion and clearing for fire break.

Photo 37: Unsuitable habitat for the *H. puberula* group.

Left, looking westward from the electricity easement to disturbed PCT 849. Right, looking eastward across a highly disturbed electricity easement chronically infested with exotic pasture.

Photo 38: Unsuitable habitat for the *H. puberula* group.

Left, highly disturbed PCT 849, the ground layer dominated by *Eragrostis curvula*. Right, farmland.

The electricity easement in the eastern sector of the road corridor is unlikely habitat, it is the wrong PCT for the species and is highly degraded due to past rural uses, urban runoff and subsequent weed invasion.

Ropes Creek Vicinity

A number of areas were targeted for survey along the Ropes Creek corridor, these were

- Whalan Reserve
- Tregear Reserve
- South of Whalan Reserve
- East of and to the south of St Marys Rugby League Club, Boronia Road North St Marys
- Electricity Substation vicinity Kurrajong Road and Boronia Road, North St Marys, and
- Shephard Street Vicinity, Colyton.

The potential habitat sites in the Ropes Creek vicinity were selected based on the PCT mapping, aerial imagery and the following BioNet records:

Grevillea parviflora: 28/01/2015, Ropes Creek, Mt Druitt includes Whalan Reserve and Tregear Reserves, -33.77797 150.80575.

Dillwynia tenuifolia: near corner Roper Rd & Carlisle Ave, Colyton, -33.78435, 150.80540, Ropes Creek, Mt Druitt includes Whalan Reserve and Tregear Reserves -33.78544, 150.80727

Eucalyptus parramattensis subsp. *parramattensis*: Roper Road, St. Marys, -33.78435, 150.80540

Hibbertia pedunculata: Between power station and railway line near Boronia Park, St Marys

Grevillea juniperina: M4 Motorway, Ropes Creek includes Whalan Reserve and Tregear Reserves and near corner Roper Rd & Carlisle Ave, Colyton.

Grevillea parviflora and *Eucalyptus parramattensis* subsp. *parramattensis* are known co-occurring species at Moorebank and at Voyager Point. *Dillwynia tenuifolia* is a known co-occurring species at Kemps Creek and at Ropes Crossing. These species indicate the possibility of potential suitable habitat present in the Ropes Creek vicinity.

The condition of the vegetation and population status of some of the BioNet records remain unknown.

Both *Grevillea parviflora* and *Eucalyptus parramattensis* subsp. *parramattensis* were not located by this survey effort and the GPS points do not align with the descriptors.

Much of the Ropes Creek vicinity was found to be severely impacted by weed invasion displacing most native species in many of the likely habitat areas.

Further details of the habitat at these sites follows.

Whalan Reserve

Whalan Reserve is primarily developed as a recreational facility including sporting fields, BMX bike jumps, Whalan Model Car Club track, walkway / cycleway and exercise equipment.

West of the path remnant river-flat forest and supplementary plantings were observed.

In the area surveyed the canopy / subcanopy was variously comprised of *Eucalyptus tereticornis*, *Angophora floribunda*, *Casuarina glauca, Acacia decurrens, A. parramattensis* and *Melaleuca decora*. A stand of Blue Box was noted west of the access road.

Photo 39: Whalan Reserve bushland west of the pathway.

The ground layer was impacted by weeds and dominated by *Eragrostis curvula* in many places. Despite this, numerous areas were observed to support a diverse array of indigenous species including: *Acacia falcata*, *A. elongata*, *Bursaria spinosa*, *Indigofera australis, Ozothamnus diosmifolius*, *Daviesia ulicifolia* var. *stenophylla*, *Tricoryne elatior*, *Phyllanthus virgatus*, *Opercularia diphylla*, *Cyanthillium cinereum*, *Cheilanthes sieberi*, *Glossogyne tannensis*, *Goodenia hederacea*, *G. bellidifolia*, *G. paniculata*, *Brunoniella australis*, *Chorizema parviflora*, *Chrysocephalum apiculatum*, *Centella asiatica*, *Glycine tabacina*, *Desmodium varians*, *Polymeria calycina*, *Zornia dyctiocarpa*, *Dianella longifolia*, *Lomandra longifolia*, *Microlaena stipoides*, *Themeda australis* and *Aristida* *vagans*. *Eucalyptus crebra*, *Melaleuca armillaris*, *Callistemon viminalis*, and *C. salignus* were noted in the plantings.

The riverflat community is atypical of *Hibbertia puberula* habitat as the higher nutrient status of the soils supporting typically a dense grassy /herbaceous layer is unsuitable habitat. However, the presence of minor alluvial terraces in combination with lateritised soil areas with relatively open ground layer provides habitat with low potential for the species to occur.

Photo 40: Weedy understorey and habitat plantings at Whalan Reserve.

Photo 41: Remnant vegetation at Whalan Reserve severely impacted by *Eragrostis curvula*.

Photo 42: Minor alluvial terrace, potential habitat for *H. puberula* in Whalan Reserve.

Tregear Reserve

Tregear Reserve is primarily a developed recreational reserve with sporting fields, walkways/ cycleway, exercise facilities and an off-leash dog compound.

Undeveloped portions remain west of the pathway and include riverine remnant vegetation and large areas of unmown exotic grassland / herbland that has predominantly displaced the indigenous vegetation. Habitat enhancement plantings were noted along the bushland verge.

Habitat for *Hibbertia puberula* may have once existed at the interface between the alluvial floodplain and the lateritised rise. The potential habitat is mostly too degraded to now support this species.

In the area surveyed the riparian vegetation was dominated by *Eucalyptus baueriana* with *Casuarina glauca*, *Acacia parramattensis*, *Melaleuca styphelioides*, *Bursaria spinosa* and the native grass *Microlaena stipoides* being relatively common.

Other indicative indigenous species noted included *Carex appressa*, *Scaevola albida*, *Dichondra repens*, *Centella asiatica* and *Alternanthera denticulata*.

The understorey in many locales is heavily weed impacted with species such as: *Eragrostis curvula*, *Chloris gayana*, *Setaria sphacelata*, *Verbena bonariensis*, *Rumex* sp. and *Tradescantia fluminensis*.

Enhancement plantings include: *Eucalyptus crebra*, *Casuarina glauca*, *Melaleuca styphelioides*, *M. decora*, *M. linariifolia* and *Bursaria spinosa*.

Photo 43: Looking across Tregear Reserve to the riparian zone of Ropes Creek

Photo 44: Treagar Reserve chronic weed infestation eliminating potential habitat for the species.

Although very limited in extent, a number of indigenous ground layer species were noted under the canopy of the enhancement plantings and to a lesser degree within the adjoining predominantly exotic weed meadow. Indigenous species noted include: *Wahlenbergia gracilis, W. communis, Centella asiatica, Tricoryne elatior, Microlaena stipoides, Cynodon dactylon, Phyllanthus virgatus*, *Rubus parviflorus*, *Glycine tabacina*, *Haloragis heterophylla* and *Glossogyne tannensis*.

Weed meadow adjoining plantings was dominated by *Eragrostis curvula, Hypochaeris radicata Plantago lanceolata*, *Melilotus albus* and *Paspalum dilatatum*.

The majority of the potential habitat was blanketed by dense weeds, primarily comprised of: *Eragrostis curvula*, *Cirsium vulgare*, *Verbena bonariensis*, *Melilotus albus*, *Foeniculum vulgare*, *Solanum sisymbriifolium*, *Bidens pilosa*, *Lactuca serriola*, *Plantago lanceolata*, *Chloris gayana*, *Nothoscordum gracile*, *Chenopodium album* and *Sorghum halepense*.

South of Whalan Reserve

The generalised geomorphology of the site is summarised by the intersection of the alluvial floodplain deposits of Ropes Creek with low lateritised rises. It is possible that such conditions once provided localised suitable habitat for *Hibbertia puberula*.

The potential habitat in this section of Ropes Creek is severely impacted by weed invasion and the potential for threatened species to now exist is negligible. A large area is being infilled with road ballast.

Photo 45: Eastern side of Ropes Creek south of Whalan Reserve.

Photo 46: *Eragrostis curvula* smothers potential habitat area of lateritised clay.

Photo 47: Only one small area of Themeda grassland was noted to remain.

Photo 48: Photos show dense growth of *Imperata cylindrica* (top left) and a variety of weeds eliminate potential habitat for the species.

Boronia Road, North St Marys

A diverse herbaceous layer was observed in recently burnt sections of the powerline easement at North St Mary's. Most locales including the adjacent wooded areas and including PCT 724 were heavily infested with dense *Eragrostis curvula* tussocks, and this was smothering the ground layer.

Flowering species noted in one burnt area included *Murdannia graminea*, *Tricoryne elatior*, *Hypoxis hygrometrica* var. *hygrometrica*, *Isotoma fluviatilis* and *Hibbertia diffusa*, as well as fertile *Ophioglossum lusitanicum.* All of these plants were non-discernible under the adjoining tree cover and within the dense *Eragrostis* tussocks.

No *Hibbertia puberula* or *H. pedunculata* plants were observed in this locale though the survey was very limited in its extent and duration.

Photo 49: North St Marys electricity easement environs.

Photo 50: East of and to the south of Boronia Road North St Marys.

Electricity Substation vicinity Kurrajong Road and Boronia Road, North St Marys

The potential habitat areas in the vicinity of Kurrajong and Boronia Road intersections occur on slightly higher ground outside the influence of nutrified stormwater discharges and overflows from Ropes Creek.

A small highly disturbed remnant exists between the substation and the western rail line supporting a population of *Hibbertia pedunculata* estimated +/- > 50 plants.

Planted/escaped *Eucalyptus maculata*, *E. sideroxylon*, *Melaleuca armillaris*, *Callistemon salignus*, *Leptospermum petersonii*, *Melaleuca hypericifolia* and *Casuarina glauca* were common in the tree and shrub layer adjoining the substation facility.

Indigenous species noted include *Eucalyptus moluccana*, *E. tereticornis*, *Daviesia ulicifolia* subsp. *stenophylla*, *Hibbertia pedunculata, Dillwynia tenuifolia*, *Acacia decurrens*, *A. elongata*, *Ozothamnus diosmifolius*, *Pimelea linifolia*, *Leptospermum trinervium*, *Goodenia hederacea*, *Cheilanthes sieberi*, *Lepidosperma laterale*, *Microlaena stipoides* and *Entolasia stricta*.

Eragrostis curvula formed extensive swathes throughout the surrounding area including the mown perimeter of the substation.

Photo 51: An indigenous regrowth area between the substation and western railway line is potential habitat for *H. puberula*.

Photo 52: Indigenous and non-indigenous "native" vegetation form the remnant between substation and railway line.

Photo 53: *H. pedunculata* in the remnant between the substation and the railway line.

Potential habitat also exists to the east of the substation adjacent to a small stand of *Eucalyptus fibrosa* and *Melaleuca decora* within an electricity easement and extending toward the rail line. Significant numbers of *Hibbertia pedunculata* were noted in open areas.

Photo 54: Foreground, *H. pedunculata* within open areas of native grassland/herbland.

Note: Background shows dense swathes of *Eragrostis curvula* adjacent electricity substation.

Photo 55: Slashed native vegetation in the powerline easement, potential habitat for *H. puberula*.

Photo 56: Open areas of lateritised clay soil east of the substation and north of railway line west of Ropes Creek support *H. pedunculata* and provide potential habitat for *H. puberula*.

Shephard Street Vicinity, Colyton

Bushland Remnant Roper Road / Shephard Street / Western Motorway interchange.

A linear bushland remnant between Shephard Street and the Western Motorway was targeted for survey due to BioNet records for *Hibbertia pedunculata* and *Grevillea juniperina* at the site and mapping on the spatial viewer indicating the presence of PCT 724.

In consideration of its size the remnant is in good condition with the exception of the eastern extremity which has recently been further degraded by roadworks.

The understorey was noted to be impacted by drought (refer photos 60 and 61). Specimens of both *Hibbertia pedunculata* and *Grevillea juniperina* were observed but were drought impacted. A number of specimens of the *Grevillea* had senesced adjacent to the roadworks.

No *Hibbertia puberula* plants were observed at the time of survey undertaken between 11-12 am, after likely petal dehiscence. Due to the site conditions, detectability was rated as extremely low and as such the species could have easily been overlooked as the plants, if present, would have existed as tiny sprigs with a few leaves only. It is also possible that the species has retreated to the soil seed bank in response to drought.

The indigenous species noted at the site include: *Eucalyptus fibrosa*, *Melaleuca decora*, *M. nodosa*, *Allocasuarina littoralis*, *Pimelea linifolia*, *Kunzea ambigua*, *Acacia elongata*, *A. falcata*, *Callistemon pinifolius*, *Grevillea juniperina*, *Dillwynia tenuifolia*, *Hibbertia pedunculata*, *Exocarpos cupressiformis*, *Bursaria spinosa*, *Daviesia ulicifolia* subsp. *stenophylla*, *Lissanthe strigosa*, *Xanthorrhoea* sp., *Boronia polygalifolia*, *Phyllanthus hirtellus*, *Billardiera scandens*, *Goodenia hederacea*, *Cheilanthes sieberi*, *Lobelia purpurascens*, *Wahlenbergia gracilis*, *Dianella laevis*, *D. revoluta*, *Opercularia diphylla*, *Centella asiatica*, *Lomandra multiflorus*, *L. filiformis*, *Lepidosperma laterale*, *Entolasia stricta*, *E. marginata* and *Microlaena stipoides*.

Photo 57: Bushland remnant south of Shephard Street, adjacent the Western Motorway

Photo 58: *Eucalyptus fibrosa*, *Allocasuarina littoralis*, *Melaleuca decora* and *M. nodosa*.

Photo 59: Drought impacted *H. pedunculata*, the largest and only plant noted in flower.

Photo 60: Severe drought impacted understorey in western sector of the site

Photo 61: Severe drought impacted understorey in middle section of the site

Shephard Street Park environs, Colyton

The spatial viewer identifies the Shephard Street Park vicinity as PCT 724 thinned remnant, urban.

Shephard Park itself is devoid of indigenous understorey and is dominated by an upper canopy of *Melaleuca decora* and widely scattered *Eucalyptus* trees. The ground layer consists mainly of mown exotic grasses with scattered small areas of mixed native/exotic grasses and herbs. It is extremely unlikely to support a viable population of *Hibbertia puberula* due to past and current management.

Photo 62: Left and right, Shephard Park.

At the rear of Shephard Park, a linear band of remnant vegetation extends along the Western Motorway. A fire break separates the bushland from residential properties. Edge effects have and will continue to have a deleterious impact upon the vegetation.

Photo 63: Linear band of remnant vegetation along the Western Motorway near Shephard Park.

Photo 64: A small core area of weed free vegetation exists above the Motorway cutting.

South of Dunheved Circuit and north of Christie Street, St Marys

The area was included as it is mapped as PCT 725 and PCT 724 on the spatial viewer and recent records exist for *Grevillea juniperina*, *Dillwynia tenuifolia* and *Pultenaea parviflora* suggesting that sufficient habitat remains that may support *Hibbertia puberula*.

Photo 65: Dunheved Estate Reserve bushland remnant adjacent Dunheved Circuit

Photo 66: Bushland remnant north of Christie Street

Site inspection of the Dunheved Estate Reserve and surrounds observed transitional vegetation grading from PCT 725 in the eastern end to PCT 724 westward. The soil was clay with laterite nodules. The remnant vegetation was confined to a narrow band on both sides of the disused railway cutting. Of the threatened species noted; *Grevillea juniperina* was observed to be widespread and common even colonising the former station platform. *Pultenaea parviflora* and *Dillwynia tenuifolia* were more localised but frequently observed.

Eucalyptus fibrosa was the dominant tree species eastward with *E. tereticornis, Angophora floribunda* and *E. moluccana* becoming more prevalent and dominating westward. A small stand of *E. baueriana* was noted within Dunheved Estate Reserve along with planted *Corymbia maculata* and *E. crebra* noted on the northern verge.

Indigenous species recorded include: *Allocasuarina littoralis, Melaleuca decora, M. nodosa, Acacia elongata, A. falcata, A. parramattensis, Daviesia ulicifolia* var. *stenophylla, Ozothamnus diosmifolius, Bursaria spinosa, Lissanthe strigosa, Astroloma humifusum, Phyllanthus hirtellus*, *Cyanthillium cinereum*, *Linum marginale*, *Caesia parviflora* var. *vittata*, *Goodenia hederacea*, *Phyllanthus virgatus*, *Dichondra repens*, *Glycine tabacina*, *Einadia nutans*, *E. polygonoides*, *Cheilanthes sieberi*, *Opercularia diphylla*, *Hibbertia diffusa*, *Brunoniella australis*, Vittadinia sp., *Dianella revoluta*, *D. longifolia*, *Themeda australis*, *Lepidosperma laterale*, *Lomandra multiflora*, *L. filiformis*, *Microlaena stipoides* and *Aristida vagans*.

Single specimens of both *Glochidion ferdinandi* and *Melia azedarach* were observed near the overpass. *Eragrostis curvula* is the dominant weed above the cutting. Sufficient site integrity remains to support diminutive species such as *Hibbertia puberula.*

Photo 67: Park at Dunheved Circuit, rail cutting on the right of picture.

Photo 68: Rail cutting with remnant bushland on steep banks.

Photo 69: Looking along rail cutting to footbridge, remnant bushland on banks.

Photo 70: *Grevillea juniperina*, *Pultenaea parviflora* and *Dillwynia tenuifolia* on the rail cutting embankment.

Photo 71: *Grevillea juniperina* colonising the abandoned railway platform.

Photo 72: Abandoned railway platform, remnant bushland both sides of cutting.

Claremont Meadows Bushland

The area was included for consideration as the Claremont Meadows bushland is identified on the spatial viewer as containing two vegetation communities, primarily as PCT 724 and with small areas of PCT 849 indicated.

Photo 73: Equestrian Circuit - Ridgetop Woodland *Eucalyptus moluccana*, *E. eugenioides*? and *E. fibrosa*

Photo 74: Equestrian Circuit - regrowth with understorey dominated by *Eragrostis curvula*.

Claremont Meadows bushland remnant contains small areas of ridgeline vegetation primarily in the Equestrian Circuit and Blackwood Street vicinities comprised of a varying combination of *Eucalyptus tereticornis*, *E. moluccana*, *E. eugenioides*? and *E. fibrosa*. The majority of the vegetation is found on the slopes and flats and is mainly comprised of *Eucalyptus tereticornis* and *E. moluccana* with a dense understorey of *Bursaria spinosa* present on the slopes.

All the ridgetop areas adjoin recent subdivisions and are impacted by past landuse practices with most of the understorey being cleared or significantly thinned. Some areas remain unvegetated, but most are now colonised by exotic grasses and herbaceous species.

Although PCT 724 may have potential as habitat for the *Hibbertia puberula* group in some circumstances, from current known habitat information it is thought that this is only the case where this community intergrades with PCT 725, and/or PCT 883 and/or PCT 1067.

Claremont Meadows bushland is assessed as unsuitable habitat for the *Hibbertia puberula* group.

Photo 75: Understorey is cleared or dense swathes of exotic grasses.

Photo 76: Much of the understorey in the Blackwood and Fowler Street vicinities is comprised of dense swathes of exotic grasses.

Apple Gum Reserve, Glenmore Park

Apple Gum Reserve in Glenmore Park is identified on the spatial viewer as containing two vegetation communities, PCT 1395 and PCT 849, with areas mapped as Urban native / exotic – noting planted native exotic.

Apple Gum Reserve is a highly modified urban park / linear bushland reserve. The majority of the indigenous flora is situated within and on the slopes of a +/- south – north gully line to the east of Lady Jamison Drive. PCT 1395 is mapped as occurring in the higher southern portion of the reserve and PCT 849 at the northern portion. Over 1/3 of the Reserve is mown exotic grassland with significant areas of mulched beds surrounding both remnant trees and plantings including all the vegetation mapped as PCT 1395.

Although PCT 1395 is known potential habitat for the *Hibbertia puberula* group no suitable habitat exists for *Hibbertia puberula* at this locale irrespective of the mapping accuracy.

Photo 77: Apple Gum Reserve at Glenmore Park from Lady Jamison Drive.

Note: photo taken from Lady Jamison Drive looking across to the intersection of Bursaria Drive and Honeysuckle Avenue from an area mapped as Urban exotic to PCT 1395 adjoining Bursaria Drive.

Photo 78: Google Earth image of area mapped as PCT 1395, mown and mulched at corner of Bursaria Crescent and Honeysuckle Avenue.

Photo 79: Google Earth image of area mapped as PCT 1395 mown and mulched at corner of Bursaria Crescent and Honeysuckle Avenue.

Photo 80: Google Earth image Corner of Bursaria and Acacia Avenues Mapped as PCT 1395 mown and mulched.

Photo 81: Google image looking across to linear bushland remnant bordering Lady Jamison Drive mapped as PCT 849.

Photo 82: Apple Gum Reserve at Glenmore Park remnant bushland.

Note: *Eucalyptus tereticornis*, *E. moluccana* and *Bursaria* dominated bushland remnant mapped as PCT 1395 is unsuitable habitat for the *Hibbertia puberula* group.

Photo 83: Photo of Apple Gum Reserve showing mown weeds of the bushland margin.

Photo 84: Photo of Apple Gum Reserve showing chronic weed infestation of the bushland margin.

Photo 85: Apple Gum Reerve at Glenmore Park bushland remnant.

Note: *Eucalyptus tereticornis*, *E. moluccana* and *Bursaria* dominated bushland remnant is unsuitable habitat for the *Hibbertia puberula* group. Mapped as PCT 1395.

Kemps Creek area, Lot 3 DP 812284, 90 Clifton Avenue Kemps Creek

Most of the block is cleared and is used for storage of materials and logged timber.

A narrow strip along the southern boundary supports native plants including 4 endangered species. More than 20 plants of *H. puberula* were found in this area during our survey on 9 November 2018. The majority of the *Hibbertia puberula* plants observed had shed their petals prior to start of the site inspection at 11am to 12.15pm. The species had not previously been recorded for the Kemps Creek vicinity.

The remaining species habitat has been excluded from the biodiversity certification footprint but remains threatened by vast mounds of mulch, fill and invasive weeds.

Photo 86: The remaining threatened species habitat at 90 Clifton Avenue Kemps Creek.

Note that the habitat exists only as a linear band adjacent to northern boundary of the adjoining block to the south.

The vegetation in the immediate vicinity has been variously described as PCT 883 by Eco Logical Australia (2013), Ecoplanning (2015) and the Vegetation 100km consolidated layer in the Spatial Viewer, and Shale Gravel Transition Forest by Envirotech (2013). It is identified on the spatial viewer as PCT 725 on Lots 1, 2 and 3 DP812248 and PCT 724 as occurring to the east and west.

The vegetation in the Kemps Creek area has been dramatically altered with clearing for agriculture and removal of trees for various uses such as fence posts and firewood. The precise abundance of the various *Eucalyptus* species through the area is difficult to ascertain. *Eucalyptus sclerophylla* is obviously a major component within limited areas with stands still occurring south of Elizabeth Drive adjacent to Bill Anderson Park and the Christadelphian Heritage College Sydney. Scribbly Gum also appears to have been a major component of the canopy within Lot 3 DP 812284 prior to clearance as documented within the Eco Logical 2013 report, refer photo 88.

Photo 87: Looking westward along the remaining threatened species habitat

Photo 88: Scribbly Gum was an obvious common component of the site (photo Eco Logical 2013).

It is likely that *Hibbertia puberula* was widespread in localised patches across the site prior to development. It was observed to be co-occurring with and often intertwined amongst the remaining

Dillwynia tenuifolia noted on site. Although there is discrepancy in numbers, both the Eco Logical 2013 and Ecoplanning 2015 reports indicate the *Dillwynia* to have been widespread across the site prior to clearing.

Photo 89: Habitat and location of *H. puberula* on Lot 3 DP 812284.

Photo 90: *H. puberula* co-occurring with *Dillwynia tenuifolia,* Lot 3 DP 812284

Photo 91: *H. puberula* petal dehiscence prior to 11.24 am.

Photo 92: *H. puberula* interwtinned amongst *Dillwynia tenuiifolia.*

Photo 93: Close up photo of *H. puberula,* one partial flower remains at 11.24am.

Photo 94: *H. puberula* showing petal dehiscence 11.24 am

Photo 95: *H. puberula* floral structure, petal dehiscence prior 11.22am 9/11/2018.

Lot 1 & 2 DP812284 Clifton Avenue, Kemps Creek in the Penrith local government area

Potential habitat is likely to occur within remnant vegetation located on Lots 1 and 2 DP812284 on Clifton Avenue.

No access was granted therefore site assessment was limited to "through the fence" observation made from the adjoining property (90 Clifton Road), spatial viewer information and literature review of the Envirotech 2013 assessment.

Several plants of *H. puberula* were observed by Jan Miller, Steve Douglas and confirmed by Robert Miller approximately 5-6 metres from the fence line. Although without petals, the plants were just discernible due to the coloration of the open calyxes. Therefore, the site is known habitat for the species. Other threatened species noted include *Dillwynia tenuifolia* and *Pultenaea parviflora.* The vegetation was assessed as potential suitable habitat for a range of other threatened taxa as it is contiguous to the known habitat on Lot 3 and a number of co-occurring species were noted. The vegetation of the general area has been variously described as PCT 883 by Eco Logical Australia (2013), Ecoplanning (2015) and the Vegetation 100km consolidated layer in the Spatial Viewer, and Shale Gravel Transition Forest by Envirotech (2013). It is identified on the spatial viewer as PCT 725 on Lots 1, 2 and 3 DP812284 and PCT 724 as occurring to the east and west.

Photo 96: Bushland on Lot 2 DP812284, photo taken through fence.

Note: Subtle variation in elevation and possible substrate consistency providing periodic damp conditions supporting range of species e.g. *Xanthorrhoea minor* and potential habitat for threatened plants such as *Grevillea parviflora* and *Hibbertia* species.

An environmental assessment on this block by Envirotech 2013 noted a relatively intact flora community and that there was a healthy seed bank evidenced by the regeneration of native vegetation in disturbed portions of the property. Envirotech considered the site to have high species diversity including "well-represented herbaceous, understory and canopy layers that were clearly identifiable". Weeds were confined to the perimeter of the property.

Photo 97: *Dillwynia tenuifolia* and habitat of the two observed *H. puberula* plants on Lot 2 DP812284.

Envirotech (2013) found no threatened fauna or individual flora species to be present on the site at the time of inspection. The habitat potential of the site for threatened species was considered to be relatively high. The Endangered Ecological Community Shale Gravel Transition Forest was detected on the site. The non-detection of threatened species is likely to be attributable to the survey being undertaken on 20 August 2013, outside the flowering period.

Lot 22 DP 60122, 1541A Elizabeth Drive Kemps Creek and Lot 2 DP 587135, 146B Clifton Avenue Kemps Creek

These two blocks in the Kemps Creek area are assessed as having a low to moderate probability of occurrence for *Hibbertia puberula*.

The majority of the understorey on Lot 2 DP 587135, 1468 Clifton Avenue could not be observed. It is included as potential habitat based on its continuity and close proximity to known habitat. The area is mapped as PCT 724 thinned on the spatial viewer.

Lot 22 DP60122 was assessed by ''through the fence'' inspection. The area is mapped as PCT 724 thinned on the spatial viewer. Much of the observable portions of the site are disturbed with weeds and fill dumping. Small areas were noted to contain an intact ground layer.

Photo 98: Lot 22 DP 60122, photo taken from Lot3 DP812284.

Note: small areas of regenerating native vegetation and intact ground layer occur within Lot 22 DP 60122. These provide potential habitat for threatened taxa.

Photo 99: View from south western corner of Lot 3 DP812284 into Lot 22 DP 60122.

Note: degradation of habitat by fill dumping and invasion of weeds, notably dense swathes of *Eragrostis curvula.*

Photo 100: Evidence of clearing, fill dumping and weed invasion degrading the habitat potential for threatened species Lot 22 DP 60122.

Lot 47 DP 734584 146 – 196 Clifton Avenue Kemps Creek

The block of land to the north of Lot 3 DP812284 is cleared and under investigation. It is most likely that this block supported populations of *H. puberula* prior to clearing. From the most recent 31/10/2018 Google Earth imagery no habitat now remains in Lot 47 (referPhoto 103). A narrow strip of low potential habitat remains roadside.

Photo 101: Street view Google earth November 2016 of block to the north of Lot 3 DP812284.

Photo 102: Street view Google earth November 2016 of block to the north of Lot 3 DP812284.

Photo 103: Location of Lot 47 DP 734584, Lot 3 DP812284, Lot 2 DP587135 and Lot 22 DP601022.

Bushland Remnants Lot 4 DP812284, 373 - 381 Clifton Road and Lot 6 DP812284, 316 Clifton Road, Kemps Creek

There are two blocks on the east side of Clifton Road that both have suitable habitat type although they are disturbed. These blocks have low to moderate probability for the species to occur.

The assessment was made from data shown in the Spatial Viewer from two BAM plots located on Lot 6. Species recorded include:

BIO WSAN 13: *Eucalyptus fibrosa* 15% coverage, *Eucalyptus globoidea* 1%, *Melaleuca decora* 2% and *Melaleuca nodosa* with a 15% coverage. Other species recorded each with a 1% coverage include: *Ozothamnus diosmifolius*, *Dillwynia sieberi*, *Dodonaea viscosa*, *Bursaria spinosa*, *Exocarpos* *cupressiformis*, *Aristida vagans*, *Lomandra gracilis*, *Daviesia ulicifolia*, *Dillwynia parvifolia*, *Pultenaea microphylla*, *Einadia hastata*, *Phyllanthus hirtellus*, *Pratia purpurascens*, *Eragrostis leptostachya*, *Entolasia stricta*, *Lepidosperma gunnii*, *Lepidosperma laterale*, *Cyathochaeta diandra*, *Lomandra longifolia*, and *L. multiflora*.

The only weed recorded in the BAM data is *Eragrostis curvula* with a 2% coverage.

BIO WSAN 14: *Eucalyptus globoidea* 30%, *Melaleuca decora* 2%, *Bursaria spinosa* 1% and *Cassinia uncata* 1% coverage. Ground layer species recorded cover 45% of the ground layer. They include: *Einadia hastata*, *Lomandra multiflora*, *Entolasia stricta*, *Eragrostis brownii*, *Dichelachne micrantha, Cynodon dactylon* and with *Microlaena stipoides* a 40% coverage.

Weeds in total had an 8% coverage, species recorded are: *Axonopus affinis*, *Sporobolus creber*, *Hypochaeris radicata*, *Sida rhombifolia*, *Eragrostis curvula* 1%, *Senecio madagascariensis*, and *Setaria parviflora*.

Photo 104: Google Earth image of Lot 6 DP812284 viewed from Clifton Road.

Remnant Vegetation North of Elizabeth Drive, Kemps Creek

The following Lots contain potential habitat for *Hibbertia puberula*: Lot 1 DP747285 1521 – 1539 Elizabeth Drive, Lot 1 DP1212980 1503 Elizabeth Drive, Lot 10 DP 1087346 1495 Elizabeth Drive Lot 16 DP2566 1491 Elizabeth Drive and Lot 1 DP 1o90754 1481-1489 Elizabeth Drive.

The two vegetation remnants north of Elizabeth Drive and south of Lot 1 & 2 DP812284 Clifton Avenue were assessed by ‘’over the fence’’ and ‘’drive-by’’ observation as access was not granted at the time of survey. Both sites were noted to have potential habitat from information contained within the spatial viewer, field observation revealed the small observable areas to be in poor condition and with low habitat suitability. Most of the vegetation was not able to be seen from the roadside.

The majority of the largest remnant Lot 1 DP716403 1521 – 1539 Elizabeth Drive was not visible from the road. It is a large block extending northward and adjoining Lot 1 & 2 DP812284 Clifton Avenue. There is no BAM Plot data available for this site. The spatial viewer maps two vegetation types PCT 1067 thinned and PCT 725 thinned providing potential likely habitat for the species. The remnant is bordered by a wholesale nursery in the west and a quarry to the east. Numerous site disturbances such as large areas of fill emplacement are observable on Google Earth Imagery providing evidence of degradation of habitat across much of the site.

The smaller remnant is bordered by the quarry on two sides and rural residential properties on Elizabeth Drive, consequently the impact of edge effects is likely to be high. Two BAM plots are located in this remnant and the Spatial viewer maps the site as PCT 725. The information provides some insight into the habitat.

BIO WSAN 9: *Angophora floribunda*, *Eucalyptus tereticornis*, *Melaleuca decora, Acacia decurrens*, *Ozothamnus diosmifolius*, *Bursaria spinosa*, *Dillwynia sieberi*, *Themeda triandra*, *Glycine tabacina*, *Einadia trigonos*, *Opercularia diphylla*, *Brunoniella australis*, *Centella asiatica*, *Pratia puberula*, *Polymeria calycina*, *Microlaena stipoides*, *Aristida vagans*, *Entolasia marginata*, *E. stricta*, *Paspalidium distans*, *Dichelachne crinita*, *Echinopogon caespitosus*, *Lomandra multiflora*, *Carex inversa*, *Dichondra repens*, *Lepidosperma laterale*, *Cynodon dactylon*, *Lomandra filiformis* and *Cheilanthes sieberi*.

Weeds recorded in the BAM Plot include: *Senecio madagascariensis*, *Ehrharta erecta*, *Asparagus asparagoides*, *Cirsium vulgaris*, *Pennisetum clandestina*, *Cuscuta campestris*, *Sida rhombifolia*, *Opuntia stricta*, *Plantago lanceolata*, *Tradescantia fluminensis* and *Hypochaeris radicata*.

BIO WSAN 10: *Angophora subvelutina* 15%, *Eucalyptus tereticornis* 5%, *Allocasuarina littoralis*, *Acacia decurrens*, *Ozothamnus diosmifolius*, *Acacia elongata*, *Cryptandra spinescens*, *Eragrostis brownii*, *Themeda australis*, *Glycine clandestina*, *Solanum prinophyllum*, *Hibbertia aspera*, *Microlaena stipoides* 50%, *Panicum simile*, *Eragrostis brownii*, *Cynodon dactylon*, *Lomandra multiflora*, *Juncus usitatus*, *Dichondra repens*, and *Lepidosperma laterale*.

Weeds recorded in the BAM Plot include: *Ligustrum lucidum*, *Verbena bonariensis*, *Setaria parviflora*, *Bidens pilosa*, *Sonchus oleraceus*, *Eragrostis curvula*, *Senecio madagascariensis*, *Cyperus eragrostis*, *Ehrharta erecta*, *Anagallis arvensis*, *Araujia sericifera*, *Passiflora subpeltata*, *Chloris gayana*, *Axonopus compressus*, *Conyza* sp., *Sida rhombifolia*, and *Asparagus asparagoides*.

The representativeness of the habitat information contained within the BAM plot data is unknown. It is also unknown whether or not localised habitat niches prevail within the broader vegetation type as observed at other locales at Kemps Creek. Accordingly, the presence of *Hibbertia puberula* could not be ruled out but the likelihood of occurrence was assessed as low.

Photo 105: Location of BAM plots BIO WSAN 9 and BIOWSAN 10.

Note: Labels show the location of Lot 1 DP716403, Lots 4 and 5 DP255566, Lot 1 DP1212980 and Lot 230 DP1134016.

SUEZ Kemps Creek Resource Recovery Park and Landfill, Elizabeth Drive, Kemps Creek

Remnant vegetation exists on the western margin of the Suez facility which is managed under the facilities' conditions of consent.

The vegetation is mapped as PCT 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats intact and PCT 849 - Grey Box - Forest Red Gum grassy woodland on flats - Scattered Trees on the spatial viewer.

Survey of this site was incorporated into the survey strategy to:

- confirm that the habitat was not suitable for the subject species,
- check habitat because suitable habitat is mapped as occurring proximally, and to
- facilitate over the fence inspection of adjoining properties mapped as containing the suitable habitat and where access was not granted.

Photo 106: Intergrading vegetation between PCT 849 and PCT835 between the Suez facility and Badgery's Creek.

Understorey species noted at the site included *Melaleuca decora*, *Bursaria spinosa*, *Einadia hastata*, and *Hibbertia aspera*, with a relatively dense grassy and herbaceous layer.

This is not suitable habitat for *Hibbertia puberula.*

Photo 107: Mown mixed native / exotic grassland/herbland at edge of the Suez western access road.

A diverse derived grassland herbland exists at the interface of the remnant vegetation on the SUEZ site. Weeping Meadow Grass (*Microlaena stipoides*) is the dominant grass with common herbaceous species such as *Brunoniella australis*, *Goodenia hederacea, Caesia parviflora, Cheilanthes sieberi, Commelina cyanea, Dichondra repens, Lomandra filiformis, Oxalis perennans, Lobelia purpurascens, Tricoryne simplex, Veronica plebeia,* and *Wahlenbergia gracilis* noted.

Lot DP860456 South of Suez, Elizabeth Drive, Kemps Creek.

Inspection of Lot DP860456 was not granted. The area has been excluded from the certification area due to pending investigations.

The determination of potential habitat occurring on Lot DP860456 was therefore based on the information contained within the spatial viewer and google earth imagery. Drive-by inspection was constrained by the high volume of trucks entering and exiting the site and the adjoining Suez approved facility. There is a moderate probability that the species occurred there, as the spatial viewer identifies the area to have contained both PCT 725 and 724. Lot 4 is now mostly cleared and under investigation, with high volumes of fill emplacement being observe adjacent Elizabeth Drive and the Suez facility 1.

Photo 108: Lot DP860456 viewed from Elizabeth Drive, Google Earth image taken prior to clearing.

Photo 109: Fill batter at northern end of Lot DP860456, South of Suez facility.

Note: This area is identified as not to be certified, area under Investigation. Photo taken through fence from the adjoining SUEZ facility.

Photo 110: Lot 4 DP860456 showing moist swale in the central portion of image prior to clearance and fill emplacement.

Photo 111. Google Earth Imagery 31/10/2018 Lot 4 DP860456 showing high volume of fill emplacement across most of the site. A small area remains providing some habitat potential.

Cross and Western Streets, Kemps Creek

This area of bushland between Cross Street, Western Street and Elizabeth Drive, and adjacent to the Bill Anderson Park, was included within the survey for this assessment as a surrogate site, as the presence of threatened taxa here is well documented and the site has previously been assessed by CFFIS in 2002 and NPWS *Dillwynia tenuifolia* survey CFFIS 2001.

This current survey revealed significant decline of the apparent population of all recorded threatened species. It is likely in most cases to be attributable to the fire regime in combination with drought. Areas were noted to be impacted by anthropogenic factors, mostly in association with illegal dumping of waste including asbestos and other rubbish requiring remediation. This has resulted in the bulldozing of tracks which facilitates the spread of invasive weed species through the displacement of weed seed infected soils and the infilling of minor habitat swales which previously supported *Grevillea parviflora*.

Despite the signage the area is poorly managed and is an example demonstrating that non-clearance is not protection without fencing and appropriately allocated management funds. The site requires selective management burns, but this should be avoided until the site is fully secured by barriers to exclude indiscriminate access by rubbish dumpers.

Photo 112: Bushland remnant at Cross Street Kemps Creek, adjacent to Bill Anderson Park.

Photo 113: Suppressed understorey under canopy at Cross Street bushland.

Photo 114: Cross Street bushland showing track bulldozed to remove dumped asbestos.

Photo 115: Disturbed bushland verge adjacent Bill Anderson Park.

Note scattered occurrences of *Dillwynia tenuifolia* and assorted indigenous grasses and forbs. The invasive *Eragrostis curvula* is common along the bushland margin and is a serious threat to the biodiversity of the remnant.

Photo 116: Chronic rubbish dumping in bushland on the verge, Western Street, Kemps Creek

Photo 117: Chronic rubbish dumping in bushland on the verge, Western Street, Kemps Creek

Jamisontown Vicinity, Huntington Reserve and fields in the area

During the course of the field survey many areas were traversed by car to the designated target survey locations. Targeted ‘drive-by’ assessments were selected on route to sample both identified PCTs and unidentified derived habitats in light of the high diversity of species located under the powerline easement adjacent to the Wianamatta Regional Park. An example of such an area is in the Jamisontown vicinity.

Review of Google Earth Imagery identified areas proposed for future urban development in the Jamisontown vicinity that appeared to have the prospects of derived native grassland habitat east of Tench Avenue and east and west of Blaikie Road. ‘Drive-by’ assessment revealed the area to be unsuitable habitat for *Hibbertia puberula* (refer photos 118 and 119). Dense swathes of exotic grasses and/or herbaceous species dominate the majority of the landscape. Some areas contain wetland and riparian values.

Photo 118: View from Tench Avenue looking east toward Blaikie Road.

Note: area appears to be dominated by a nutrified exotic grassland herbland, unsuitable habitat.

Photo 119: Fields in Tench and Blaikie Roads, Jamisontown.

Note: left photo looking south east toward Anakai Drive, dense swathes of exotic vegetation blanket the landscape. Right photo, exotic weeds dominate the area adjacent to the wetland habitat along School House Creek. Unsuitable habitat for *Hibbertia*.

4.5.2 DETERMINATION OF SPECIES POLYGONS

Based on the available vegetation mapping, site survey and knowledge of the species habitat requirements, the following maps show the polygons of likely habitat and the estimated probability for the species to occur.

Hibbertia puberula subsp. *puberula* was found to be present within the powerline easement, coloured yellow on map 11. This area is outside the footprint.

Areas shown in dark orange on Map 16 are in the proposed transport corridor through the Park, and in the proposed transport corridor to the north of Captain Cook Drive. There is moderate probability for the species to occur here. Areas of the regional park adjacent to the footprint and in the southeastern section also have moderate probability for the species.

In the eastern end of the northern corridor there are sections with low probability.

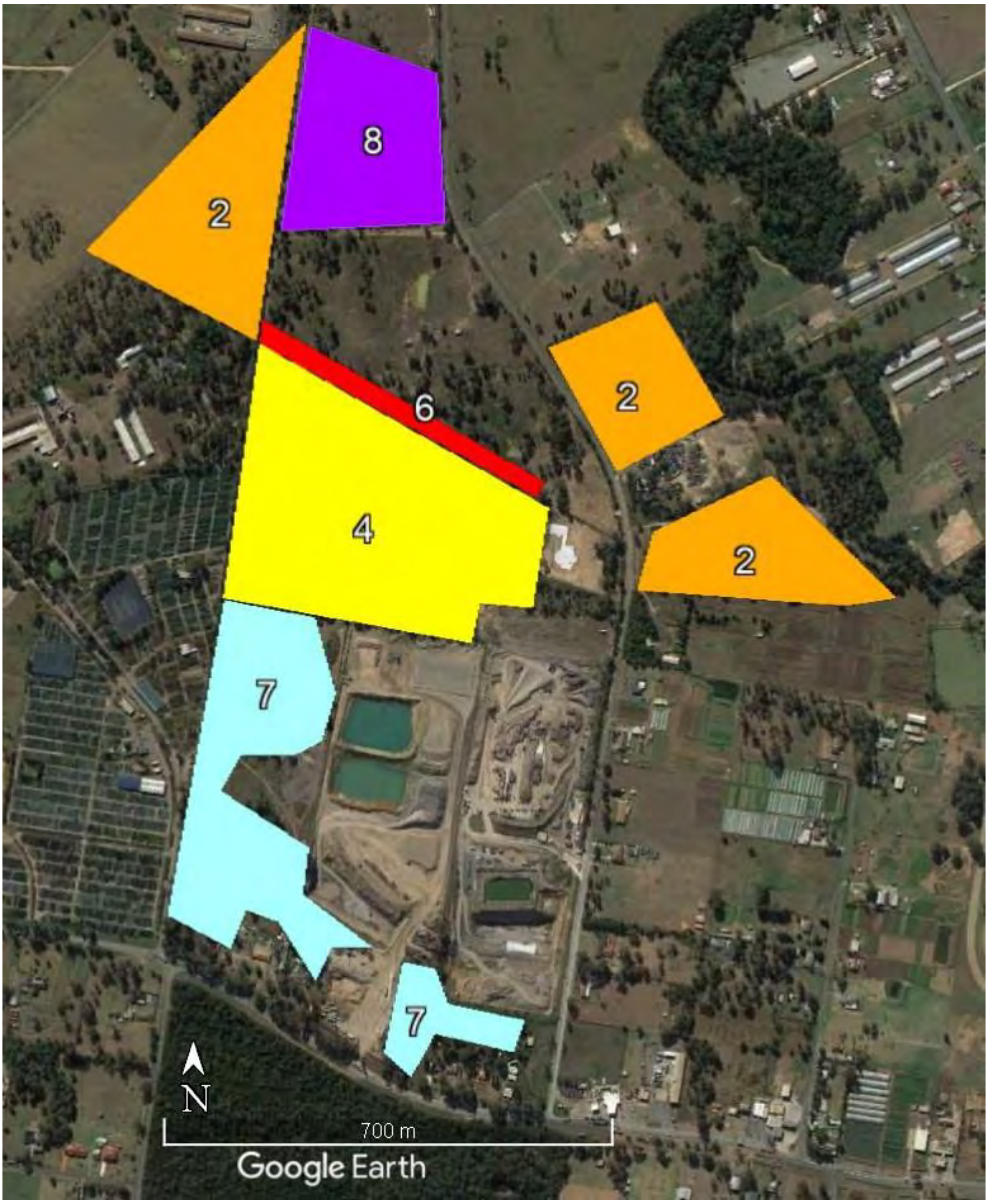
Map 16: Wianamatta Regional Park potential habitat sites.

Key:
In footprint, moderate probability for the species – dark orange - 1
Proximate to the footprint, moderate probability for the species – pale orange - 2
In the footprint, low probability for the species – olive green - 3
Proximate to the footprint, species known to be present – yellow - 4

Map 17: Ropes Creek area potential habitat sites.

Map 18: Shepherd Street Colyton vicinity potential habitat site.

Key: Areas are outside the footprint, low probability of occurrence - peach colour - 5



Map 19. Kemps Creek area potential habitat sites.

Key:

Removed from certification area, species known to be present – red - 6

Proximate to the footprint, species known to be present – yellow - 4

Proximate to the footprint, species moderate probability – pale orange - 2

Proximate to the footprint, species low probability – pale blue - 7

Proximate to the footprint, moderate probability prior to clearing – purple - 8

Map 20: Partially cleared block south of SUEZ landfill site.
Key: Adjacent footprint, moderate probability prior to clearing – purple - 8

4.5.3 ESTIMATE OF AREA OF HABITAT

Greater Penrith to Eastern Creek Urban Release Investigation Area

Wianamatta Regional Park and northern corridor

In footprint, moderate probability, 34 ha.

In footprint, low probability, 3.5 ha.

Proximate to the footprint, moderate probability, 77 ha.

Powerline easement adjacent Wianamatta Regional Park

Outside footprint, species is present, 4 ha.

Ropes Creek vicinity

Outside footprint, low probability, 10 ha.

Colyton vicinity

Outside footprint, low probability, 1.1 ha.

Western Sydney Aerotropolis Growth Area

Kemps Creek area

Removed from certification area, species is present, 1.47 ha

Proximate to the footprint, species is present, 14.4 ha

Proximate to the footprint, moderate potential, 15.6

Proximate to the footprint, low potential, 10.25 ha

Proximate to the footprint, moderate potential prior to clearing, 6.25 ha.

South of SUEZ landfill

Proximate to the footprint, moderate potential prior to clearing, 4.4 ha.

In summary, a total of 37.5 ha of potential habitat for the species lies within the transport corridor.

A further 20 ha where the species is known to be present, and 125 ha of potential habitat, are located within the growth area proximate to potential development and are therefore at risk of edge effects and anthropogenic impacts.

5. Information used in the assessment

Information used in this assessment includes taxonomic papers, BioNet and ALA records of the target species, Critically Endangered Listing, online Threatened Species profile and associated documents, personal observations and site inspections, and the spatial viewer including the layers: survey access and coverage, (BAM plots, polygons and transects), PGA layer and geology and soils.

6. References

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Eco Logical Australia, 2013. *Lot 3, No 90-145 Clifton Avenue Kemps Creek – Flora and Fauna Impact Assessment,* prepared for Sydney Metro Tree Services Pty. Ltd.

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Ecoplanning, 2015. *Flora and Fauna Assessment and Vegetation Management Plan – 90-145 Clifton Road Kemps Creek NSW,* prepared for TreeServe.

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NSW Department of Environment, Climate Change and Water, 2010. *Cumberland Plain Recovery Plan*, available at http://www.environment.nsw.gov.au/research-and-publications/publications-search/cumberland-plain-recovery-plan

Price, O. F., Horsey, B. & Jiang, N. (2016). Local and regional smoke impacts from prescribed fires. *Natural Hazards and Earth System Sciences*, 16 (10), 2247-2257, available at http://ro.uow.edu.au/cgi/viewcontent.cgi?article=5192&context=smhpapers

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Toelken, H. R. and Miller, R. T., 2012. Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in *Journal of Adelaide Botanic Gardens* 25 (2012) 71–96 and available at https://data.environment.sa.gov.au/Content/Publications/JABG25P071_Toelken.pdf

Toelken, H. R., 2013. Notes on *Hibbertia* subg. *Hemistemma* (Dilleniaceae) 9. The eastern Australian *H. vestita* group, including *H. pedunculata* and *H. serpyllifolia* Journal of the Adelaide Botanic Gardens 26 (2013) 31–69 and available at https://data.environment.sa.gov.au/Content/Publications/JABG26P031_Toelken.pdf

7. Appendices

Appendix 1. Curriculum Vitae

Robert Miller *Curriculum Vitae*

Contact Details:

Address	13 Park Road Bulli NSW 2516
Telephone	(02) 42 846768
	0410 244 865
Email	janrob02@gmail.com

Current Position:

Principal of Cumberland Flora & Fauna Interpretive Services

Qualifications:

Associate Diploma Horticulture from the University of Western Sydney (formerly Hawkesbury Agricultural College), conferred on 17 April 1982

Journal Articles

H.R. Toelken & R.T. Miller **2012** Notes on *Hibbertia* (Dilleniaceae) 8. Seven new species, a new combination and four new subspecies from subgen. *Hemistemma*, mainly from the central coast of New South Wales, in Journal of the Adelaide Botanic Gardens, Vol. 25.

Miller J and Miller R **2005** Aquatic macroinvertebrates of headwater streams in the south east forests – diversity and conservation management issues, Wetlands (Australia) 23 (1).

Employment Record

1993 - present

Cumberland Flora and Fauna Interpretive Services

Principal - flora surveys, plant identifications, vegetation assessment, project impact assessment, bush regeneration, rehabilitation, habitat enhancement, seed collection and propagation services.

1990 - 1997 **Sylvan Grove Native Gardens**

Curator of gardens and adjoining bushland - maintenance of and improvement to the plant collection, training and supervision of staff, liaison with other botanic gardens, guided tours, technical advice.

1982 - 1990 **Sylvan Grove Native Gardens**

Horticulturist Specialising in Australian Flora - collection, propagation, identification, and growing of native plants.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES INFORMATION AND RELEVANT EXPERIENCE

Cumberland Flora and Fauna Interpretive Services have provided technical expertise since 1993 to numerous clients including Local Government, NSW Roads and Maritime, NSW Office Environment Heritage NPWS and community groups. Following is a list of some of our projects and clients:

REPORT	CLIENT
Expert advice for Conservation Assessment of *Solanum celatum* Eren Delgado 16/04/2018, Science Division, NSW Office of Environment and Heritage	OEH
Saving our Species (SoS) project for *Pomaderris adnata* a post fire population census Grid D 2018	OEH
Provision of expert advice to update the current ecological data for southern NSW threatened flora species, as part of the review of biodiversity assessments under the Biodiversity Conservation Act 2016.	OEH

REPORT	**CLIENT**
Expert witness in botany Residents Against Intermodal Development Moorebank Incorporated v NSW Minister for Planning and Anor – NSW Land & Environment Court Class 1 Proceedings No. 2017/81889. Review of project documentation, in particular the various biodiversity assessments including the BAM assessment for the project and Individual Expert Witness report of Dr David Robertson 15 October 2017; Site inspections to identify the location of and/or potential habitat for *Hibbertia fumana*, *Hibbertia puberula*, *Grevillea parviflora*, *Persoonia nutans*, *Acacia bynoeana*, provision of an expert report in accordance with Division 2 of Part 31 of the UCPR; confer with the other parties experts at a joint conference and produce a joint expert report; and f appear at the section 34 conciliation conference	EDO
Saving our Species (SoS) project for *Pomaderris adnata* a population census 2017	OEH
Central Coast Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Great Lakes Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2016 – Vegetation Consultant	OEH
Northern Beaches Creek Monitoring Evaluating and Reporting 2015 – Vegetation Consultant	OEH
Clarence Colliery Discharge Investigation April 2015	OEH
Vegetation Assessment as part of the Lachlan Wetlands Condition Assessment Project October 2013 – May 2014	Lachlan Catchment Management Authority
Field expertise and guidance in the Sydney basin to PhD candidate Karen Muscat studying the molecular phylogenetics and morphology of the genus Dianella with close scrutiny of the variation in the D. *caerulea* group of species in eastern Australia	Volunteer to University of Melbourne
Survey for *Pomaderris adnata* to determine population size, structure, occupancy and threats 2014	NPWS Illawarra Region
Survey of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats. Collection of voucher herbarium material for taxonomic review June 2014	OEH
Survey of the southern populations of *Hibbertia stricta* subsp. *furcatula* (Hibbertia species ‘Menai’) to determine population size, structure, occupancy and threats May 2014	OEH
Investigation of works within the Sublime point precinct Illawarra Escarpment State Conservation Area February 2014.	NPWS Illawarra Region
Identification of Hibbertia species in proposed control burn sites Victoria Road precinct Dharawal National Park.	NPWS Illawarra Region
Assessment of impact of infrastructure upgrade Victoria Road, Dharawal National Park – location of threatened species.	NPWS Illawarra Region
APPEAL IN RESPECT OF PROPERTY AT Lot 1 and 2 DP 224431 Site 2 Sturdee Avenue, Bulli	Roy ‘Dootch’ Kennedy

REPORT	CLIENT
Expert Witness Report Relating to Some Environmental Issues Land & Environment Court of New South Wales PROCEEDINGS NO 10982 of 2012	Roy 'Dootch' Kennedy
Field surveys, collection, pressing, curation of botanical specimens and contributions of notes in association with the manuscript "Notes on Hibbertia subgen. Hemistemma (Dilleniaceae) 7. Eight new species, a new combination and four new subspecies from mainly central New South Wales H.R. Toelken & R.T. Miller 2006 - 10 July 2012	Volunteer to Adelaide Botanic Gardens
Vegetation Surveys and assessments & input into the preparation of REF for proposed car-park and amenities Victoria Road Precinct Dharawal National Park November 12.	NPWS Illawarra Region
Office of Environment and Heritage – Priority Action Statement Expert Consultant Interviews June 2012 – January 2013	OEH
Vegetation Surveys and assessments & input into the preparation of REF for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking track re-alignment Maddens Falls in Dharawal National Park 2011 – 12.	NPWS Illawarra Region
Vegetation Surveys and assessments for proposed walking tracks in Dharawal National Park input into conservation risk assessments 2011 – 12.	NPWS Illawarra Region
Nomination to list Prostanthera saxicola R. Br. S. Str. as an Endangered Species under the NSW TSC Act September 2011	
Field surveys, collection, pressing and curation of botanical specimens of undescribed Kunzea to assist in the taxonomic circumscription of previously presumed extinct, rare and/or poorly known taxa for Dr. H.R. Toelken Honorary Research Associate State Herbarium Science Resource Centre Department of Environment and Natural Resources SA 2011	Volunteer to Adelaide Botanic Gardens
Significant Plant Survey – Maddens Plains Forest Path to Mount Mitchell Precinct IIllawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Significant Plant Survey – Wongawillii Precinct Illawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Significant Plant Survey – Kembla State Forest Precinct Illawarra Escarpment State Conservation Area Cumberland Flora & Fauna Interpretive Services June 2011	NPWS Illawarra Region
Site Inspections and Vegetation Survey of Proposed Minor Track Re-Alignments: Forest Path to Woodward Track & Sublime Point to Austinmer Track Maddens Plains To Sublime Point Precinct Illawarra Escarpment State Conservation Area August 2010	NPWS Illawarra Region

REPORT	CLIENT
Sandon Point Aboriginal Place and Kuradji Lands Vegetation Management Plan April 2010	Illawarra Aboriginal Land Council, Wollongong Council, Southern Rivers Catchment Management Authority.
Forest Path to Woodward Track Precinct Track-head Realignment Maddens Plains IESCA Vegetation Survey April 2010.	NPWS Illawarra Region
Bushland Conservation Project 95 Glendiver Road, The Oaks 2008	A & S Fitzsimmons / Hawkesbury Nepean Catchment Management Authority
Significant Plant Survey – Maddens Plains Forest Path to Woodward Track Precinct Illawarra Escarpment State Conservation Area June 2007	NPWS Illawarra Region
Nomination of Hibbertia "Bankstown Airport" (R.T. Miller & C.P. Gibson s.n. 18/10/2006) as Critically Endangered under the Environment Protection and Biodiversity Conservation Act	Bankstown Bushland Society
Proposal to Demolish A Derelict Amenities Block at Deepwater Park Webster Street Milperra Environmental Assessment of Impacts	Bankstown City Council
Significant Plant Survey – Sublime Point to Panorama House Precinct Illawarra Escarpment Conservation Area August – September 2006	NPWS Illawarra Region
A Consultant for Priority Action Statement Workshop July 2005	NPWS
PHD research assistance – 'The Benefits of Riparian Vegetation in Maintaining Water Quality as Assessed Using Biological Indicators".	UNSW
Plan of Management for Part Lot 11 DP 1049307 Kurrajong Road Prestons January 2005	Sule College
Preliminary Investigation & Vegetation Survey of Lands At Prestons Bounded By Maxwells Creek, Kurrajong Road, Ash Road & The Western Sydney Orbital December 2003	Sule College
Supply and collection of seed for a research project entitled: Factors Affecting Seed Germination and Mycorrhizal Development of the Epacrid: *Woollsia pungens* (2001-2003)	UNSW
Compensatory Habitat Assessment Western Sydney Orbital March 2004	RTA
Compensatory Habitat Assessment Western Sydney Orbital July 2002	RTA
Compensatory Habitat Assessment of Flora at Rouse Hill, Doonside, Cecil Hills & Kemps Creek for The Western Sydney Orbital March 2002	RTA
Compensatory Habitat Assessment Western Sydney Orbital November 2001	RTA
Preliminary Vegetation Survey Between Lawson Rd & Alfords Point Rd, Menai as Part of The Proposed Bangor Bypass 2001	RTA
8-Part Tests for The Proposed Bangor Bypass 2000	RTA
Preliminary Vegetation Survey for The Proposed Bangor Bypass 2000	RTA
Species Impact Statement for the Western Sydney Orbital 2000	Sinclair Knight Mertz

REPORT	**CLIENT**
Review of Environmental Assessments – Proposed Cricket Ground - Louisa Reserve, The Crest of Bankstown 2000	Bankstown Bushland Society
Review of Environmental Assessments – Proposed Olympic Criterium Circuit the Crest Statement of Environmental Effects	Bankstown Bushland Society
Vegetation Survey – 60 Yanderra Road, Yanderra 1999	Mr. Brian Timmis
Review and Comments on Environmental Assessment – Bankstown City Council - Proposed Cricket Ground – 8 – Part Test- The Crest 1999	Bankstown Bushland Society
Vegetation Survey and Review of Proposed Sand Mining Restoration Works – Howard Park, Lansvale 1999	Chipping Norton Lakes Authority
Rare Species Survey – Blue Mountains & Central Western Slopes 1999	National Parks & Wildlife Service
Vegetation Survey - Kookaburra Road and Camden Valley Way Intersection 1999	Roads & Traffic Authority
Chullora Detention Basin Wetlands Habitat Enhancement 1998	Business Land Group DUAP
Vegetation Study Maxwells Creek Trunk Drainage Stage 1 Vegetation Assessment 1998	Bewsher Consulting
Vegetation Study Prestons Urban Release Area Part 3 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 2 1998	Liverpool City Council
Vegetation Study Prestons Industrial Release Area Part 1 1998	Liverpool City Council
Survey of Remnant Flora for Proposed Nth Liverpool Rd to Edensor Rd Interim Transitway 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management 1998	Roads & Traffic Authority
Beverly Grove Bushland Plan of Management Discussion Paper 1998	Roads & Traffic Authority
Eastern and Western Alignments WSO Cecil Hills Flora Study 1998	Roads & Traffic Authority
Valmay Road Development Vegetation Study 1998	LesryK Pty Ltd
Western Sydney Orbital Prestons To West Baulkham Hills Descriptive Inventory of Remnant Bushland 1998	Roads & Traffic Authority
Vegetation Survey River Road M5 East 1998	Roads & Traffic Authority
Tree Survey, Great Western Highway, Faulconbridge 1998	Roads & Traffic Authority
Eve & Marsh Street Wetlands M5 East 1997	Roads & Traffic Authority
Beverley Grove Bush M5 East 1997	Roads & Traffic Authority
Vegetation Survey - Salt Pan Creek Bridge Duplication M5 East 1997	Roads & Traffic Authority

REPORT	CLIENT
Survey of Flora: Trees and Shrubs, Princes Highway Interchange M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Adjacent to Proposed Exhaust Stack Henderson Avenue, M5 East 1997	Roads & Traffic Authority
Survey of Remnant Vegetation Illoura Reserve, Adjacent to Air Intake Vent M5 East 1997	Roads & Traffic Authority
Lansdowne Reserve Survey of Remnant Flora 1997	Bankstown City Council
Villawood Drain Vertebrate Fauna Survey 1997	Bankstown City Council
Kelso Wetlands Survey of Remnant Flora 1997	Bankstown City Council
Deverall Park Survey of Remnant Flora 1997	Bankstown City Council
Louisa & McClean Reserves Bass Hill Survey of Remnant Flora 1997	Bankstown City Council
The Crest of Bankstown Survey of Remnant Flora 1997	Bankstown City Council
Lawson Bridge Roadworks Survey of Remnant Flora 1997	Roads & Traffic Authority
Davidson Street Scrub Survey of Remnant Flora 1997	Strathfield Council
Freshwater Creek Bushland Survey of Remnant Flora 1996	Bankstown Bushland Society for the EPA
Vegetation Survey Forest Lawn Cemetery Roadworks, Leppington 1996	Roads & Traffic Authority
Vegetation Survey Catherine Fields Road Intersection, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Springfields Road Intersection and Camden Valley Way, Catherine Field 1996	Roads & Traffic Authority
Vegetation Survey Deepfields Road Intersection Camden Valley Way, Catherine Fields 1996	Roads & Traffic Authority
Picnic Point Reserve Vegetation Survey 1996	Bankstown City Council
East Hills Park Vegetation Survey 1996	Bankstown City Council
Monash Reserve Vegetation Survey 1995	Bankstown City Council
Vegetation Consultant on Plan of Management for Cox's Creek for the Endangered Green and Gold Bell Frog 1995	Urban Bushland Management
Smith Park Vegetation Survey 1995	Bankstown City Council
Flora and Fauna Survey, Villawood Stormwater Channel 1995	Bankstown City Council
Virginius Reserve Vegetation Survey 1994	Bankstown City Council
Carysfield Park Vegetation Survey 1993	Bankstown City Council

Ongoing research projects:

Private taxonomic research into the Australian plant genera *Prostanthera*, *Westringia*, *Dianella*, *Thelionema*, *Viola* and *Hibbertia*.

Private research into the invertebrate fauna of the Illawarra with particular emphasis on the Mayfly genus *Atalophlebia*

Flora of Bankstown" a botanical inventory

Botanical inventories of the Sublime Point and Maddens Plains precincts in the Illawarra Escarpment State Conservation Area

Other Publications & Reports

Miller, R.T. (1984 to 2006) numerous papers for the Prostanthera and Westringia Study Group Newsletters.

Miller, R.T. (1991) Vegetation Consultant on Eloura Nature Reserve Vegetation Survey: Report to Liverpool City Council, Greening Australia.

Miller, R.T. Vegetation Consultant on Salt Pan Creek Stage 1 Vegetation Survey: Report to Bankstown City Council, Ian Olsen.

Gibson, C.P. & Miller, R.T. Plant Species List for Bankstown's Natural Heritage: McLaughlin, L., BCC.

Gibson, C.P. & Miller, R.T. Flora of Bankstown Scientific Inventory of Botanical Heritage: Report to Australian National Parks and Wildlife Service, Gibson, C.P. and Miller, R.T. (in preparation).

Nomination of *Prostanthera saxicola* R. Br. s. str. As an Endangered Species under the NSW TSC Act November 2011

Special Projects

- "Flora of Bankstown" a botanical inventory
- Founder & Convener Cookson's Landcare Group Bulli (2003 – 2007)
- President, Society for Growing Australian Plants, East Hills Region, 1987-1995.

- Vice President, Society for Growing Australian Plants, East Hills Region, 1996.
- Plant Steward, Society for Growing Australian Plants, East Hills Region, 1987-1996.
- Leader of the Prostanthera Study Group Australian Plant Society, 1992 - 2010.
- Editor and publisher of Prostanthera & Westringia Study Group's Newsletter *The National Mint* and the Study Groups' Journal – *Lasianthos*.
- Vice President and Founding Member, Bankstown Bushland Society.
- Coordinator Grants Application, Bankstown Bushland Society.
- Bushland Regeneration Grants Project Manager, Bankstown Bushland Society:

- Deverall Park Restoration and Rehabilitation Swamp Woodland ($17,880).
- The Crest of Bankstown Restoration and Rehabilitation ($27,850).
- Airport and Ashford Reserves Restoration and Rehabilitation Swamp Woodland ($45,000).

- Co-recipient of Save the Bush grant for Flora of Bankstown by Hon. Ross Kelly, Minister for Arts, Sports and Environment, 1992-93 ($11,050).
- Founding Member of Illawarra Grevillea Park, Bulli.
- Curator, Lamiaceae collection, Illawarra Grevillea Park, Bulli.
- Former Bankstown City Council's Bushfire Taskforce Community Representative.
- Former presenter of an adult education course in gardening at Bankstown Evening College.
- Development and curation of a private regional herbarium.
- Expert Witness for NSW Police murder trial
- Former appointee as Trustee of the Georges River State Recreational Trust by the Minister for the Environment (the Hon. Tim Moore).

Appendix 2. *Hibbertia puberula* subs. *puberula* collection records 2018

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 28/10/2018 **COLLECTING No.**

LOCALITY: -33.681349 150.715089 Opposite the intersection of Smeeton, Taylor and Nutt Roads in bushland Londonderry NSW 2753. North of Fire Trail

HABITAT: PCT No: 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion Castlereagh Scribbly Gum Woodland

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: Localised in heath patch of *Banksia spinulosa*, *Grevillea mucronulata*, *Philotheca salsolifolia*, *Acacia bynoeana*, *Patersonia sericea*, *Cyathochaeta diandra* etc., within *Eucalyptus sclerophylla Angophora bakeri* Woodland

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 28/10/2018 **COLLECTING No.**

LOCALITY: -33.681753 150.716233 Bushland verge Southern Corner Smeeton, Taylor and Nutt Roads bushland Londonderry NSW 2753

HABITAT: PCT No: 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion Castlereagh Scribbly Gum Woodland

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: Disturbed road verge / bushland from recent road works with weedy fill dumping

2 plants noted – population size unknown

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller, Jan Miller & Stephanie Clark

DATE: 1/11/2018 **COLLECTING No.**

LOCALITY: Castlereagh Nature Reserve Powerline Trail vicinity. Opposite the intersection of The Northern Road and Whitegates Road, Berkshire Park. South of North Trail along unnamed track.

-33.671177 150.753032 -33.672284 150.75167 -33.671676 150.75272

HABITAT: Mapped PCT No: 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion Castlereagh Scribbly Gum Woodland

Associated species: *Eucalyptus sclerophylla, Corymbia gummifera*, *Eucalyptus sideroxylon*, *Allocasuarina littoralis*, *Kunzea ambigua*, *Hakea sericea*, *Bossiaea rhombifolia, Micromyrtus minutiflora, Dillwynia tenuifolia*, *Petrophile* sp., *Brachyloma daphnoides*, *Dillwynia tenuifolia*, *Styphelia laeta*, *Dianella revoluta*, *Patersonia sericea*, *Goodenia hederacea*, *Entolasia stricta* etc.

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: Disturbed bushland from historic laterite extraction – extensive laterite deposits observed in the general vicinity

30 plants noted

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller, Jan Miller & Stephanie Clark

DATE: 1/11/2018 **COLLECTING No.**

LOCALITY: Castlereagh Nature Reserve west of the Powerline Trail. Opposite the Northern Wreckers Northern Road Berkshire Park.

-33.680743 150.745126 -33.67895 150.746758 -33.679531 150.745583

HABITAT: Mapped PCT No: 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion Castlereagh Scribbly Gum Woodland

Associated species: *Eucalyptus sclerophylla, Eucalyptus parramattensis*, *Banksia spinulosa*, *Hakea laevipes*, *Callistemon pinifolius*, *Daviesia squarrosa*, *Micromyrtus minutiflora,* forbs and sedges.

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: A few nonflowering plants noted.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 28/10/2018 **COLLECTING No.**

LOCALITY: -33.642716 150.690815 West trail, Agnes Banks Nature Reserve

HABITAT: Open heathy patch in +/- transition vegetation between

PCT 958 Narrow-leaved Apple - Hard-leaved Scribbly Gum heathy woodland on sand at Agnes Banks, Sydney Basin Bioregion

PCT 1067 Parramatta Red Gum woodland on moist alluvium of the Cumberland Plain, Sydney Basin Bioregion

PCT 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: A few nonflowering plants noted.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 1/11/2018 **COLLECTING No.**

LOCALITY: In bushland – In the vicinity of the track. Entrance south of and near the intersection of Spence and Judd Roads, to the west of Government Road Berkshire Park

-33.687696 150.778284 -33.687557 150.778307 -33.687313 150.777579 -33.687223 150.777563

HABITAT: Open heathy patch in +/- transition vegetation between

Mapped as PCT 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion

Associated species: *Eucalyptus sclerophylla*, *E. parramattensis*, *Angophora bakeri*, *Hakea laevipes*, *Leptospermum trinervium*, *Banksia oblongifolia*, *B. spinulosa*, *Melaleuca nodosa*, *M. thymifolia*, *Grevillea mucronulata*, *Acacia lunata*, *Kunzea capitata*, *Pimelea linifolia*, Cryptandra sp., *Dianella revoluta*, *Patersonia sericea*, *Xanthorrhoea minor*?, *Cyathochaeta diandra*, *Lomandra multiflora*, etc.

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: 10 plants noted at one locale and 7 elsewhere. Mostly nonflowering with petal dehiscence by 9.16 (temp 32) and completed by 9.30 am.

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 29/10/2018 **COLLECTING No.**

LOCALITY: -33.733452 150.794676 East of Wianamatta Regional Park, in powerline easement. South of the Corner of Forrester and Palmyra Roads under powerlines

HABITAT: Derived shrubland/grassland /herbland – unmapped significant vegetation with many threatened species adjoining open forest. Mapped as PCT 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion.

Associated species: *Leptospermum parvifolium*, *Melaleuca nodosa*, *Grevillea mucronulata*, *Pimelea linifolia*, *Micromyrtus minutiflora*, *Dillwynia tenuifolia*, *Pultenaea parviflora*, *Hibbertia pedunculata*, *H. diffusa*, *Brachyloma daphnoides*, *Dodonaea falcata*, *Dianella revoluta*, *Lomandra multiflora*, etc.

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: 10 plants noted at one locale. Mostly nonflowering with petal dehiscence already commenced 10.15 am

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller & Jan Miller

DATE: 31/10/2018 **COLLECTING No.**

LOCALITY: -33.733543 150.794597 and -33.733417 150.794474 East of Wianamatta Regional Park, in powerline easement. South of the Corner of Forrester and Palmyra Roads under powerlines

HABITAT: Derived shrubland/grassland/herbland – unmapped significant vegetation with many threatened species adjoining open forest Mapped as PCT 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion

Associated species: *Allocasuarina littoralis, Melaleuca decora, Leptospermum parvifolium*, *Melaleuca nodosa*, *Grevillea mucronulata*, *Pimelea linifolia*, *Micromyrtus minutiflora*, *Dillwynia tenuifolia*, *Pultenaea parviflora*, *Hibbertia pedunculata*, *H. diffusa*, *Brachyloma daphnoides*, *Dodonaea falcata*, *Lissanthe strigosa*, *Acacia elongata*, *A. ulicifolia*, *Astroloma humifusum*, *Patersonia sericea*, *Phyllanthus hirtellus*, *Gompholobium* sp., *Pomax umbellata*, *Dianella revoluta*, *Lomandra multiflora*, *Lepidosperma laterale*, etc.

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: 15+ plants noted in two patches. These are additional patches from the one patch observed on the 29/10/18 brief inspection. Mostly nonflowering with petal dehiscence near complete 12.38

CUMBERLAND FLORA & FAUNA INTERPRETIVE SERVICES

FAMILY: Dilleniaceae

GENUS: *Hibbertia*

SPECIES: *puberula*

DET.: Robert T. Miller

COLLECTOR(s): Robert T. Miller, Jan Miller & Steve Douglas

DATE: 9/11/2018 **COLLECTING No.**

LOCALITY: TreeServe property: Lot 3 DP 812284, 90 Clifton Avenue Kemps Creek

HABITAT: Derived shrubland/grassland at verge of extensive fill mound growing on disturbed soil with laterite nodules often intertwined with *Dillwynia tenuifolia*.

Remnant trees observed in the general vicinity include *Eucalyptus sclerophylla*, *E. fibrosa*,

E. eugenioides, *E. longifolia* and *E. tereticornis.*

Large shrubs: *Allocasuarina littoralis, Melaleuca decora, Melaleuca nodosa*.

Three additional threatened species were noted: *Dillwynia tenuifolia* (common), *Pultenaea parviflora* and *Persoonia nutans* (1 plant).

HABIT: small sprawling subshrub with occasional +/- semierect wiry branches arising from a rootstock.

NOTES: 20+ plants noted. Mostly +/- finished flowering with petal dehiscence near complete at 11 AM.

Two additional plants observed trough the fence within the adjacent property to the south.

Appendix 3. *Hibbertia puberula* subs. *puberula* collection records 2007

Field notes compiled by Miller and Miller & Gibson

Site: Lucas Heights Site 1 16/10/07

Abundance: extremely localised, rare < 12 plants noted.

Field notes: Lucas Heights Soil Landscape, Gentle plateau slope, skeletal soil above first sandstone outcropping +/- intermittent seepage zone. Vegetation sparse and stunted probably from the impact of drought and fire episode > 2 years. All *Hibbertia* appeared to be seedlings at this locale. Open Woodland / heath – Canopy: *Eucalyptus haemastoma*? and Stringybark species. Associated understorey: *Banksia ericifolia, B. oblongifolia, Leptospermum arachnoides, Grevillea sericea, Xanthorrhoea* sp., *Cyathochaeta diandra, Burchardia umbellata, Hypoxis hygrometrica*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 1 Ridgetop Laterite

Field notes: Very disturbed site (past trailbike/FWD and possible laterite extraction but now protected and regenerating. Open Woodland/Laterite Heath: *Eucalyptus punctata.* Associated understorey species: *Exocarpos cupressiformis, Goodenia hederacea, Pomax umbellata, Brachyloma daphnoides, Patersonia sericea, Gompholobium minus, Leptospermum parvifolium, Kunzea ambigua, Persoonia laurina, Micrantheum ericoides.*

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 2 Easterly Plateau slope above Georges River

Abundance: Very localised but locally common c. 20 plants noted.

Field notes: Soil: fine sand with clay component, undisturbed habitat, walking track only. Habit: compact wiry shrub 30-60cm wide with many lax stems arising from a rootstock. In Open Woodland. *Eucalyptus sclerophylla? E. punctata, Angophora bakeri*. Associated understorey: *Melaleuca nodosa, Lambertia formosa, Leptospermum trinervium, Callistemon linearis, Kunzea ambigua, Kunzea capitata, Coronidium oxylepis, Xanthorrhoea sp., Stipa pubescens, Themeda australis*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 3 Upperslope/headwaters of upper drainage line.

Field notes: Undisturbed. *Eucalyptus punctata, E. sclerophylla*? and *Angophora bakeri*. Associated understorey: *Kunzea ambigua, Melaleuca nodosa, Gompholobium minus, Isopogon anemonifolius, Leucopogon, Kunzea capitata, Xanthorrhoea* sp. Dominated by *Kunzea* and *Melaleuca nodosa*.

Site: Simmos Beach Recreation Reserve Macquarie Fields, Habitat 4 Laterite Ridgetop.

Field notes: *Angophora bakeri. Leptospermum parvifolium* (dominates), *Kunzea ambigua, Petrophile sessilis, Micrantheum ericoides, Kunzea capitata, Lambertia formosa, Pimelea linifolia, Stipa pubescens*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 1: Lateritic Heath

Field notes: *Eucalyptus* sp. (Stringybark), *E. squamosa, Allocasuarina littoralis, Angophora hispida*. Associated understorey*: Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis, Persoonia lanceolata, Isopogon anemonifolius, Hakea laevipes, H. sericea, Grevillea diffusa, Actinotus minor, Cyathochaeta diandra, Entolasia stricta, Caustis flexuous*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 2: Lateritic Heath

Field notes: Soil very fine sandy loam. Habit: low +/- prostrate shrub sprawling through sedges. *Angophora hispida, Corymbia gummifera, Allocasuarina littoralis*. Associated understorey: *Leptospermum trinervium* (narrow-leaved form), *Petrophile sessilis, Persoonia lanceolata, Pultenaea elliptica, Isopogon anemonifolius, Banksia spinulosa, Grevillea diffusa, Actinotus minor, Cyathochaeta diandra, Entolasia stricta*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 3

Field notes: Soil sandy loam with small sandstone outcroppings. Open Forest *Eucalyptus punctata*, E. sp. (Stringybark), and *Corymbia gummifera.* Associated understorey: *Hakea laevipes, Leptospermum parvifolium, Isopogon anemonifolius, Lissanthe strigosa, Grevillea diffusa, Hakea sericea, Acacia linifolia, Themeda australis, Lomandra obliqua, Lomandra cylindrica, Cyathochaeta diandra*.

Site: Keith Longhurst Reserve (formerly The Basin Reserve) Georges River Road Kentlyn Habitat 4

Field notes: Soil: fine sandy loam scattered lateritic fragments. Open Forest with grassy and herbaceous understorey comprised of *Eucalyptus punctata*, E. sp. (Stringybark), and *Corymbia gummifera.* Associated understorey: *Leptospermum parvifolium, Isopogon anemonifolius, Lissanthe strigosa, Grevillea diffusa, Goodenia hederacea, Stipa pubescens, Themeda australis, Entolasia stricta, Hypoxis hygrometrica, Hovea linearis, Cryptandra* sp., *Lobelia dentata, Patersonia sericea, Cyathochaeta diandra* and *Xanthorrhoea* sp.

Site: Peter Meadows Reserve Old Kent Road Kentlyn

Field notes: Soil: sandy, lateritic. Lateritic Ridgetop Heath *Eucalyptus sclerophylla, E. squamosa, Angophora hispida* heath. Lateritic Ridgetop Heath /Woodland interface: *Eucalyptus sclerophylla, E. punctata, Angophora hispida*. Associated understorey species: *Petrophile sessilis, Lambertia formosa, Kunzea capitata, Leptospermum arachnoides, Brachyloma daphnoides, Hakea laevipes, Xanthorrhoea sp., Actinotus minor, Pultenaea elliptica, Hakea sericea, Gompholobium minus, Goodenia hederacea* and *Entolasia stricta*.

Site: Freres Crossing Reserve, Freres Road Kentlyn 2/11/07, Ridgetop slopes

Field notes: *Eucalyptus punctata, Syncarpia glomulifera* Associated understorey: *Hakea laevipes, Persoonia linearis, Leptospermum trinervium, Isopogon anemonifolius, Gompholobium minus,* *Acacia terminalis, Gonocarpus tetragynus, Brachyloma daphnoides, Eriostemon australis, Grevillea diffusa, Hibbertia diffusa, Hypoxis hygrometrica, Xanthorrhoea* sp.*, Themeda australis, Lomandra obliqua, Entolasia stricta.*

Site: Freres Crossing Reserve, Freres Road Kentlyn 2/11/07, Ridgetop

Field notes: *Eucalyptus punctata, Angophora costata*, Stringybark sp. Associated understorey*: Allocasuarina littoralis, Kunzea ambigua, Acacia terminalis, Brachyloma daphnoides, Hypoxis hygrometrica, Themeda australis* and *Stipa pubescens*.

Site: Ella Avenue Barden Ridge (formerly Lucas Heights) 20/11/07 Below Detention Basin

Field notes: Localised in drainage line. Site impacted by housing development – weed invasion occurring due to urban runoff and sedimentation. *Eucalyptus punctata*, E. sp. (Stringybark), *E. haemastoma, Corymbia gummifera, Angophora hispida*. Associated understorey: *Hakea sericea, Banksia oblongifolia, Leptospermum polygalifolia, L. arachnoides, Lambertia formosa, Kunzea ambigua, Grevillea sericea, Epacris pulchella, Banksia spinulosus, B. marginata, Isopogon anemonifolius, Hakea laevipes, Phyllota phylicoides, Actinotus minor, Patersonia sericea, Xanthorrhoea resinosa, Stipa pubescens, Xanthosia tridentata, Lomandra obliqua, Cyathochaeta diandra, Lepyrodia scariosa, Schoenus brevifolius, Lindsaea linearis*.

Site: Ella Avenue Barden Ridge (formerly Lucas Heights) 20/11/07 Downslope of Detention Basin

Field notes: Scattered through sedges - relatively rare at edge of wet heath/swamp. *Eucalyptus haemastoma*, E. sp. (stringybark), *E. punctata*. Associated understorey: Sedges dominate understorey: *Leptocarpus tenax, Schoenus brevifolius, Xanthorrhoea resinosa, Leptospermum polygalifolia, Banksia oblongifolia, Actinotus minor, Dampiera stricta, Epacris pulchella, Entolasia stricta, Deyeuxia decipiens.*

Site: Little Forest Lucas Heights 20/11/07

Field notes: Soil: fine sandy loam with clay content, +/- impeded drainage, Lucas Heights Soil Landscape, Localised in narrow zone in upper drainage line. *Eucalyptus oblonga, E. haemastoma, Corymbia gummifera, Angophora hispida.* Associated understorey: *Callistemon citrinus, Banksia oblongifolia, Leptospermum polygalifolia, L. arachnoides, Lambertia formosa, Kunzea ambigua, Grevillea diffusa, G. sericea, Melaleuca thymifolia, Callistemon linearis, Hakea sericea, H. teretifolia, Acacia linifolia, Mirbelia rubiifolia, Actinotus minor, Patersonia sericea, Xanthorrhoea resinosa, Stipa pubescens, Xanthosia tridentata, Lomandra obliqua, Cyathochaeta diandra, Schoenus brevifolius*.

Site: Voyager Point Adjacent Old Single Mens Quarters

Field notes: Soil: Fine sand atop of lateritic gravels – Surface layer -Well drained, Aspect: easterly Slope: 0-2. Open Woodland: *Eucalyptus sclerophylla, E. parramattensis, Angophora bakeri*. Understorey diverse open to moderately dense with well-developed ground layer. Dominant Associated Shrub Species: *Melaleuca nodosa, Petrophile sessilis, Leptospermum parvifolium, L.*

trinervium, Banksia spinulosa, Hakea laevipes, Kunzea ambigua, Persoonia lanceolata, Callistemon linearis, Hakea sericea, Acacia brownii, Daviesia acicularis. Dominant Associated Ground Layer Species: *Platysace ericoides, Hovea linearis, Lomandra obliqua, Lepyrodia scariosa, Austrostipa pubescens, Austrodanthonia tenuior, Cyathochaeta diandra*.

Site: Voyager Point adjacent Sirius Drive

Field notes: Soil: Fine sand and laterite – Surface layer -Well drained. Aspect northerly slope 0-2. Open Woodland: *Eucalyptus sclerophylla, Angophora bakeri* and *Eucalyptus oblonga*. Understorey diverse, open to moderately dense with well-developed ground layer. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, Banksia spinulosa, Babingtonia densiflora, Brachyloma daphnoides, Kunzea ambigua, Persoonia levis, Grevillea sericea, Hakea sericea, Isopogon anemonifolius, Melaleuca nodosa, Lambertia formosa, Philotheca scaber, Styphelia laeta.* Dominant Associated Ground Layer Species: *Platysace ericoides, Dianella revoluta, Lomandra obliqua, Lepyrodia scariosa, Austrostipa pubescens, Cyathochaeta diandra.*

Site: Yeramba Lagoon 2/1/07 Ridge slopes 1

Field notes: Shelving sandstone terraces. Soil: Sandy loam. Surface layer: Well drained but drainage impeded by sandstone bedrock. Aspect: westerly slope: 5. Open Woodland: *Eucalyptus racemosa, Corymbia gummifera, Eucalyptus oblonga & Angophora bakeri.* Understorey diverse, open grassy site. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum polygalifolium, Banksia oblongifolia, B. spinulosa, B. marginata, Kunzea ambigua, Persoonia levis, Grevillea sericea, Hakea sericea, Grevillea sericea, Hakea laevipes, Leptospermum arachnoides, Epacris microphylla, Hibbertia stricta.* Dominant Associated Ground Layer Species: *Actinotus minor, Schoenus moorei, Austrostipa pubescens, Themeda australis, Entolasia stricta, Lomandra multiflora.*

Site: Yeramba Lagoon 2/1/07 Ridge slopes 2

Field notes: Ridge slopes – shelving sandstone terraces. Soil: Sandy loam. Surface layer: Well drained. Aspect: northwest. Slope: 5. Interface between Woodland*: Eucalyptus oblonga, Corymbia gummifera, Eucalyptus punctata* Open Woodland: *Eucalyptus racemosa, Corymbia gummifera, Eucalyptus oblonga & Angophora bakeri.* Understorey diverse and well developed moderately dense. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, B. marginata, Hibbertia stricta*, *Leucopogon microphyllus, Lambertia formosa, Callistemon linearis, Melaleuca thymifolia, Gompholobium grandiflora, Epacris microphylla, Lasiopetalum ferrugineum.*

Dominant Associated Ground Layer Species: *Themeda australis, Entolasia stricta, Burchardia umbellata*, *Actinotus minor, Lomandra obliqua, Schoenus moorei, Austrostipa pubescens.*

Site: Blackwall 2/1/07 Ridgetop / Plateau

Field notes: Soil: relatively deep sand. Aspect: Northerly Slope: < 2. Open Woodland: *Corymbia gummifera, Eucalyptus racemosa, E. punctata, and E. oblonga.* Understorey diverse. Dominant Associated Shrub Species: *Brachyloma daphnoides, Banksia spinulosa, Petrophile sessilis, Leptospermum trinervium, L. parvifolium, Isopogon anemonifolius, Babingtonia densifolia, Dillwynia* *retorta, Philotheca scabra, Grevillea sericea, Gompholobium glabratum, Xanthorrhoea media, Kunzea ambigua, Bossiaea heterophylla, Acacia myrtifolia.* Dominant Associated Ground Layer Species: *Phyllanthus hirtellus, Pomax umbellata, Austrostipa pubescens, Themeda australis* and *Cyathochaeta diandra.*

Site: Mickeys Point 2/1/07 Ridgetop / Plateau

Field notes: Soil: lateritic. Aspect: North east Slope: < 2. Open Woodland / Heath: *Eucalyptus racemosa, Angophora hispida,* and *Allocasuarina littoralis.* Understorey diverse. Dominant Associated Shrub Species: *Petrophile sessilis, Leptospermum trinervium, Hakea sericea, Persoonia levis, Kunzea ambigua, Styphelia triflora, Isopogon anemonifolius, Brachyloma daphnoides, Babingtonia densifolia, Hemigenia purpurea, Hibbertia stricta*. Dominant Associated Ground Layer Species: *Actinotus minor, Baeckea ramosissima, Poranthera ericoides, Lomandra obliqua, Austrostipa pubescens, Entolasia stricta.*

Appendix 4. *Hibbertia puberula* identification characters

All microscopic photos by Miller 2018.

Photo 120: *Hibbertia puberula* subsp. *puberula* Canoelands.

Photo shows that the hairs are “worn off” on the older growth.

Photo 121: *Hibbertia puberula* subsp. *puberula* Canoelands

Photo shows tomentum characteristics of new shoots, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface.

Photo 122: *Hibbertia puberula* subsp. *puberula* from Lucas Heights.

Photo 123: *Hibbertia puberula* subsp. *puberula* (Lucas Heights)

Photo shows leaf and stem tomentum, revolute margins and bulging broader central vein obscuring the leaf undersurface of new shoot.

Photo 124: *Hibbertia puberula* subsp. *puberula,* Smith's Creek Reserve 4th June 2018.

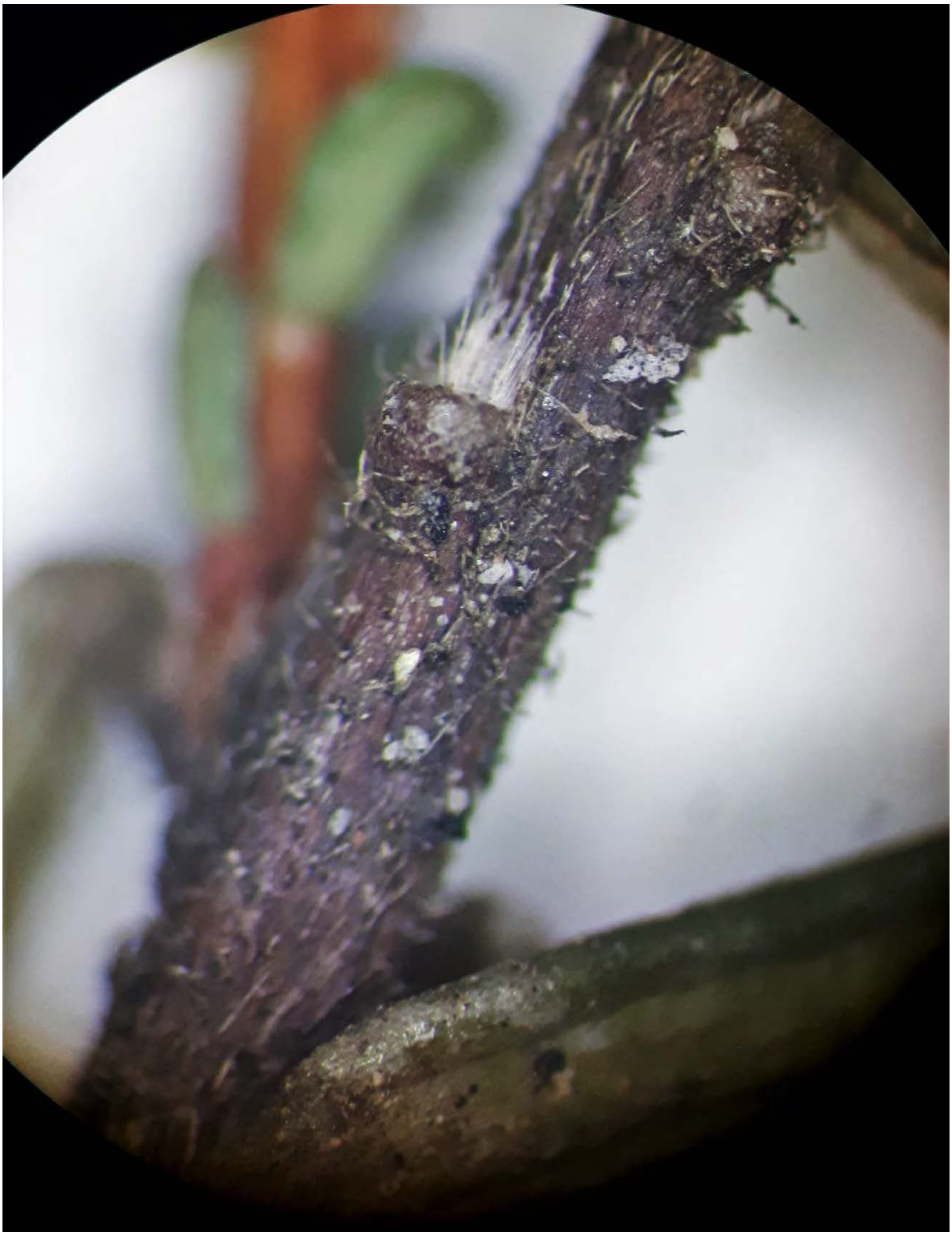


Photo 125: *Hibbertia puberula* subsp. *puberula,* Smith's Creek Reserve 4th June 2018.

Photo 126: *Hibbertia puberula* subsp. *extensa* flower morphology noting four stamens in this specimen.

Photo 127 *Hibbertia puberula* subsp. *extensa* calyces and leaf characteristics 30/11/2018

Photo 128: *Hibbertia puberula* subsp. *extensa* juvenile shoot.

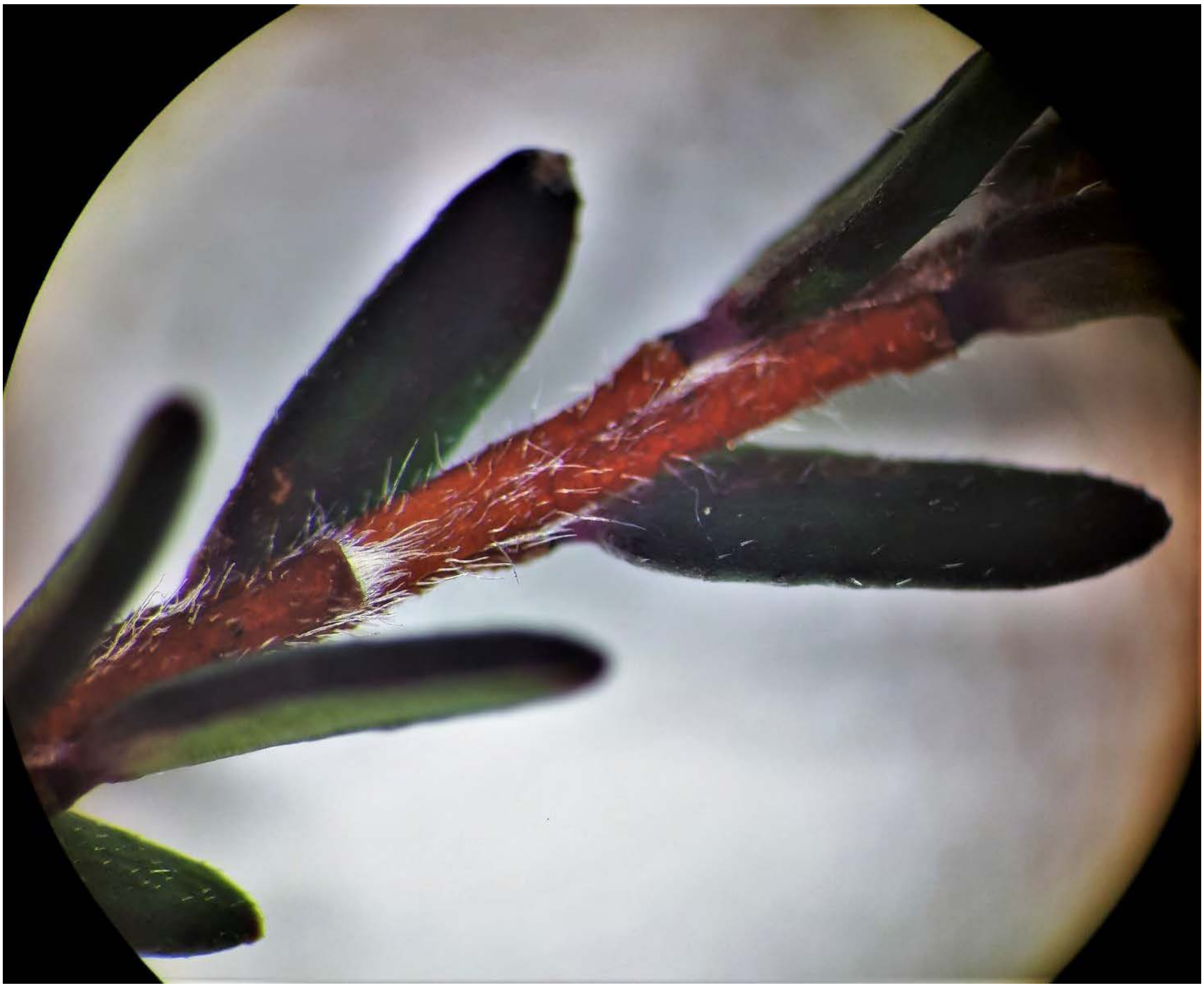


Photo 129: *Hibbertia puberula* subsp. *extensa* juvenile shoot showing tomentum characteristics.

Photo 130: *Hibbertia puberula* subsp. *extensa*

Photo shows typical lateral branching habit and tomentum characteristics of calyxes, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface.

Photo 131: *Hibbertia puberula* subsp. *extensa*

Photo shows tomentum characteristics of stem, revolute leaf margins and bulging broader central vein that obscures the leaf undersurface noting that tomentum has “worn off”.

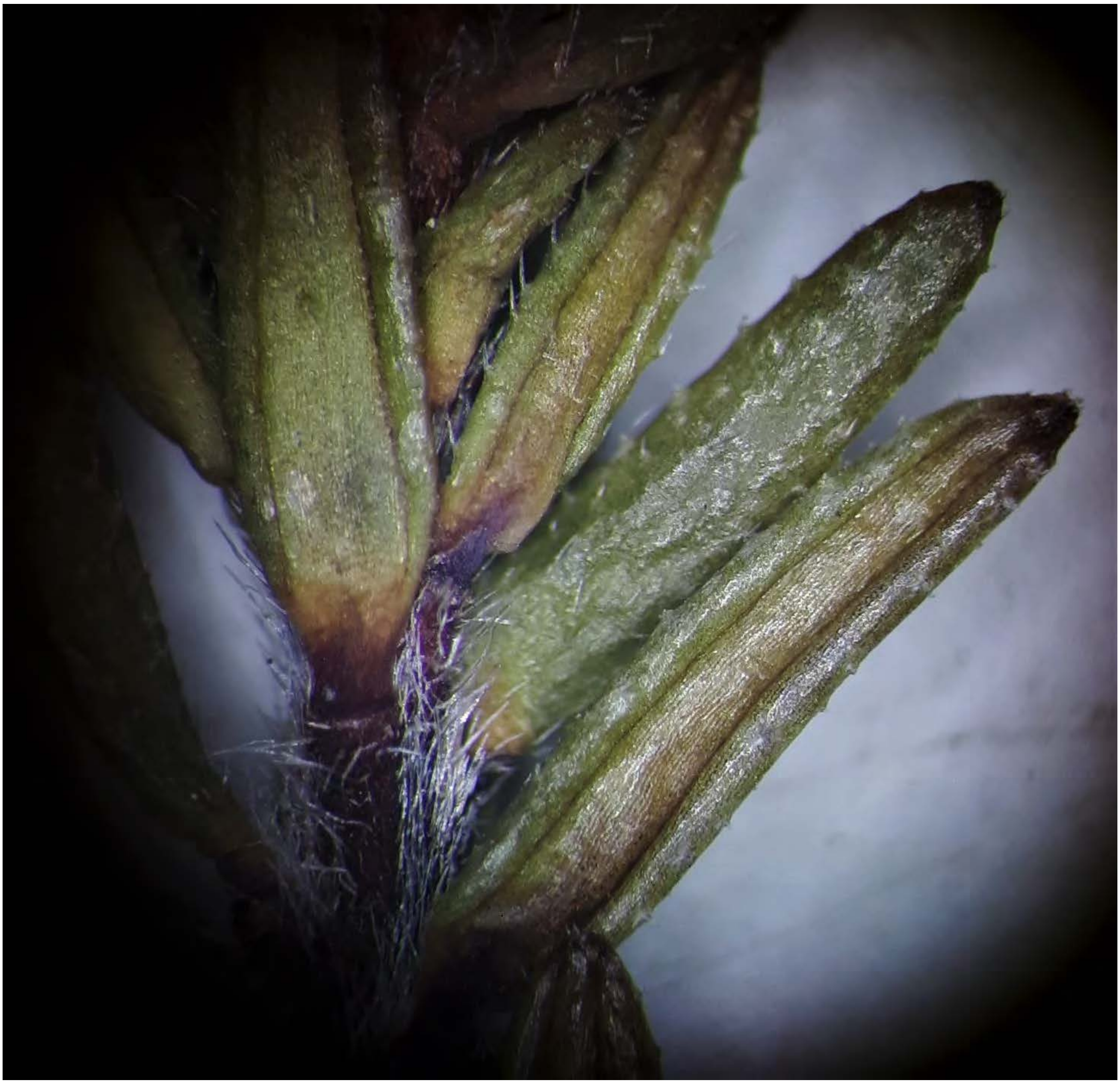


Photo 132: *Hibbertia puberula* subsp. *extensa.*

Photo shows tomentum characteristics of an upper portion of the branchlet, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Note that much of the tomentum has not “worn off”.

Photo 133: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing tomentum characteristics, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 134: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing interpetiolar tuffs, glabrescent tomentum characteristics, revolute margins and recessed to bulging broader central vein that obscures the leaf undersurface. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 135: *Hibbertia puberula* subsp. *glabrescens.*

Photo showing interpetiolar tuffs of hair and scattered simple hairs on upper shoot. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Photo 136: *Hibbertia puberula* subsp. *glabrescens.*

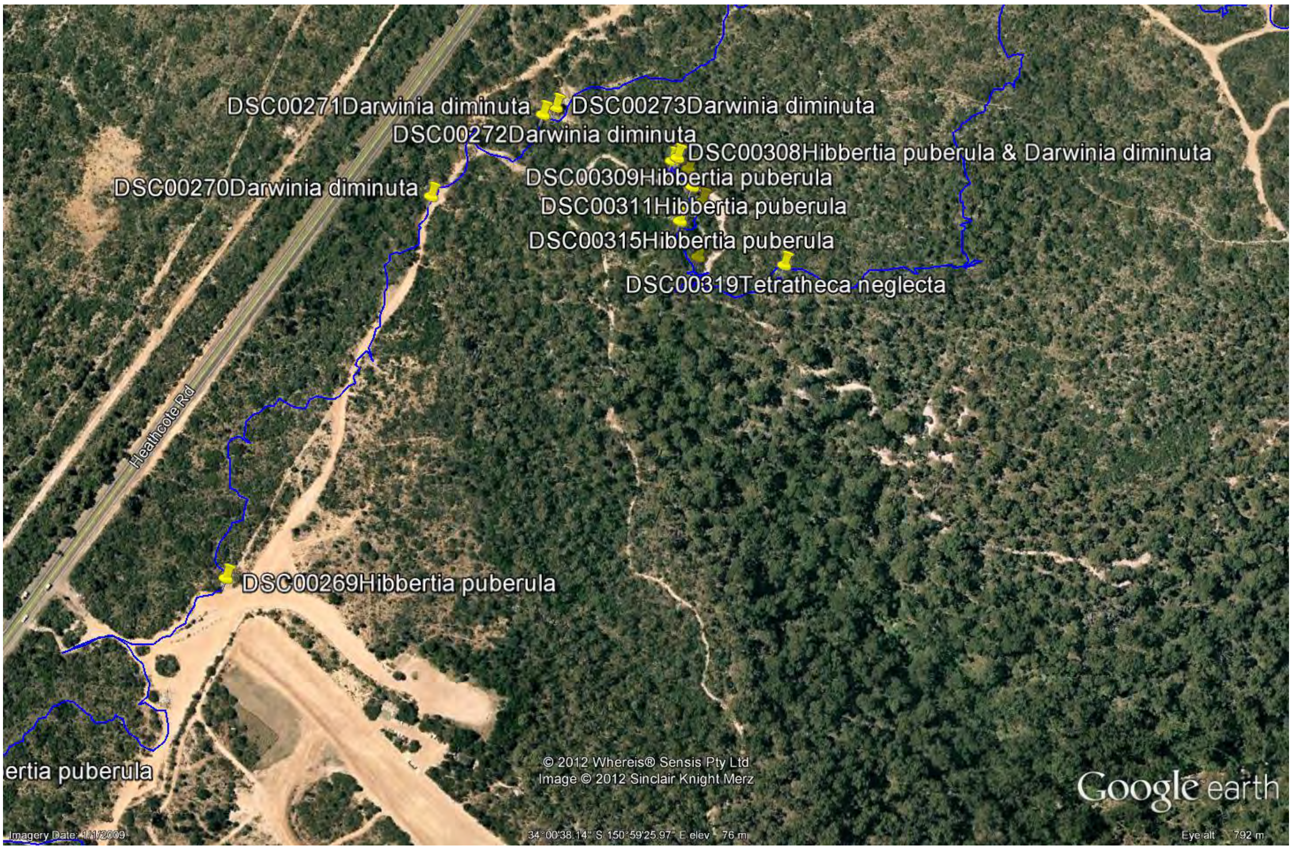
Photo showing glabrescent calyces. Specimen collected by C.P Gibson and R.T. Miller 02/01/2007.

Appendix 5. Indicative distribution of *Hibbertia puberula* at Menai.

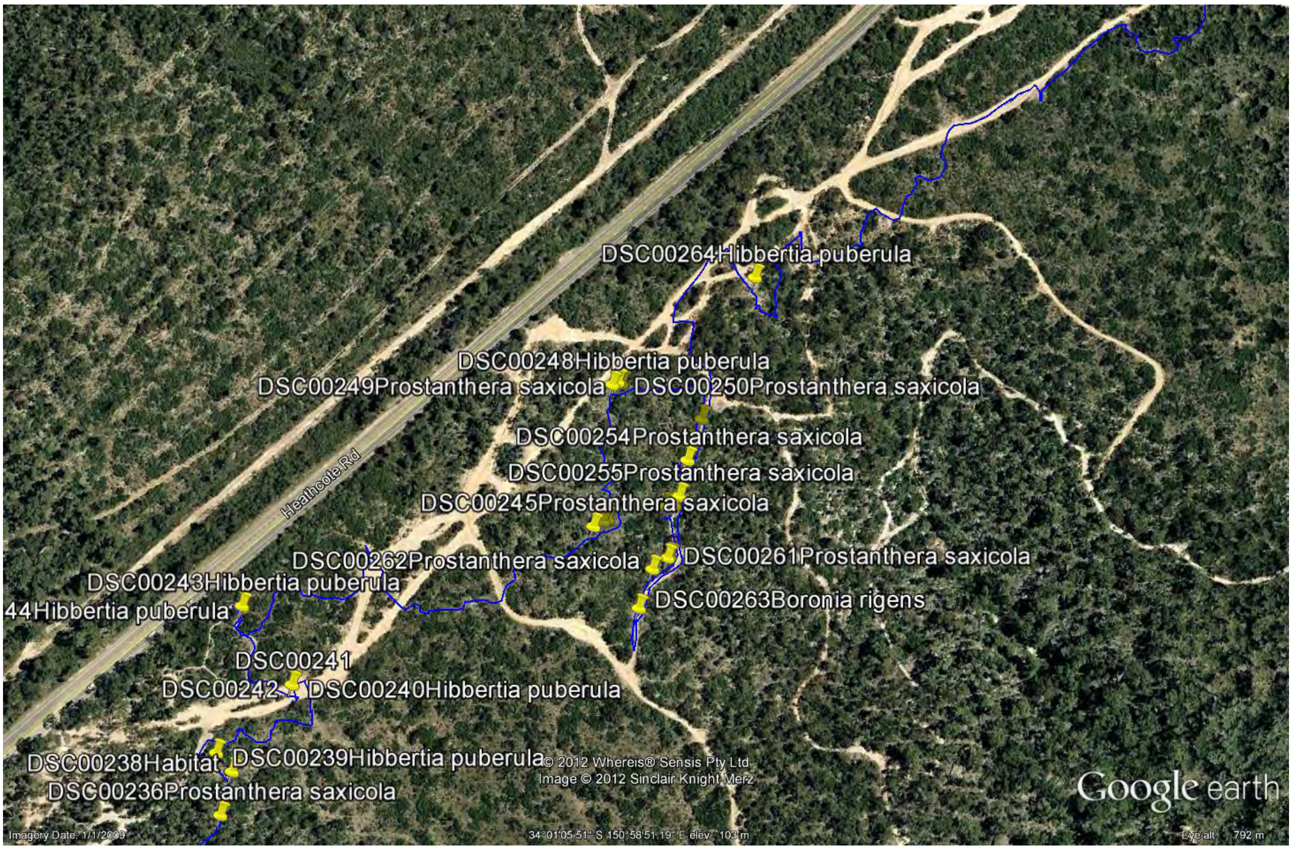
The following Google Earth images show the indicative distribution of threatened taxa east of Heathcote Road within a Menai proposed development footprint, recorded on two brief CFFIS site inspections.

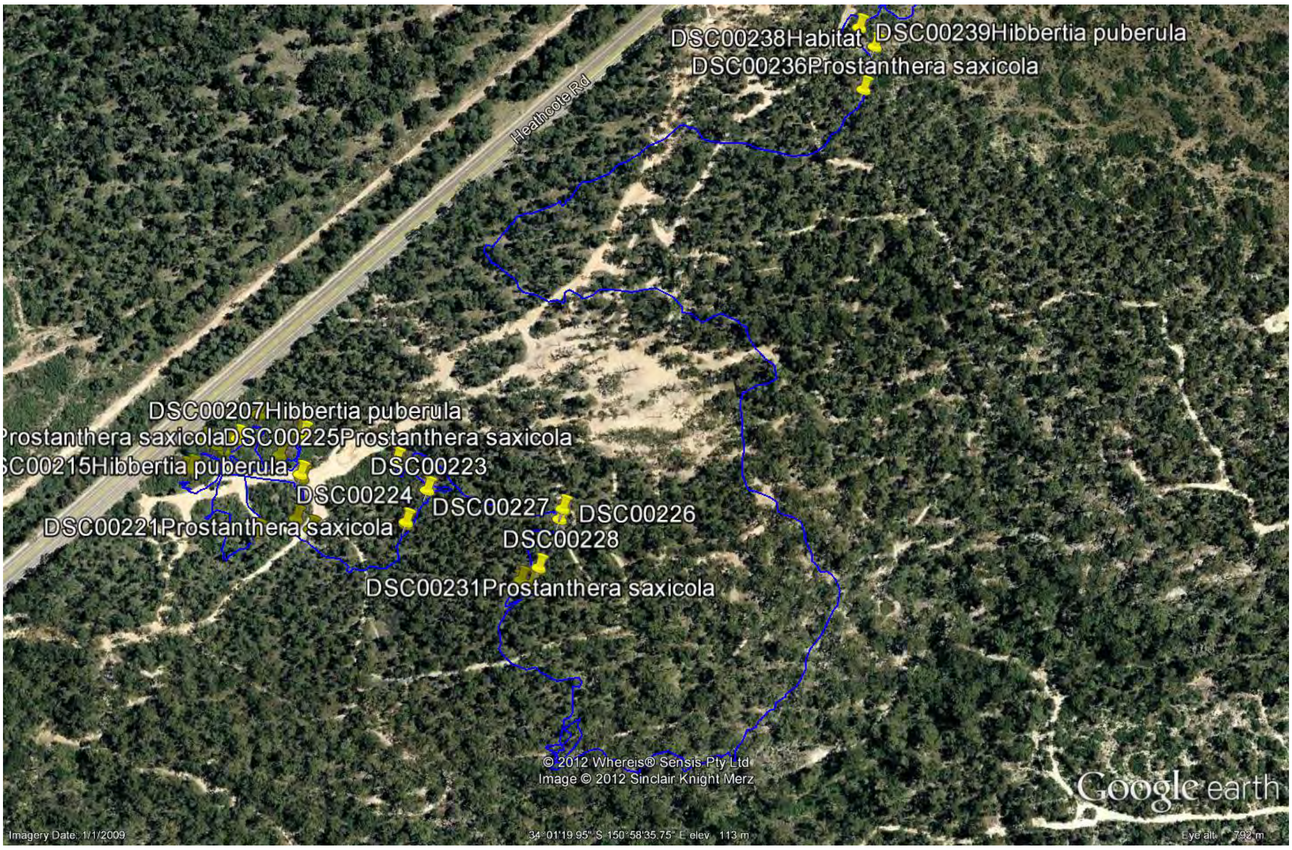

Heathcote Rd
318Acacia bynoeana
319Acacia bynoeana
317Prostanthera saxicola
315Prostanthera saxicola
314Prostanthera saxicola
313Prostanthera saxicola
320Prostanthera saxicola
321Prostanthera saxicola
322Prostanthera saxicola
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


311Acacia bynoeana
312Acacia bynoeana
308Hibbertia puberula
310Hibbertia puberula
DSC00321Hibbertia puberula
Survey
DSC00277habitat
DSC00278habitat
DSC00275habitat
DSC00320Acacia bynoeana
DSC00274habitat
DSC00273Darwinia diminuta
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00271Darwinia diminuta
DSC00273Darwinia diminuta
DSC00272Darwinia diminuta
DSC00308Hibbertia puberula & Darwinia diminuta
DSC00270Darwinia diminuta
DSC00309Hibbertia puberula
DSC00311Hibbertia puberula
DSC00315Hibbertia puberula
DSC00319Tetratheca neglecta
Heathcote Rd
DSC00269Hibbertia puberula
ertia puberula
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00268Hibbertia puberula
DSC00267Hibbertia puberula
DSC00265Hibbertia puberula
DSC00266Hibbertia puberula
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00264Hibbertia puberula
DSC00248Hibbertia puberula
DSC00249Prostanthera saxicola
DSC00250Prostanthera saxicola
DSC00254Prostanthera saxicola
DSC00255Prostanthera saxicola
DSC00245Prostanthera saxicola
Heathcote Rd
DSC00262Prostanthera saxicola
DSC00261Prostanthera saxicola
DSC00263Boronia rigens
DSC00243Hibbertia puberula
44Hibbertia puberula
DSC00241
DSC00242
DSC00240Hibbertia puberula
DSC00238Habitat
DSC00239Hibbertia puberula
DSC00236Prostanthera saxicola
© 2012 Whereis® Sensis Pty Ltd
Image © 2012 Sinclair Knight Merz
Google earth


DSC00238Habitat
DSC00239Hibbertia puberula
DSC00236Prostanthera saxicola
Heathcote Rd
DSC00207Hibbertia puberula
rostanthera saxicola
DSC00225Prostanthera saxicola
C00215Hibbertia puberula
DSC00223
DSC00224
DSC00227
DSC00226
DSC00221Prostanthera saxicola
DSC00228
DSC00231Prostanthera saxicola
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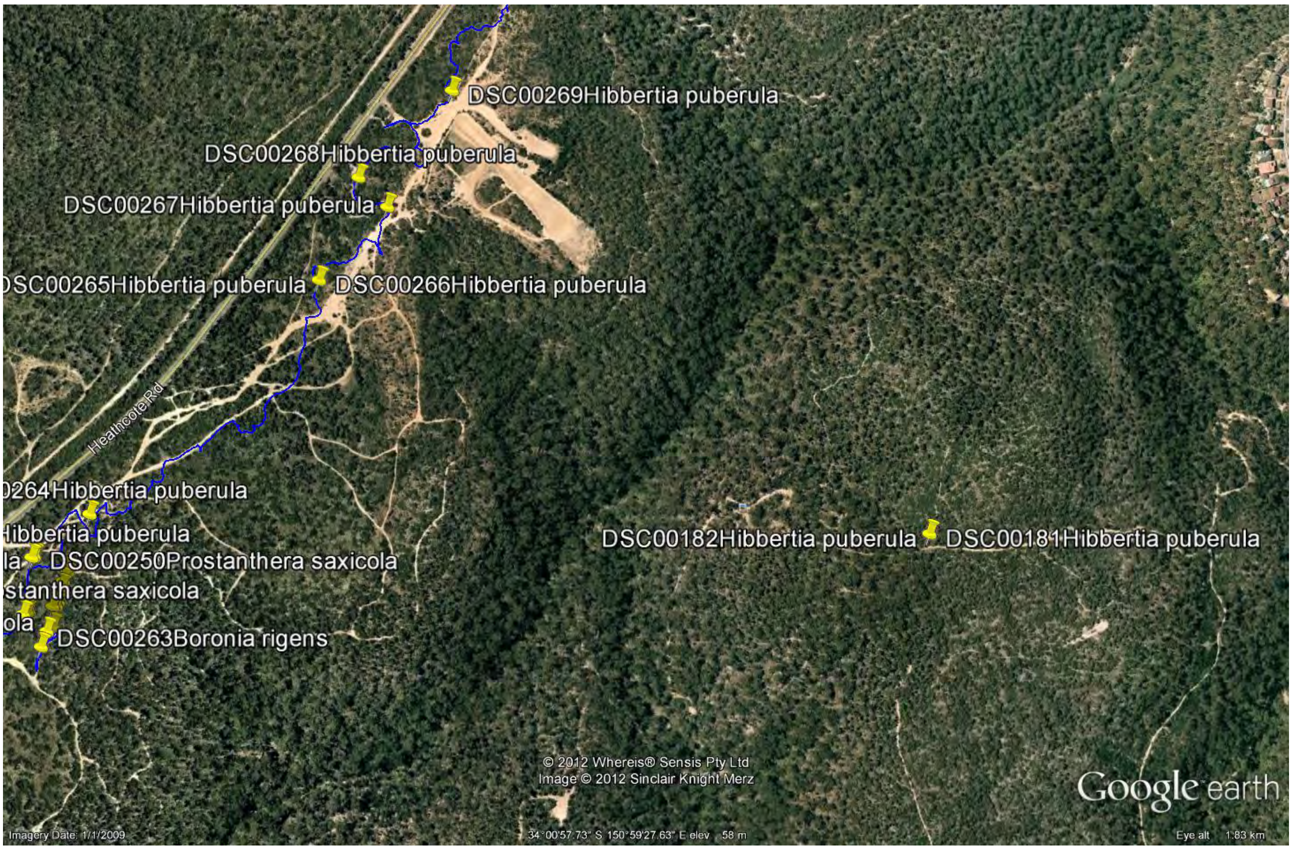
DSC00269Hibbertia puberula
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DSC00250Prostanthera saxicola
stanthera saxicola
DSC00263Boronia rigens
DSC00182Hibbertia puberula
DSC00181Hibbertia puberula
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Appendix 6: *Hibbertia pedunculata* cited specimens Toelken 2013

The following table is derived from Toelken (2013) and contains the cited specimens of *Hibbertia pedunculata* examined from Metropolitan Sydney, outlining their current status according to Miller.

Collection Details	**Extant**	**Presumed Extinct at locale**	**Unknown imprecise locale suitable extant habitat in the area.**
J.H.Maiden NSW243240, St Marys Station, South Creek, 24.ix.1887 (NSW);			Yes?
J.L.Boorman NSW85891, St Marys, ix.1920 (NSW);			Yes
W.Woolls MEL35562 & 35565, Parramatta, – (MEL).		Presumed Extinct unless in Parramatta Park	
O.D.Evans NSW85863, Yennora, 13.x.1961 (NSW);		Extinct due redevelopment	
J.J.Fletcher NSW85893/4/5, Cabramatta, 9.xi.1889 (NSW);		Likely to be extinct	
C.P.Gibson & R.T.Miller 26, Shaddock Ave, Villawood (extinct), 26.ix.1990 (AD, NSW);		Extinct	
M.Fuller 304, Chester Hill, x.1927 (CANB);		Likely to be extinct unless the locality refers to Walshaw Park	
C.P.Gibson 61,Walshaw Park, Bass Hill, 12.x.2000 (AD, NSW);	Small population under threat from mismanagement		
C.P.Gibson s.n., Deverall Park at Condell Park, 26.x.2005 (AD, NSW);	Small population under severe threat due in appropriate adjoining development.		
R.T.Miller s.n., Rookwood Cemetery, 16.x.2007 (AD, NSW);	Under threat		

Collection Details	**Extant**	**Presumed Extinct at locale**	**Unknown imprecise locale suitable extant habitat in the area.**
C.P.Gibson 81, Chullora Rail Yards, 9.x.2006 (NSW);	Small population under threat		In part extinct
R.T.Miller & C.P.Gibson 25, Chullora Railway Yards, Muston site 3, 24.x.1990 (NSW);		Likely to be extinct due to development	
A.A.Hamilton NSW85888, Duck River, Clyde, 9.1914 (NSW);	Population under severe threat		
N.King NSW243235, Homebush, 1.ix.1891 (NSW);			Unknown possibly extinct
J.H.Maiden NSW243239, Homebush, x.1893 (NSW);			Unknown possibly extinct
C.P.Gibson & R.T.Miller 24, Smith Park, East Hills, xi.1988 (NSW);	Small population under threat		
R.H.Cambage 828, Peakhurst, xii.1902 (NSW);		No suitable habitat remains	
J.H.Camfield NSW85889, near Kogarah, x.1893 (NSW);		No suitable habitat remains	
J.H.Camfield NSW85892, Bexley, x.1893 (NSW);		No suitable habitat remains	
S.King MEL1009762, near Blue Mountains, 1893 (MEL);			Unknown

Expert report – Little Eagle and Square-tailed Kite

Strategic Assessment for the Little Eagle *Hieraaetus morphnoides* in the Greater Macarthur Growth Area and the Wilton Growth Area, Tony Saunders and Stephen Debus, August 2018

Strategic Assessment for the Square-tailed Kite *Lophoictinia isura* in the Greater Macarthur Growth Area and the Wilton Growth Area, Tony Saunders and Stephen Debus, August 2018

Appendix 1: Habitat descriptions of each site in Greater Macarthur and Wilton Growth Areas

Review of updates to the development footprints of the Greater Macarthur and Wilton urban growth areas in relation to strategic assessments on the Little Eagle and the Square-tailed Kite

Strategic Assessment

for the

Little Eagle *Hieraaetus morphnoides*

in the

Greater Macarthur Growth Area

and the

Wilton Growth Area

Report prepared for the Department of Environment and Planning

Prepared by Tony Saunders and Stephen Debus
Merops Services Pty Ltd

Prepared August 2018

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Appendices

Strategic Assessment for the Little Eagle *Hieraaetus morphnoides* in the Growth Areas of Greater Macarthur and Wilton

1. Introduction

Purpose

The purpose of this report is to assess the likelihood of occurrence and potential impacts of the urban growth in the Greater Macarthur and Wilton areas on the Little Eagle *Hieraaetus morphnoides*. In particular, this report will assess the presence of breeding and foraging habitat within these growth areas as required under the Biodiversity Assessment Method. It will also discuss conservation measures required to mitigate potential impacts.

The Little Eagle is listed in New South Wales as vulnerable under the *Biodiversity Conservation Conservation Act* 2016 and is an uncommon species found in open forests and woodlands. It shows a preference for areas containing a mosaic of open woodland and open grasslands with scattered trees, but can also be found along timbered watercourses and the edges of forest remnants. Records for this species exist in and around the area to be impacted by the urban development. However, the species is encountered infrequently in this area and its interactions with local habitat have not been well studied.

The existence of potential habitat for the Little Eagle and of records for the species within the area has meant that a more detailed assessment of the likelihood of impacts from the development in the area is required, particularly of the species' potential for foraging and breeding in the area. Targeted surveys could gather this information, but the survey effort required to collect sufficient data would be great and in the order of hundreds of hours in the appropriate seasons over several years. This would also require tracking of individual birds to gather information on foraging, breeding locations and behaviour at nests etc. Access to several potential habitat areas also proved difficult during the survey period. Knowledge of the habitat structure and plant community types (PCTs) that the Eagle has been recorded in within the growth area and of the ecology of the species can be used as a surrogate for this fieldwork.

Project Context

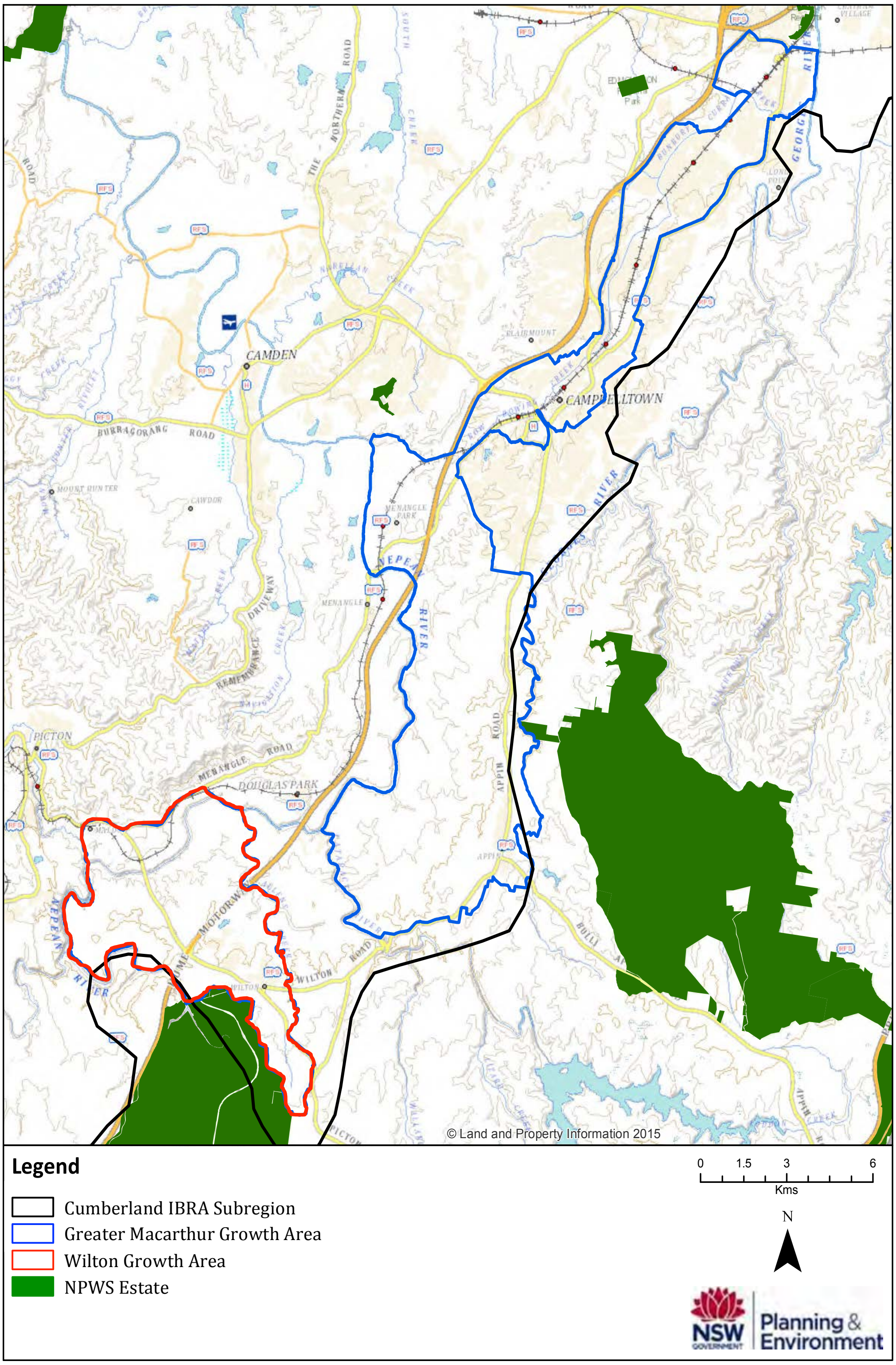
The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

The timeframe for this project, and difficulties in accessing private lands have resulted in some survey challenges for the project. Only 68% of the potential habitat available for this species in the Wilton and Greater Macarthur Growth Areas has been successfully surveyed. Significant areas of the Greater Macarthur Growth Area were unable to be adequately surveyed due to restrictions around land access. Around 900 hectares of potential habitat was not surveyed within this growth area. In particular PCTs 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, 850 Grey Box - Forest Red Gum grassy woodland on shale of the Cumberland Plain, Sydney Basin Bioregion and 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion were unable to be adequately surveyed.

Study Area

The study area is in the Macarthur and Wilton areas, which extend from the southern parts of Liverpool, down to Appin, across to Wilton and then towards the area between Wilton and Picton. The area is within the Cumberland IBRA subregion and the location is shown in Figure 1. The area is bound within a latitude range from -33.88 to -34.33 and a longitude range of 150.55 to 150.97.

Figure 1. Location of Growth Areas and the Cumberland IBRA Subregion.



Survey Methods

Vegetation maps (as supplied by The Department of Planning and Environment NSW) of the Greater-Macarthur Growth Area and the Wilton Growth Area were used to select patches of remnant vegetation that may provide suitable habitat for the Little Eagle. Fifty potential sites were chosen from these maps. Sufficient access was feasible for 40 of these remnants.

The remnants were visited over 4 days from the 18-06-2018 to the 21-06-2018 inclusive. Each site was surveyed for between 0.5 and 1.0 hours. The aim was to collect qualitative data on each of the following:

habitat structure -	tree height range, DBH range, canopy cover, tree maturity, shrub density, grass cover, ground cover
habitat quality -	tree age diversity, shrub layer diversity, presence of woody weeds, evidence of regeneration
connectivity -	degree of connectivity, relative width of corridor to other remnants, presence of gaps in vegetation
aspect and slope -	slope steepness, direction of slope and relationship of site to structural features e.g. watercourses etc.
avian species -	overall diversity, species composition, presence of feral species

The aim was to assess if these sites contained suitable habitat for foraging and breeding and whether they allowed for dispersal of prey and the target species into and out of the remnants. The extent of suitable habitat across the growth areas was then used to estimate the likelihood of the Eagles using the area for foraging and/or breeding.

The Atlas of Living Australia (ALA) and the bird database from the Cumberland Bird Observers Club Inc. (CBOC) were searched for atlas records of the Little Eagle. The records within the Atlas of Living Australia had data mainly from the BioNet Atlas of NSW Wildlife with a few records from un-named individuals contributing directly to the ALA atlas. At the time of access the CBOC bird atlas had over 20,000 survey results for the section of the Cumberland IBRA sub-region that lies within the County of Cumberland. These 2 data sets combined would have captured most of the data on the Eagle for this area.

Justification for Use of an Expert Report

The presence of suitable habitat for foraging and breeding for the Little Eagle combined with the low density for this species and the difficulties with gaining sufficient access for surveys to establish the presence and habitat use by the Eagle in the growth area has meant that survey effort alone has not be able to establish the potential importance of the area for this Eagle.

An expert in the breeding and foraging ecology of the Eagle would be required to assess the importance of the habitat remnants and the likelihood of occurrence within the growth areas. The Eagle is a forest and woodland specialist whose major food in its breeding season is mainly ground foraging mammals, birds and reptiles, although it also takes birds from the tree canopy. Therefore, an expert would also need to also be expert on the avifauna populations occurring in forest and woodland in the Cumberland IBRA Subregion.

The report will address the food resources and foraging space of this raptor as well as the Eagle's potential nest sites and breeding habitat within the growth areas.

Credentials of the Experts Preparing this Report

Dr. Tony Saunders
BSc University of Sydney 1976, PhD University of Western Sydney 2005.

Company Director and Avian Ecologist, Merops Services Pty Ltd 1995 to present.

Relevant experience in surveys and the study of woodland and forest birds of the Cumberland plain:

- Cumberland Plain woodland bird surveys for the NSW Bird Atlas and then for the CBOC Bird Atlas 1982 to the present.
- Cumberland Plain woodland bird surveys on the UWS Hawkesbury Campus 1998 to 2005.
- Woodland bird surveys for Holroyd Council's reserves and parklands 2008 to 2011.
- Survey for threatened woodland birds in proposed urban development of the former ADI site at Penrith 2002.
- Survey for threatened woodland birds in proposed rural subdivision at Badgerys Creek 2006.
- Presented the opening presentation ' Birds of the Cumberland Plain. What was there? What have we lost?' at the ABSA Conference 2016.
- Presented 'Trends in woodland birds of the Cumberland Plain' at the RZS of NSW Conference in 2016.
- Avifauna surveys of sites for development applications and assessment of status of threatened bird species with recommendations for minimising impact of development on these species within the Cumberland Plain and eastern New South Wales. (21 years)
- Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (21 years)

Relevant publications relating to woodland birds of the Cumberland Plain:

- Saunders, T. (2016). Birds of the Cumberland Plain. What was there? What have we lost? Abstract from ‘Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future’ Australian Bird Study Association Conference - 23 January 2016. *Corella* **40**: 46.
- Saunders, T. (in prep.). Trends in woodland bird populations in the Cumberland Plain. *Australain Zoologist.*

Dr. Stephen Debus
Bachelor Arts (Biology/Behavioural. Science), Dip. Natural Resources (Wildlife), MSc. (Zoology), PhD (Zoology)

Adjunct associate lecturer/research associate, Zoology University of New England, Armidale. 2004 to present
Senior Ecologist (casual) Eco Logical Australia 2014 to present

Relevant experience in surveys and the study of the Little Eagle *Hieraaetus morphnoides* and of woodland birds:

- Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report (Northern Tablelands Local Land Services 2017-18)
- Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting (North West Local Land Services 2015-18)
- Co-supervising, and finding all 13 Little Eagle nests and sharing the fieldwork for, a UNE Zoology student Honours project near Armidale in 2017 on the breeding habitat and nest-site characteristics of the Eagle (Candice Larkin, B Zool. Hons thesis duly submitted and awarded)

Relevant publications relating to foraging and breeding biology of the Little Eagle *Hieraaetus morphnoides*:

- Debus, S.J.S. 1993. Falconiformes, Accipitridae, Falconidae, Gurney's Eagle, Little Eagle, Square-tailed Kite, Osprey texts in Marchant, S. & Higgins, P.J. (Eds), *Handbook of Australian, New Zealand and Antarctic Birds, Vol. 2: Raptors to Lapwings*. Oxford University Press, Melbourne.
- Debus, S. 2017. *Australasian Eagles and Eagle-like Birds*. CSIRO Publishing, Melbourne. [The Little Eagle chapter is a 25-year update of the Debus 1993 *HANZAB* Little Eagle account.]
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- Debus, S.J.S. 1984. Biology of the Little Eagle on the Northern Tablelands of New South Wales. *Emu* 84: 87-92.
- Debus, S.J.S., Hatfield, T.S., Ley, A.J. & Rose, A.B. 2007b. Breeding biology and diet of the Little Eagle *Hieraaetus morphnoides* in the New England region of New South Wales. *Australian Field Ornithology* 24: 137-157.
- Debus, S.J.S. & Ley, A.J. 2009. Aspects of the breeding cycle of the Little Eagle *Hieraaetus morphnoides*. *Australian Field Ornithology* 27: 76-99.
- Olsen, J., Fuentes, E., Judge, D., Rose, A.B. & Debus, S.J.S. 2010. Diets of Wedge-tailed Eagles (*Aquila audax*) and Little Eagles (*Hieraaetus morphnoides*) breeding near Canberra, Australia. *Journal of Raptor Research* 44: 50-61.
- Debus, S.J.S. 2011. Parental time-budgets and breeding behaviour of the Little Eagle *Hieraaetus morphnoides* in northern New South Wales. *Corella* 35: 65-72.
- Debus, S.J.S., Olsen, J., Judge, D. & Butterfield, M. 2013. Numbers of breeding Little Eagles *Hieraaetus morphnoides* near Canberra in relation to atlas counts. *Corella* 37: 30-32.
- Olsen, J., Debus, S.J.S. & Judge, D. 2013. Declining Little Eagles *Hieraaetus morphnoides* and increasing rabbit numbers near Canberra: is secondary poisoning by Pindone the problem? *Corella* 37: 33-35.
- Olsen, J., Debus, S.J.S., Judge, D. & Rose, A.B. 2013. Diets of Wedge-tailed Eagles *Aquila audax* and Little Eagles *Hieraaetus morphnoides* breeding near Canberra, 2008–2009. *Corella* 37: 25-29.

2. Species Information

Species Description

The Little Eagle is a smaller bird than the Wedge-tailed Eagle and about the same size as the Whistling Kite. However, it is more robust than the Whistling Kite with shorter wings and a shorter square-edged tail. It glides and soars on flat wings or slightly raised wings when gaining height. The head is short and broad compared with the Whistling Kite. There is a light morph which is light and dark brown with light rufous underparts. The underwings have a distinctive pale 'M' pattern and the tail is barred (Debus 2012). When observed from underneath they appear to have dark leading and trailing edges to the underwing, compared with the Whistling Kite which only has dark trailing edges to the wing (pers. obs.). The dark morph has a rufous body with slightly darker brown wings, which from the underside appear all dark except for pale inner primaries (Debus 2012).

Life Cycle

Little Eagles will form pairs in breeding territory, but are solitary outside the breeding season (Debus 1993). In New South Wales, nest building or renovation occurs in August, egg laying from August to September, incubation lasts from 37-39 days with hatching from October to December, fledging occurs from December to January and post-fledglings are dependent on adults for 2 or more months after that (Olsen 2014, Olsen et al. 2017, Debus et al. 2007, Debus and Ley 2009, Debus 2011). Banded individuals have been recovered up to 26 years after banding and banding data suggest that birds occupy a home range or wintering range for at least 6-10 years (Debus 2015).

Breeding has been reported during October and November in the Cumberland County from the Royal National Park and Warriewood on the northern beaches of Sydney, but no nests were recorded within the Cumberland Plain (CBOC Atlas accessed 29-06-2018). However, they have bred within the Cumberland Plain at Cobbity in 1978 (Hoskin *et al.* 1991).

Distribution and Abundance

The Little Eagle is endemic to Australia, but is not found in Tasmania (Olsen et al. 1993). The New Guinea form is now a separate species (Debus 2017). The global population is estimated to be a maximum of 80,000 (Debus 2017). It is considered to be resident for at least several consecutive years at nesting sites (Debus et al. 2007, Debus and Ley 2009). It may also be a partial migrant with some movement north in the non-breeding period (Olsen 1995). It is capable of traversing the continent (>2000 km: Debus 2015), and a satellite-tracked breeding male near Canberra wintered in the Top End of the Northern Territory before returning (Dabb 2018).

The Little Eagle is considered moderately common and a partial nomad in New South Wales (Morris et al. 1981). They are found throughout New South Wales, but are more common in the western two-thirds of the state (Cooper et al. 2014). It was rarely noted in lightly timbered country of the Cumberland County prior to the 1950s (Hindwood and McGill 1958) but had become a frequent visitor over the next 30 years (Hoskin 1991). It is often recorded from western Sydney in lightly timbered country away from areas of dense urbanisation (Patrick 2016). It is reported as an uncommon resident of open forest and farmland in the Shoalhaven area and has been reported in the Picton/Wilton area (Chafer *et al.* 1999).

Little Eagles have declined by 14% nationally between the two national bird atlases over an approximately 20-year period (Barrett *et al.* 2003), and declined by 39% in New South Wales over the same period (Barrett *et al.* 2007). The reporting rates in the NSW Bird Atlas declined by 70% since the mid-1980s (Cooper *et al.* 2014).

The CBOC Atlas (accessed 29-06-2018) holds 336 records of the Eagle. Each survey detected mostly a single bird, but sometimes pairs. Four birds, two adults and two fledglings, were recorded in the Royal National Park. Two hundred and seventy nine of the 336 records for the County were recorded from the Cumberland Plain and 35 of those records are from inside the growth areas or within 5 kilometres of the growth area boundaries. The highest reporting rate was 2.2% for the Cumberland Plain for records prior to 1970, but after declining to 0.8% during the 1970s, recovered in the 1990s and the Eagle has been recorded in 1.3% of surveys since the year 2000 (Saunders in prep.).

The declines are thought to be due to loss of woodland habitat (Cooper et al. 2014), disturbance to nests, loss of breeding habitat, urbanisation and high density rural subdivision and subsequent competition for remaining habitat by Wedge-tailed Eagles (Debus et al. 2007, Debus and Ley 2009, Debus 2011, Dabb 2018). Declines in the ACT and NSW may also be due to control of rabbits, which are a major prey item, and the use of Pindone for rabbit control, which possibly affects the predator as well through secondary poisoning from eating baited rabbits (Olsen et al. 2013). Urban encroachment not only affects nesting woodland habitat but also the surrounding open areas used for foraging (Walsh and Beranek 2017) and nesting and foraging areas may become disjunct (ACT Government 2008). They are easily disturbed while nesting (Cupper and Cupper 1981) and will flush from the nest when approached to within 50 to 140 metres (Debus *et al.* 2007).

Breeding density in eastern NSW has been estimated at 1 pair per 1600 hectares in the early 1980s (Debus 1984) and one pair per 2100-3000 hectares since 2000 (Debus 2017). Active nests in eastern NSW are between 2 and 5 kilometres apart and birds will forage up to at least 1.8 kilometres from the nest (Debus 1984, Debus and Ley 2009); average inter-nest distance in contiguous wooded habitat is 3.6 km (Larkin and Debus unpublished data). Walsh and Beranek (2017) found that the Eagles will forage up to 3 kilometres from the nest, which gives a minimum breeding/ foraging territory of 2800 hectares. In the ACT, active nests were on average 5 km apart (Rae *et al.* 2018), and one post-breeding adult male had an elongated foraging range of 6500 hectares, with foraging journeys of 10-20 km, around the outer edge of Canberra (Brawata and Gruber 2016).

Habitat Requirements

Little Eagles prefer open woodland, but are also found along forest edges, timbered watercourses through open country and open grazing country (Hollands 1984, Taylor and Canberra Ornithologists Group 1992, Olsen *et al.* 1993). They hunt over most open habitats and will seek areas where there is a mosaic of treed habitat and open country

(Debus 1993, Cooper et al. 2014). They can also be found in woodland associated with wetlands (Debus 1993, CBOC Atlas accessed 29-06-2018).

They will nest in tall living eucalypts between 5 and 30 metres tall in open forest, woodland, and remnant woodland in farmland (Debus 1993, Debus *et al.* 2007, Debus and Ley 2009). Nests are generally between 13 and 20 metres above ground (Debus 1993, Debus and Ley 2009, T. Saunders pers. obs.). They prefer to nest in dense woodland adjacent to open habitat e.g. grassy woodland for foraging (Debus 1993, Debus and Ley 2009, Debus 2011). Nests are typically in an emergent eucalypt, the tallest in the stand and often with the largest girth, in woodland patches at least 4.8 hectares in size (average 85 ha); mostly within 200 m of an edge; more distant from sealed roads (average 838 m) than gravel roads (average 546 m) than tracks (average 304 m), at least 38 m from the nearest dwelling (average 457 m), and at least 1 km from suburbia (Larkin and Debus unpublished data). Near Canberra, nests were at least 215 m from a dwelling, at least 122 m from an urban edge, and farther from sealed roads (average 710 m) than gravel roads (260 m) or footpaths (average 90 m) (Rae *et al.* 2018). The minimum nesting requirements as per a review of the literature are provided in Tables 1 and 2 below.

Table 1. Minimum distances of active Little Eagle nests from developments in 2 studies:

Parameter	Armidale (C. Larkin et al. unpubl.)	Canberra (Rae et al. 2018)
Dwelling	38 m	215 m
Urban area	1 km	122 m
Industrial building	–	65 m
Sealed road	65 m	31 m
Unsealed road	135 m	29 m
Track/path	34 m	24 m

Table 2. Minimum criteria for active Little Eagle nest-site characteristics (Armidale, C. Larkin *et al.* unpublished data):

Parameter	Measurement
Woodland patch size	4.8 ha
Nest-tree height	20.5 m
Reference tree height*	14.6 m
Nest-tree DBH**	37 cm
Reference tree DBH*	54 cm
Nest height	15 m

*Reference trees are other trees within the nest stand (within 25 m of the eagle's nest tree)
**Diameter at breast height

Foraging requires open woodland areas and open grasslands adjacent to woodlands because the preferred prey includes mainly ground foraging prey species. These are across a broad range of prey species and include insects, reptiles, birds, mammals and carrion. The prey types that have been recorded for the Little Eagle are listed as follows:

Insects	grasshoppers, beetles, cicadas (Debus 1993, 2017)
Reptiles	Bearded Dragon, Eastern Blue-tongue, Cunningham's Skink, goannas (Debus 1993, Debus *et al.* 2007, Debus 2017)
Birds	Crimson and Eastern Rosellas and other parrots, Galah, Australian Magpie-lark, Peaceful Dove, Common Starling, ducks, pigeons, small to large passerines (Debus 1993, Debus *et al.* 2007, Olsen *et al.* 2010, Debus 2017, Rae *et al.* 2018)
Mammals	Rabbit, Hare, Mouse, Rat, Cat, *Antechinus*, bandicoot, possums (Debus 1993, Debus *et al.* 2007, Walsh & Beranek 2017)
Carrion	macropods, Hare, Sheep, Fox (Debus 1993, Olsen *et al.* 2010, Debus 2017)

There is some information on local vegetation types within the Cumberland County that are preferred by the Little Eagle. One hundred and twenty-six records out of the 325 records held with the CBOC Atlas (accessed 29-06-2018) contain information about the habitat type where the Eagle was encountered. In order of most to least common they were:

Pastureland with Scattered Trees	27%
Cumberland Plain Woodland	22%
Heath	15%
Urban Parkland	10%
Tall Forest	8%
Sandstone Woodland	8%
Rainforest	8%
Swamp and River Woodland	2%

The OEH Threatened Species Data Collection indicates that the Little Eagle has the potential to inhabit the following plant communities within the Wilton and Greater Macarthur Growth Areas:

830	Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain
883	Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain
1800	Wetlands

The habitat requirements discussed above have been used in this report to identify important habitat areas. They have been grouped into the habitat criteria listed below. The greater the number of criteria that are met the more likely it is that the remnant will provide habitat for Little Eagle.

1. Site contains tall open forest or woodland.
2. Site is near or along a timbered watercourse.
3. Site contains one or more of the following PCTs: -
   830, 835, 849, 850, 883 and 1395.
4. Site contains a mosaic of open grazing land and woodland.
5. Site contains ground foraging prey species
   e.g. rabbits, hares, mice, passerines, parrots and pigeons.
6. Site has open grassy areas around the edges of remnants, timbered corridors and watercourses.
7. Site has tall or emergent trees suitable for nesting.

3. Description of the Study Area's Relevance to the Little Eagle

Land Use History

Much of the northern half of the Greater Macarthur growth area has been developed as residential, commercial and industrial land decades ago and any remaining habitat can only be found along watercourses and on steep slopes where these developments are not appropriate. Much of this area would have been a mix of cleared grazing land and bushland prior to this stage of development.

The southern half of the Greater Macarthur and the Wilton growth areas contain older small towns, which now have a few larger new residential developments. These occupy only a small area within the growth areas. Much of the land consists of small to medium rural holdings and grazing agricultural land that was cleared for farming decades ago. Throughout this area there are many watercourses that are tributaries to either the Georges or Nepean rivers and the forests along these watercourses has largely been left intact with some clearing or thinning at the edges. Many of the remnant patches and forested watercourses have been affected by woody weed invasion since development in the area.

Landscape Context

The growth areas follow the transport corridor along the Hume Motorway that connects the area to the south-western areas of greater Sydney to the north. The area abuts intact, contiguous, forested areas to the east and to the south. These are in water catchments or national park reserves, which cover hundreds of square kilometres. The western edge abuts mostly cleared rural holdings either side of the Nepean River and then further west to the Warragamba Dam water catchment area.

Much of the region is in the western half of the Cumberland IBRA subregion, which contains most of the remaining large woodland remnants and is an important area for this reason. The woodlands of the Cumberland Plain are threatened ecological communities and have been prioritised by the Office of Environment and Heritage for habitat protection and enhancement (DECCW 2010).

Native Vegetation

The remnant native vegetation within the growth areas is mainly eucalypt forest and woodland. Forested areas on steep slopes and along watercourses have largely been left intact and often contain a structurally and species diverse understorey. Woodland areas remaining on flat or gently undulating land have a few scattered dense patches of understorey, but are mostly open woodland with a grassy understorey. Many of the remnant patches have been invaded by woody weeds and many woodland remnants are subjected to grazing pressure and are clear of any understorey. Some of the remnants have also been thinned and have only scattered paddock trees along their edges.

The following plant community types are found in these remnants within the growth areas:

PCT Codes and Names

- 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
- 850 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
- 877 Grey Myrtle dry rainforest of the Sydney Basin Bioregion and South East Corner Bioregion
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion
- 1081 Red Bloodwood - Grey Gum woodland on the edges of the Cumberland Plain, Sydney Basin Bioregion
- 1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux of the Sydney Basin Bioregion
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion
- 1292 Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion
- 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

Potential Habitat

Most of the uncleared areas in the northern half of the Greater Macarthur growth area are remnant forest patches along watercourses that were unsuitable for development. They are small, often isolated and mostly surrounded by urban development with little or no open areas surrounding each remnant to act as buffers. Some have open areas within them that have mown grass and are now parkland. Few of the reserves have open edges or grazing areas around them and as such do not provide suitable foraging habitat. This area has a major watercourse near the eastern edge, which is the Georges River. This river would provide access to the reserves that provide some suitable resources for the Eagle.

The southern half of the Greater Macarthur and the Wilton growth areas have small areas of urban development and larger areas of open grazed pastureland and rural holdings. There are very large remnants of forest and woodland that mainly follow watercourses that are connected to either the Georges or Nepean Rivers. In the south and east sections of the growth areas many of these forest remnants are also part of contiguous habitat into water catchment reserves or national parks. The forest remnants often border open areas with scattered trees and provide good edge habitat for the Eagle. There are many areas, which have a mosaic of open grazed land and small patches of open forest and woodland.

Some 40 sites, scattered over the whole length of the growth areas, were sampled for habitat quality and their ability to provide foraging and nesting resources for the Eagle. Fifty potential sites were selected based on the vegetation maps of the area but access into much of the area was difficult. The habitat requirements for the Eagle are described in detail in Section 2 of the report and are grouped into seven different criteria for assessing suitable habitat. Details of each site's location, their PCTs and which of the criteria were satisfied are listed below (see Table 3) and a more-detailed description of each site can be found in Appendix 1. All of the sites met at least one of the criteria and 20 of the sites meet at least 5 of the 7 criteria. The PCTs where the Eagle has been observed from previous records (BioNet Atlas of NSW Wildlife, accessed 29-06-2018) include 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, 850 Grey Box - Forest Red Gum grassy woodland on shale of the Cumberland Plain, Sydney Basin Bioregion, 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain, Sydney Basin Bioregion and 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion, which were recorded on many sites.

These sites represent only a small portion of the forest remnants within the growth areas, yet nearly all sites satisfied many of the criteria used to assess whether suitable habitat existed on-site for the Eagle. This implies that most of the remaining forest and woodland habitat in the area is potential Eagle habitat, especially as the remnants are tall, have open edges and follow watercourses. Open areas that exist adjacent to the forest and woodland remnants, and especially where there is a mosaic of open grazing areas and woodland remnants provide potential habitat. All forest, woodland and open areas that provide potential habitat will be shown as species polygons in Section 4 of this report. It should be noted that some of the important open areas adjacent to forest and woodland remnants overlap with the proposed urban development footprint.

Although there is much potential breeding habitat within the growth areas, BAM defines breeding habitat as live (occasionally dead) large old trees within suitable vegetation AND the presence of an adult with nesting material; or an individual on a large stick nest in the top half of the tree canopy. Adults with nesting material or their presence on a large stick nest were not observed during surveys. These criteria would need to be met to confirm the presence of breeding habitat within the growth areas.

Table 3. Criteria relating to habitat resources for the Little Eagle that were satisfied for each of the study sites.

Site No.	Latitude	Longitude	PCTs	Criteria Satisfied
1	-33.96801	150.90682	849	1,2,3,5,6,7
2	-33.97577	150.90994	835, 849	1,2,3,4,5,6,7
3	-33.98336	150.89717	1395	1,2,3,4,5,6,7
4	-33.99160	150.87588	835	1,2,3,5,6,7
5	-33.99667	150.87933	849	3,5
6	-33.00763	150.86866	835	2,3
7	-34.01357	150.85682	835, 1395	1,2,3,7
8	-34.01049	150.84202	849	3,7
9	-34.00402	150.83964	1395	3
10	-34.03953	150.84055	849	2,3,5,6
11	-34.05475	150.83743	1081, 1181	1,2,3,7
12	-34.05460	150.81757	850	1,3
13	-34.05984	150.79926	850	2,3,7
14	-34.05677	150.80422	850	2,3
15	-34.06471	150.79735	835	1,2,3,7
16	-34.07929	150.80041	849	3
17	-34.07103	150.79253	835	1,2,3,7
18	-34.07175	150.78816	849	1,2,3,7
19	-34.07426	150.77886	849	1,2,3,7
20	-34.09521	150.75699	835	1,3,4,5,6,7
21	-34.10223	150.75169	1395	1,2,3,4,5,6,7
22	-34.09795	150.74683	849	1,3,5,6,7
23	-34.09972	150.7786	830	1,3,7
24	-34.11215	150.77988	835	1,2,3,5,6,7
25	-34.12015	150.79354	1395	3,4,5,6,7
26	-34.12996	150.78533	1395	1,3,4,5,6,7
27	-34.14001	150.79018	1395	1,3,6,7
28	-34.15692	150.78909	1395	1,3,4,5,6,7
29	-34.19165	150.78422	1395	1,2,3,6,7
30	-34.20653	150.76729	850	1,3,4,5,6,7
31	-34.20109	150.75721	1395	2,3,4,5,6
32	-34.22262	150.7522	1395	3,4,5,6
33	-34.26687	150.71363	1395	3,4,5,6
34	-34.24750	150.70141	1395	1,2,3,6,7
35	-34.23376	150.69217	1395	1,2,3,4,5,6,7
36	-34.23014	150.68057	1395	3,5,6,7
37	-34.21825	150.66305	849	1,2,3,4,5,6,7
38	-34.22517	150.64112	1395	1,2,3,4,5,6,7
39	-34.23169	150.63132	1395	1,2,3,4,5,6,7
40	-34.20781	150.63328	1081	1,2,4,5,6,7

Criteria:
1. Site contains tall open forest or woodland.
2. Site is near or along a timbered watercourse.
3. Site contains one or more of the following PCTs - 830, 835, 849, 850, 883, 1181 and 1395.
4. Site contains a mosaic of open grazing land and woodland.
5. Site contains ground foraging prey species e.g. rabbits, hares, mice, passerines, parrots and pigeons.
6. Site has open grassy areas around the edges of remnants, timbered corridors and watercourses.
7. Site has tall or emergent trees suitable for nesting.

4. Assessment of Species Presence and Suitable Habitat

Species Records for the Greater Macarthur and Wilton Growth Areas

There were 78 records for the Little Eagle from the area containing the urban development area (ALA Atlas and CBOC Atlas, accessed 29-06-2018). The list of records is shown in Table 4 and the distribution of these records is shown in Figure 2.

Table 4. Records of the Little Eagle *Hieraaetus morphnoides* in and around the Greater Macarthur and Wilton Growth Areas.

Location Name	Latitude	Longitude	Date	Source
Mount Annan Botanical Gardens	-34.06250	150.7708333	27-03-1999	CBOC Inc.
Macdonald Road, Ingleburn	-33.98444	150.8563889	10-04-1999	CBOC Inc.
Macquariedale Road, Appin	-34.17083	150.7711111	01-07-1999	CBOC Inc.
Macquariedale Road, Appin	-34.17083	150.7711111	01-08-1999	CBOC Inc.
Riverside Reserve, Elderslie	-34.05389	150.7008333	01-06-1993	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	30-09-2000	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	19-08-2000	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	27-05-2000	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	17-10-1999	CBOC Inc.
Georges River, Macquarie Fields	-33.99611	150.9030556	26-06-2000	CBOC Inc.
Mount Annan Botanical Gardens	-34.06944	150.7677778	07-04-2001	CBOC Inc.
Mt Annan Botanic Gardens	-34.07500	150.775	17-05-2001	CBOC Inc.
Long Point, Macquarie Fields	-34.01778	150.9036111	20-04-2002	CBOC Inc.
Mt. Annan Botanical Gardens	-34.07194	150.7666667	11-05-2003	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	16-12-2000	CBOC Inc.
Mount Annan Botanical Gardens	-34.05389	150.7694444	15-12-2001	CBOC Inc.
Varroville, NSW- St Andrews Rd (Glendallo)	-33.95778	150.8375	09-11-2003	CBOC Inc.
Leppington NSW - Lawn Cemetery (eastern remnant)	-33.95778	150.8377778	10-01-2002	CBOC Inc.
Harrington Park, NSW - Narellan Creek	-34.03472	150.7402778	21-01-2005	CBOC Inc.
Raby, NSW - Raby Road.	-34.01500	150.8036111	27-01-2005	CBOC Inc.
Rossmore, NSW - South Creek, Rossmore Grange	-33.92806	150.7580556	13-02-2005	CBOC Inc.
Leppington NSW - Lawn Cemetery (eastern remnant)	-33.95778	150.8377778	08-03-2005	CBOC Inc.
Mt Annan Botanic Gardens	-34.06583	150.7694444	08-04-2006	CBOC Inc.
Glen Alpine	-34.08472	150.7763889	07-11-2009	CBOC Inc.
Mount Annan Botanic Gardens	-34.07000	150.7708333	19-11-2013	CBOC Inc.
Mt Annan Botanic Gardens	-34.06583	150.7694444	19-11-2013	CBOC Inc.
Mt.Annan Botanic Gardens, Campbelltown	-34.07250	150.7672222	01-11-1996	CBOC Inc.
Lieutenant Cantello Reserve, Hammondville	-33.95111	150.9669444	08-06-2014	CBOC Inc.
Mt Annan Botanic Gardens	-34.05389	150.7677778	23-10-2016	CBOC Inc.
Mt Annan Botanical Gardens	-34.07000	150.7705556	01-01-2017	CBOC Inc.
Mt Annan Botanical Gardens	-34.07000	150.7705556	23-01-2017	CBOC Inc.
Mt Annan Botanic Gardens	-34.07000	150.7705556	27-07-2017	CBOC Inc.
Mt Annan Botanic Gardens	-34.07000	150.7705556	24-08-2017	CBOC Inc.
Mt Annan Botanic Gardens	-34.07000	150.7705556	13-10-2017	CBOC Inc.
Mt Annan Botanic Gardens	-34.07000	150.7705556	31-10-2017	CBOC Inc.
	-34.16283	150.790372		BioNet Atlas of NSW Wildlife
	-34.16018	150.793163		BioNet Atlas of NSW Wildlife
	-34.16205	150.792898		BioNet Atlas of NSW Wildlife
	-34.16283	150.790372		BioNet Atlas of NSW Wildlife

	-34.16205	150.792898		BioNet Atlas of NSW Wildlife
	-34.16018	150.793163		BioNet Atlas of NSW Wildlife
	-33.99842	150.867836	26-12-1986	BioNet Atlas of NSW Wildlife
	-34.25867844	150.5614166		
CAMPBELLTOWN	-33.99841943	150.8678364	26-12-1986	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.92865874	150.8590417	22-01-1985	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.92865874	150.8590417	03-02-1985	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.92865874	150.8590417	21-04-1985	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.06231705	150.7817252	30-10-1994	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.18931555	150.7186366	13-09-2007	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.10632606	150.7259794	01-01-1998	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.10632606	150.7259794	01-01-1999	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.10632606	150.7259794	01-01-2000	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.10632606	150.7259794	01-01-2001	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.91688232	150.962082	09-02-1996	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.96674653	150.8716143	23-09-1998	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.08870094	150.7392383	14-03-2003	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.09695161	150.7314649	14-03-2003	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.93513506	150.8426533	31-05-2004	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.08812956	150.737097	14-09-2008	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-33.97527778	150.8630556	19-04-2013	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.30863396	150.6021486	20-02-2013	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.19170843	150.5864347	30-07-2013	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.11952649	150.6010416	06-03-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.972419	150.8475765	13-05-2014	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.00694444	150.8336111	13-06-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.923655	150.945471	28-05-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.952063	150.964321	08-06-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.95874478	150.9292539	02-05-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.92452167	150.9405973	28-05-2014	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.068907	150.776461	08-12-2014	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.15753198	150.6856719	23-05-2006	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.9655606	150.8459273	18-03-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.9743899	150.8453699	31-03-2014	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.90482214	150.852501	31-08-2007	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-33.97454806	150.824829	31-08-2007	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-33.99418471	150.8044648	26-04-2007	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.9589684	150.8806809	18-01-1999	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.31134794	150.6040053	01-03-2015	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.94682494	150.866701	15-03-2001	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.94002463	150.8754603	11-07-2006	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.31388162	150.5806545	21-04-2004	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.90600632	150.7990515	20-01-2004	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.93060527	150.9631288	06-06-2003	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.97654526	150.9587325	28-04-2006	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.16861374	150.609128	01-01-1994	BioNet Atlas of NSW Wildlife

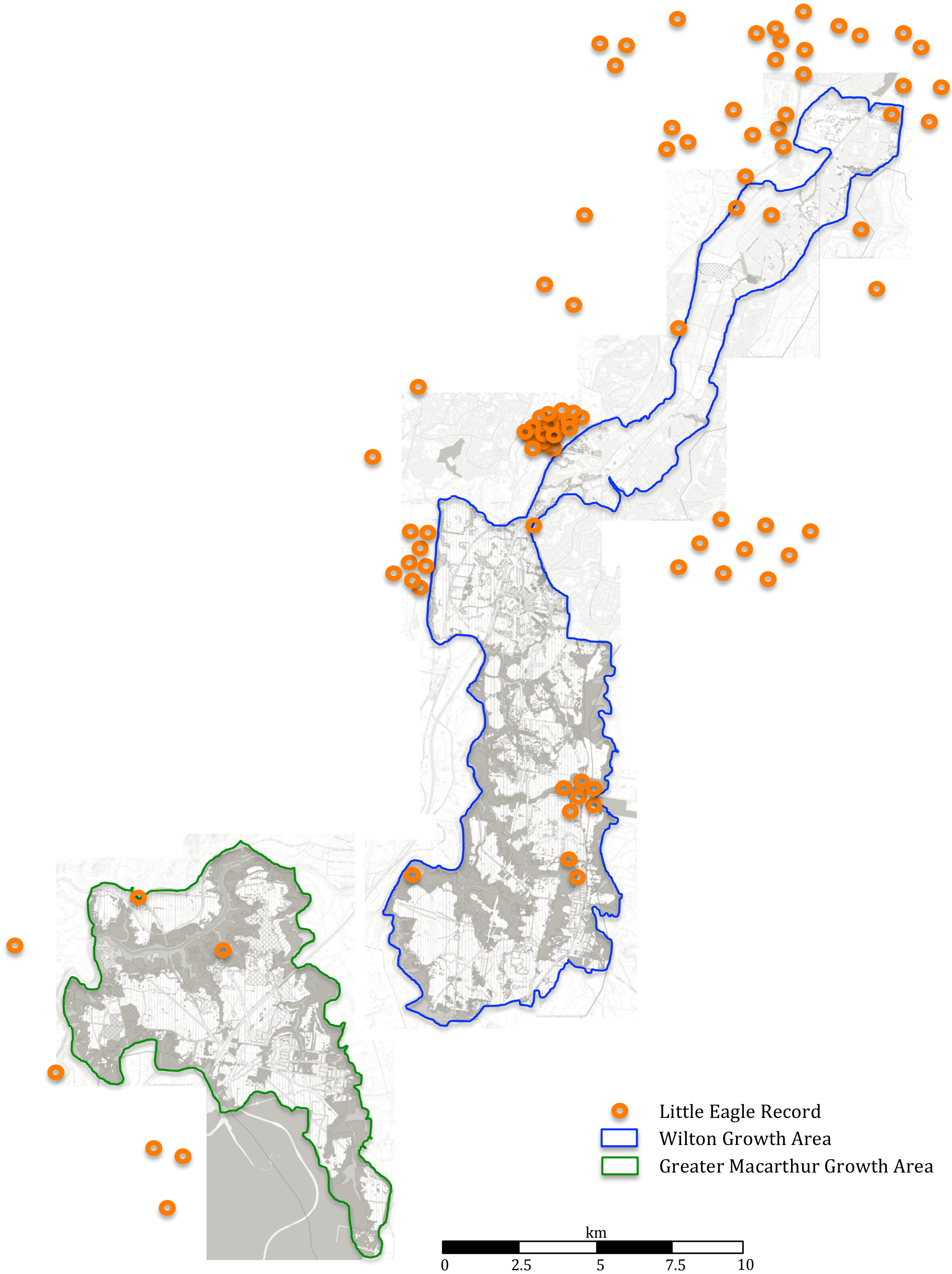

Figure 2. Species records for the Little Eagle *Hieraaetus morphnoides* in and around the Greater Macarthur and Wilton Growth Areas (source ALA and CBOC Inc.).

Of these 78 records, 15 were within the Greater Macarthur growth area and the Wilton growth area. The other 63 records are within 5 kilometres of the boundaries of the growth areas. There was no discernible seasonality in the records, although they were slightly more common from January through to May (the post-breeding dispersal phase). Records from August to December raise the possibility of the Eagle breeding in the vicinity of the growth areas or within 10 km. For instance, possible breeding behaviour (mating) was observed near Camden where a pair was regularly seen, although no nest was found on the site (a 1600 ha agricultural research station: Starr *et al.* 2004). Most of the Eagle records are associated with large patches of open woodland that occur within open grassland areas, such as pastureland and parkland; some are found in forest along watercourses and were obtained close to the edges of remnant forest. A few records were from woodlands associated with wetlands. The records support the conclusion that a mosaic of open woodland and open grassland with scattered trees provides important habitat for the Eagle. We are not aware of any previous habitat assessments for the Little Eagle in the study area.

Assessment of Suitable Habitat in the Growth Areas, Distribution Polygons and Justification for Determination

The areas of potential breeding and foraging habitats for the Greater Macarthur growth area are shown in maps 1 to 7 in Figure 3. The areas of potential breeding and foraging habitats for the Wilton Growth Area are shown in maps 1 to 3 in Figure 4. The existing remnant patches containing potential habitat for the Eagle are shown as an overlay over the vegetation maps. Sites where the habitat structure, plant community type and placement in the landscape all indicate potential breeding habitat breeding and foraging habitat for the species are shown in red. Some areas have potential as foraging habitat but a low likelihood for breeding and these are shown in orange. Some of these areas are within the proposed urban development footprint and have been included because they satisfy several of the following conditions. They contain good edge habitat adjacent to an existing habitat remnant e.g. open areas with scattered trees, provide good foraging habitat, provide connectivity between existing remnants, contain a mosaic of woodland patches and open grassland, broaden a connecting corridor or protect an edge habitat (shown in yellow). They also provide a buffered foraging area between habitat areas and the urban development footprint. Other areas, which also satisfied any of these same conditions and that are not within the urban development footprint, are included as they are areas where habitat enhancement would improve the Eagle's access to resources within the growth areas (shown in green).

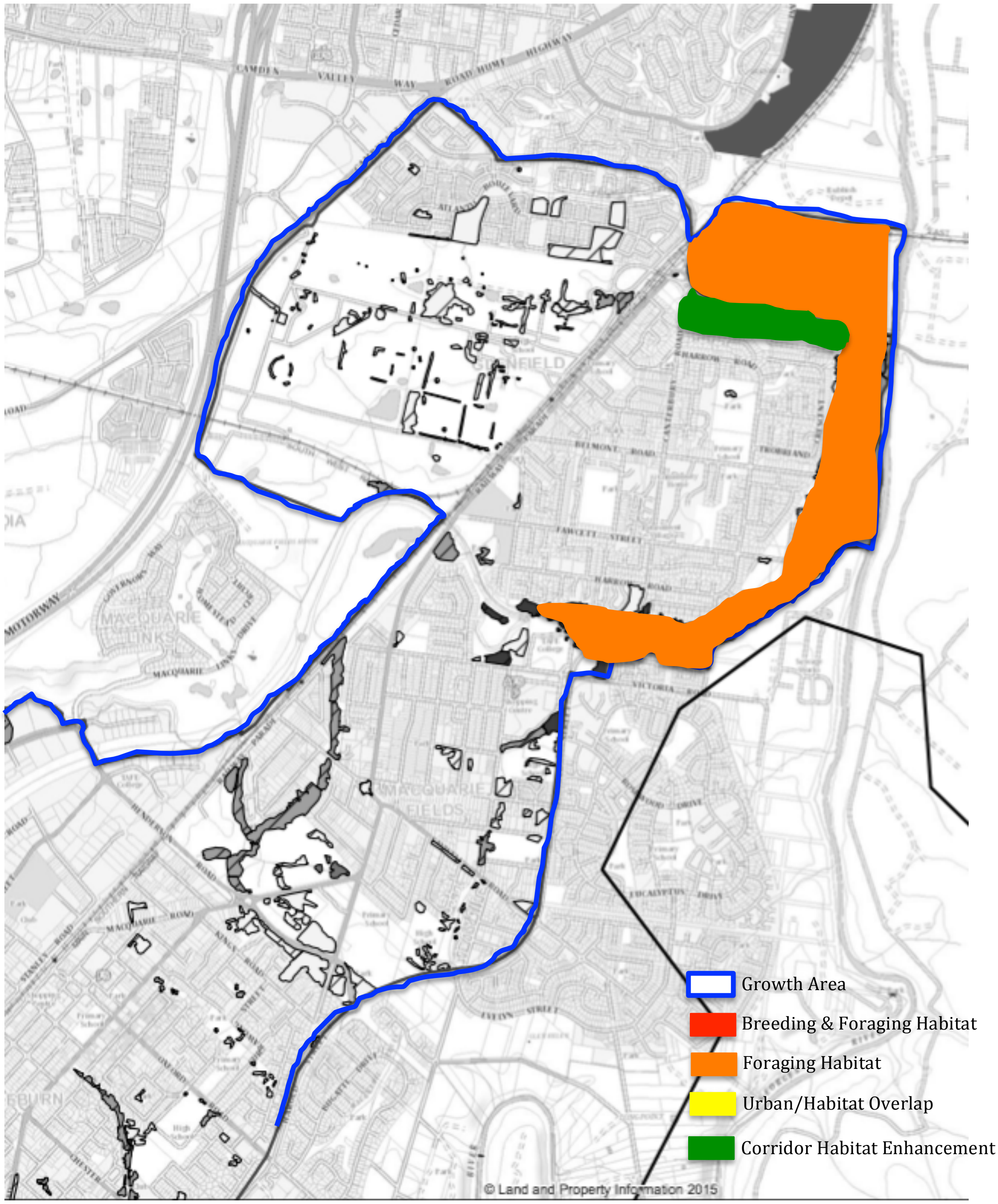

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 1). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

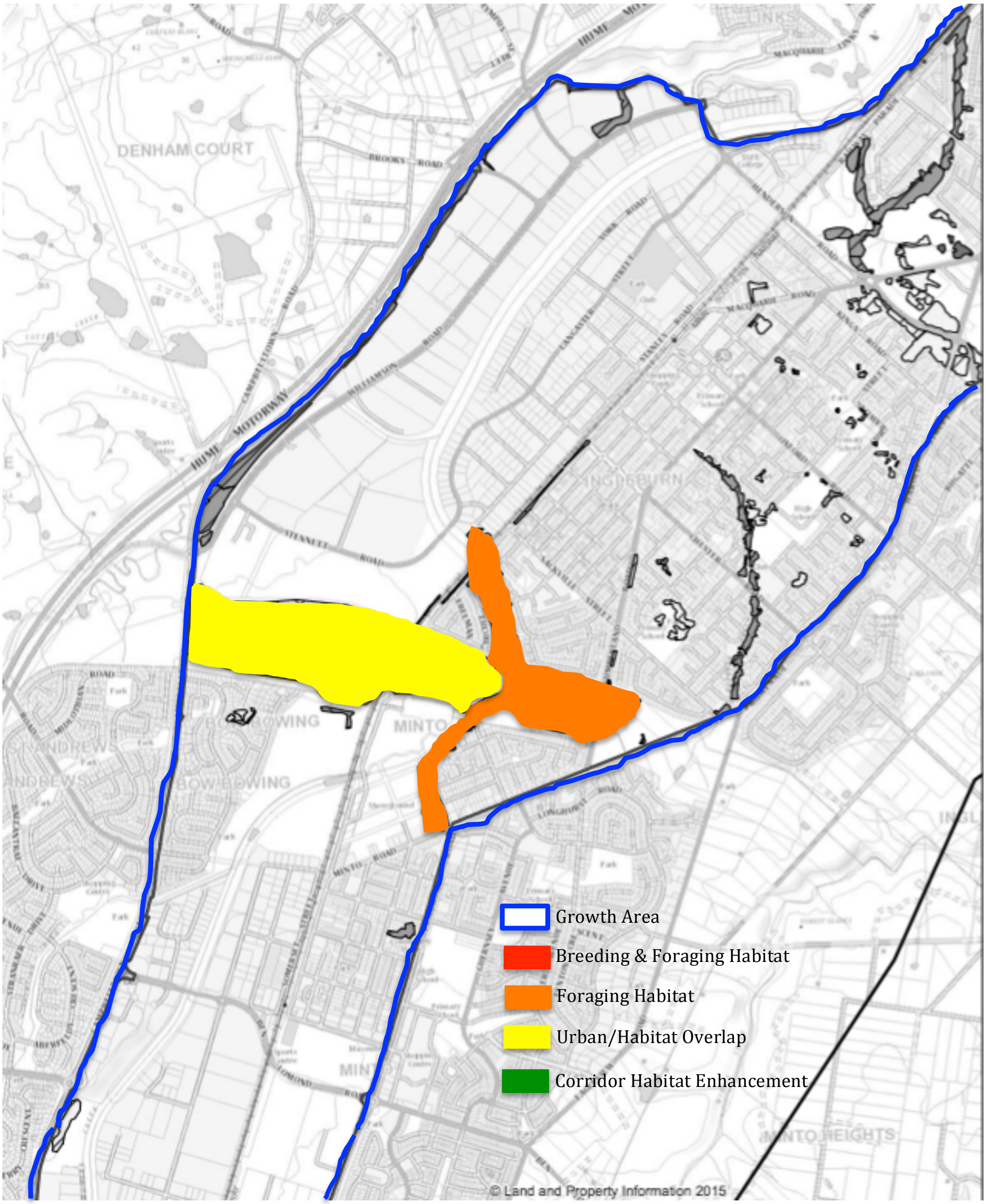

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 2). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

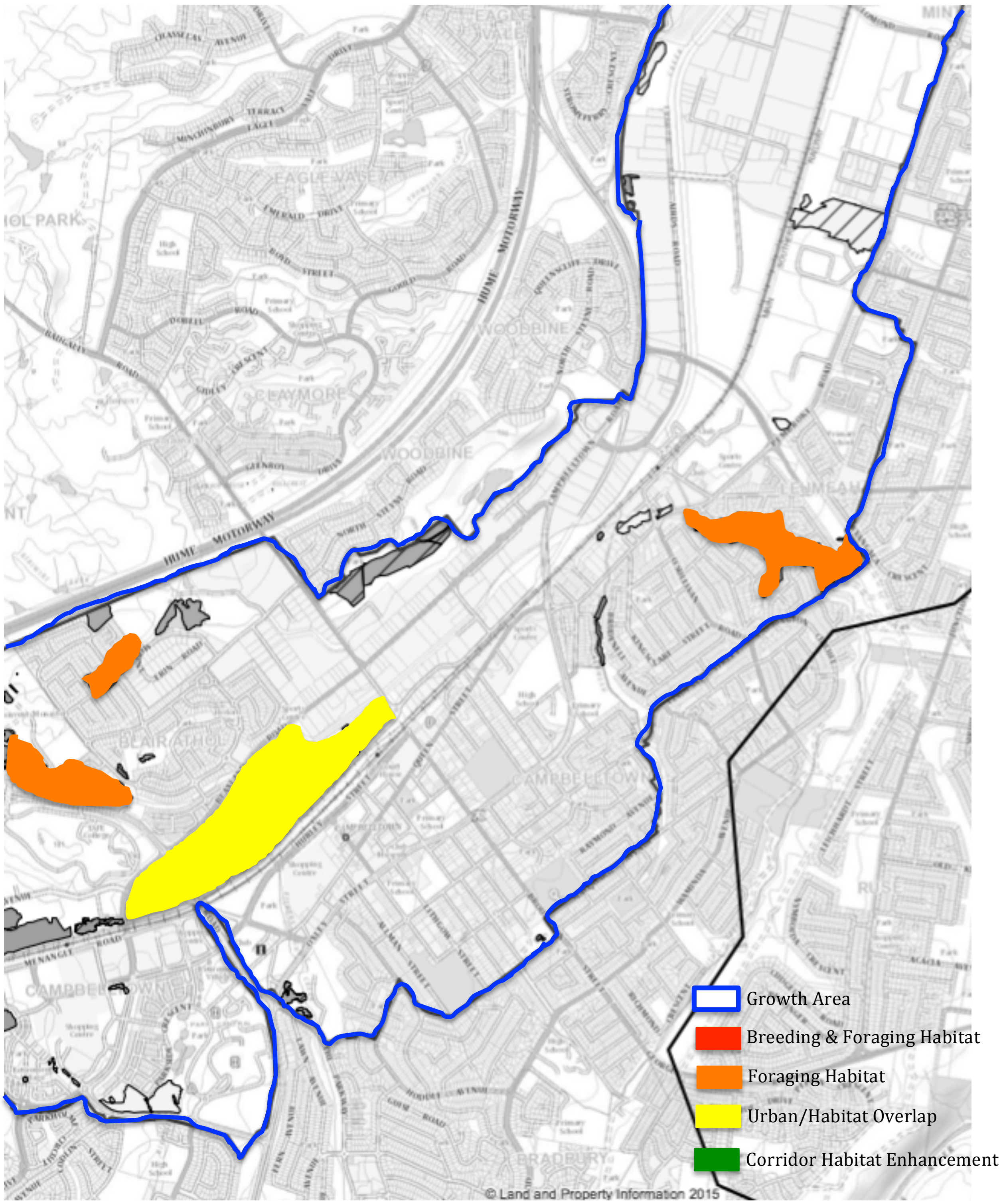

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 3). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

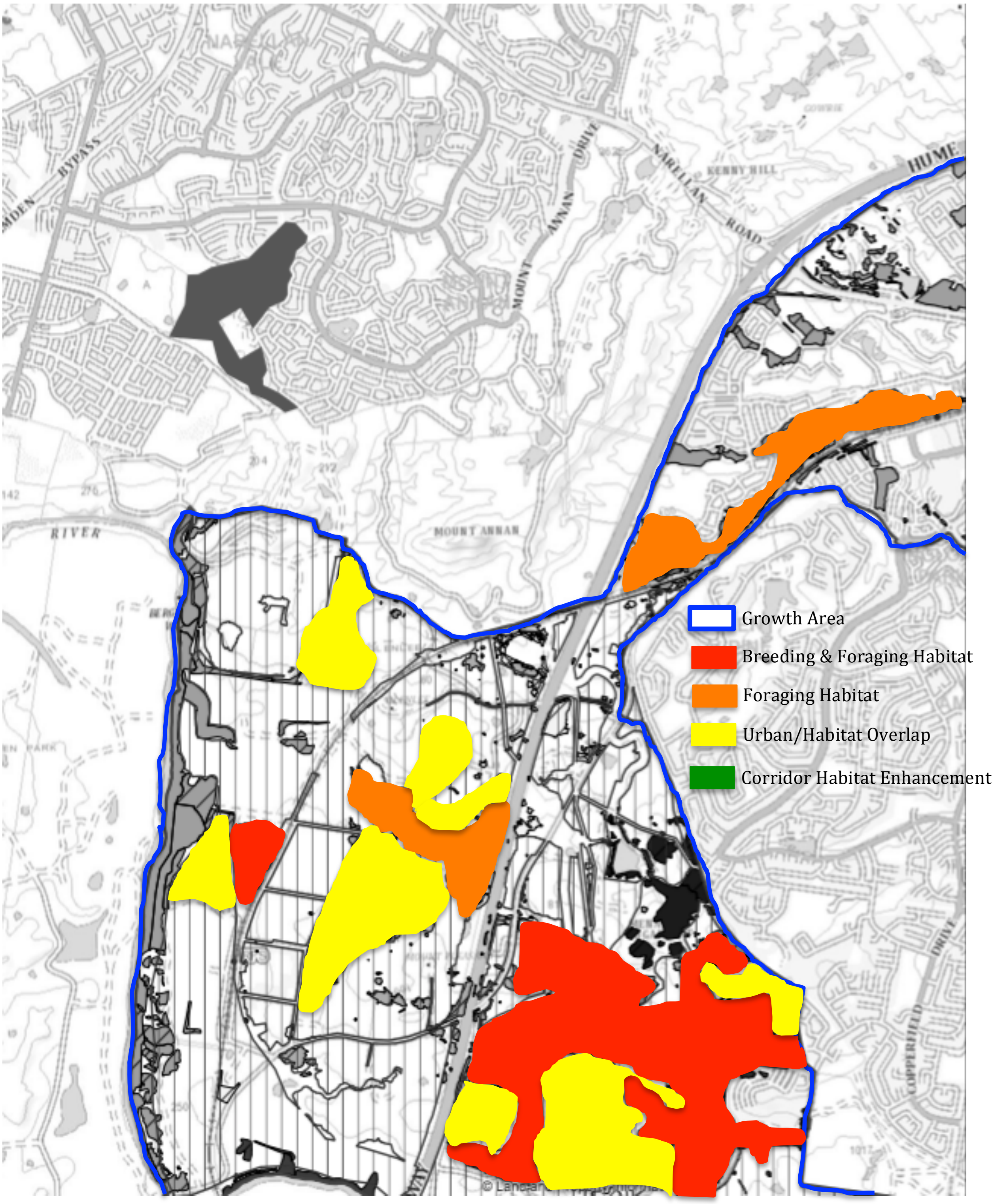

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 4). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

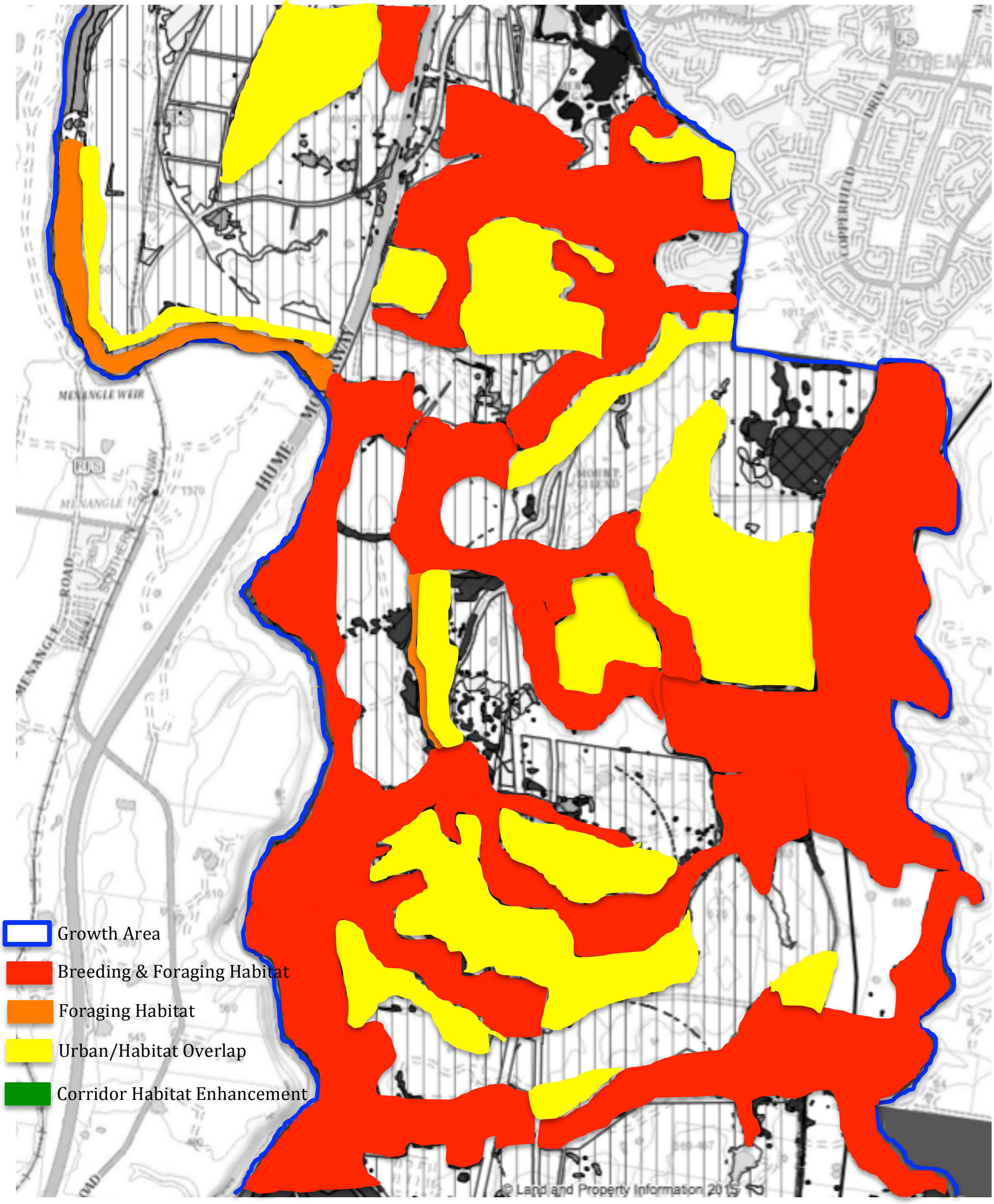

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 5). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

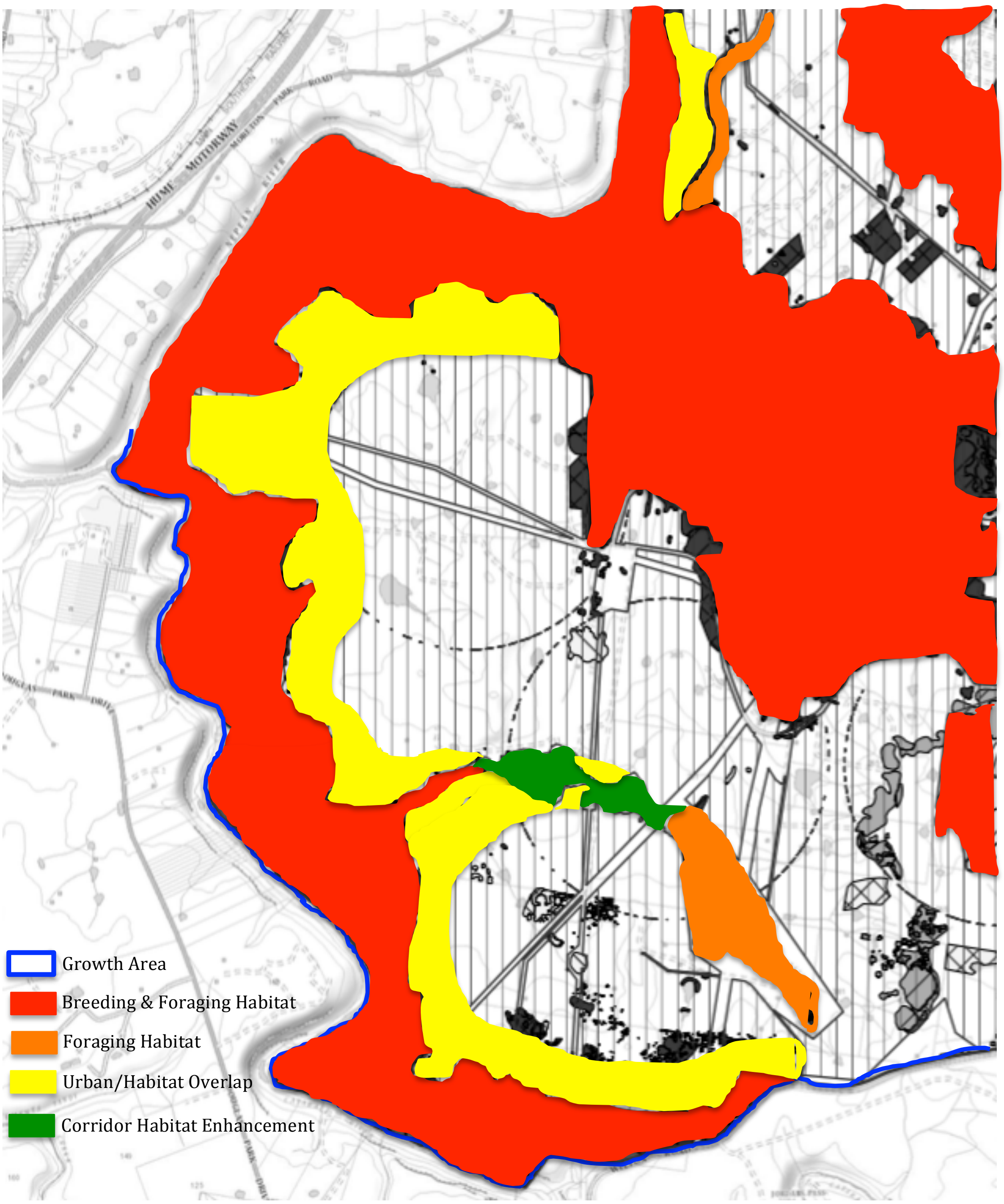

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 6). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

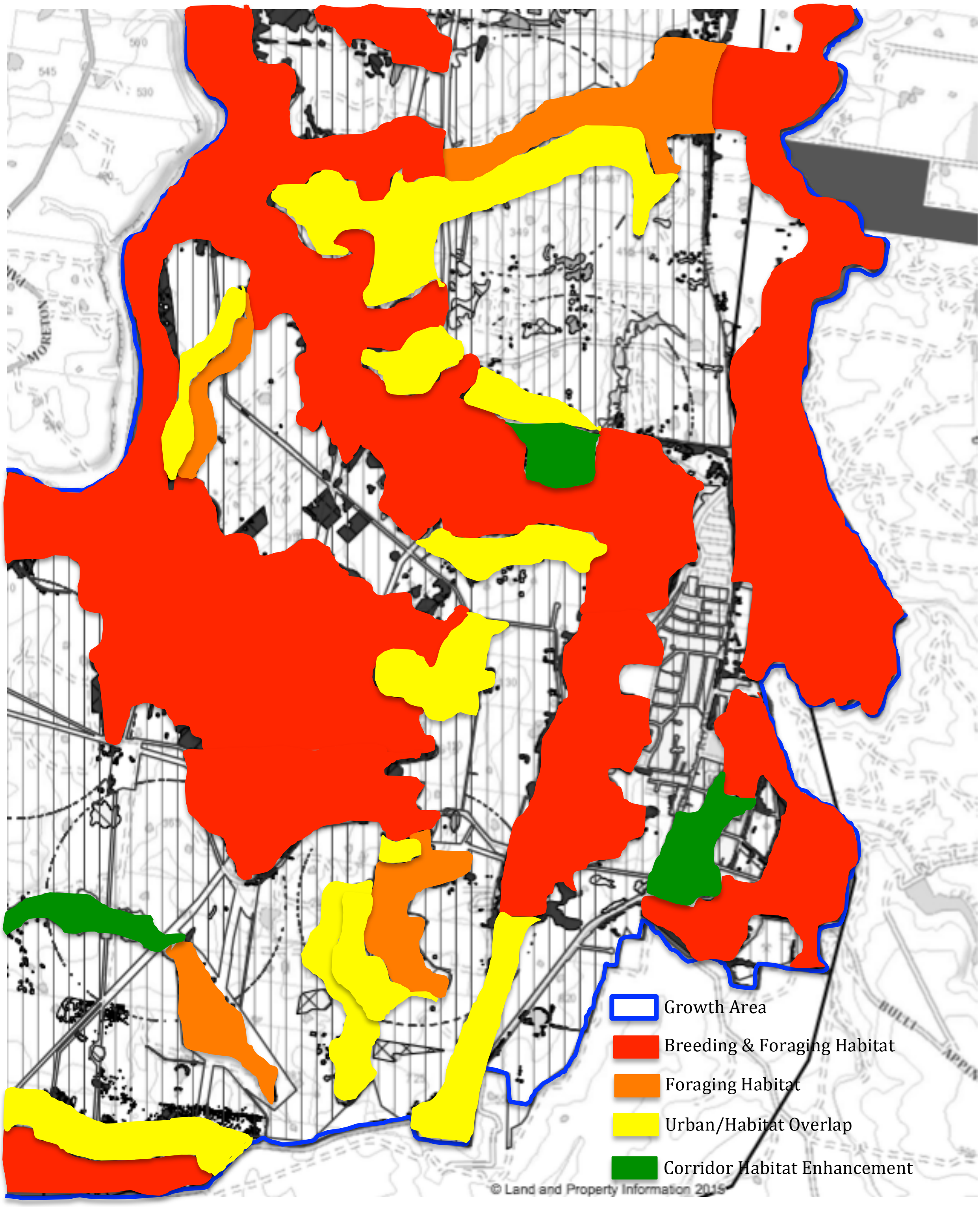

Figure 3. Potential breeding and potential foraging habitat for the Little Eagle in the Greater Macarthur growth area (Map 7). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

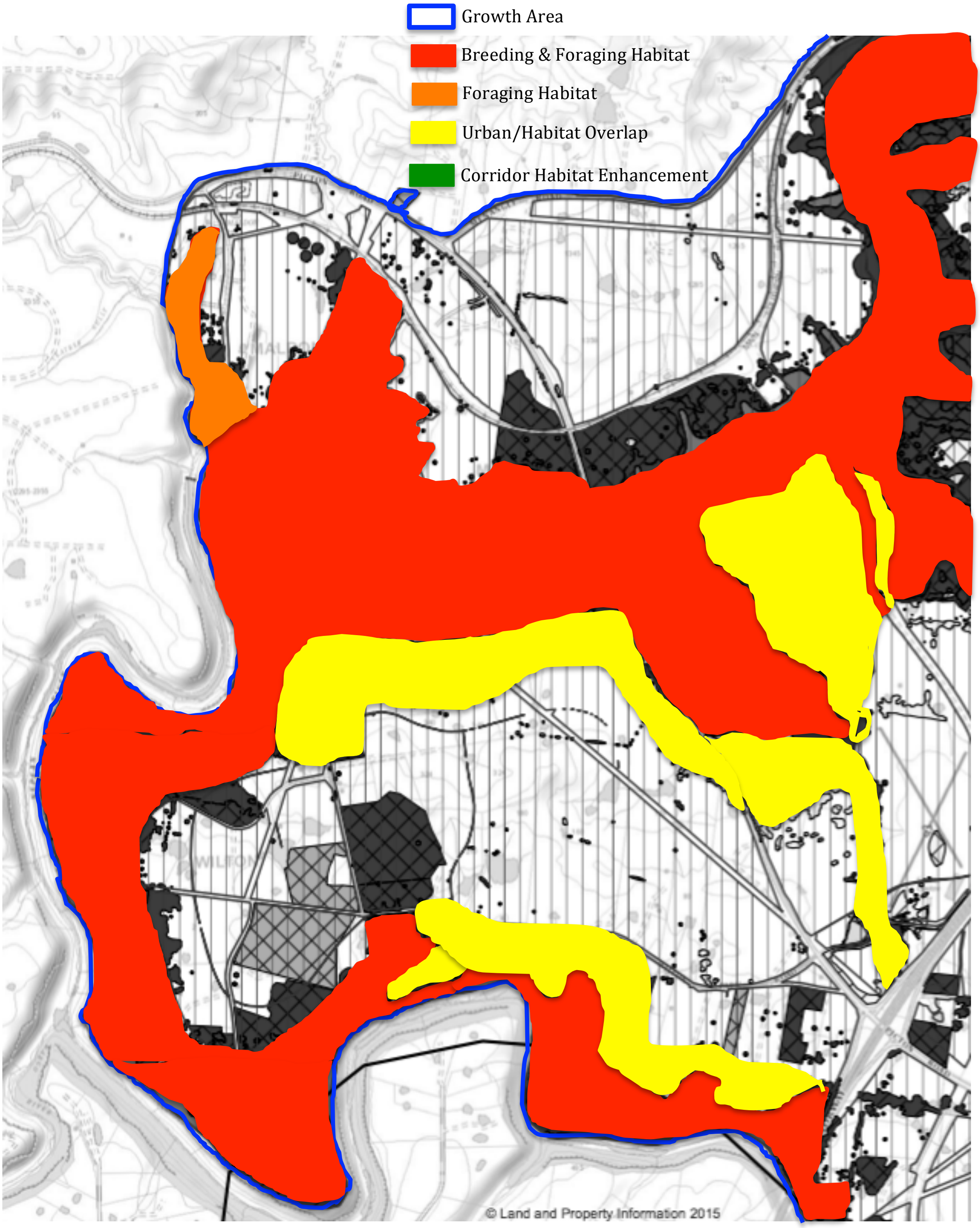

Figure 4. Potential breeding and potential foraging habitat for the Little Eagle in the Wilton growth area (Map 1). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

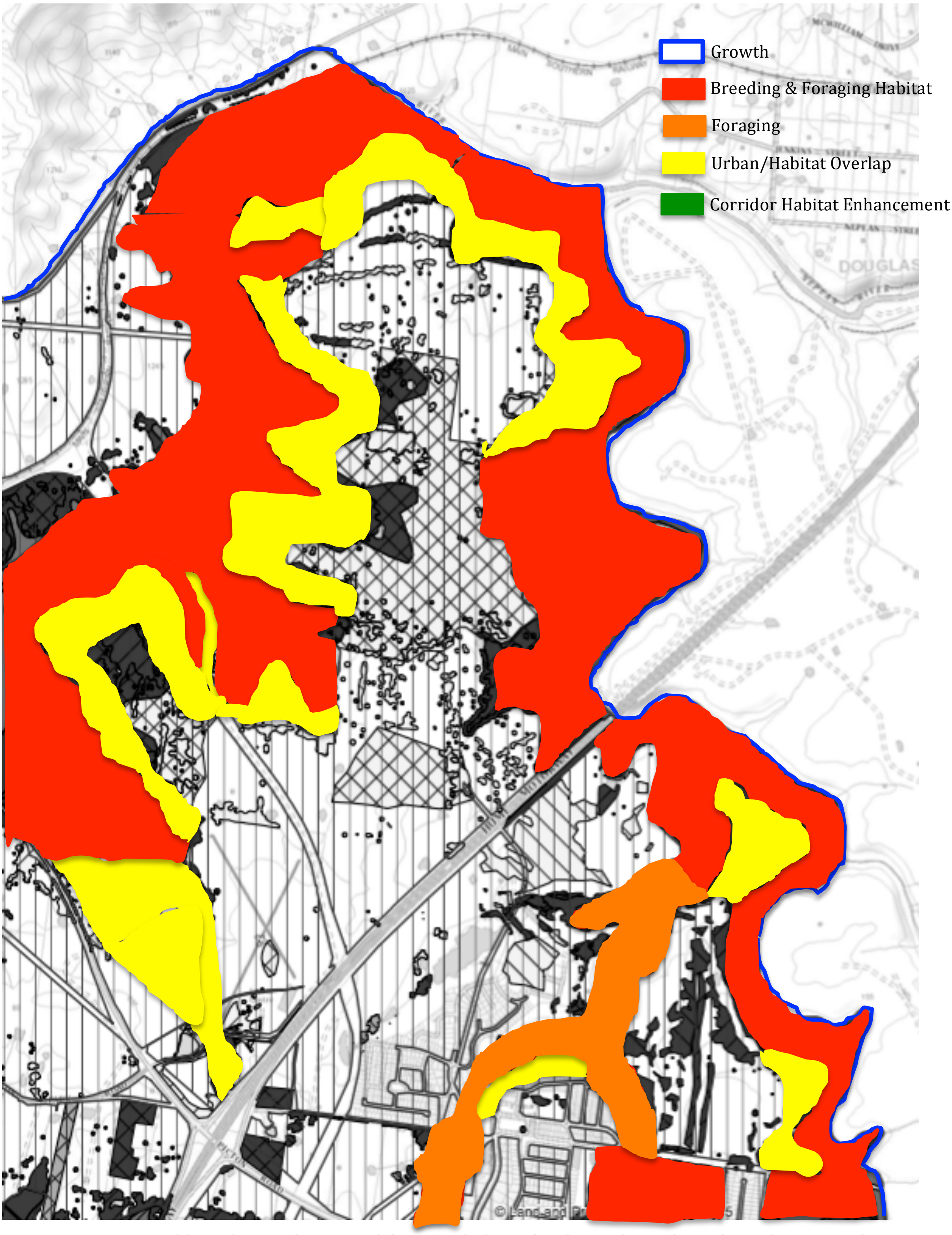

Figure 4. Potential breeding and potential foraging habitat for the Little Eagle in the Wilton growth area (Map 2). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

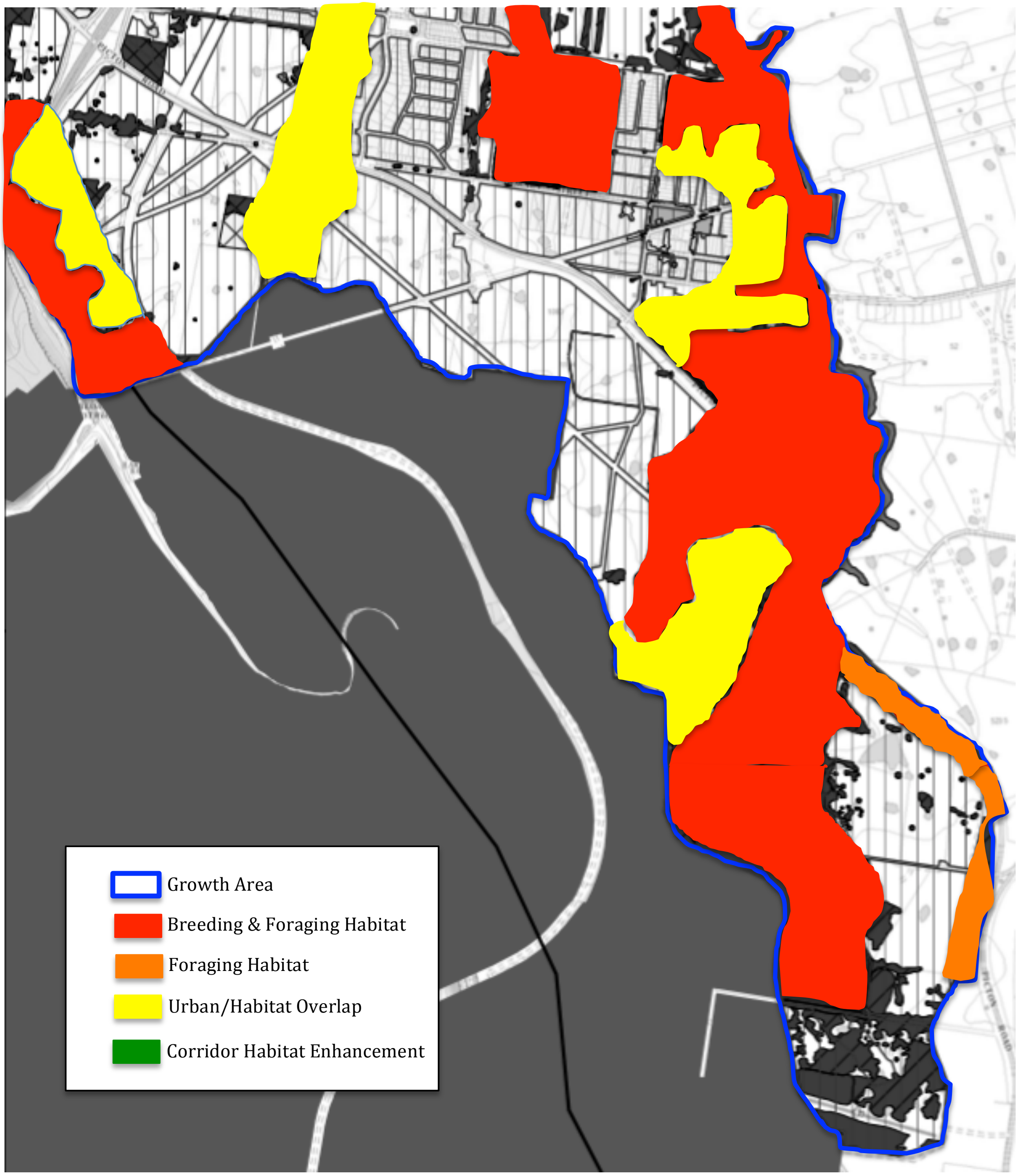

Figure 4. Potential breeding and potential foraging habitat for the Little Eagle in the Wilton growth area (Map 3). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

Assessment of the Likelihood of Species Presence in the Growth Areas, Distribution, Population Estimate and Justification for Determination

There is a very high likelihood of Little Eagles occurring within the growth areas at any time of the year. The habitat remnants within the growth areas are tall open forests and woodland, are mostly along watercourses and have abundant edges. There are also areas of open woodland dispersed through open grazing land with scattered trees. These factors provide good foraging habitat for the Eagle. The Eagle has also been recorded in most of the plant community types that occur within the growth areas, and again this aspect supports a high likelihood of Little Eagles occurring in the site.

No nests have ever been recorded in the growth areas and no evidence of breeding was observed during surveys by Biosis or by the authors. Although breeding has not been observed within the growth areas it is very likely that they forage in the area while breeding outside the growth areas. As the Little Eagle is considered to be resident for at least several consecutive years while nesting it is likely that if nesting has occurred within the growth areas it should have been detected. However, the Eagle has nested in similar situations elsewhere and nesting within the growth areas would also be possible as there is suitable nesting habitat within the growth areas. This view is supported by the occurrence of records for the Eagle within and around the growth areas in the breeding season, and the mating pair observed by Starr *et al.* (2004) near Camden.

The minimum requirements for Little Eagle nests are described in Tables 1 and 2. The Greater Macarthur and Wilton growth areas are more similar to Canberra than to Armidale. Armidale is a large town surrounded by a mosaic of remnant patches of vegetation and cleared grazing pastureland, whereas, Canberra and the growth areas are more spread-out and scattered along transport corridors. This implies that the minimum nesting requirements for Canberra in Table 1 are more relevant to this study.

The distribution of records and the size of a breeding territory at about 3 kilometres radius, as reported in the literature (see above), suggest that there are likely to be 4 to 6 breeding pairs in the area. There is likely to be a pair at the north end of the Greater Macarthur growth area as there are 36 records from this area. The sightings are associated with the large rural subdivision areas with scattered woodland remnants around Kemps Creek and with the Georges River woodland corridor. Sightings within the growth area suggest that the Eagles come in for foraging. It is possible that more than one pair is associated with this area.

The next important area is towards the middle of the Greater Macarthur growth area with another 34 records from this area. The sightings are centred on the Mount Annan Botanical Gardens and the area of woodland mosaic between Camden Park and the Nepean River. These two areas are 5 kilometres apart and there is sufficient habitat to support another 2 pairs of Eagles here. There is also much suitable foraging habitat east of these two locations within the growth area that provide foraging habitat. Although there was only one sighting within this part of the growth area it is likely that they would have been detected more frequently with more survey effort.

The next important area is in the south of the Greater Macarthur growth area along the forest edges found along Appin Road and around Appin. There is likely to be another pair here that could nest within or adjacent to the growth area. There are open grassland areas on the edges of forest remnants and along watercourses associated with the Nepean River that provide good foraging and breeding habitat. There is also likely to be another pair associated with the Nepean River around the Wilton to Pheasants Nest area. There were 7 sightings in this area and 2 of them were within the Wilton growth area.

In summary, the evidence suggests that the Little Eagle is found within the growth areas of Greater Macarthur and Wilton and that there are likely to be 4 to 6 pairs resident in the area. However, no evidence of breeding as defined by the presence of a bird on a nest or by the presence of pairs of birds in suitable habitat was observed within the growth areas. The presence of suitable foraging habitat within these growth areas means that protection of habitat within them may be critical to the continued presence of the Eagle in the area. It will also be important to provide a 100 m to 200 m buffer of open grassy woodland between any urban development and forest remnants to not only provide foraging habitat but also to prevent disturbance during nesting attempts within the growth areas.

5. Information Used in the Assessment

Data:

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BioNet Atlas of NSW Wildlife (accessed 29-06-2018).

Biosis - vegetation mapping and field survey data (supplied by the Department of Environment and Planning 21-05-2018).

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References:

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Atlas of Living Australia - occurrences of Little Eagle and Little Eagle in Liverpool, Campbelltown and Wollondilly LGAs. accessed 29-06-2018. <https://biocache.ala.org.au/occurrences/search>

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Debus, S.J.S. 1984 Biology of the Little Eagle on the Northern Tablelands of New South Wales. *Emu* 84: 87-92.

Debus, S.J.S. 1993 Falconiformes, Accipitridae, Falconidae, Gurney's Eagle, Little Eagle, Little Eagle, Osprey texts in Marchant, S. & Higgins, P.J. (Eds), *Handbook of Australian, New Zealand and Antarctic Birds, Vol. 2: Raptors to Lapwings*. Oxford University Press, Melbourne.

Debus, S.J.S., Hatfield, T.S., Ley, A.J. & Rose, A.B. 2007 Breeding biology and diet of the Little Eagle *Hieraaetus morphnoides* in the New England region of New South Wales. *Aust. Field Ornithology* 24: 137-157.

Debus, S.J.S. & Ley, A.J. 2009 Aspects of the breeding cycle of the Little Eagle *Hieraaetus morphnoides*. *Australian Field Ornithology* 27: 76-99.

Debus, S.J.S. 2011 Parental time-budgets and breeding behaviour of the Little Eagle *Hieraaetus morphnoides* in northern New South Wales. *Corella* 35: 65-72.

Debus, S.J.S. 2012 *Birds of Prey of Australia: A Field Guide (2nd ed.).* CSIRO Publishing, Clayton South.

Debus, S.J.S., Olsen, J., Judge, D. & Butterfield, M. 2013 Numbers of breeding Little Eagles *Hieraaetus morphnoides* near Canberra in relation to atlas counts. *Corella* 37: 30-32.

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Garnett, S. (ed) 1993 *Threatened and Extinct Birds of Australia RAOU Report Number 82.* Royal Australasian Ornithologists Union and Australian National Parks and Wildlife Service, Moonee Ponds, Victoria.

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Olsen, J., Debus, S.J.S. & Judge, D. 2013 Declining Little Eagles *Hieraaetus morphnoides* and increasing rabbit numbers near Canberra: is secondary poisoning by Pindone the problem? *Corella* 37: 33-35.

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Starr, M., Starr, M.J. and Wilson, S.C. 2004 Raptor populations at an agricultural site featuring sustainable farming practices near Sydney, New South Wales. *Australian Field Ornithology* 21: 67-71.

6. Curriculum Vitae

Dr Tony Saunders

Name: Anthony Stephen John Saunders

Contact Details: 1878 Taralga Road Laggan NSW 2583 0409 399 849

Academic Qualifications:

BSc University of Sydney 1976
Dip Ed Sydney Teachers College 1977
PhD University of Western Sydney 2005

Other Qualifications:

LR Drivers Licence
Public Vehicle Driver Authority
Work Health & Safety General Construction Induction (White Card)
Chemical Use and Handling Certificate
Resuscitation Certificate
Emergency Care Certificate
Anaphylaxis Training Certificate
Drone Essentials Certificate

Fields of expertise:

Bird habitat assessment on reserves, lands in production and potential offset property.
Bird monitoring in natural, modified and managed habitats.
Assessment of likelihood of threatened woodland bird species occurrence on development sites.
Coordinating projects between government and non-government organisations.
Coordination of volunteers collecting wildlife data.
Ecotourism: guiding general interest and specialists groups in flora and fauna.
Environmental and science education at high school, TAFE, and university levels.
Habitat management for terrestrial woodland birds and other wildlife.
Presentations on ecology to public interest groups and at professional workshops.
Remote area wildlife atlassing.
Wildlife database design and management.
Land for Wildlife assessments and habitat enhancement planning.

Professional positions held:

2010 - 2018	Merops Services Pty Ltd (director, avifaunal ecologist). Environmental and landscape consultant and contractor, flora and fauna surveys, habitat enhancement plans.
2013 - 2018	Land for Wildlife Assessor for Community Environment Network
1995 - 2010	Merops Services (avifaunal ecologist). Environmental and landscape consultant and contractor.
2006 - 2018	Part-time teacher, mainly science, but also industrial arts, English and maths, Crookwell High School, Goulburn High School and Trinity Grammar School.
1997 - 2005	Part-time bird guide and ecotourism bus driver.
1993 - 2004	Part-time lecturer, supervisor and demonstrator, University of Western Sydney (biology, ecology and field survey techniques).
2001 - 2004	Atlas Facilitator, Birds Australia (organising remote atlassing, facilitating data exchange and communication between Birds Australia, state government organizations and other non-government organisations).
1997	Field Technical Officer, Birds Australia (monitoring breeding success of endangered bird species).
1996	Field Technical Officer, University of Western Sydney (reptile, bird and plant survey techniques and data analysis).
1978 - 1994	High School Science Teacher at Marsden, Heathcote, Penrith and Kingswood High Schools.

Other volunteer positions held:

2014 - 2017	Assistant to Co-ordinator of the Sydney Bird Fair.
2009 – 2018	President - Crookwell Native Flora and Fauna Club.
2013 - 2018	Secretary - Grabine/Foggs Crossing Landcare Group
2001 - 2018	Avifaunal Advisor and Education Officer for Oolong Sanctuary, Dalton.
1997 - 2010	Project Manager for Atlas of Birds of the County of Cumberland.
2010 - 2018	Technical advisor to the Cumberland Bird Observer's Club's Atlas Databasae Management Committee.
1996 - 2009	Committee Member - CBOC (Cumberland Bird Observers Club Inc.).
1998 – 2014	CBOC representative to Bird Interest Group Network (BIGnet).
1997 - 2002	Faunal Advisor for the Hawkesbury Rainforest Network.
1999 - 2002	Member of Steering Committee of Birds in Backyards for Birds Australia.
1998 - 1999	Consultant to Birds Australia Birds for Birds in Backyards Project.
1998 - 2003	Regional Organiser for Sydney and the Blue Mountains, NSW facilitator and NSW/ACT representative on the Steering Committee for the National Bird Atlas for Birds Australia.
2002	Representative on NSW NPWS Wildlife Issues Advisory Panel for Birds Australia.

Relevant experience:

Co-ordination, facilitation and organization of exhibits and presentations at field-day events and indoor venues. This has involved allocating space, providing necessary facilities and setting-up audio-visual equipment for exhibitors and presenters (18 years)

Co-ordinator of volunteers for the CBOC Inc. and the Birds Australia national birds atlas. (13 years)

Facilitated the BIGnet data exchange agreement between Birds Australia, NSW Bird Atlassers, Canberra Ornithologists Group and the Cumberland Bird Observers Club. Facilitated bird data exchanges between Birds Australia, NSW State Forests and NSW DECC. (4 years)

Presenter at seminars for Bushcare, Landcare, Greening Australia, Wires and local councils, conservation societies and garden clubs on habitat management for birds and bird survey techniques. (32 years)

Educator at public, tertiary and secondary levels in the area of bird habitat management and bird survey methodology. (23 years)

Ecotourism and bird guiding (19 years).

Undertaking avifauna surveys of sites for development applications and assessment of status of threatened bird species on sites and making recommendations for minimising impact of development on these species.

Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (21 years)

Design, building and management of the bird database for the birds of the County of Cumberland on behalf of CBOC Inc. (16years)

Membership and professional affiliations:

Australian Bird Study Association
Australian Bush Heritage
Birdlife Australia
Crookwell Native Flora and Fauna Society
Cumberland Bird Observers Club
Ecological Consultants Association of NSW
Grabine/Foggs Crossing Landcare Group
Greening Australia
NSW Bird Atlassers
Royal Zoological Society (Scientific member)
Wildlife Preservation Society of Queensland

Papers, Articles and Reports:

Saunders, T. 1985. Common Bronzewings at Round Hill Nature Reserve. *CBOC Newsletter* Vol. 6 No. 6 : 5

Saunders, T. 1986. Eastern Bristlebird at Ku-Ring-Gai Chase National Park. *CBOC Newsletter* Vol. 8 No. 2 : 1

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Saunders, T. 2011 *Habitat Enhancement Plan for 'Garrallan' Cowra*, Unpublished Report.

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Saunders, T. 2015 *Land for Wildlife Assessment for Lot3 DP 789337 Taralga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot 57 Bevendale*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48541Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

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Saunders, T. 2016 *Land for Wildlife Assessment for 'The Angle' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Bobbins' Reids Flat*, Unpublished Report.

Saunders, T. 2016 Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future.' Australian Bird Study Association Conference - 23 January 2016. *Corella* 40: 46

Saunders, T. 2016 *Bird surveys, likelihhood for threatened birds and habitat description for Syerston Mine Project, Fifield,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bohara' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Greendale' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bunduluk' Laggan*, Unpublished Report.

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Saunders, T. 2017 *Bird surveys, likelihhood for threatened birds and habitat description for Vickery Mine Project, Boggabri,* Unpublished Report.

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Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 'Tanjenong' Abercrombie*, Unpublished Report.

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Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 1206394 Red Ground*, Unpublished Report.

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Maxwell Mine Project, Jerrys Plains,* Unpublished Report.

Saunders, T. in prep. Trends in woodland bird populations on the Cumberland Plain.

Thesis:

Saunders, A.S.J. 2006 Comparative Foraging Ecology of the Noisy Friarbird *Philemon corniculatus* and the Red Wattlebird *Anthochaera caruncalata* in central eastern New South Wales.

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BA (Biol./Behav. Sc.), Dip. Natural Resources (Wildlife), Dip. Ed. (Sci.), MSc. (Zool.), PhD (Zool.)

Contact details:

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Professional capacities:

Vertebrate fauna surveys. Research and survey of threatened forest and woodland birds, particularly raptors and owls. Ecology/biology/behaviour of birds, especially predatory species. Conservation and management of threatened bird species. Distribution, status and biology/ecology of NSW birds. Reviews and biological profiles of bird species. Editing ornithological papers. Peer review of ornithological documents/EISs/species impact statements. Impact assessment (avifauna). Review of conservation status of NSW fauna.

Computer skills:

Proficient in Word and Excel, limited experience with GIS and ArcView

Employment:

Eco Logical Australia 2011-18 (casual; senior ecologist: fauna survey and report)

EA Systems (now EnviroAg Australia) 2000-14 (casual; ecologist: fauna survey and assessment)

Research assistant, Zoology, UNE, casual 1984-2014 (field ornithology: bird banding, bird surveys/censusing, ecological studies)

Tutor/demonstrator, Zoology UNE (casual), 2007-13

NSW Dept Environment & Climate Change, 2008-09 (temporary) (threatened species officer: Project Officer, NSW Scientific Committee)

Research Assistant, Ecosystem Management UNE (casual), 2008-09 (bird survey)

Post-doctoral research fellow, Zoology, UNE, 2005-07 (ecology of woodland birds)

Junior research fellow, Zoology, University of New England, 1990-1993, 1998-2004 (ecology of rare forest owls in relation to habitat and forest management; ecology and management of birds)

Technical officer, University Partnerships Pty Ltd (UNE), 1995-1996 (fauna survey and report, Eastlink EIS)

Casual assistant demonstrator, Depts Zoology and Ecosystem Management, UNE, 1988-2002 (field practical classes on population ecology and behavioural ecology of birds)

Casual teacher, New England Institute of TAFE, 1987-1993 (bird biology: including laboratory and field practical classes on classification, identification and ecology)

Field technician, National Parks & Wildlife Service Armidale, 1986 (fauna inventory, vegetation sampling and analysis)

Research assistant, Department of Ecosystem Management, University of New England, casual 1986-1987 (field survey of vegetation and fauna)

Honorary position:

Adjunct associate lecturer/research associate, Zoology UNE, 2004-2017 (includes collaborative research and publication, co-supervision of Honours/Masters/PhD students)

Consultant biologist:

Whitehaven Coal 2018 (field survey, assessment and report on potential BioBank site for Regent Honeyeater)

Northern Tablelands Local land Services 2017-18 (Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report)

North West Local Land Services 2015-18 (Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting)

28 South Environmental 2013-2018 (threatened fauna survey/assessment and report)

Fenner School of Environment and Society, Australian National, University 2016-17 (Regent Honeyeater surveys and data submission)

3E Environmental 2012-17 (flora & fauna survey and reporting)

BirdLife Australia – Northern NSW (for Bundarra-Barraba Operations Group of the Regent Honeyeater Recovery Team), 2007-17 (Regent Honeyeater/woodland bird survey and monitoring)

Southern New England Landcare 2014-16 (fauna surveys on farms, data submission, landholder workshop, report review)

James Warren & Associates 1997-2016 (fauna survey and reporting)

Conacher Environmental Group 2008, 2015 (fauna survey and report)

Ecotone Environmental Services 2012-13 (peer review of threatened fauna assessment; targeted fauna survey: federally listed birds)

NSW National Parks & Wildlife Service/Dept Environment & Conservation/DECC 1987-2013 (fauna survey, review of avifaunal component of environmental impact statements/ fauna impact statements/fauna reports, preparation of recovery plans and species profiles for threatened species)

Australian Museum, 1995, 2012 (review of fauna impact statement, avifauna; feather sampling of wild-caught birds for DNA analysis)

Cumberland Ecology 2004-2012 (fauna survey and report)

Arnhem Environmental 1996-2012 (fauna survey)

Eco Logical Australia 2010-2011 (threatened bird research, fauna database compilation)

Warkworth Mining Ltd 2008, 2011 (avifauna survey and report)

Terra Consulting/Geolyse/Orogen 2004-11 (fauna survey and assessment)

State Forests of NSW 1987-2009 (fauna survey, review of avifaunal component of environmental impact statements/fauna impact statements/fauna reports, fauna survey worskhop)

TransGrid 2009 (investigation and report: bird-related outages on 500 kV transmission lines)

Earth Services 2007-08 (fauna survey and report)

Armidale Dumaresq Council 2006-08 (fauna assessment)

Tamworth Regional Council 2007-08 (starling control/raptor assessment)

PLACE Environmental 2006-07 (fauna assessment)

ACT Planning & Land Authority 2005-06 (fauna survey and assessment)

Greenloaning Biostudies 1996-2004 (fauna survey)

Burnett Shire Council 2003 (fauna survey and assessment)

Inverell Shire Council 2003 (fauna assessment)

HWR Ecological 2003 (fauna survey)

WBM Oceanics 1999-2002 (fauna survey)

Resource Strategies 1999 (fauna survey)

Network Design & Construction Ltd, 1999 (fauna survey)

Woodward-Clyde Pty Ltd, 1994-1999 (fauna survey)

Telstra Environmental Evaluation Team 1998 (fauna survey and report)

Maunsell Pty Ltd, 1995-97 (fauna survey, review of environmental assessment)

Austeco Pty Ltd, 1990-1997 (fauna survey)

North-west Ecological Services 1997 (fauna survey)

ANCA 1995-1996 (fauna survey, Jervis Bay National Park)

SA National Parks & Wildlife Service, 1995 (fauna survey)

Grants and awards:

Search for Red Goshawk in NSW: $1,000 from the Australian Bird Environment Fund (Bird Observers Club of Aust.), 1987.

Distribution, status and habitat requirements of the Sooty Owl in northern NSW: $2,000 as a Cayley Memorial Scholarship (Gould League of NSW) 1990-93; with Associate Professors Hugh Ford & Harry Recher (UNE), $34,280 from WWF Australia and $64,835 from ANPWS (Endangered Species Program) 1990-93.

Will wildlife corridors work for sedentary birds?: with Professor Hugh Ford, $42,565 from the NSW Environmental Trust 2005, $43,359 in 2006-07.

Bird Observers Club of Australia: Distinguished Service Award, 2005 (editing the *Australian Bird Watcher*/*Australian Field Ornithology* for 21 years 1984-2005).

Royal Zoological Society of NSW Whitley Award, 2013 (*Birds of Prey of Australia: A Field Guide*, 2nd edn, best vertebrate guide in 2012)

BirdLife Australia's D.L. Serventy Medal for publication in ornithology, 2015

Voluntary work:

Editor: *Australasian Raptor Association News* 1980-1989 and *Boobook* (re-named) 2004-17 (biannual journal for bird-of-prey enthusiasts); *Australian Field Ornithology* 1984-2015 (quarterly journal)

Sub-editor: *Corella* Wedge-tailed Eagle special issue, 2007; White-bellied Sea-Eagle special issue, 2009; rare raptors special issue, 2011

Committee member: Australian Bird Study Association 1981-1988, 2005-17; Birds Australia Northern NSW Group 1996-99, 2004-12, 2015-17; Australasian Ornithological Conference 2009 organising committee 2008-09; ABSA/BirdLife Southern NSW conference organising committee 2013-14

Regent Honeyeater Recovery Team: Bundarra-Barraba Operations Group rep, 2008-18

Red Goshawk National Recovery Team 2014-18

Publications:

~130 refereed papers (selection appended), books and book contributions, theses: see appended list

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Strategic Assessment

for the

Square-tailed Kite *Lophoictinia isura*

in the

Greater Macarthur Growth Area

and the

Wilton Growth Area

Report prepared for the Department of Environment and Planning

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Prepared August 2018

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Strategic Assessment for the Square-tailed Kite *Lophoictinia isura* in the Growth Areas of Greater Macarthur and Wilton

1. Introduction

Purpose

The purpose of this report is to assess the likelihood of occurrence and potential impacts of the urban growth in the Greater Macarthur and Wilton areas on the Square-tailed Kite *Lophoictinia isura*. In particular, this report will assess the presence of breeding and foraging habitat within these growth areas as required under the Biodiversity Assessment Method. It will also discuss conservation measures required to mitigate potential impacts.

The Square-tailed Kite is listed in New South Wales as vulnerable under the *Biodiversity Conservation Act 2016* and is an uncommon species found in coastal and sub-coastal forests and woodlands. Inland, it shows a preference for timbered watercourses, though not necessarily strictly so near the coast, and is a summer breeding migrant to south-eastern Australia, arriving in September and leaving by March. Records for this species exist in and around the area to be impacted by the development. However, the species is encountered infrequently in this area and its interactions with local habitat have not been well studied.

The existence of potential habitat for the Square-tailed Kite and of records for the species within the area has meant that a more detailed assessment of the likelihood of impacts from the development in the area is required, particularly of the species' foraging and breeding use of the area. Targeted surveys could gather this information, but the survey effort required to collect sufficient data would be great and in the order of hundreds of hours in the appropriate seasons over several years. This would also require tracking of individual birds to gather time budgets and breeding locations and behaviour at nests etc. Access to several potential habitat areas also proved difficult during the survey period. Knowledge of the habitat structure and plant community types (PCTs) that the Kite has been recorded in within the development area and of the ecology of the species can be used as a surrogate for this fieldwork.

Project Context

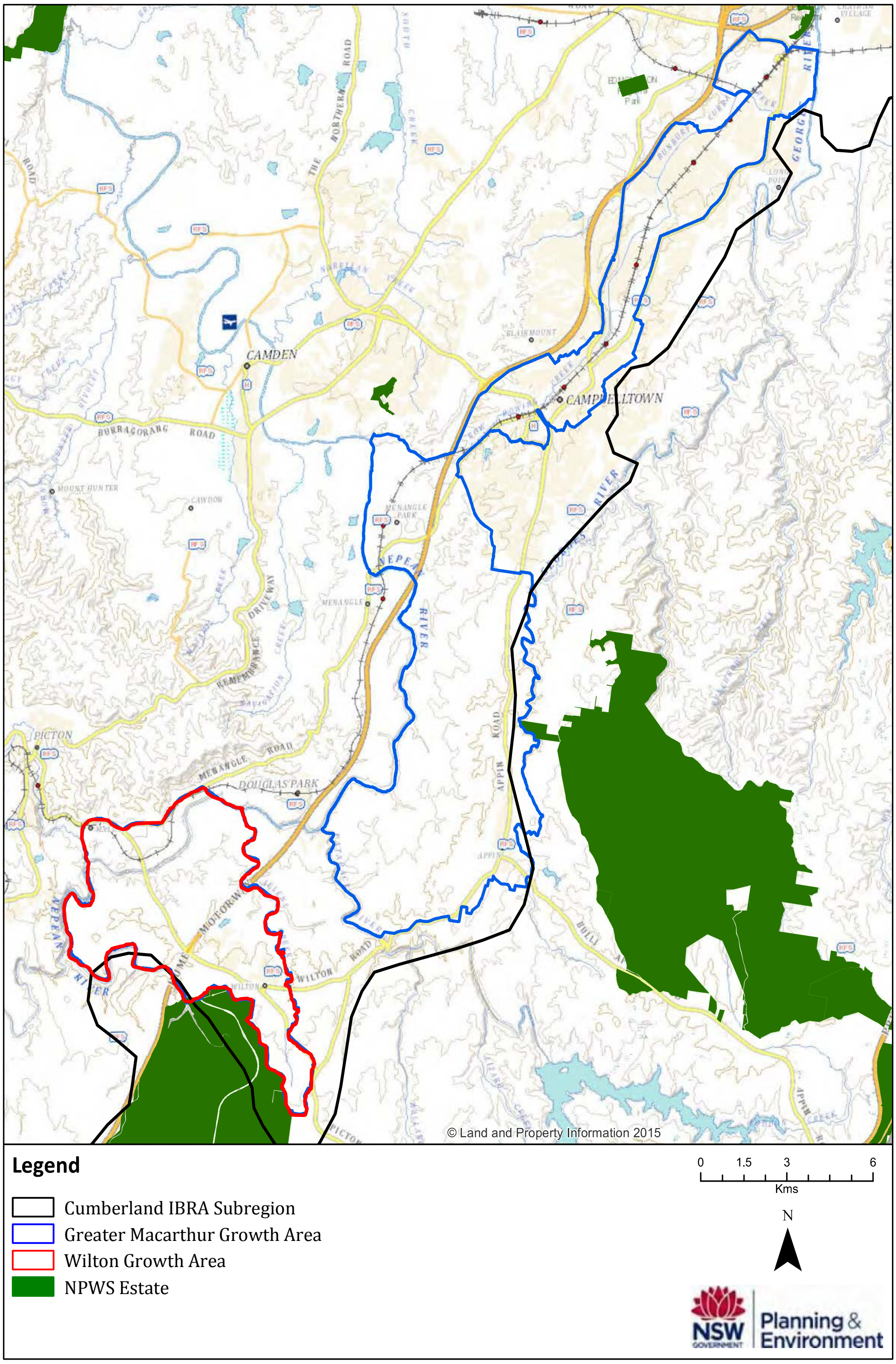
The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

The timeframe for this project, and difficulties in accessing private lands have resulted in some survey challenges for the project. Only 68% of the potential habitat available for this species in the Wilton and Greater Macarthur Growth Areas has been successfully surveyed. Significant areas of the Greater Macarthur Growth Area were unable to be adequately surveyed due to restrictions around land access. Around 363 hectares of potential habitat was not surveyed within this growth area, and only 35% of PCT 850 Grey Box-Red Gum grassy woodland on shale of the southern Cumberland Plain within this growth area was successfully accessed for survey.

Study Area

The study area is in the Macarthur and Wilton areas, which extend from the southern parts of Liverpool, down to Appin, across to Wilton and then towards the area between Wilton and Picton. The area is within the Cumberland IBRA subregion and the location is shown in Figure 1. The area is bound within a latitude range from -33.88 to -34.33 and a longitude range of 150.55 to 150.97.

Figure 1. Location of Growth Areas and the Cumberland IBRA Subregion.



Survey Methods

Vegetation maps (as supplied by The Department of Planning and Environment NSW) of the Greater-Macarthur Growth Area and the Wilton Growth Area were used to select patches of remnant vegetation that may provide suitable habitat for the Square-tailed Kite. Fifty potential sites were chosen from these maps. Sufficient access was feasible for 40 of these remnants.

The remnants were visited over 4 days from the 18-06-2018 to the 21-06-2018 inclusive. Each site was surveyed for between 0.5 and 1.0 hours. The aim was to collect qualitative data on each of the following:

habitat structure -	tree height range, DBH range, canopy cover, tree maturity, shrub density, grass cover, ground cover
habitat quality -	tree age diversity, shrub layer diversity, presence of woody weeds, evidence of regeneration
connectivity -	degree of connectivity, relative width of corridor to other remnants, presence of gaps in vegetation
aspect and slope -	slope steepness, direction of slope and relationship of site to structural features e.g. watercourses etc.
avian species -	overall diversity, species composition, presence of feral species

The aim was to assess if these sites contained suitable habitat for foraging and breeding and whether they allowed for dispersal of prey and the target species into and out of the remnants. The extent of suitable habitat across the growth areas was then used to estimate the likelihood of the Kites using the area for foraging and/or breeding.

The Atlas of Living Australia (ALA) and the bird database from the Cumberland Bird Observers Club Inc. (CBOC) were searched for atlas records of the Square-tailed Kite. The records within the Atlas of Living Australia had data mainly from the Bionet Atlas of NSW Wildlife with a few records from un-named individuals contributing directly to the ALA. At the time of access the CBOC bird atlas had over 20,000 survey results for the section of the Cumberland IBRA sub-region that lies within the County of Cumberland. These 2 data sets combined would have captured most of the data on the Kite for this area.

Justification for Use of an Expert Report

The presence of suitable habitat for foraging and breeding for the Square-tailed Kite combined with the low density for this species and the difficulties with gaining sufficient access for surveys to establish the presence and habitat use by the Kite in the development area has meant that survey effort alone has not been able to establish the potential importance of the area for this Kite.

An expert in the breeding and foraging ecology of the Kite would be required to assess the importance of the habitat remnants and the likelihood of occurrence within the growth areas. The Kite is a forest and woodland specialist whose major food in its breeding season is forest and woodland birds, particularly small to medium-sized passerines and the contents of their nests, but also in recent times introduced and native pigeons and doves, and an abundant native bird (the Noisy Miner *Manorina melanocephala*), all of which are increasing in urban and near-urban areas and fragmented bushland. Therefore, an expert would also need to also be expert on the avifauna populations occurring in forest and woodland in the Cumberland IBRA Subregion. The report will address the food resources and foraging space of this raptor as well as the Kite's potential nest sites and breeding habitat within the growth areas.

Credentials of the Experts Preparing this Report

Dr. Tony Saunders

BSc University of Sydney 1976.
Dip.Ed. Sydney Teachers College 1977.
PhD University of Western Sydney 2005.

Company Director and Avian Ecologist, Merops Services Pty Ltd 1995 to present.

Relevant experience in surveys and the study of woodland and forest birds of the Cumberland plain:

- Cumberland Plain woodland bird surveys for the NSW Bird Atlas and then for the CBOC Bird Atlas 1982 to the present.
- Cumberland Plain woodland bird surveys on the UWS Hawkesbury Campus 1998 to 2005.
- Woodland bird surveys for Holroyd Council's reserves and parklands 2008 to 2011.
- Survey for threatened woodland birds in proposed urban development of the former ADI site at Penrith 2002.
- Survey for threatened woodland birds in proposed rural subdivision at Badgerys Creek 2006.
- Presented the opening presentation ' Birds of the Cumberland Plain. What was there? What have we lost?' at the ABSA Conference 2016.
- Presented 'Trends in woodland birds of the Cumberland Plain' at the RZS of NSW Conference in 2016.
- Avifauna surveys of sites for development applications and assessment of status of threatened bird species with recommendations for minimising impact of development on these species within the Cumberland Plain and eastern New South Wales. (21 years)
- Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (21 years)

Relevant publications relating to woodland birds of the Cumberland Plain:

- Saunders, T. (2016). Birds of the Cumberland Plain. What was there? What have we lost? Abstract from ‘Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future’ Australian Bird Study Association Conference - 23 January 2016. *Corella* **40**: 46.

- Saunders, T. (in prep.). Trends in woodland bird populations in the Cumberland Plain. *Australain Zoologist.*

Dr. Stephen Debus

Bachelor Arts (Biology/Behavioural. Science), Dip. Natural Resources (Wildlife), MSc. (Zoology), PhD (Zoology)

Adjunct associate lecturer/research associate, Zoology University of New England, Armidale. 2004 to present
Senior Ecologist (casual) Eco Logical Australia 2014 to present

Relevant experience in surveys and the study of the Square-tailed Kite *Lophoictinia asura* and of woodland birds:

- Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report (Northern Tablelands Local Land Services 2017-18)
- Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting (North West Local Land Services 2015-18)

Relevant publications relating to foraging and breeding biology of the Square-tailed Kite *Lophoictinia isura*:

- Barnes, C.P., Zillmann, E.E., Rose, A.B. and Debus, S.J.S. 2001 Diet and biology of Square-tailed Kites *Lophoictinia isura* breeding in south-eastern Queensland: nest building to post-fledging. *Australian Bird Watcher* 19: 28-43.
- Bischoff, T., Lutter, H. and Debus, S 2000 Square-tailed Kites on the mid-north coast of New South Wales. *Australian Bird Watcher* 18: 233-240.
- Brown, B., Brown, F. and Debus S.J.S. 2000 Further observations on a pair of Square-tailed Kites nesting near Grafton, New South Wales. *Australian Bird Watcher* 18: 270-273.
- Debus, S.J.S. 1993. Falconiformes, Accipitridae, Falconidae, Gurney's Eagle, Little Eagle, Square-tailed Kite, Osprey texts in Marchant, S. & Higgins, P.J. (Eds), *Handbook of Australian, New Zealand and Antarctic Birds, Vol. 2: Raptors to Lapwings*. Oxford University Press, Melbourne.
- Debus, S. 2017. *Australasian Eagles and Eagle-like Birds*. CSIRO Publishing, Melbourne. [Square-tailed Kite chapter is a 25-year update of the Debus 1993 *HANZAB* Kite account.]
- Debus, S. 2012. *Birds of Prey of Australia: A Field Guide*, 2nd ed. CSIRO Publishing, Melbourne.
- Griffiths, H., Lutter, H., Rose, A.B. and Debus, S.J.S. 2002 Breeding and diet of a pair of Square-tailed Kites *Lophoictinia isura* on the mid-north coast of New South Wales. *Australian Bird Watcher* 19: 184-193.
- Lutter, H., Dinnie, R. and Debus S.J.S. 2003 Square-tailed Kites breeding in northern coastal New South Wales: post-fledging diet and behaviour. *Australian Field Ornithology* 20: 94-104.
- Lutter, H., Lutter, M., Rose, A.B. and Debus, S.J.S. 2004 Breeding biology and diet of the Square-tailed Kite on the mid-north coast of New South Wales. *Australian Field Ornithology* 21: 141-157.

2. Species Information

Species Description

Adult Square-tailed Kites are brown with a white crown and face, with dark streaked rufous nape and underparts. The tail is about half the total length and is grey-brown with a dark terminal band (Debus 2012). They can be confused with other raptors, but can be distinguished by the white cap (in adults), long and widely splayed, boldly banded primaries when soaring or gliding on upswept wings, slender bill, small feet and very short legs hidden by feathers when perched and with the long wing tips crossing below the tail tip at rest (Debus 2017). It can often be observed circling low over the tree canopy on upswept wings with spread 'fingers' (Saunders pers. obs.).

Life Cycle

Square-tailed Kites usually occur singly, in pairs or (in the post-fledging period) family groups of adult(s) and fledgling(s) (Debus 2017). The highest count in one survey within the Cumberland County was 4 (CBOC Atlas accessed 29-06-2018), and most records for the Cumberland IBRA subregion were of single birds (ALA accessed 29-06-2018). They are generally solitary during the non-breeding season (Debus 1993). They appear to be long term monogamous as breeding pairs, as they are intolerant of other adults of the same species within their breeding territory and they occupy the same nest site for many years (Debus *et al.* 1993; Bischoff *et al.* 2000). In eastern New South Wales, nest building occurs in July to October, laying in August, incubation in September to November, hatching occurs in September to October, nestlings occur from October to December and fledglings from November to December (Debus 1996; Bischoff *et al.* 2000; Brown *et al*. 2000; Griffiths *et al.* 2002; Lutter *et al.* 2003,2004; Stowe 2009). In the Cumberland County breeding has been recorded from July to February (CBOC Atlas, accessed 29-06-2018). Nestlings remain in the nest for between 55 and 60 days (Barnes *et al.* 1999, 2001; Lutter *et al.* 2003, 2004). Fledglings are dependent on the parents for about 2 months after which they generally disperse (Bischoff *et al.* 2000; Barnes *et al.* 2001; Lutter *et al.* 2003). The generational cycle is estimated to be 10 years (Garnett & Crowley 2000).

Distribution and Abundance

The Square-tailed Kite is an endemic species found over most of the Australian mainland and some larger offshore islands. It avoids the most arid, treeless central regions, where it is scarce or absent (Debus 2012). It is primarily found in open eucalypt forests, woodland and mallee where passerines are common (Garnett 1993). They are generally absent from south-eastern New South Wales during the non-breeding period (Debus 1993) and are considered to be a summer breeding migrant to the south east of New South Wales (Square-tailed Kite species profile, OEH Website, accessed 29-06-2018). Reporting rates were lower during the May to June period in the Central and South Coast regions of New South Wales (Cooper *et al.* 2014). The Kite has been recorded from August to April across the Cumberland County from the coast to the western edge of the Cumberland Plain, with a more widespread distribution in the northern half of the County (CBOC Atlas, accessed 29-06-2018). In the southern part of the Cumberland IBRA Subregion there are records from Liverpool, Macquarie Fields, Ingleburn, Appin, Wilton and Picton areas (ALA Atlas, accessed 29-06-2018, see Section 4 for more details of these atlas records). The latter area encompasses the Greater Macarthur and Wilton growth areas.

The global population of the Square-tailed Kite is estimated to be between 1000 and 10,000 birds (Ferguson-Lees and Christie 2001). Density estimates are based mainly on breeding territories. In the Bendigo area of Victoria the estimate was 25.8 pairs per 1000 km^2 of forest (Robinson *et al.* 2016). In northern coastal NSW the estimates vary from one pair per 120 km^2 to one pair per 170 km^2 (Debus 1996, Lutter *et al.* 2004).

There was a twofold increase in reporting rates in NSW over a 20-year period prior to 2006, mostly concentrated on coastal areas (Cooper *et al.* 2014). Barrett *et al.* (2007) reported a 40.8% increase in reporting rates for NSW, but this was not considered a significant change due to small sample size. Morris *et al.* (1981) reported that the Kite was scarce in coastal NSW based on records prior to the date of publication.

In the County of Cumberland there were only 2 records from more than 100 years ago (Hindwood & McGill 1958). Hoskin (1991) reported that the Kite was only a rare straggler to the County with only a few records. There has been an increase in the number of records over the last two decades and there are now breeding records for the County, from near Asquith in 2012 and 2013 and in Lane Cove National Park in 2015 (Patrick 2016). The Kite has also been recorded in the Shoalhaven area (Chafer *et al.* 1999). There were 40 records for the County in 2017 (CBOC Atlas, accessed 29-06-2018). It was seldom recorded in the Cumberland Plain prior to 1990 but has shown an increase in reporting rate from 0.5% in the 1990s to 2.5% since 2010 (Saunders in prep.). All records for the Liverpool, Campbelltown and Wollondilly Local Government Areas, which includes the growth areas, have been made since 2000 (ALA Atlas, accessed 29-06-2018). There is a recent breeding record for the Cumberland Plain (near Penrith), and recent breeding records for bushland within the Sydney suburbs (Asquith and South Turramurra) (Optland 2015; I. McAllan pers. comm.).

There have been suggestions as to why the Kite has increased in some areas. It appears to be adapting to urban bushland areas around coastal cities where it feeds on abundant native passerines and introduced bird species (Bischoff *et al.* 2000, Debus 2012). Lower competition from the Brown Goshawk *Accipiter fasciatus* (nestling predation) has been suggested as a possible explanation for the increase in breeding observed in the Bendigo area (Robinson *et al.* 2016), but reporting rates for the Brown Goshawk have increased from 2% to 7% over the last six decades in Cumberland Plain woodland sites where the Kite has also increased and so does not support this suggestion (Saunders in prep.).

Habitat Requirements

Square-tailed Kites are found mainly in coastal and sub-coastal eucalypt dominated forests and woodland, as well as treed areas in urban habitats (Debus 1993, Olsen 1995, Debus 2017), open forests and woodland (Cupper & Cupper 1981, Chafer *et al.* 1999, Barrett *et al.* 2007), passerine-rich woodlands when breeding and more open country when not breeding (Olsen *et al.* 1993) and open forests that are contiguous with very large areas of forest (Griffiths *et al.* 2002). They prefer timbered watercourses through open or cleared land and the margins between open and timbered country (Debus 1993).

When breeding, the Kite requires open forest where it can forage for nestlings in the canopy and approach the nest easily (Hollands 1984). Tall living eucalypt trees are chosen for nest sites (Debus 1993), especially where they are close to open edges (Lutter *et al.* 2004). They can tolerant human disturbance and use areas of urban bushland (Bischoff *et al.* 2000, Griffiths *et al.* 2002). Nests are mostly between 15 and 28 metres above ground in trees that range from 20 to 40 metres tall (Cupper & Cupper 1981, Bischoff *et al.* 2000, Barnes *et al.* 2001, Griffiths *et al.* 2002, Lutter *et al.* 2003, 2004, Stowe 2009 and Optland 2015). The minimum requirements for nesting based on the literature review are described in Tables 1 and 2 below.

Table 1. Minimum distances of active Square-tailed Kite nests from developments (collated from various studies cited by Debus 2017, eastern/south-eastern Australia):

Parameter	
Dwelling	60–70 m
Urban area	Within*
Industrial building	–
Sealed road	5–10 m**
Unsealed road	15 m
Track/path	0 m#

*In the carpark of a suburban facility (animal hospital) in a bushland setting
**Almost overhanging the verge of a highway
#Directly over a trail-bike track

Table 2. Minimum criteria for active Square-tailed Kite nest-site characteristics (collated from various studies cited by Marchant and Higgins 1993 and Debus 2017, eastern/south-eastern Australia):

Parameter	Measurement
Forest/woodland patch size	5 ha*
Nest-tree height	20 m
Reference tree height**	10 m
Nest-tree DBH#	30 cm
Reference tree DBH	–
Nest height	9 m

*In fragmented landscapes with much larger patches nearby
**Reference trees are other trees within the nest patch
#Diameter at breast height

There is some information on local vegetation types that are preferred by the Square-tailed Kite. One hundred and twenty one records out of the 289 records held with the CBOC Atlas (accessed 29-06-2018) contain information about the habitat type where the Kite was encountered. In order of most to least common they were:

Tall Forest	17%
Sandstone Woodland	17%
Pastureland with Scattered Trees	17%
Urban Parkland	14%
Cumberland Plain Woodland	13%
Swamp and River Woodland	9%
Heath	9%
Freshwater Wetlands	4%

The OEH Threatened Species Data Collection indicates that the Square-tailed Kite has the potential to inhabit the following plant communities within the Wilton and Greater Macarthur Growth Areas:

835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion
850	Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion

The habitat requirements discussed above have been used in this report to identify important habitat areas. They have been grouped into the habitat criteria listed below. The greater the number of criteria that are met the more likely it is that the remnant will provide habitat for Square-tailed Kite.

1. The site contains tall open forest or woodland.
2. The site is near or along a timbered watercourse.
3. The site contains one or more of the following PCTs - 835, 849,850 and 1181.
4. Canopy foliage nesters, particularly honeyeaters, are common on site.
5. The site contains urban edge tolerant bird species e.g. Noisy Miner, Red Wattlebird, Lorikeets, Crested Pigeon or Spotted Dove.
6. Forest or woodland that has open edges around remnants, timbered corridors and along watercourses.
7. Forest or woodland that has tall trees (> 20m) near outer edges or emergent trees suitable for nesting.

3. Description of the Study Area's Relevance to the Square-tailed Kite

Land Use History

Much of the northern half of the Greater Macarthur growth area has been developed as residential, commercial and industrial land decades ago and any remaining habitat can only be found along watercourses and on steep slopes where these developments are not appropriate. Much of this area would have been a mix of cleared grazing land and bushland prior to this stage of development.

The southern half of the Greater Macarthur and the Wilton growth areas contain older small towns, which now have a few larger new residential developments. These occupy only a small area within the growth area. Much of the land consists of small to medium rural holdings and grazing agricultural land that was cleared for farming decades ago. Throughout this area there are many watercourses that are tributaries to either the Georges or Nepean rivers and the forests along these watercourses has largely been left intact with some clearing or thinning at the edges. Many of the remnant patches and forested watercourses have been affected by woody weed invasion since development in the area.

Landscape Context

The growth areas follow the transport corridor along the Hume Motorway that connects the area to the south-western areas of greater Sydney to the north. The area abuts intact, contiguous, forested areas to the east and to the south. These are in water catchments or national park reserves, which cover hundreds of square kilometres. The western edge abuts mostly cleared rural holdings either side of the Nepean River and then further west to the Warragamba Dam water catchment area.

Much of the region is in the western half of the Cumberland IBRA subregion, which contains most of the remaining large woodland remnants and is an important area for this reason. The woodlands of the Cumberland Plain are threatened ecological communities and have been prioritised by the Office of Environment and Heritage for habitat protection and enhancement (DECCW 2010).

Native Vegetation

The remnant native vegetation within the growth areas is mainly eucalypt forest and woodland. Forested areas on steep slopes and along watercourses have largely been left intact and often contain a structurally and species diverse understorey. Woodland areas remaining on flat or gently undulating land have a few scattered dense patches of understorey, but are mostly open woodland with a grassy understorey. Many remnants have been invaded by woody weeds and many woodland remnants are subjected to grazing pressure and are clear of any understorey. Some of the remnants have also been thinned and have only scattered paddock trees along their edges.

The following plant community types are found in these remnants within the growth areas:

Potential Habitat

Most of the uncleared areas in the northern half of the Greater Macarthur growth area are remnant forest patches along watercourses that were unsuitable for development. They are small, often isolated and mostly surrounded by urban development with little or no open areas surrounding each remnant to act as buffers. Some have open areas within them that have mown grass and are now parkland. Only the steeper slopes along the watercourse have any shrub layer, but they also have tall eucalypts that provide suitable foraging habitat and potential nesting trees. This area has a major watercourse near the eastern edge, which is the Georges River. This river would provide access to the reserves that provide some suitable resources for the Kite.

The southern half of the Greater Macarthur and the Wilton growth areas have small areas of urban development and larger areas of open grazed pastureland and rural holdings. There are very large remnants of forest and woodland that mainly follow watercourses that are connected to either the Georges or Nepean Rivers. In the south and east sections of the growth areas many of these forest remnants are also part of contiguous habitat into water catchment reserves or national parks. The forest remnants often border open areas with scattered trees and provide good edge habitat for the Kite.

Some 40 sites, scattered over the whole length of the growth areas, were sampled for habitat quality and their ability to provide foraging and nesting resources for the Kite. Fifty potential sites were selected based on the vegetation maps of the area but access into much of the area was difficult. The habitat requirements for the Kite are described in detail in Section 2 of the report and are grouped into seven different criteria for assessing suitable habitat. Details of each site's location, their PCTs and which of the criteria were satisfied are listed below (see Table 1) and a more-detailed description of each site can be found in Appendix 1. All of the sites met at least one of the criteria and 27 of the sites meet at least 5 of the 7 criteria. The PCTs where the Kite has been observed from previous records (Bionet Atlas of NSW Wildlife, accessed 29-06-2018) include 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, 850 Grey Box - Forest Red Gum grassy woodland on shale of the Cumberland Plain, Sydney Basin Bioregion and 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, Sydney Basin Bioregion, which were recorded on many sites. Most of the larger remnants in the south Greater Macarthur and in the Wilton growth areas contain PCT 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion. Many of these sites contain emergent Grey Gums *Eucalyptus punctata,* which would provide nesting sites and this tree species would provide foraging opportunities because it is also popular with honeyeaters and other small passerines (Saunders and Burgin 2001).

These sites represent only a small portion of the forest remnants within the growth areas, yet nearly all sites satisfied many of the criteria used to assess whether suitable habitat existed on-site for the Kite. This implies that most of the remaining forest and woodland habitat in the area is potential Kite habitat, especially as the remnants are tall, have open edges and follow watercourses. Open areas that exist adjacent to the forest and woodland remnants, and especially between open woodland patches and timbered watercourses should also be accepted as potential habitat for the Kite. All forest, woodland and open areas that provide potential habitat will be shown as species polygons in Section 4 of this report. It should be noted that some of the important open areas adjacent to forest and woodland remnants overlap with the urban development footprint.

Table 3. Criteria relating to habitat resources for the Square-tailed Kite that were satisfied for each of the study sites.

Site No.	Latitude	Longitude	PCTs	Criteria Satisfied
1	-33.96801	150.90682	849	1,2,3,5,6,7
2	-33.97577	150.90994	835, 849	1,2,3,4,5,6,7
3	-33.98336	150.89717	1395	1,2,3,4,5,6,7
4	-33.99160	150.87588	835	1,2,3,5,6,7
5	-33.99667	150.87933	849	3,5,6
6	-33.00763	150.86866	835	2,3,5
7	-34.01357	150.85682	835, 1395	1,2,3,5,6,7
8	-34.01049	150.84202	849	3,6,7
9	-34.00402	150.83964	1395	3
10	-34.03953	150.84055	849	2,3,5,6
11	-34.05475	150.83743	1081, 1181	1,2,3,4,5,6,7
12	-34.05460	150.81757	850	1,3,5
13	-34.05984	150.79926	850	2,3,5,6,7
14	-34.05677	150.80422	850	2,3,
15	-34.06471	150.79735	835	1,2,3,4,5,7
16	-34.07929	150.80041	849	3,4,5
17	-34.07103	150.79253	835	1,2,3,4,5,6,7
18	-34.07175	150.78816	849	1,2,3,5,6,7
19	-34.07426	150.77886	849	1,2,3,5,6,7
20	-34.09521	150.75699	835	1,3,5,6,7
21	-34.10223	150.75169	1395	1,2,3,4,5,6,7
22	-34.09795	150.74683	849	1,3,4,5,6,7
23	-34.09972	150.7786	830	5,6
24	-34.11215	150.77988	835	1,2,3,4,5,6,7
25	-34.12015	150.79354	1395	3,5
26	-34.12996	150.78533	1395	1,5,6,7
27	-34.14001	150.79018	1395	1,3,4,5,6,7
28	-34.15692	150.78909	1395	1,3,4,5,6,7
29	-34.19165	150.78422	1395	1,2,4,5,6,7
30	-34.20653	150.76729	850	1,3,5,6,7
31	-34.20109	150.75721	1395	2,3,4,5,6
32	-34.22262	150.7522	1395	3,5
33	-34.26687	150.71363	1395	3,4,6
34	-34.24750	150.70141	1395	1,2,3,4,6,7
35	-34.23376	150.69217	1395	1,2,3,4,5,6,7
36	-34.23014	150.68057	1395	5,6,7
37	-34.21825	150.66305	849	1,2,3,4,5,6,7
38	-34.22517	150.64112	1395	1,2,3,5,6,7
39	-34.23169	150.63132	1395	1,2,3,5,6,7
40	-34.20781	150.63328	1081	1,2,4,5,6,7

Criteria:
1. Site contains tall open forest or woodland.
2. Site is near or along a timbered watercourse.
3. Site contains one or more of the following PCTs - 835, 849,850, 1181 and 1395.
4. Canopy foliage nesters, particularly honeyeaters, are common on site.
5. Site contains urban edge tolerant bird species e.g. Noisy miner, Red wattlebird, Lorikeets, Crested Pigeon or Spotted Dove.
6. Forest or woodland has open edges around remnants, timbered corridors and along watercourses.
7. Forest or woodland has tall trees near outer edges or emergent trees suitable for nesting.

4. Assessment of Specie's Presence and Suitable Habitat

Species Records for the Greater Macarthur and Wilton Growth Areas

There were 32 records for the Square-tailed Kite from the area containing the urban development area (ALA Atlas and CBOC Atlas, accessed 29-06-2018). The list of records is shown in Table 2 and the distribution of these records is shown in Figure 2.

Table 4. Records of the Square-tailed Kite *Lophoictinia isura* in and around the Greater Macarthur and Wilton Growth Areas.

Location Name	Latitude	Longitude	Date	Source
Kentlyn, NSW - Peter Meadows Creek	-34.06667	150.8513889	26-01-2003	CBOC Inc.
Leumeah, NSW, Smiths Creek Reserve	-34.0725	150.8338889	26-11-2004	CBOC Inc.
Allenby Rd, Rossmore, NSW - South Creek	-33.95306	150.7619444	05-02-2005	CBOC Inc.
Macquarie Fields	-33.99028	150.9069444	03-03-2008	CBOC Inc.
Macquarie Fields	-33.99028	150.9069444	13-05-2008	CBOC Inc.
Mannix Park, Liverpool	-33.091	150.895	28-01-2011	CBOC Inc.
Mt Annan Botanic Gardens	-34.07	150.7708333	14-02-2013	CBOC Inc.
Welling Drive, Mt Annan	-34.06278	150.7555556	16-02-2013	CBOC Inc.
Mt Annan Botanic Gardens, Mt Annan	-34.07	150.7708333	02-04-2013	CBOC Inc.
Long Point, Georges River	-34.01639	150.9022222	13-12-2016	CBOC Inc.
Appin Road	-34.122015	150.795294	23-01-2015	BioNet Atlas of NSW Wildlife
Appin Road	-34.135717	150.791111	23-01-2015	BioNet Atlas of NSW Wildlife
Wilton	-34.240399	150.698782	03-04-2016	BioNet Atlas of NSW Wildlife
Allens Creek, Wilton	-34.20266	150.694503	12-10-2017	BioNet Atlas of NSW Wildlife
Appin Road, Near Georges River	-34.160179	150.793163		BioNet Atlas of NSW Wildlife
Appin Road	-34.1235	150.798638		BioNet Atlas of NSW Wildlife
Appin Road	-34.1235	150.798638		BioNet Atlas of NSW Wildlife
Appin Road, Near Georges River	-34.160179	150.793163		BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.16	150.86	01-10-2010	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.12	150.8	01-01-2015	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.14	150.79	01-01-2015	BioNet Atlas of NSW Wildlife
CAMPBELLTOWN	-34.17	150.81	01-03-2015	BioNet Atlas of NSW Wildlife
LIVERPOOL	-34.02	150.94	01-10-2010	BioNet Atlas of NSW Wildlife
LIVERPOOL	-33.93	150.71	18-01-2012	BioNet Atlas of NSW Wildlife
LIVERPOOL	-34	150.92	16-06-2006	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.25	150.85	23-03-2009	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.08	150.5	30-01-2013	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.26	150.69	03-04-2016	BioNet Atlas of NSW Wildlife
WOLLONDILLY	-34.24	150.7	03-04-2016	OEH Atlas of NSW Wildlife
WOLLONDILLY	-33.99	150.61		Citizen Science ALA Website
WOLLONDILLY	-34.2	150.6	20-04-2010	OEH Atlas of NSW Wildlife
WOLLONDILLY	-33.9	150.6	10-01-2005	OEH Atlas of NSW Wildlife

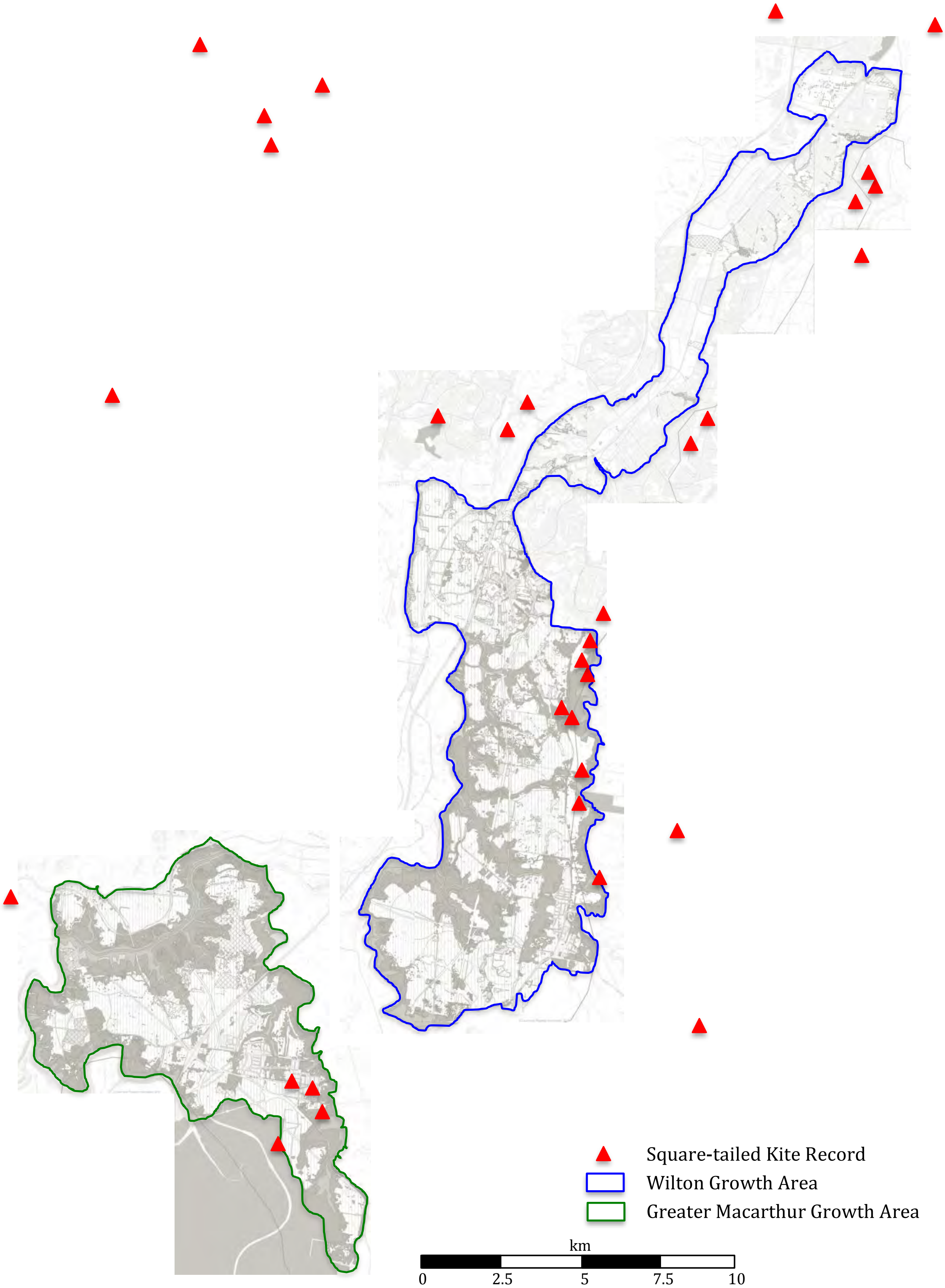


Figure 2. Distribution of records for the Square-tailed Kite *Lophoictinia isura* in and around the Greater Macarthur and Wilton Growth Areas (source ALA and CBOC Inc.).

Of these 32 records, 12 were within the southern half of the Greater Macarthur Growth Area and the Wilton Growth Area. Another 15 records are within 5 kilometres of the boundaries of the PGAs, with 11 of them just outside the northern section of the Greater Macarthur Growth Area. There were no records for July through to September with the majority of records from January through to April, being the post-breeding dispersal phase. Most of the records are associated with forest along watercourses and were made close to the edges of remnant forest. The records support that these two factors, timbered watercourses and forest edges, as being important habitat requirements for the Square-tailed Kite. These records also show that PCT 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion is an important plant community type for the Kite. We are not aware of any previous habitat assessments for the Square-tailed Kite in the study area.

Assessment of Suitable Habitat in the Growth Areas, Distribution Polygons and Justification for Determination

The areas of potential foraging habitat and potential breeding habitat for the Greater Macarthur Growth Area are shown in maps 1 to 7 in Figure 3. The areas of potential foraging habitat and potential breeding habitat for the Wilton Growth Area are shown in maps 1 to 3 in Figure 4. The existing remnant patches containing potential habitat for the Kite are shown as an overlay over the vegetation maps. These are sites where the habitat structure, plant community type and placement in the landscape, all indicate potential breeding and foraging habitat for the species (shown in red). Some habitat areas would provide potential foraging habitat but not breeding habitat (shown in orange). Some of the areas within the urban development footprint have been included because they satisfy several of the following conditions. They contain good edge habitat adjacent to an existing habitat remnant e.g. open areas with scattered trees, provide good foraging habitat, provide connectivity between existing remnants, broaden a connecting corridor or protect an edge habitat (shown in yellow). Other areas, which also satisfied any of these same conditions and that are not within the urban development footprint, are included as they are areas where habitat enhancement would improve the Kite's access to resources within the growth areas (shown in green).

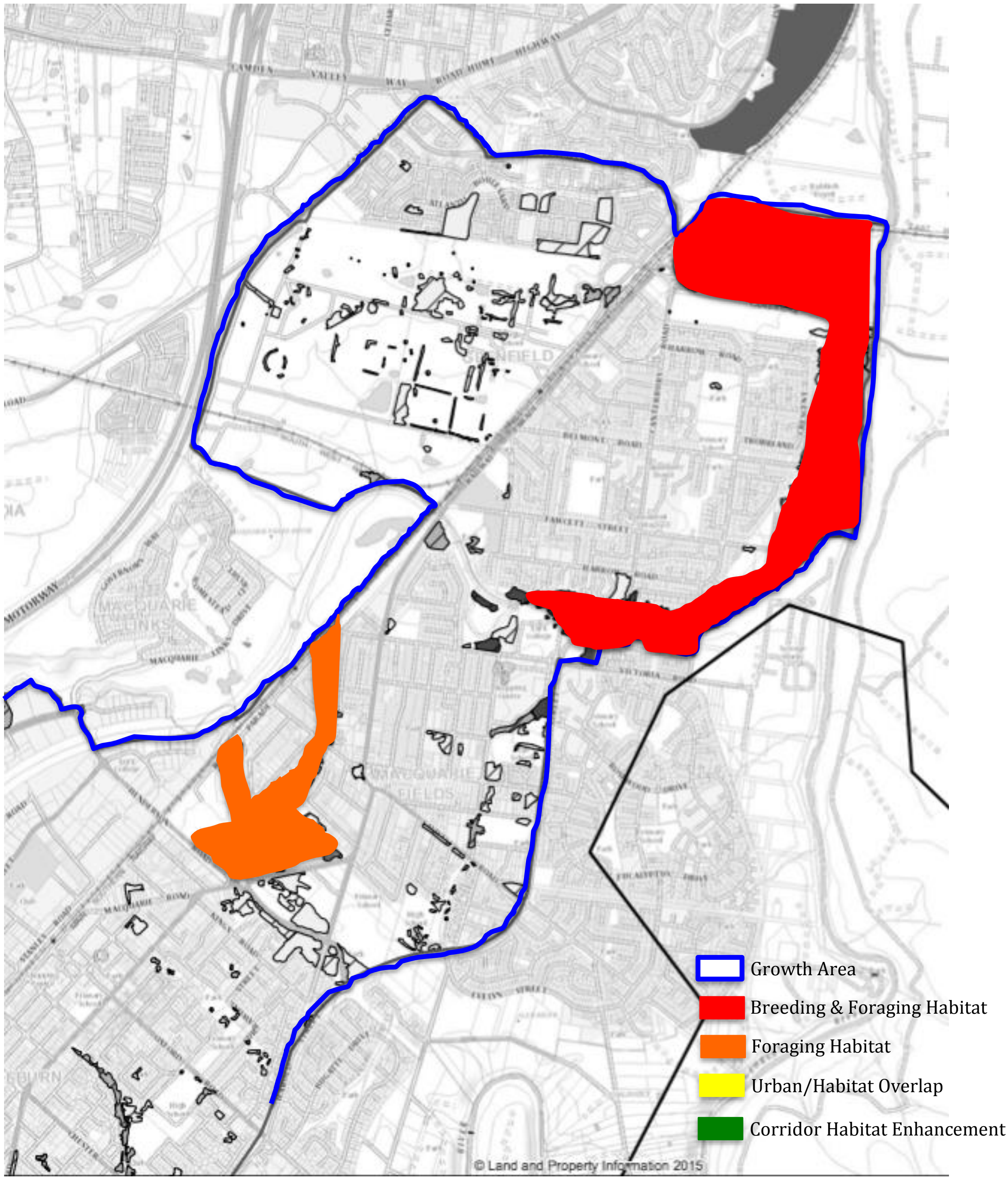


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 1). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

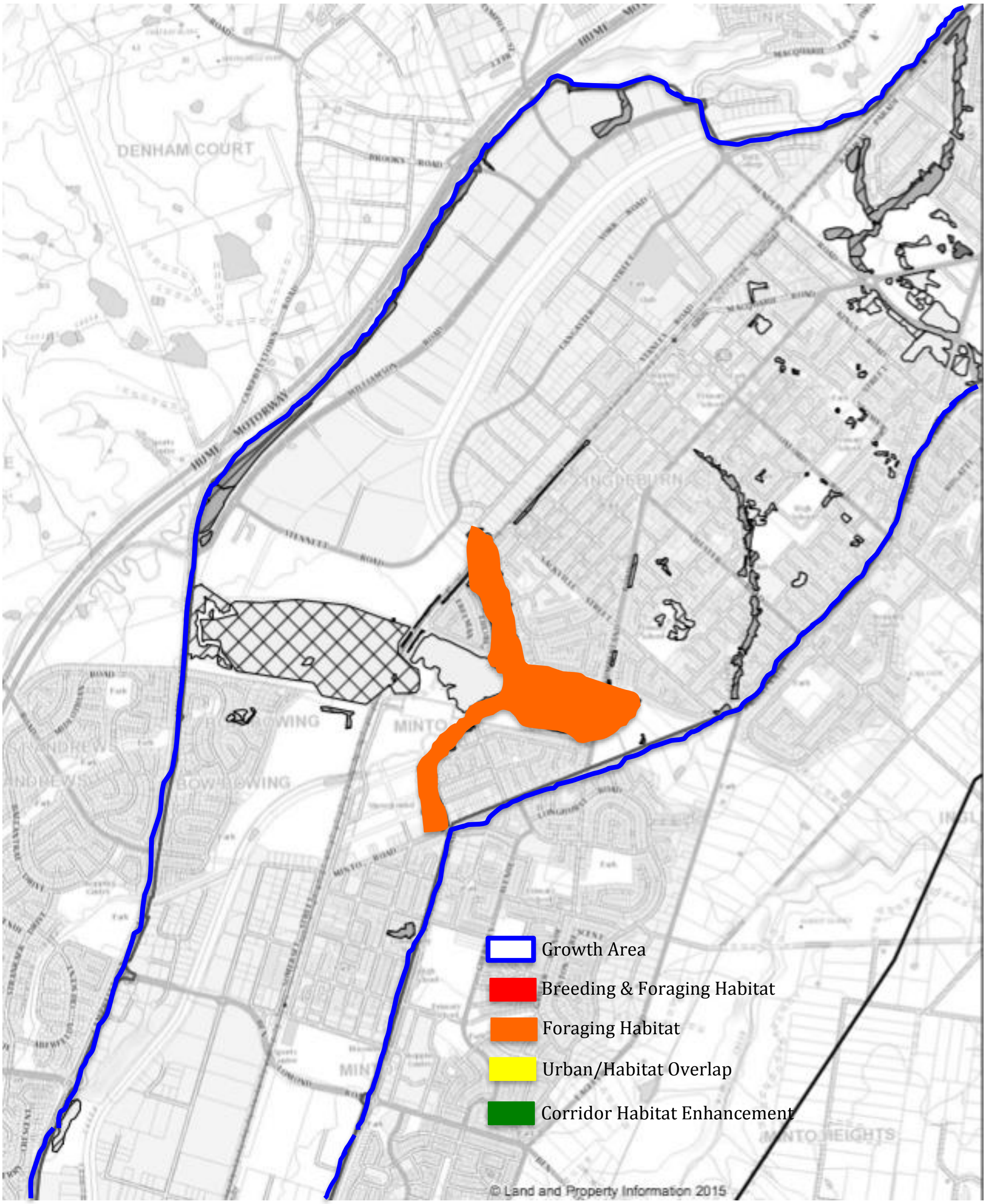


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 2). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

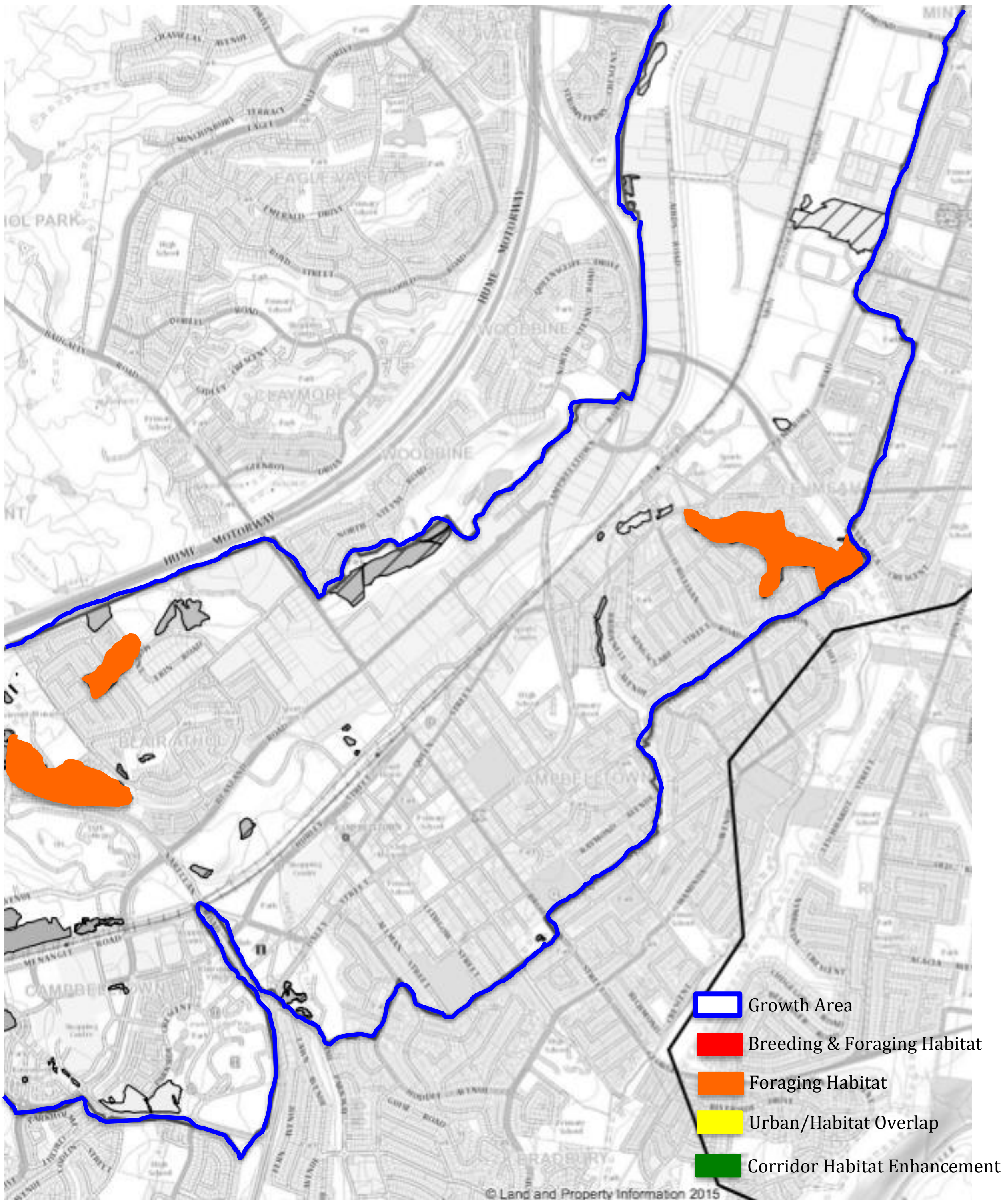


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 3). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

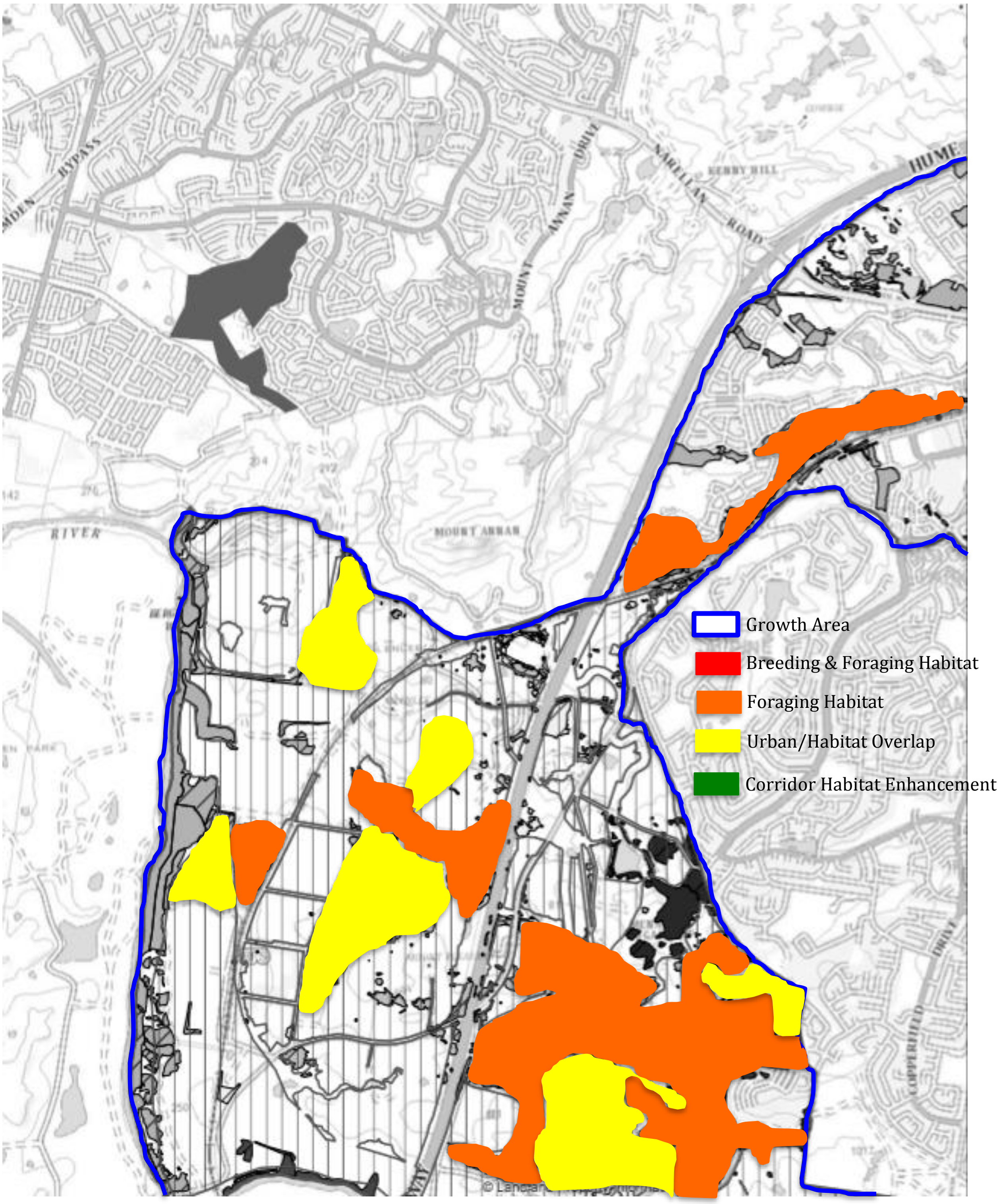


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 4). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

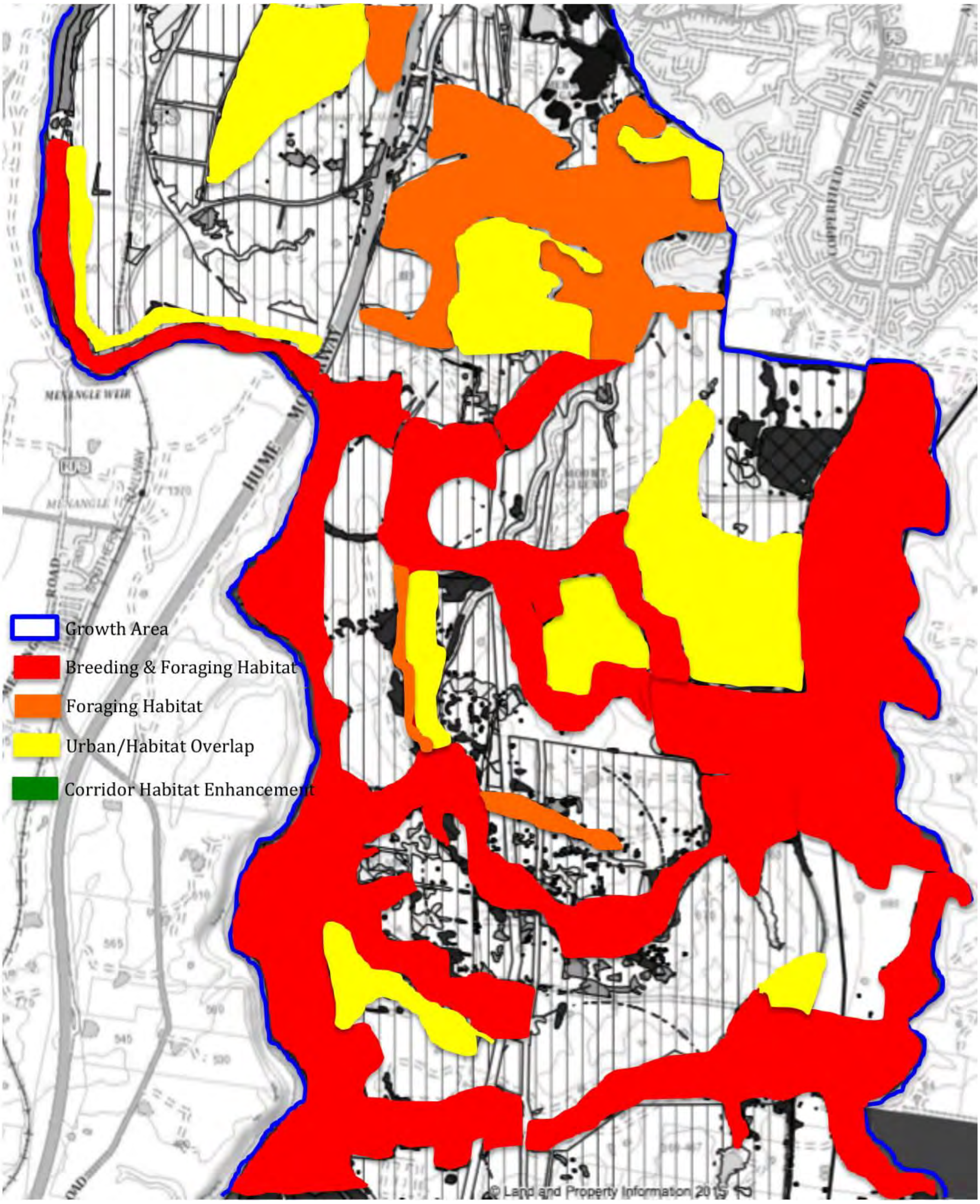


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 6). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

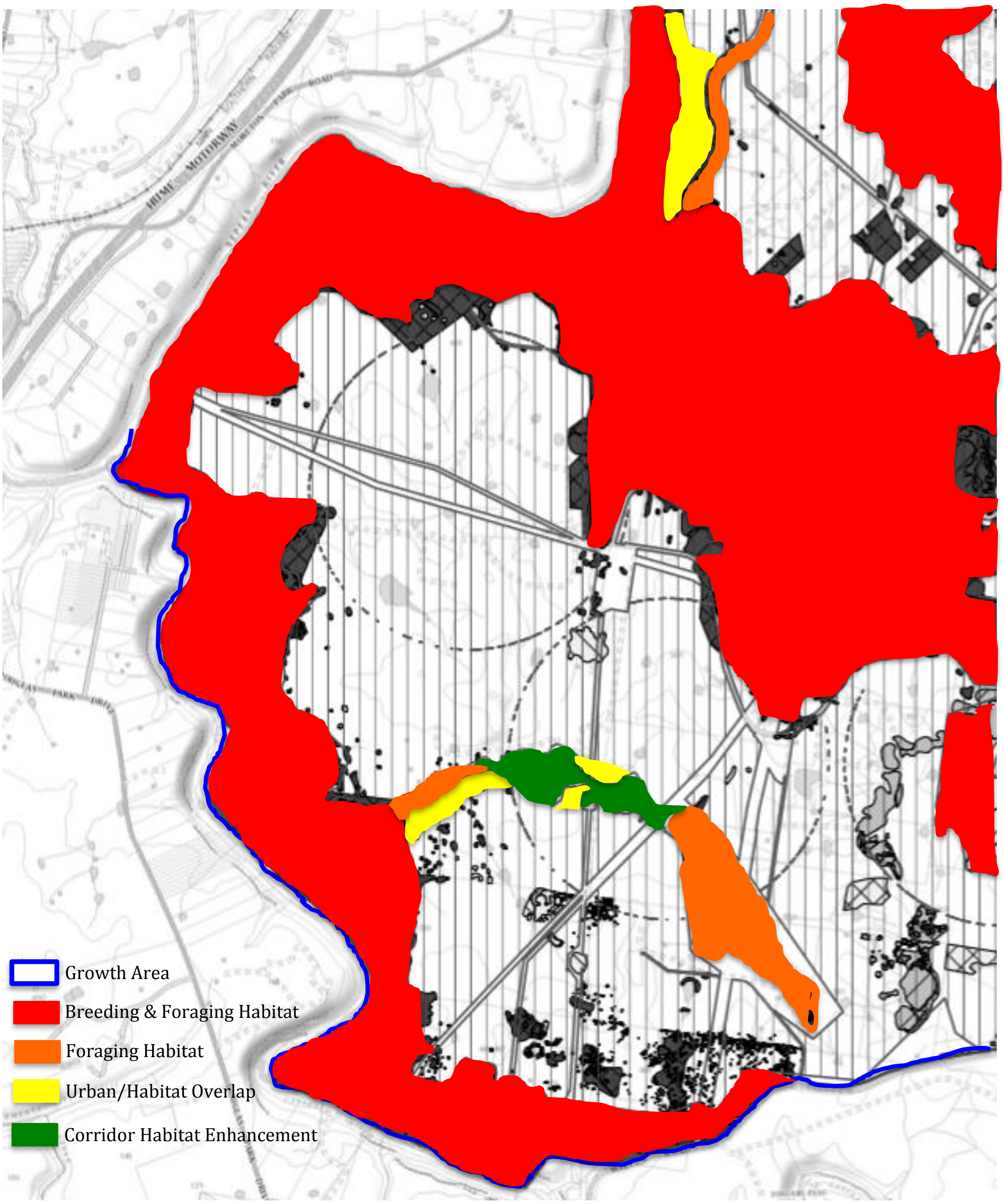


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 6). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

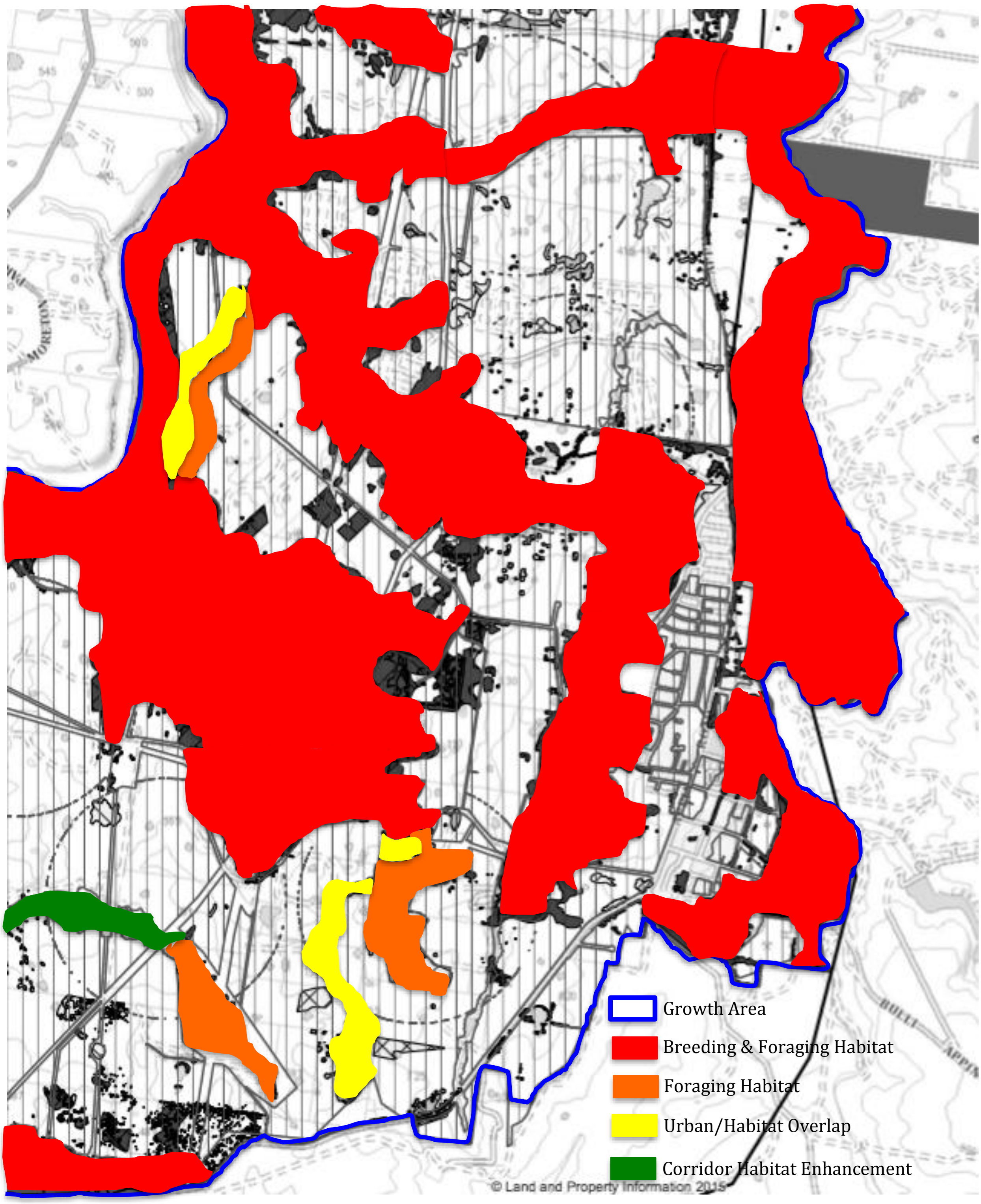


Figure 3. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 7). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

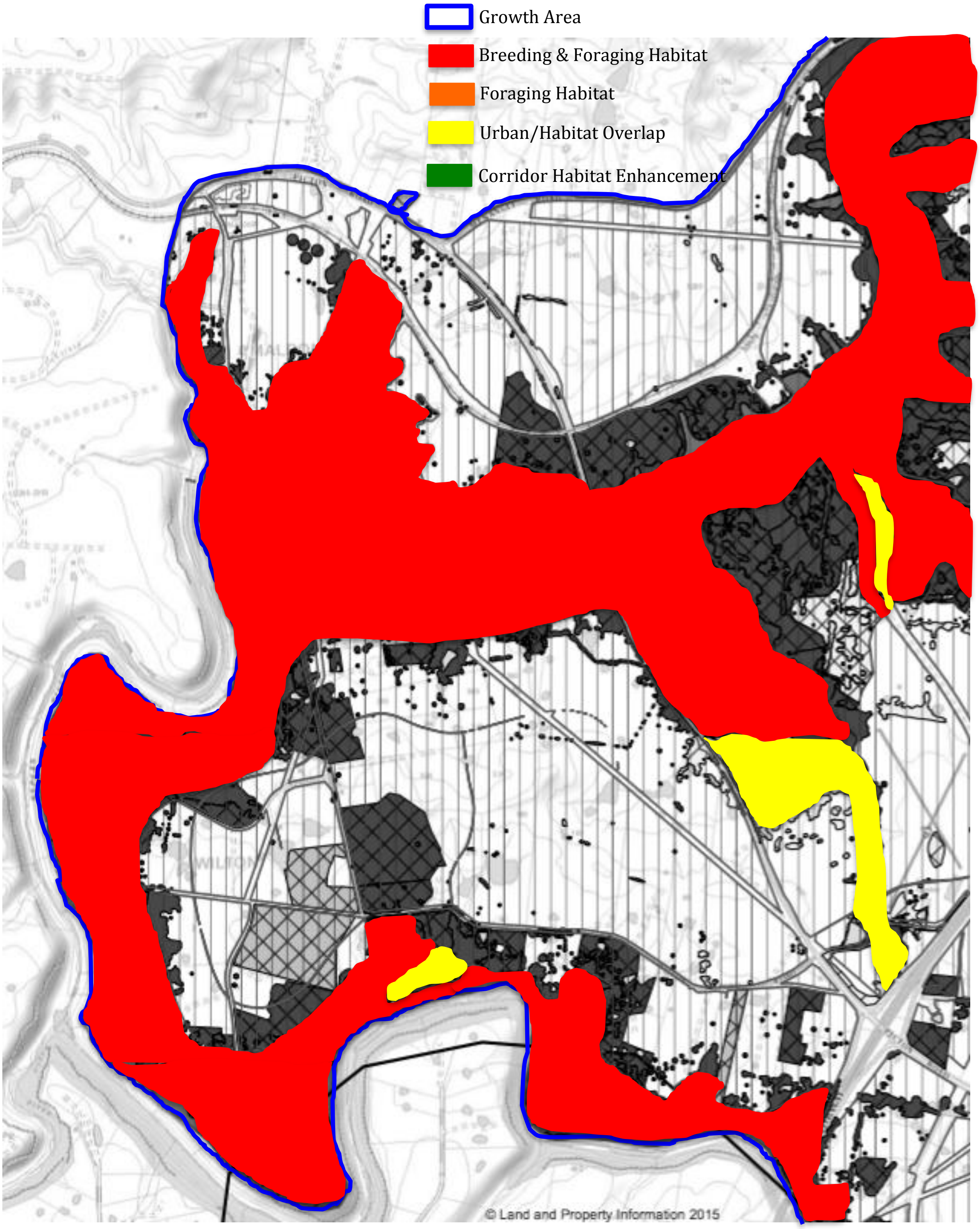


Figure 4. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Wilton growth area (Map 1). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

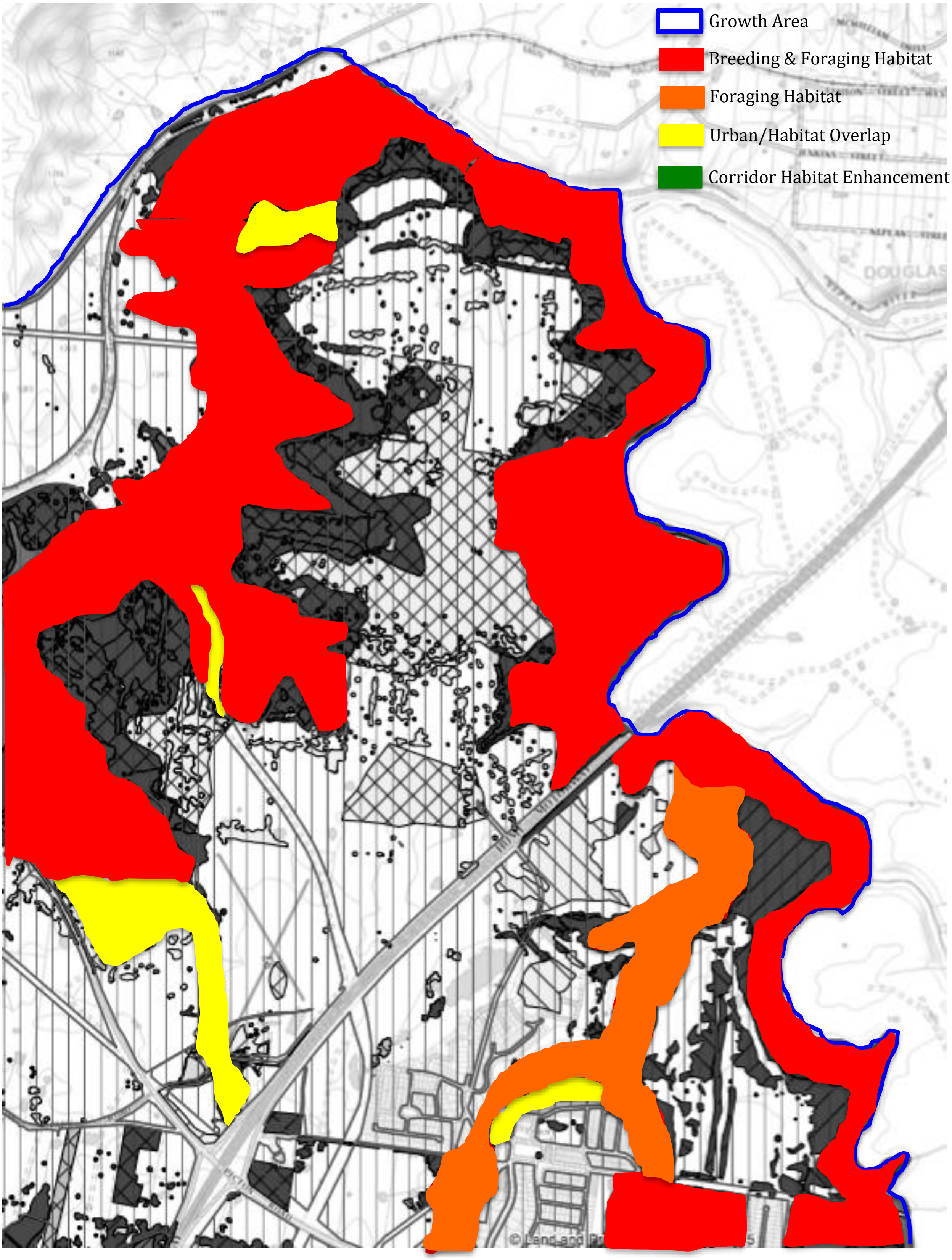


Figure 4. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Wilton growth area (Map 2). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

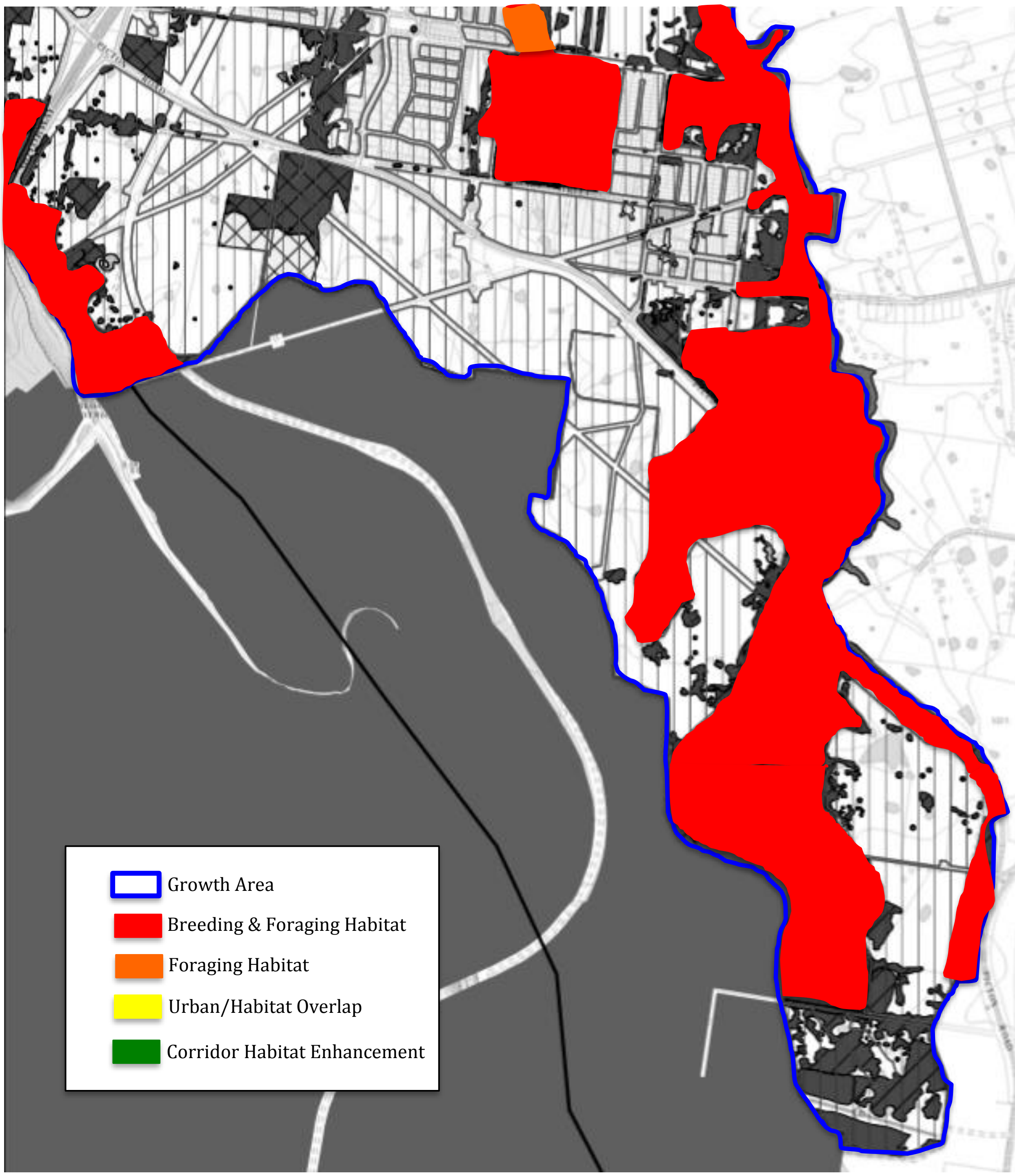


Figure 4. Potential breeding and potential foraging habitat for the Square-tailed Kite in the Greater Macarthur growth area (Map 3). Potential breeding and foraging habitat areas are shown in red, potential foraging areas are shown in orange, potential foraging areas that overlap urban development footprint shown in yellow and potential areas for habitat enhancement and improved connectivity shown in green.

Assessment of the Likelihood of Species Presence in the Growth Areas, Distribution, Population Estimate and Justification for Determination

There is a very high likelihood of Square-tailed Kites occurring within the growth areas during the breeding season. Although breeding has not been observed within the growth areas it is very likely that they will forage in the area while breeding. However, the Kite has nested in similar situations elsewhere and nesting within the growth areas would also be possible. This is supported by the occurrence of records for the Kite within and around the growth areas in October to December. The habitat remnants within the growth areas are tall open forests and woodland, are mostly along watercourses and have abundant edges. These factors provide good foraging habitat for the Kite. The Kite has also been recorded in most of the plant community types that occur within the growth areas, and again this supports a high likelihood of Square-tailed Kites occurring there.

It would appear from the distribution of records that there are likely to be 2 to 3 breeding pairs in the area that will use the site for foraging during the breeding season. Although the distance between adjacent nests in published data on nesting Kites exceeds the total length from north to south through the growth areas, there is connectivity to several larger areas of suitable habitat around the growth areas. This means that each pair's breeding territory could extend into the site from a larger area outside the growth areas. The distribution of records suggests that there may be a pair centred along the Georges River along the eastern edge of the northern half of the Greater Macarthur growth area. Another pair is likely to occur along the Appin Road area that extends into contiguous forest to the east of the southern section of the Greater Macarthur growth area. It is also possible that another pair occupies the area around the southern section of the Wilton growth area.

However, no nests have ever been recorded in the growth areas. Breeding was not observed during the surveys undertaken by Biosis or by us during our surveys. As other bird species build similar stick nests it is difficult to identify a Square-tailed Kite nest without the bird being in attendance, which would be required to confirm breeding within the growth areas. The breeding habitat areas indicated in Figures 3 and 4 are based on the minimum criteria presented in Tables 1 and 2. Although, there is much potential breeding habitat within the growth areas no breeding habitat, as defined by BAM requirements, was observed.

In summary, the evidence suggests that the Square-tailed Kite is found within the growth areas of Greater Macarthur and Wilton and that are likely to be 2 or 3 pairs occurring during the breeding season. The presence of suitable foraging habitat and potential breeding habitat within these growth areas means that protection of habitat within them may be critical to the continued presence of the Kite in the area.

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6. Curriculum Vitae

Dr Tony Saunders

Name: Anthony Stephen John Saunders

Contact Details: 1878 Taralga Road Laggan NSW 2583 0409 399 849

Academic Qualifications:

BSc University of Sydney 1976
Dip Ed Sydney Teachers College 1977
PhD University of Western Sydney 2005

Other Qualifications:

LR Drivers Licence
Public Vehicle Driver Authority
Work Health & Safety General Construction Induction (White Card)
Chemical Use and Handling Certificate
Resuscitation Certificate
Emergency Care Certificate
Anaphylaxis Training Certificate
Drone Essentials Certificate

Fields of expertise:

Bird habitat assessment on reserves, lands in production and potential offset property.
Bird monitoring in natural, modified and managed habitats.
Assessment of likelihood of threatened woodland bird species occurrence on development sites.
Coordinating projects between government and non-government organisations.
Coordination of volunteers collecting wildlife data.
Ecotourism: guiding general interest and specialists groups in flora and fauna.
Environmental and science education at high school, TAFE, and university levels.
Habitat management for terrestrial woodland birds and other wildlife.
Presentations on ecology to public interest groups and at professional workshops.
Remote area wildlife atlassing.
Wildlife database design and management.
Land for Wildlife assessments and habitat enhancement planning.

Professional positions held:

2010 - 2018 Merops Services Pty Ltd (director, avifaunal ecologist). Environmental and landscape consultant and contractor, flora and fauna surveys, habitat enhancement plans.

2013 - 2018 Land for Wildlife Assessor for Community Environment Network

1995 - 2010 Merops Services (avifaunal ecologist). Environmental and landscape consultant and contractor.

2006 - 2018 Part-time teacher, mainly science, but also industrial arts, English and maths, Crookwell High School, Goulburn High School and Trinity Grammar School.

1997 - 2005 Part-time bird guide and ecotourism bus driver.

1993 - 2004 Part-time lecturer, supervisor and demonstrator, University of Western Sydney (biology, ecology and field survey techniques).

2001 - 2004 Atlas Facilitator, Birds Australia (organising remote atlassing, facilitating data exchange and communication between Birds Australia, state government organizations and other non-government organisations).

1997 Field Technical Officer, Birds Australia (monitoring breeding success of endangered bird species).

1996 Field Technical Officer, University of Western Sydney (reptile, bird and plant survey techniques and data analysis).

1978 - 1994 High School Science Teacher at Marsden, Heathcote, Penrith and Kingswood High Schools.

Other volunteer positions held:

2014 - 2017 Assistant to Co-ordinator of the Sydney Bird Fair.

2009 – 2018 President - Crookwell Native Flora and Fauna Club.

2013 - 2018 Secretary - Grabine/Foggs Crossing Landcare Group

2001 - 2018 Avifaunal Advisor and Education Officer for Oolong Sanctuary, Dalton.

1997 - 2010 Project Manager for Atlas of Birds of the County of Cumberland.

2010 - 2018 Technical advisor to the Cumberland Bird Observer's Club's Atlas Databasae Management Committee.

1996 - 2009 Committee Member - CBOC (Cumberland Bird Observers Club Inc.).

1998 – 2014 CBOC representative to Bird Interest Group Network (BIGnet).

1997 - 2002 Faunal Advisor for the Hawkesbury Rainforest Network.

1999 - 2002 Member of Steering Committee of Birds in Backyards for Birds Australia.

1998 - 1999 Consultant to Birds Australia Birds for Birds in Backyards Project.

1998 - 2003 Regional Organiser for Sydney and the Blue Mountains, NSW facilitator and NSW/ACT representative on the Steering Committee for the National Bird Atlas for Birds Australia.

2002 Representative on NSW NPWS Wildlife Issues Advisory Panel for Birds Australia.

Relevant experience:

Co-ordination, facilitation and organization of exhibits and presentations at field-day events and indoor venues. This has involved allocating space, providing necessary facilities and setting-up audio-visual equipment for exhibitors and presenters (18 years)

Co-ordinator of volunteers for the CBOC Inc. and the Birds Australia national birds atlas. (13 years)

Facilitated the BIGnet data exchange agreement between Birds Australia, NSW Bird Atlassers, Canberra Ornithologists Group and the Cumberland Bird Observers Club. Facilitated bird data exchanges between Birds Australia, NSW State Forests and NSW DECC. (4 years)

Presenter at seminars for Bushcare, Landcare, Greening Australia, Wires and local councils, conservation societies and garden clubs on habitat management for birds and bird survey techniques. (32 years)

Educator at public, tertiary and secondary levels in the area of bird habitat management and bird survey methodology. (23 years)

Ecotourism and bird guiding (19 years).

Undertaking avifauna surveys of sites for development applications and assessment of status of threatened bird species on sites and making recommendations for minimising impact of development on these species.

Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (21 years)

Design, building and management of the bird database for the birds of the County of Cumberland on behalf of CBOC Inc. (16years)

Membership and professional affiliations:

Australian Bird Study Association
Australian Bush Heritage
Birdlife Australia
Crookwell Native Flora and Fauna Society
Cumberland Bird Observers Club
Ecological Consultants Association of NSW
Grabine/Foggs Crossing Landcare Group
Greening Australia
NSW Bird Atlassers
Royal Zoological Society (Scientific member)
Wildlife Preservation Society of Queensland

Papers, Articles, Book sections and Reports:

Saunders, T. 1985. Common Bronzewings at Round Hill Nature Reserve. *CBOC Newsletter* Vol. 6 No. 6: 5

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Saunders, T. 2011 *Criteria for Ranking Priorities for Habitat Enhancement for Lachlan Catchment Management Authority,* Unpublished Report.

Saunders, T. 2012 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Final Report.

Saunders, T. 2013 Birdscaping Gardens. p 16 *Our Gardens* Volume 55, The Garden Clubs of Australia.

Saunders, T. 2014 *Habitat Survey of Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Mitchell' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Douglass' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Holmes' Peelwood*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Ollis' Bigga*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Flat Rocks' Bigga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Gunthori' Yass*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot3 DP 789337 Taralga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot 57 Bevendale*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48541Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48016 Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 823525 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 753055 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for DP 1217631 Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Callarah' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'The Angle' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Bobbins' Reids Flat*, Unpublished Report.

Saunders, T. 2016 Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future.' Australian Bird Study Association Conference - 23 January 2016. *Corella* 40: 46

Saunders, T. 2016 *Bird surveys, likelihhood for threatened birds and habitat description for Syerston Mine Project, Fifield,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bohara' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Greendale' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bunduluk' Laggan*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 48618 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 1185604 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 823489 Cullulla for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Bird surveys, likelihhood for threatened birds and habitat description for Vickery Mine Project, Boggabri,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bimbimbie' Bigga*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for DP 1162296 Crookwell*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 1206394 Red Ground*, Unpublished Report.

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Maxwell Mine Project, Jerrys Plains,* Unpublished Report.

Saunders, T. in prep. Trends in woodland bird populations on the Cumberland Plain.

Thesis:

Saunders, A.S.J. 2006 Comparative Foraging Ecology of the Noisy Friarbird *Philemon corniculatus* and the Red Wattlebird *Anthochaera carunculata* in central eastern New South Wales.

Dr Stephen Debus

Abridged CV: Stephen John Stewart DEBUS

BA (Biol./Behav. Sc.), Dip. Natural Resources (Wildlife), Dip. Ed. (Sci.), MSc. (Zool.), PhD (Zool.)

Contact details:

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Addresses: Zoology, University of New England, Armidale NSW 2351 (business)
PO Box 1015 (6 Holloway St), Armidale NSW 2350 (private)

Website www.une.edu.au/staff-profiles/ers/sdebus

Professional capacities:

Vertebrate fauna surveys. Research and survey of threatened forest and woodland birds, particularly raptors and owls. Ecology/biology/behaviour of birds, especially predatory species. Conservation and management of threatened bird species. Distribution, status and biology/ecology of NSW birds. Reviews and biological profiles of bird species. Editing ornithological papers. Peer review of ornithological documents/EISs/species impact statements. Impact assessment (avifauna). Review of conservation status of NSW fauna.

Computer skills:

Proficient in Word and Excel, limited experience with GIS and ArcView

Employment:

Eco Logical Australia 2011-18 (casual; senior ecologist: fauna survey and report)

EA Systems (now EnviroAg Australia) 2000-14 (casual; ecologist: fauna survey and assessment)

Research assistant, Zoology, UNE, casual 1984-2014 (field ornithology: bird banding, bird surveys/censusing, ecological studies)

Tutor/demonstrator, Zoology UNE (casual), 2007-13

NSW Dept Environment & Climate Change, 2008-09 (temporary) (threatened species officer: Project Officer, NSW Scientific Committee)

Research Assistant, Ecosystem Management UNE (casual), 2008-09 (bird survey)

Post-doctoral research fellow, Zoology, UNE, 2005-07 (ecology of woodland birds)

Junior research fellow, Zoology, University of New England, 1990-1993, 1998-2004 (ecology of rare forest owls in relation to habitat and forest management; ecology and management of birds)

Technical officer, University Partnerships Pty Ltd (UNE), 1995-1996 (fauna survey and report, Eastlink EIS)

Casual assistant demonstrator, Depts Zoology and Ecosystem Management, UNE, 1988-2002 (field practical classes on population ecology and behavioural ecology of birds)

Casual teacher, New England Institute of TAFE, 1987-1993 (bird biology: including laboratory and field practical classes on classification, identification and ecology)

Field technician, National Parks & Wildlife Service Armidale, 1986 (fauna inventory, vegetation sampling and analysis)

Research assistant, Department of Ecosystem Management, University of New England, casual 1986-1987 (field survey of vegetation and fauna)

Honorary position:

Adjunct associate lecturer/research associate, Zoology UNE, 2004-2017 (includes collaborative research and publication, co-supervision of Honours/Masters/PhD students)

Consultant biologist:

Whitehaven Coal 2018 (field survey, assessment and report on potential BioBank site for Regent Honeyeater)

Northern Tablelands Local land Services 2017-18 (Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report)

North West Local Land Services 2015-18 (Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting)

28 South Environmental 2013-2018 (threatened fauna survey/assessment and report)

Fenner School of Environment and Society, Australian National, University 2016-17 (Regent Honeyeater surveys and data submission)

3E Environmental 2012-17 (flora & fauna survey and reporting)

BirdLife Australia – Northern NSW (for Bundarra-Barraba Operations Group of the Regent Honeyeater Recovery Team), 2007-17 (Regent Honeyeater/woodland bird survey and monitoring)

Southern New England Landcare 2014-16 (fauna surveys on farms, data submission, landholder workshop, report review)

James Warren & Associates 1997-2016 (fauna survey and reporting)

Conacher Environmental Group 2008, 2015 (fauna survey and report)

Ecotone Environmental Services 2012-13 (peer review of threatened fauna assessment; targeted fauna survey: federally listed birds)

NSW National Parks & Wildlife Service/Dept Environment & Conservation/DECC 1987-2013 (fauna survey, review of avifaunal component of environmental impact statements/ fauna impact statements/fauna reports, preparation of recovery plans and species profiles for threatened species)

Australian Museum, 1995, 2012 (review of fauna impact statement, avifauna; feather sampling of wild-caught birds for DNA analysis)

Cumberland Ecology 2004-2012 (fauna survey and report)

Arnhem Environmental 1996-2012 (fauna survey)

Eco Logical Australia 2010-2011 (threatened bird research, fauna database compilation)

Warkworth Mining Ltd 2008, 2011 (avifauna survey and report)

Terra Consulting/Geolyse/Orogen 2004-11 (fauna survey and assessment)

State Forests of NSW 1987-2009 (fauna survey, review of avifaunal component of environmental impact statements/fauna impact statements/fauna reports, fauna survey worskhop)

TransGrid 2009 (investigation and report: bird-related outages on 500 kV transmission lines)

Earth Services 2007-08 (fauna survey and report)

Armidale Dumaresq Council 2006-08 (fauna assessment)

Tamworth Regional Council 2007-08 (starling control/raptor assessment)

PLACE Environmental 2006-07 (fauna assessment)

ACT Planning & Land Authority 2005-06 (fauna survey and assessment)

Greenloaning Biostudies 1996-2004 (fauna survey)

Burnett Shire Council 2003 (fauna survey and assessment)

Inverell Shire Council 2003 (fauna assessment)

HWR Ecological 2003 (fauna survey)

WBM Oceanics 1999-2002 (fauna survey)

Resource Strategies 1999 (fauna survey)

Network Design & Construction Ltd, 1999 (fauna survey)

Woodward-Clyde Pty Ltd, 1994-1999 (fauna survey)

Telstra Environmental Evaluation Team 1998 (fauna survey and report)

Maunsell Pty Ltd, 1995-97 (fauna survey, review of environmental assessment)

Austeco Pty Ltd, 1990-1997 (fauna survey)

North-west Ecological Services 1997 (fauna survey)

ANCA 1995-1996 (fauna survey, Jervis Bay National Park)

SA National Parks & Wildlife Service, 1995 (fauna survey)

Grants and awards:

Search for Red Goshawk in NSW: $1,000 from the Australian Bird Environment Fund (Bird Observers Club of Aust.), 1987.

Distribution, status and habitat requirements of the Sooty Owl in northern NSW: $2,000 as a Cayley Memorial Scholarship (Gould League of NSW) 1990-93; with Associate Professors Hugh Ford & Harry Recher (UNE), $34,280 from WWF Australia and $64,835 from ANPWS (Endangered Species Program) 1990-93.

Will wildlife corridors work for sedentary birds?: with Professor Hugh Ford, $42,565 from the NSW Environmental Trust 2005, $43,359 in 2006-07.

Bird Observers Club of Australia: Distinguished Service Award, 2005 (editing the *Australian Bird Watcher*/*Australian Field Ornithology* for 21 years 1984-2005).

Royal Zoological Society of NSW Whitley Award, 2013 (*Birds of Prey of Australia: A Field Guide*, 2nd edn, best vertebrate guide in 2012)

BirdLife Australia's D.L. Serventy Medal for publication in ornithology, 2015

Voluntary work:

Editor: *Australasian Raptor Association News* 1980-1989 and *Boobook* (re-named) 2004-17 (biannual journal for bird-of-prey enthusiasts); *Australian Field Ornithology* 1984-2015 (quarterly journal)

Sub-editor: *Corella* Wedge-tailed Eagle special issue, 2007; White-bellied Sea-Eagle special issue, 2009; rare raptors special issue, 2011

Committee member: Australian Bird Study Association 1981-1988, 2005-17; Birds Australia Northern NSW Group 1996-99, 2004-12, 2015-17; Australasian Ornithological Conference 2009 organising committee 2008-09; ABSA/BirdLife Southern NSW conference organising committee 2013-14

Regent Honeyeater Recovery Team: Bundarra-Barraba Operations Group rep, 2008-18

Red Goshawk National Recovery Team 2014-18

Publications:

~130 refereed papers (selection appended), books and book contributions, theses: see appended list

Refereed publications (selected titles):

Debus, S.J.S. 1984. Biology of the Little Eagle on the Northern Tablelands of New South Wales. *Emu* 84: 87-92.

_____, Ley, A.J., Trémont, S. & Trémont, R. 1991. Breeding behaviour and diet of the Australian Hobby *Falco longipennis* in northern New South Wales. *Aust. Bird Watcher* 14: 123-137.

Debus, S.J.S. 1992. A survey of diurnal raptors in north-east New South Wales, 1987-1990. *Aust. Birds* 25: 67-77.

Debus, S.J.S. 1993a. The mainland Masked Owl *Tyto novaehollandiae*: a review. *Aust. Bird Watcher* 15: 168-191.

_____ 1993b. The status of the Red Goshawk *Erythrotriorchis radiatus* in New South Wales, in Olsen, P.D. (Ed.), *Australian Raptor Studies*, pp. 182-191. Australasian Raptor Association, RAOU, Melbourne.

Debus, S.J.S., Ley, A.J., Trémont, S.M., Trémont, R.M. & Collins, J.L. 1993. Breeding behaviour and diet of the Collared Sparrowhawk *Accipiter cirrhocephalus* in northern New South Wales. *Aust. Bird Watcher* 15: 68-91.

Debus, S.J.S., McAllan, I.A.W. & Mead, D.A. 1993a,b. Museum specimens of the Red Goshawk *Erythrotriorchis radiatus*. I. Annotated list of specimens; II. Morphology, biology and conservation status in eastern Australia. *Sunbird* 23: 5-28; 75-89.

Debus, S.J.S., McAllan, I.A.W. & Morris, A.K. 1993. The Square-tailed Kite *Lophoictinia isura* in New South Wales. *Aust. Birds* 26: 104-118.

Peake, P., Conole, L.E., Debus, S.J.S., McIntyre, A. & Bramwell, M. 1993. The Masked Owl *Tyto novaehollandiae* in Victoria. *Aust. Bird Watcher* 15: 124-136.

Ford, H.A., Davis, W.E., Debus, S., Ley, A., Recher, H. & Williams, B. 1993. Foraging and aggressive behaviour of the Regent Honeyeater *Xanthomyza phrygia* in northern New South Wales. *Emu* 93: 277-281.

Debus, S.J.S. 1994. The Sooty Owl *Tyto tenebricosa* in New South Wales. *Aust. Birds* 28 supplement: 4-19.

_____ & Chafer, C.J. 1994. The Powerful Owl *Ninox strenua* in New South Wales. *Aust. Birds* 28 supplement: 21-38.

_____ & Rose, A.B. 1994. The Masked Owl *Tyto novaehollandiae* in New South Wales. *Aust. Birds* 28 supplement: 40-64.

Debus, S.J.S. 1995. Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella* 19: 38-50.

Kavanagh, R.P., Debus, S., Tweedie, T. & Webster, R. 1995. Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history. *Wildlife Research* 22: 359-377.

Debus, S.J.S. 1997a. A survey of the raptors of Jervis Bay National Park. *Aust. Birds* 30: 29-44.

_____ 1997b. The Barking Owl in New South Wales. *Aust. Birds* 30: 53-80.

_____ 1997c. Aspects of the biology of captive-bred, hack-released Masked Owls *Tyto novaehollandiae*. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 14-33. Birds Australia Monograph 3, Birds Australia, Melbourne.

_____ 1997d. Vocal behaviour of the Southern Boobook *Ninox novaeseelandiae* and other nocturnal birds. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 71-85. Birds Australia Monograph 3, Birds Australia, Melbourne.

Mathieson, M.T., Debus, S.J.S., Rose, A.B., McConnell, P.J. & Watson, K.M. 1997. Breeding diet of the Letter-winged Kite *Elanus scriptus* and Black-shouldered Kite *Elanus axillaris* during a House Mouse plague. *Sunbird* 27: 65-71.

Debus, S.J.S., Maciejewski, S.E. & McAllan, I.A.W. 1998. The Grass Owl in New South Wales. *Aust. Birds* 31: 29-45.

Brigham, R.M., Debus, S.J.S. & Geiser, F. 1998. Cavity selection for roosting, and roosting ecology of forest-dwelling Australian Owlet-nightjars (*Aegotheles cristatus*). *Aust. J. Ecol.* 23: 424-429.

Bischoff, T., Lutter, H. & Debus, S. 2000. Square-tailed Kites breeding on the mid-north coast of New South Wales. *Aust. Bird Watcher* 18: 233-240.

Brown, B., Brown, F. & Debus, S.J.S. 2000. Further observations on a pair of Square-tailed Kites nesting near Grafton, New South Wales. *Aust. Bird Watcher* 18: 270-273.

Debus, S.J.S. & Rose, A.B. 2000. Diet of Grey Falcons *Falco hypoleucos* breeding extralimitally in New South Wales. *Aust. Bird Watcher* 18: 280-281.

Harrington, G.N. & Debus, S.J.S. 2000. Dietary items of the Rufous Owl *Ninox rufa* on the Atherton Tableland, north Queensland. *Aust. Bird Watcher* 18: 251-252.

Debus, S.J.S. 2001. Surveys of the Barking Owl and Masked Owl on the North-west Slopes of New South Wales. *Corella* 25: 5-11.

Barnes, C.P., Zillmann, E.E., Rose, A.B. & Debus, S.J.S. 2001. Diet and biology of the Square-tailed Kite *Lophoictinia isura* in south-eastern Queensland: nest-building to post-fledging. *Aust. Bird Watcher* 19: 28-43.

Debus, S.J.S., Agnew, L.R. & Schulz, M. 2001. Surveys of the Grass Owl *Tyto capensis* in coastal New South Wales. *Aust. Bird Watcher* 19: 94-102.

Debus, S.J.S. 2002. Distribution, taxonomy, status and major threatening processes of owls of the Australasian Region. In Newton, I., Kavanagh, R., Olsen, J. & Taylor, I. (Eds), *Ecology and Conservation of Owls*, pp. 355-363. CSIRO, Melbourne.

Griffiths, H., Lutter, H., Rose, A.B. & Debus, S.J.S. 2002. Breeding and diet of a pair of Square-tailed Kites *Lophoictinia isura* on the mid-north coast of New South Wales. *Aust. Bird Watcher* 19: 184-193.

Debus, S.J.S. & Rose, A.B. 2003. Diet of a Barking Owl *Ninox connivens* in the channel country of south-west Queensland. *Corella* 27: 18-19.

Lutter, H., Dinnie, R. & Debus, S.J.S. 2003. Square-tailed Kites breeding in northern coastal New South Wales: post-fledging diet and behaviour. *Aust. Field Ornithology* 20: 94-104.

Debus, S.J.S., Olsen, J. & Rose, A.B. 2004. Diet of the Barn Owl *Tyto alba* near Lake Frome in arid South Australia. *Corella* 28: 40-42.

Debus, S.J.S. & Rose, A.B. 2004. Diet of the Barn Owl *Tyto alba* near Tamworth, New South Wales. *Corella* 28: 95.

Lutter, H., Lutter, M., Rose, A.B. & Debus, S.J.S. 2004. Breeding biology and diet of the Square-tailed Kite on the mid-north coast of New South Wales. *Aust. Field Ornithology* 21: 141-157.

Olsen, J., Debus, S., Rose, A.B. & Hayes, G. 2004. Breeding success, cliff characteristics, and diet of Peregrine Falcons at high altitude in the Australian Capital Territory. *Corella* 28: 33-37.

Barnes, C.P., Rose, A.B. & Debus, S.J.S. 2005. Breeding behaviour and diet of a family of Barking Owls *Ninox connivens* in south-eastern Queensland. *Aust. Field Ornithology* 22: 182-195.

Debus, S.J.S. 2005. White-bellied Sea-Eagles breeding in the Australian Capital Territory? *Canberra Bird Notes* 30: 146-147.

Debus, S.J.S., Ford, J.A. & Rose, A.B. 2005. Breeding-season diet of a pair of Barking Owls near Armidale, New South Wales. *Corella* 29: 15-16.

Debus, S.J.S. & Lollback, G. 2005. Breeding behaviour of the Restless Flycatcher near Armidale, New South Wales. *Aust. Field Ornithology* 22: 22-28.

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Debus, S.J.S., Hatfield, T.S., Olde, G.S. & Rose, A.B. 2005. Breeding behaviour and diet of a pair of Black Falcons *Falco subniger* in northern New South Wales. *Aust. Field Ornithology* 22: 165-181.

Courtney, J. & Debus, S.J.S. 2006a. Breeding habits and conservation status of the Musk Lorikeet *Glossopsitta concinna* and Little Lorikeet *G. pusilla* in northern New South Wales. *Aust. Field Ornithology* 23: 109-124.

_____ & _____ 2006b. Observations on the post-fledging period of the Barn Owl *Tyto alba*. *Aust. Field Ornithology* 23: 159-162.

Debus, S.J.S. 2006a. Breeding and population parameters of robins in a woodland remnant in northern New South Wales, Australia. *Emu* 106: 147-156.

_____ 2006b. Breeding biology and behaviour of the Scarlet Robin *Petroica multicolor* and Eastern Yellow Robin *Eopsaltria australis* in remnant woodland near Armidale, New South Wales. *Corella* 30: 59-65.

_____ 2006c. Breeding habitat and nest-site characteristics of Scarlet Robins and Eastern Yellow Robins near Armidale, New South Wales. *Pacific Conservation Biology* 12: 261-271.

_____ 2006d. The role of intense nest predation in the decline of Scarlet Robins and Eastern Yellow Robins in remnant woodland near Armidale, New South Wales. *Pacific Conservation Biology* 12: 279-287.

Debus, S.J.S. & Rose, A.B. 2006. Supplementary data on breeding and diet of the Northern Forest Raven *Corvus tasmanicus boreus*. *Aust. Field Ornithology* 23: 96-101.

Debus, S.J.S., Ford, H.A. & Page, D. 2006. Bird communities in remnant woodland on the New England Tablelands, New South Wales. *Pacific Conservation Biology* 12: 50-63.

Debus, S.J.S., Ford, H.A. & Trémont, S.M. 2006. Bird communities in remnant woodland on the upper North-west Slopes of New South Wales. *Aust. Zoologist* 33: 519-529.

Debus, S.J.S., Lollback, G., Oliver, D.L. & Cairns, S.C. 2006. The birds of Bulgunnia and Mulyungarie Stations in the pastoral zone of arid South Australia. *South Australian Ornithologist* 35: 27-37.

Debus, S.J.S., Olde, G.S., Marshall, N., Meyer, J. & Rose, A.B. 2006. Foraging, breeding behaviour and diet of a family of Black-shouldered Kites *Elanus axillaris* near Tamworth, New South Wales. *Aust. Field Ornithology* 23: 130-143.

Lutter, H., McGrath, M.B., McGrath, M.A. & Debus, S.J.S. 2006. Observations on nesting Brahminy Kites *Haliastur indus* in northern New South Wales. *Aust. Field Ornithology* 23: 177-183.

Debus, S.J.S. 2007a. Avifauna of remnant bushland in south-east Queensland I: Brisbane and hinterland. *Sunbird* 37(2): 14-24.

_____ 2007b. Avifauna of remnant bushland in south-east Queensland II: The Gold Coast hinterland. *Sunbird* 37(2): 25-32.

_____ 2007c. Avifauna of remnant bushland in south-east Queensland III: The Sunshine Coast and hinterland. *Sunbird* 37(2): 33-44.

_____ 2007d. Avifauna of remnant bushland on the Tweed Coast of New South Wales. *Sunbird* 37(2): 45-55.

Debus, S.J.S. & Wood, C. 2007. Growth of a nestling Masked Owl *Tyto novaehollandiae*. *Aust. Field Ornithology* 24: 49-53.

Debus, S.J.S., Hatfield, T.S., Ley, A.J. & Rose, A.B. 2007a. Breeding biology and diet of the Wedge-tailed Eagle *Aquila audax* in the New England region of New South Wales. *Aust. Field Ornithology* 24: 93-120.

Debus, S.J.S., Hatfield, T.S., Ley, A.J. & Rose, A.B. 2007b. Breeding biology and diet of the Little Eagle *Hieraaetus morphnoides* in the New England region of New South Wales. *Aust. Field Ornithology* 24: 137-157.

Debus, S.J.S., Ley. A.J. & Rose, A.B. 2007. Winter diet of a Barn Owl and a Nankeen Kestrel in Diamantina National Park, western Queensland. *Sunbird* 37: 1-8.

Debus, S.J.S. 2008a. The effect of Noisy Miners on small bush birds: an unofficial cull and its outcome. *Pacific Conservation Biology* 14: 185-190.

Debus, S.J.S. 2008b. Biology and diet of the White-bellied Sea-Eagle *Haliaeetus leucogaster* breeding in northern inland New South Wales. *Aust. Field Ornithology* 25: 165-193.

Debus, S.J.S., Ley, A.J. & Rose, A.B. 2008. Further dietary items of the Eastern Barn Owl *Tyto javanica* in Diamantina National Park, Queensland. *Australian Field Ornithology* 25: 149–152.

Trost, S., Olsen, J., Rose, A.B. & Debus, S.J.S. 2008. Winter diet of Southern Boobooks *Ninox novaeseelandiae* in Canberra 1997-2005. *Corella* 32: 66-70.

Debus, S.J.S. & Ley, A.J. 2009. Aspects of the breeding cycle of the Little Eagle *Hieraaetus morphnoides*. *Australian Field Ornithology* 27: 76-99.

Cherriman, S.C., Foster, A. & Debus, S.J.S. 2009. Supplementary notes on the breeding behaviour of Wedge-tailed Eagles *Aquila audax*. *Australian Field Ornithology* 27: 142-147.

Ford, H.A., Walters, J.R., Cooper, C.B., Debus, S.J.S. & Doerr, V.A.J. 2009. Extinction debt or habitat change? – Ongoing losses of woodland birds in north-eastern New South Wales, Australia. *Biological Conservation* 142: 3182-3190.

Debus, S.J.S., Ley, A.J. & Rose, A.B. 2010. Diet of the Eastern Barn Owl *Tyto (javanica) delicatula* in Diamantina National Park, south-western Queensland, in 2008–2009. *Australian Field Ornithology* 27: 179-183.

Olsen, J., Fuentes, E., Judge, D., Rose, A.B. & Debus, S.J.S. 2010. Diets of Wedge-tailed Eagles (*Aquila audax*) and Little Eagles (*Hieraaetus morphnoides*) breeding near Canberra, Australia. *J. Raptor Research* 44: 50-61.

Debus, S.J.S. 2011. Parental time-budgets and breeding behaviour of the Little Eagle *Hieraaetus morphnoides* in northern New South Wales. *Corella* 35: 65-72.

Debus, S.J.S. & Olsen, J. 2011. Some aspects of the biology of the Black Falcon *Falco subniger*. *Corella* 35: 29-36.

Debus, S.J.S. & Tsang, L.R. 2011. Notes on Black Falcons *Falco subniger* breeding near Tamworth, New South Wales. *Australian Field Ornithology* 28: 13-26.

Barnes, C.P. & Debus, S.J.S. 2012. A snapshot in the post-fledging period of the Black Falcon. *Australian Field Ornithology* 29: 86-88.

Debus, S.J.S. 2012. Hunting behaviour of Black Falcons. *Australian Field Ornithology* 29: 83-85.

Debus, S.J.S. & Ford, H.A. 2012. Responses of Eastern Yellow Robins *Eopsaltria australis* to translocation into vegetation remnants in a fragmented landscape. *Pacific Conservation Biology* 18: 194-202.

O'Donnell, W.B. & Debus, S.J.S. 2012. Nest-sites and foraging of the White-bellied Sea-Eagle *Haliaeetus leucogaster* on the subtropical eastern Australian coast. *Australian Field Ornithology* 29: 149-159.

Debus, S.J.S. 2013. Breeding of the Hooded Robin *Melanodryas cucullata* in native and exotic woodlands near Armidale, New South Wales. *Corella* 37: 49-56.

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Appendix 1. Habitat descriptions for each Site in greater Macarthur and Wilton Proposed Growth Areas.

Site No.	Latitude	Longitude	PCTs	Canopy Height (m)	Canopy Spacing	DBH Range (m)	Shrub Cover	Ground Cover	Woodland Maturity	Shrub Diversity	Regeneration	Connectivity	Aspect/Slope	Avian Community
1	-33.96801	150.90682	849	15-20	Closed	0.3-0.7	Sparse tall shrubs	Sparse grass and mainly leaf litter	Mature	Poor and weedy	None evident	Good	Flat	Large passerines and parrots
2	-33.97577	150.90994	835, 849	15-20	Closed	0.4-1.3	Dense	Native grasses in open areas	Mature	Good with some weeds	Some regeneration	Very good	Along watercourse valley	Large passerines and parrots
3	-33.98336	150.89717	1395	15-20	Closed	0.2-0.5	Dense	Mainly leaf litter	Mature	Good	Some regeneration	Good	Along watercourse	Diverse, with small passerines
4	-33.99160	150.87588	835	15-20	Open and patchy	0.2-0.9	Dense along creek, absent in parkland	Mainly mown grass	Mature	Good but only along creek	None evident	Good	Along watercourse	Low diversity - dominated by N.Miner
5	-33.99667	150.87933	849	15	Open	0.3-0.7	Some dense patches	Mainly mown grass	Mature	Low	Some regeneration	Moderately good	Flat and along watercourse	Low diversity - dominated by N.Miner
6	-33.00763	150.86866	835	10-15	Scattered trees	0.3-0.7	Low	Mainly mown grass	Mature	Low	None evident	Isolated	Along watercourse	Low diversity - dominated by N.Miner
7	-34.01357	150.85682	835, 1395	15-20	Open and patchy	0.3-1.2	Dense along creek with some small patches away from creek	Mainly leaf litter and native grass in open areas	Mature	Good with some weeds	Some regeneration	Good	Along watercourse valley	Diverse, with small passerines
8	-34.01049	150.84202	849	20	Scattered trees	0.8	Mostly absent with small scattered dense patches	Native grasses in open areas	Mature	Poor and weedy	None evident	Poor	Flat area	Low diversity - dominated by N.Miner
9	-34.00402	150.83964	1395	15	Open	0.7	Dense	Mainly leaf litter	Mature	Poor mainly natives	None evident	Poor	Along a canal	Some small passerines

Appendix 1. Habitat descriptions for each Site in greater Macarthur and Wilton Proposed Growth Areas.

Site No.	Latitude	Longitude	PCTs	Canopy Height (m)	Canopy Spacing	DBH Range (m)	Shrub Cover	Ground Cover	Woodland Maturity	Shrub Diversity	Regeneration	Connectivity	Aspect/Slope	Avian Community
10	-34.03953	150.84055	849	12-15	Closed	0.2-0.8	Dense along creek, absent in parkland	Mainly mown grass	Mature	Good but only along creek with woody weeds	None evident	Poor	Along watercourse	Large passerines and parrots
11	-34.05475	150.83743	1081, 1181	20-25	Open	0.2-1.2	Dense with variable height	Mainly leaf litter	Mature	Very good	Some regeneration	Good	Along watercourse valley	Diverse with small passerines
12	-34.05460	150.81757	850	10-18	Open and patchy	0.2-0.6	Dense with variable height	Mainly leaf litter	Mature	Poor and weedy	None evident	Isolated	North facing steep slope	Large passerines and parrots
13	-34.05984	150.79926	850	10-15	Open	0.2-0.8	Some dense patches	Mainly leaf litter and native grass in open areas	Mature	Poor and weedy, but with some *Bursaria spinosa*	None evident	Isolated	Along watercourse valley	Large passerines and parrots
14	-34.05677	150.80422	850	15	Scattered trees	0.4	Some dense patches	Mainly leaf litter and native grass in open areas	Mature	Good	None evident	Isolated	Along watercourse	Large passerines and parrots
15	-34.06471	150.79735	835	15-18	Closed	0.2-0.6	Some large dense patches	Mainly leaf litter and native grass in open areas	Young	Good with some weeds	Some regeneration	Isolated	Along watercourse	Some small passerines
16	-34.07929	150.80041	849	10-15	Open and patchy	0.3-0.5	Some large dense patches	Mainly leaf litter and native grass in open areas	Mature	Poor and weedy	Some regeneration	Isolated	Along east facing slope	Large passerines and parrots
17	-34.07103	150.79253	835	12-20	Closed	0.3-0.8	Dense	Mainly leaf litter	Mature	Good with very few weeds	Some regeneration	Poor	Along watercourse	Diverse, with small passerines
18	-34.07175	150.78816	849	15-20	Open	0.3-0.8	Very dense	Mainly leaf litter	Mature	Poor and weedy	Some regeneration	Poor	Along watercourse	Large passerines and parrots
19	-34.07426	150.77886	849	15-20	Open	0.3-0.8	Very dense	Mainly leaf litter	Mature	Poor and weedy	Some regeneration	Poor	Along watercourse	Large passerines and parrots

Appendix 1. Habitat descriptions for each Site in greater Macarthur and Wilton Proposed Growth Areas.

Site No.	Latitude	Longitude	PCTs	Canopy Height (m)	Canopy Spacing	DBH Range (m)	Shrub Cover	Ground Cover	Woodland Maturity	Shrub Diversity	Regeneration	Connectivity	Aspect/Slope	Avian Community
20	-34.09521	150.75699	835	15-20	Open and patchy	0.5-0.8	Some dense patches	Mainly leaf litter and native grass in open areas	Mature	Good with some weeds	Some regeneration	Moderately good	Along watercourse	Diverse, with small passerines
21	-34.10223	150.75169	1395	15-20	Open and patchy	0.2-0.7	Mostly sparse with some small dense patches	Mainly leaf litter and native grass in open areas	Mature	Poor and weedy	None evident	Poor	Gently sloping hilltop	Low diversity - dominated by N.Miner
22	-34.09795	150.74683	849	12-20	Closed but open at patch edges	0.2-1.3	Sparse	Dense cover of native grasses	Young with some scattered mature emergent trees	None	Some regeneration	Very good	Flat area	Large passerines and parrots
23	-34.09972	150.7786	830	18-20	Open and patchy	0.3-0.6	Dense with variable height	Mainly leaf litter	Young with some scattered mature emergent trees	Poor and weedy	Some regeneration	Moderately good	Steep-sided hilltop	Low diversity - dominated by N.Miner
24	-34.11215	150.77988	835	20-25	Open and patchy	0.6-1.2	Dense with variable height	Mainly leaf litter	Mature	Poor mainly natives	None evident	Good	Along watercourse valley	Diverse, with small passerines
25	-34.12015	150.79354	1395	20-25	Scattered trees	1.0-1.3	Absent	Heavily grazed native grasses	Mature	None	None evident	Moderately good	Gently undulating	Large passerines and parrots
26	-34.12996	150.78533	1395	20-25	Small patches and scattered trees	0.6-1.3	Absent	Heavily grazed native grasses	Mature	None	None evident	Good	Gently undulating	Large passerines and parrots
27	-34.14001	150.79018	1395	15-20	Closed	0.2-0.7	Moderate shrub cover in patches	Mainly leaf litter	Mature	Good with no obvious woody weeds	Much sapling regrowth	very good	Gently undulating	Diverse, with small passerines

Appendix 1. Habitat descriptions for each Site in greater Macarthur and Wilton Proposed Growth Areas.

Site No.	Latitude	Longitude	PCTs	Canopy Height (m)	Canopy Spacing	DBH Range (m)	Shrub Cover	Ground Cover	Woodland Maturity	Shrub Diversity	Regeneration	Connectivity	Aspect/Slope	Avian Community
28	-34.15692	150.78909	1395	15-25	Closed but open at patch edges	0.2-0.7	Dense with variable height, but patchy	Mainly leaf litter	Mature	Good with no obvious woody weeds	Some regeneration	Very good	Gently undulating	Diverse, with small passerines
29	-34.19165	150.78422	1395	15-20	Closed but open at patch edges	0.3-0.9	Dense with variable height	Mainly leaf litter	Mature	Good with very few weeds	None evident	Very good	Along watercourse	Diverse, with small passerines
30	-34.20653	150.76729	850	20-25	Open and patchy	0.8-1.3	Sparse with some scattere d dense patches	Heavily grazed native grasses	Mature	Good with very few weeds	None evident	Fair	Hilltop with NW facing slope	Large passerines and parrots
31	-34.20109	150.75721	1395	15	Closed but open at patch edges	0.2-0.8	Dense with variable height	Mainly leaf litter	Mature	Good with very few weeds	Some regeneration	Very good	Gently undulating	Diverse, with small passerines
32	-34.22262	150.7522	1395	3-5	Open and patchy	0.2-0.3	Moderat e shrub cover in patches	Mainly leaf litter and native grass in open areas	Young	Poor mainly natives	Some regeneration	Good	Hillside sloping to the south	Some small passerines
33	-34.26687	150.71363	1395	10-18	Closed	0.2-0.7	Sparse	Mainly leaf litter and native grass in open areas	Young with some scattered mature emergent trees	Good with very few weeds	Much sapling regrowth	Good	Flat area	Diverse, with small passerines
34	-34.24750	150.70141	1395	15-20	Closed	0.4-1.2	Dense along creek with some small patches away from creek	Mainly leaf litter	Mature	Good with very few weeds	Some regeneration	Very good	Along watercourse valley	Diverse, with small passerines

Appendix 1. Habitat descriptions for each Site in greater Macarthur and Wilton Proposed Growth Areas.

Site No.	Latitude	Longitude	PCTs	Canopy Height (m)	Canopy Spacing	DBH Range (m)	Shrub Cover	Ground Cover	Woodland Maturity	Shrub Diversity	Regeneration	Connectivity	Aspect/Slope	Avian Community
35	-34.23376	150.69217	1395	15-25	Open	0.3-0.8	Dense with variable height	Mainly leaf litter and native grass in open areas	Mature	Good with some weeds	Some regeneration	Moderately good	Flat area	Diverse, with small passerines
36	-34.23014	150.68057	1395	20	Small patches and scattered trees	0.4-1.2	Absent	Mainly mown grass	Mature	None	None evident	Good	Along watercourse	Low diversity - dominated by N.Miner
37	-34.21825	150.66305	849	10-20	Open and patchy	0.4-0.8	Absent	Heavily grazed native grasses	Mature	None	None evident	Good	Flat and along watercourse	Large passerines and parrots
38	-34.22517	150.64112	1395	10-20	Open and patchy	0.4-0.8	Absent	Heavily grazed native grasses	Mature	None	None evident	Good	Gentle slope to the south	Large passerines and parrots
39	-34.23169	150.63132	1395	10-12	Open and patchy	0.2-0.4	Dense along creek with some small patches away from creek	Heavily grazed native grasses	Young with some scattered mature emergent trees	Poor mainly natives	Mostly regeneration	Good	Gentle slope to the south	Low diversity - dominated by N.Miner
40	-34.20781	150.63328	1081	15-20	Open	0.4-0.6	Dense with variable height	Mainly leaf litter	Mature with some regeneration	Good with very few weeds	Some regeneration	Good	Slopes to the west	Diverse, with small passerines

Review of updates to the development footprints of the Greater Macarthur and Wilton urban growth areas in relation to strategic assessments on the Little Eagle and the Square-tailed Kite

This supplementary report has been requested by Biosis Pty Ltd in order to examine how changes in the development footprint of the growth areas may affect some of the conclusions made in the strategic assessments for the Little Eagle and the Square-tailed Kite done by Merops Services Pty Ltd in 2018.

This has involved comparisons between the maps of the development footprints from 2018 to 2020 and in particular whether there are changes to the potential breeding habitat for both bird species.

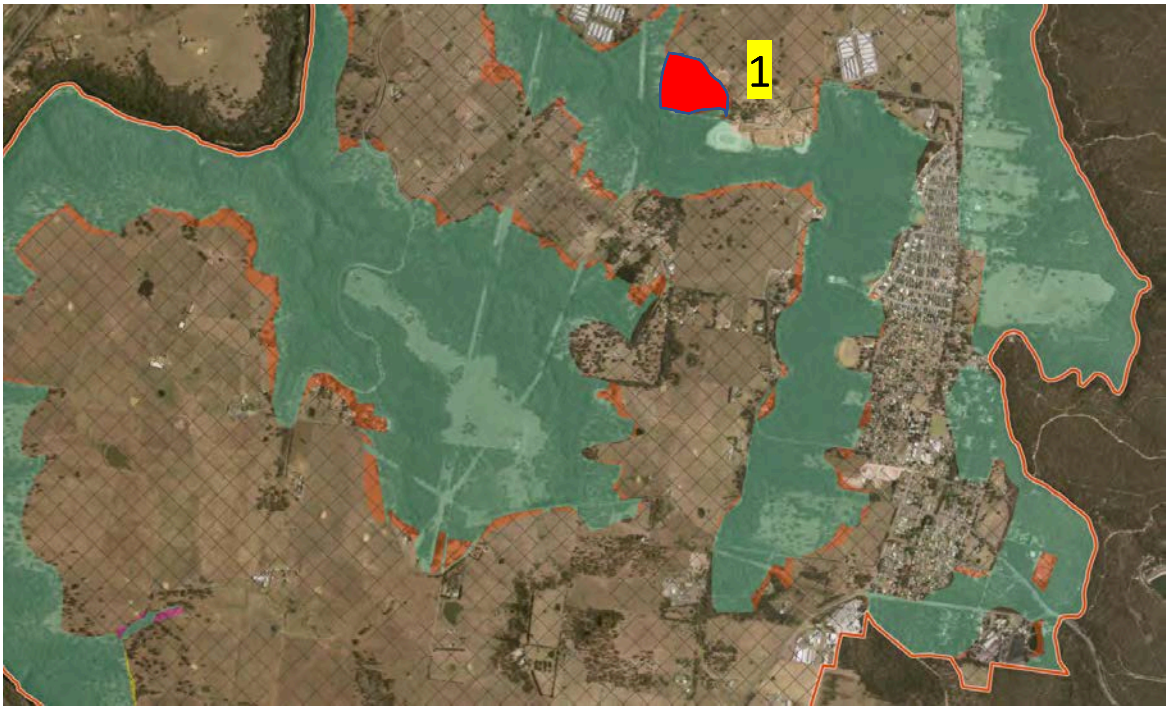
As described in the 2018 strategic assessments, there was no evidence found for breeding for either bird species within the development footprints. As a result, habitat structure, plant species composition and presence of prey species was used to assess whether potential breeding habitat areas existed for either species within the development footprint. The timing of the survey work (late May and June) was outside the breeding period for both raptor species. Although the Little Eagle is present for most of the year the Square-tailed Kite is mostly absent from south-eastern New South Wales during the non-breeding season. In addition, access to much of the area was restricted and often many of the potential areas were examined only from the edges. This was sufficient to describe habitat structure, confirm PCTs and detect potential prey species, but we were not able to check for nests that may have suggested that either species could be using the area. The habitat criteria were used as a surrogate for actual sightings of either species, detection of nests and breeding activity.

The maps created for the 2018 reports indicated potential breeding habitat and potential foraging habitat. The Square-tailed Kite will forage along forest and woodland edges and is somewhat tolerant of nearby human activity. However, the Little Eagle requires a greater buffer between urban areas and breeding habitat. Many of the areas suitable for the Little Eagle have been mapped to show foraging areas working as buffers for potential breeding areas for the Little Eagle. This species requires foraging areas to be adjacent to breeding areas and the more open areas adjacent to the woodland remnants provide these. The Little Eagle will often forage along the edges of timbered habitat and also nest close to edges of more open foraging habitat. The red polygons indicating breeding and foraging habitat represent these areas. The areas shown as orange polygons represent foraging habitat areas that are sufficiently close to potential breeding areas and the areas marked as yellow polygons indicate the same type of habitat, except that such areas overlap the development footprint. Both types of areas would also provide a buffer zone to any development.

The differences in mapping between 2018 and 2020 are considered under two headings. The first looks at potential differences in polygons from the 2018 reports and the 2018 footprint maps supplied to us in 2020. The second looks at whether changes to the development footprints between 2018 and 2020 have meant that changes to the conclusions in the 2018 reports are likely to be required.

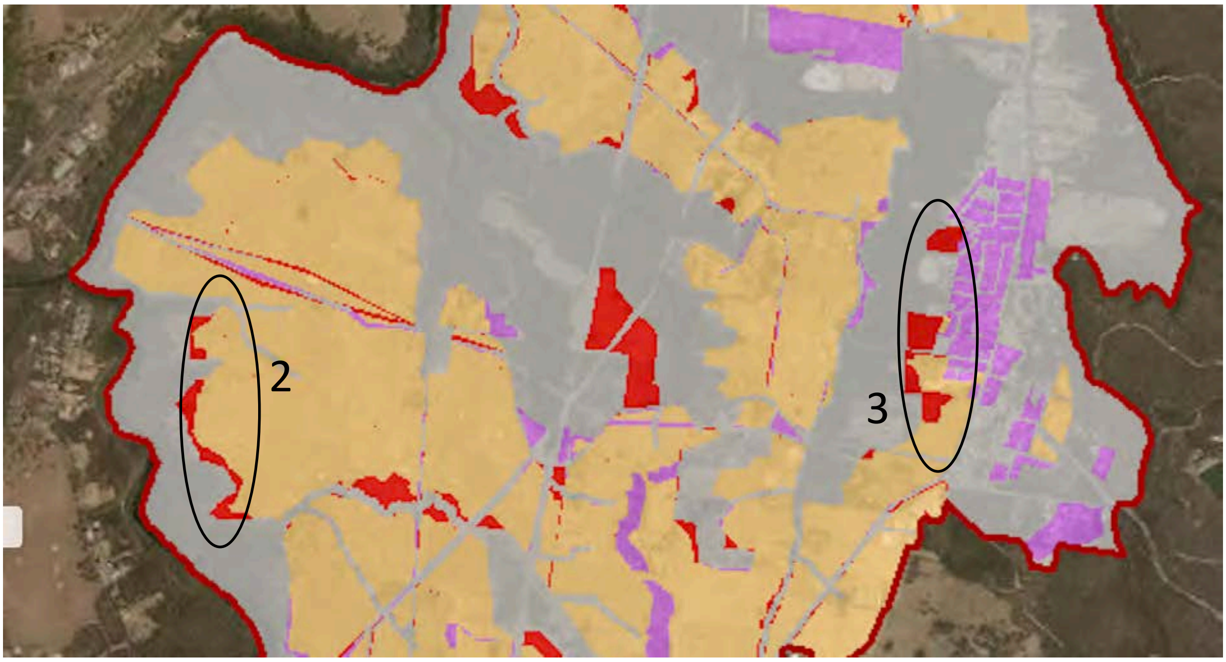
The original vegetation maps supplied to us in 2018 have large areas of PCT 1395 colour coded dark blue. Unfortunately, it was difficult to delineate between the development footprint and areas excluded from the footprint in the margins of these areas. The red polygons in the 2018 reports indicated potential breeding and foraging habitat and some edges of these polygons overlapped the development footprint. Most of these edges will need to be corrected to show foraging habitat overlapping the development footprint. Where there are exceptions to this, maps have been copied and areas of concern are labelled with a number (see sites 1, 2 and 3 on the following maps) and any concerns are discussed in the text for the area with that number.

There were three maps provided for the 2018 footprint for the Macarthur growth area. All impacted margins on the northern and middle maps will need to be changed to yellow polygons. Most of the impacted areas on the southern map will need to be changed to yellow polygons. However, it was noted that the area labelled '1' in the small section of this map inserted below was not shown as being in the original 2018 maps supplied to me. I don't think this is a problem because I also notice that the area and the adjacent area to the east have now been removed from the 2020 footprint. The two maps for the Wilton growth area can also have all impacted margin errors corrected to show yellow polygons. Hopefully this removes any problems with discrepancies between maps for the 2018 development footprints.



The change in footprint maps supplied for this report indicated areas that were not to be developed in both the 2018 and 2020 footprints, areas that were to be developed in both the 2018 and 2020 footprints, development areas that were in the 2018 footprint but which have since been removed and areas that have been added to the development footprint since the 2018 surveys.

Only the changes in footprint are considered here. We have no problems with the areas that have been removed from the development footprint unless there are substantial changes in land-use practices somewhere in the future. At present we see that these changes reduce some of the pressures on local populations of both raptor species. From the maps it appears that most extensions to the development footprint are in areas that have been mostly already cleared of woodland. They are mostly pastureland with some areas where substantial tree thinning has occurred. We can see no problems with these extensions for either raptor species. There are only two areas that may be of concern and these are in the southern section of the Macarthur growth area (see sites 2 and 3 in the section of map shown below). In area 2 the development footprint has been extended into the open woodland buffer zone adjacent to potential breeding habitat and is likely to impact on potential breeding. In area 3 the changes in the development footprint further fragment PCT 1395 habitat which is part of a north-south trending tongue of habitat area. The edge effect of urban development in this area is likely to reduce the area of habitat available to either species, particularly the Little Eagle.



It is suggested that the development footprint within area 2 be moved back to the 2018 position to protect the buffer area and provide more foraging area adjacent to the potential breeding area. Without this suggested change, area 2 should be labelled with yellow polygons as under this development footprint the urban area will overlap foraging habitat. It is difficult to tell from the maps what the habitat quality is like in areas where the development footprint has been extended in area 3 and it may be necessary to examine the site to further assess possible impacts.

In summary, most of the red areas that are margins to potential breeding habitat can be removed as this was due to not being able to see where the development footprint extended into PCT 1395, and the new development footprint appears to be fine except for areas 2 and 3 as described above.

Expert report – *Melaleuca deanei*

Expert report for *Melaleuca deanei* (Deane's Paperbark), Dr Steven Douglas, February 2019

ECOLOGICAL
SURVEYS & PLANNING

Expert Report For

Melaleuca Deanei

(Deane's Paperbark)

Strategic Assessment for the Cumberland Plain Conservation Plan

Greater Macarthur, Greater Penrith to Eastern Creek,
Wilton, and Western Sydney Aerotropolis Growth Areas

Prepared for NSW Department of Planning & Environment, February 2019

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1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Melaleuca deanei*, insufficient survey extent; constraints on the effectiveness of survey; and unreliability of detection due to aspects of the species' ecology are the primary reasons for preparing an Expert Report.

The purpose of this Report is to provide an assessment of the current status and conservation requirements of *Melaleuca deanei* within the four priority growth areas of Greater Macarthur (GMGA); Wilton (WGA); Greater Penrith to Eastern Creek (GPECGA); and Western Sydney Aerotropolis (WSAGA)to determine whether:

a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within growth areas and development footprints as part of the biocertification process.

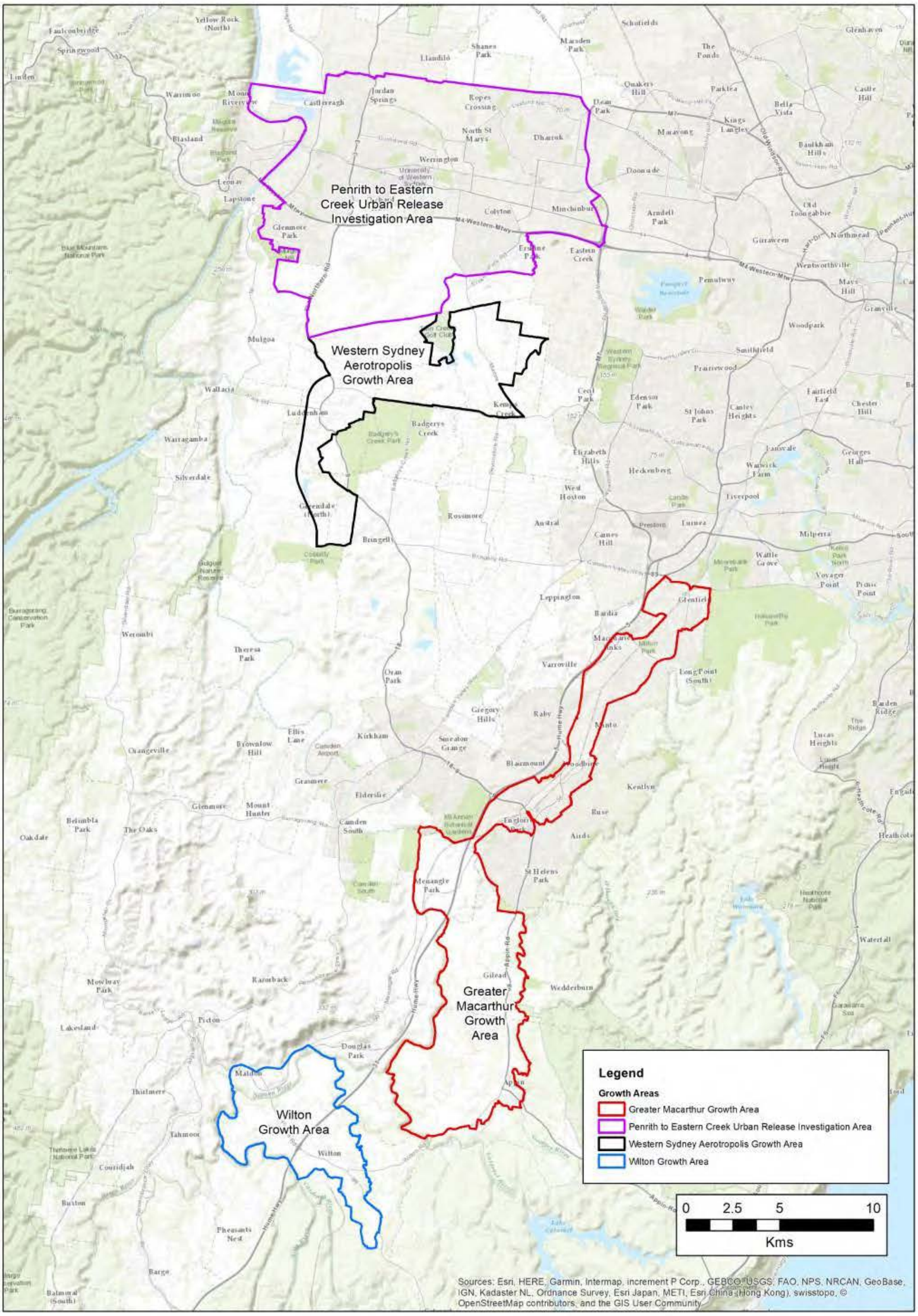
1.2 Project context

The NSW Government is identifying areas for future urban land use and associated infrastructure in western Sydney. The four priority growth areas are all located in the Cumberland Subregion under the Interim Biogeographic Regionalisation for Australia (IBRA) (SEWPaC, 2012).

As part of the planning for these areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify land use outcomes. A strategic assessment of this Plan is underway, and this Expert Report will assist in determining the extent and quantum of impacts of the proposed urban growth on *Melaleuca deanei*.

Melaleuca deanei © Martin Bremner

1.3 Study area



Map 1. Growth Areas subject to this Expert Report

Greater Penrith & Eastern Creek Growth Area (GPECGA)

A large portion of this Growth Area is already urbanised, with several areas of industrial land use. Significant rural and peri-urban areas remain in the central north, the centre, and the southwest. Large areas of remnant vegetation are present in the far north (former Australian Defence Industries site, now in part Wianamatta Regional Park), and the Orchard Hills Defence facility. Mining of alluvium for sand and soil continues in the far northwest of the area in the Penrith Lakes locality.

The area has been extensively cleared because of its relatively arable terrain, based mainly on shale and alluvium. Some of the remaining vegetation is associated with the much less arable to infertile Castlereagh Woodlands and its older, leached and mineralised alluvium and shale-derived soils. Strips of remnant vegetation are present along some of the larger watercourses such as Eastern and South Creeks. Significant parts of the study area are or were flood-prone, and this has influenced the retention of vegetation in some affected areas.

Western Sydney Aerotropolis Growth Area (WSAGA)

This Growth Area adjoins the Greater Penrith to Eastern Creek area, extending south to the locality of Greendale, west of Bringelly. It is currently largely rural, with villages at Luddenham and Kemps Creek. Most rural areas are pastoral, but there are significant areas of more intensive rural use, including poultry and egg production, a large dairy and associated fodder cropping, and some market gardens and enclosed fruit and vegetable production. Quarrying occurs at the localities of Badgerys Creek and Kemps Creek.

This Growth Area is extensively cleared but retains native vegetation in areas where rural uses were constrained by steeper terrain, flooding along streams, or unsuitable soils.

Greater Macarthur Growth Area (GMGA)

The GMGA occurs in southwestern Sydney on predominantly shale soils that have been heavily cleared for agriculture and urban or industrial use. The northernmost section has long-established urban and commercial / industrial land use, while the southern section is largely rural (pastoral, minor cropping), with some villages and primarily subsurface mining (e.g. coal and coal seam gas). It extends from urban Glenfield in the north, to the rural village of Appin in the south.

In the southernmost section, geological uplift and erosion have exposed infertile sandstone terrain along gullies and valleys. Much of that terrain remains naturally vegetated because it is unsuited to agriculture, however it occupies only a small percentage of the total area of this heavily-cleared region. Between the infertile sandstone valleys and the relatively arable shale plateau and hills is a geological and ecological transition zone. Whilst much of the vegetation of the shale terrain has been cleared, a greater area of vegetation remains on the transition zone, primarily in the south. Both the shale and transition zones support Critically Endangered ecological communities that are potential habitat for some threatened plant and animal species.

Wilton Growth Area (WGA)

The Wilton Growth Area is the most southerly of the four Western Sydney Growth Areas dealt with in this Report. It extends from the village of Douglas Park in the north, to the village of Wilton in the south. It is primarily rural (pastoral) area with some more intensive agriculture, significant but mostly underground mining (primarily coal), and some long-established villages. The Hume Motorway dissects this Growth Area.

The pattern of clearing and vegetation retention is broadly similar to that of Greater Macarthur, with the majority of remnant vegetation associated with infertile but biodiverse sandstone gullies and the Nepean River gorge, and with associated transition into the heavily cleared shale landscapes.

1.4 Justification for the use of an Expert Report

An Expert Report for *Melaleuca deanei* is required as part of the threatened biota assessment for the Cumberland Plain Conservation Plan because:

1) Survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH, 2016) for field traverses due to limitations on land access, particularly in the GMGA;
2) Survey quality was constrained by drought conditions. Whilst this species is perennial, under sufficiently severe drought and associated total grazing pressure (livestock, if relevant; native species; feral species), it can be suppressed such that it only remains apparent (but likely undetectable) as rootstock and as seed bank;
3) Survey effectiveness was further constrained by parts of the study area having been long-unburnt. This can create an unnaturally dense shrub layer that limits access.

Surveys associated with biocertification of the study areas and earlier projects in those areas have been insufficient to reliably determine the presence and extent of the species. An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region, but also in the ACT, Central Coast, southern NSW (coast, tablelands and slopes), throughout Victoria and into eastern South Australia. I have primarily been self-employed, with a mix of government, private, and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for OEH (Native Vegetation Information Science). A summary of my credentials as required under the BAM is provided below as Table 1. I was approved by OEH as a species expert for *Melaleuca deanei* under s.6.5 of the BAM in November 2018.

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Melaleuca deanei*

BAM section	BAM requirement	Details
s.6.5.2.8 (g)	Name of expert	Dr Steven Douglas
s.6.5.2.3 (a)	Expert's qualifications	Bachelor of Science (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. Master of Environmental Planning, Graduate School of Environment, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006. BAM Accredited Ecologist, 2018.
s.6.5.2.3 (b)	History of experience in ecological research and survey method for the relevant entity	Partial review of BioNet and incorporated NSW Herbarium database records of *Melaleuca deanei* in the Cumberland Subregion and immediately adjoining areas (DPE, 2018). Discovery and documentation of new populations of *Melaleuca deanei* in The Hills Shire (former Maroota State Forest, 1994 and 2001). Contributor to National Recovery Plan for *Melaleuca deanei* (2010). Preparation of species management profile for Hornsby and later Gosford LGA Threatened Biota Management Plans (1999, 2001). Surveys, documentation and recommendations for threatened species including *Melaleuca deanei* as part of the Landcom ESD report (Total Environment Centre, 1999). Successfully nominated species for listing as Vulnerable under Threatened Species Conservation Act 1995 (1998-99). Numerous historic surveys in northwest and western Sydney including Hills Shire, Hornsby Shire, Blue Mountains City and Hawkesbury LGAs (1994-2000). Most records lodged are from Berowra Valley NP. Most surveys were opportunistic or if targeted, specified impact areas to be searched, e.g. road verges.
s.6.5.2.3 (c)	Resumé detailing projects pertaining to the survey of the relevant entity	See Appendix 1. Relevant surveys and works listed above.
s. 6.5.2.3 (d)	Employer's name and period of employment (if relevant)	Self-employed ecological consultant, 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map, South Coast Regional vegetation map, Review of mapping issues for TECs).
s.6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant entity	Profiles prepared for this species in threatened biota management plans for Hornsby and Gosford Councils. Successful nomination to NSW Scientific Committee required preparing of a review of the species' conservation status. Consulted by DECCW on this and other threatened flora species of the region as part of a data review for the purposes of the BioBanking Tool (2006). Approved by OEH as a species expert for *Melaleuca deanei* under s.6.5 of the BAM in November 2018.

2. Species information

2.1 Description

Melaleuca deanei is a shrub to 3 metres high with fibrous-flaky bark. Leaves are alternate, narrow-elliptic to lance-shaped and 12-25 mm long and up to 6 mm wide. The smooth leaves are not paired. The leaves are moderately dark green in colour and twisted so the edges turn towards the stem, while the leaf tip ends in a sharp point. The mature plant is hairless, however new shoots are covered in white hairs. Flowers are creamy-yellow and arranged in a typical 'bottlebrush' spike, up to 6 cm long. Within each flower, groups of stamens (17-28) are fused together at the base. Fruit is barrel-shaped, 3-7 mm in diameter, and the opening to the fruit is 3 mm in diameter (DECCW, 2010; OEH, 2017).

Melaleuca deanei (Maroota) © S. Douglas

2.2 Ecology

"The longevity of individuals is reported to be greater than 100 years (Benson & McDougall 1998). As a clonal species, *M. deanei* has the ability to re-sprout from a swollen rootstock (lignotuber) to produce coppiced growth, and it can also sucker from its rootstock (Felton 1993).

The exact age at which *M. deanei* starts to produce flowers and seed is unknown. Some observers estimate this age as 3-4 years (Wrigley pers. comm. cited in Maryott-Brown & Wilks 1993), while others claim that it may take as long as 10 years (Ross Doig, Australian Plant Society, pers. comm.). *Melaleuca* seedlings, in general, take between 7 and 20 years to start flowering (Holiday 1999, cited in Virtue 1991).

It is not known how *M. deanei* is pollinated, though insects are the most likely group of pollinators (Turnbull & Doran 1997 cited in Virtue 1991). Self-fertilisation of *M. deanei* should also not be ruled out (Virtue 1991). Clonal plants, such as *M. deanei*, are known to produce flowers and seed infrequently and at irregular periods of time (Benson & McDougall 1998). Flowering has been observed in spring (Fairley & Moore 1989; Wrigley & Fagg, 1993) and summer (Beadle *et al*., 1983; Maryott-Brown & Wilks 1993; [Hewitt *et al*., 2014a, b]).

Infrequent flowering was evident when some populations did not flower for more than 4-5 years (Benson & McDougall 1998), for 15 years (R. Payne pers. comm., cited in Benson & McDougall 1998), or for many years (Doig & Thumm, pers. obs.). In contrast, one population in Royal National Park has flowered annually for a number of years (Felton 1993). In the populations surveyed for the present Recovery Plan, only approximately half (20 of 43 surveyed) showed evidence of flowering (including the presence of fruit). Low levels of flowering are apparently common in many other *Melaleuca* species (Travers Morgan 1990; Virtue 1991). Felton (1993) suggests that in *M. deanei*, this may be a result of the following two factors: first, this species can re-sprout and hence often invests energy in vegetative reproduction rather than flower and seed production. Second, a specific stimulus (or set of stimuli) may need to trigger flowering in the species, e.g. fire or high/prolonged rainfall. However, Felton also observed that time since last fire did not influence flowering of *M. deanei*, nor did other variables, such as plant height.

Seed production is described as poor and infrequent by several authors (Virtue 1991; Travers Morgan 1990). For example, only 5 of 28 populations surveyed were carrying seed capsules (Felton 1993).

The only variable of importance in Felton's study was the size of *M. deanei* populations, as low density stands appeared less likely to flower than high density stands. The important role of population size is supported by Virtue (1991) who observed that seed set appeared to be greater in large populations. It is also supported by the data in the Recovery Plan: all populations with more than 100 ramets produced seed, and populations with less than 10 ramets were most likely to contain no seed. The relationship between population size and fruit or seed production may be explained by crossbreeding. Virtue (1991) suggests a requirement for crossbreeding in the species, that is, for breeding between different individuals" (DECCW, 2010).

Recent research on *M. deanei* (Hewitt *et al*., 2014b) confirmed that this species "had a low incidence of flowering within the small populations, significantly fewer fruiting plants per population and significantly lower numbers of viable seeds per square metre, most likely compounding its limited recruitment. Flowering, when it occurred in *M. deanei*, was from mid to late October through to late November–early December with increased flowering in response to fire and along road edges" "Results suggest that seed production within smaller populations of *M. deanei* is poor because of a low frequency of flowering and a low proportion of flowering plants per population, rather than plant-level pollination, fruit- or seed-set barriers" (Hewitt *et al*., 2014a).

Seed dispersal and seed bank dynamics

"Seed in *M. deanei* is produced in barrel shaped woody capsules that contain 500-600 seeds (Felton 1993). It is held in the canopy of the plant for several years (possibly up to 15 years) until dehydration allows the capsules to open (Benson & McDougall 1998). Seed release is triggered by fire, occasionally also by drought or frost (Virtue 1991; Felton 1993).

Melaleuca deanei seed is wind dispersed. Light winds are sufficient to empty most capsules of *M. quinquenervia*, which has similar sized seed (Virtue 1991). It is unknown whether *M. deanei* possesses a persistent soil seedbank. Its seeds remain viable for at least nine weeks following release from the capsules, but their viability after this period is unknown (Felton 1993). Felton suggests that the species does not require a persistent soil seedbank as the requirements for germination are provided by fire, which also triggers the release of the seed from its capsule.

Under laboratory conditions, seeds germinated readily and had high levels of viability (Virtue 1991; Felton 1993). Germination seems to be greatest in seeds that are sourced from large populations (Virtue 1991). However, in the wild, no seedlings have been observed during the field work associated with the preparation of this recovery plan, or in previous studies (Travers Morgan 1990; Virtue 1991; Felton 1993). Doig (pers. comm.) notes that despite setting lots of potentially viable seed, germination in the wild is poor and many seedlings do not survive. Seedling establishment is most likely also dependent on prolonged moisture availability (Virtue 1991). It appears that overall, this species relies predominantly on clonal reproduction and produces seed infrequently" (DECCW, 2010). These findings were validated by Hewitt *et al*. (2014a, b).

Disturbance ecology

"*Melaleuca deanei* frequently produces coppiced growth and suckers from its roots, particularly after fire or the disturbance and death of a major stem (Travers Morgan 1990). The species has also been observed to regenerate from epicormic buds that are protected from fire by thick, papery bark (Felton 1993).

It has been suggested that fire is required to provide the right conditions for germination and seedling growth and that seedlings very rarely establish at any time other than after fire (Felton 1993). It has also been suggested that fire may be required to stimulate flowering of *M. deanei* (L. McDougall pers. comm. cited in Benson & McDougall 1998), however Felton (1993) states that some populations flower annually regardless of time since the last fire.

Melaleuca deanei has been observed growing most commonly and vigorously in sites exposed to direct sunlight, or in places where light penetration has been increased by disturbance, such as the edge of fire trails (Travers Morgan 1990; S. Douglas, pers. comm.). The species' preference for light may explain its habitat preference for open ridgetop vegetation (Felton 1993). Shaded plants seem to have fewer and shorter new stems and leaves, and a shorter internodal distance (Travers Morgan 1990).

It is therefore likely that fire, and possibly other physical disturbances that increase light levels without impacting upon the soil, play a role in providing for the recruitment and long-term persistence of the species" (DECCW, 2010).

"The size of the minimum viable population is unknown, however, some of the small sites such as those in Pennant Hills Park (now part of Lane Cove National Park) are unlikely to survive in the long-term due to (apparent) inbreeding depression" (ESP Ecological Surveys & Planning, 1999). This view has been partially substantiated by Hewitt *et al*. (2014a, b; 2019). Without supportive intervention, it seems likely that these particularly small populations will be increasingly restricted to vegetative growth. This may undermine their long-term viability because it does not permit recombination of DNA as might allow adaptation to changing circumstances.

2.3 Distribution and abundance

Melaleuca deanei is endemic to the Sydney Basin Bioregion. The currently accepted distribution of the species extends from Colo Heights and St. Albans in the northwest and west; to Faulconbridge in the lower Blue Mountains in the west; to Brisbane Water National Park in the northeast, through several peri-coastal areas of the lower Hornsby Plateau in metropolitan Sydney, southward through Royal National Park and numerous locations on the Woronora Plateau and the Upper Nepean catchment; an unconfirmed record from Hill Top in the Southern Highlands; then a significant gap before reaching the southern limit in Colymea State Conservation Area west of Nowra; and to Tallowa Dam in the southwest (*sensu* DECC, 2010, augmented by review of BioNet records).

The species' distribution can be divided into a northern and a southern range. "The northern range extends north from Ryde LGA, including the Blue Mountains (48 populations), whereas the southern range extends south from Sutherland LGA (46 populations). The two ranges are separated by a distance of approximately 28 km. This is partly a consequence of unsuitable habitat for the species occurring on the Cumberland Plain in Western Sydney but is also the result of the loss of habitat in northern, southern, and inner western Sydney to urban development" (DECCW, 2010). The southernmost occurrence is ~ 68 km south of the nearest record to the north on the Woronora Plateau. Additionally, the southernmost records are on older, Permian geology rather than Triassic geologies typical of all of the other records.

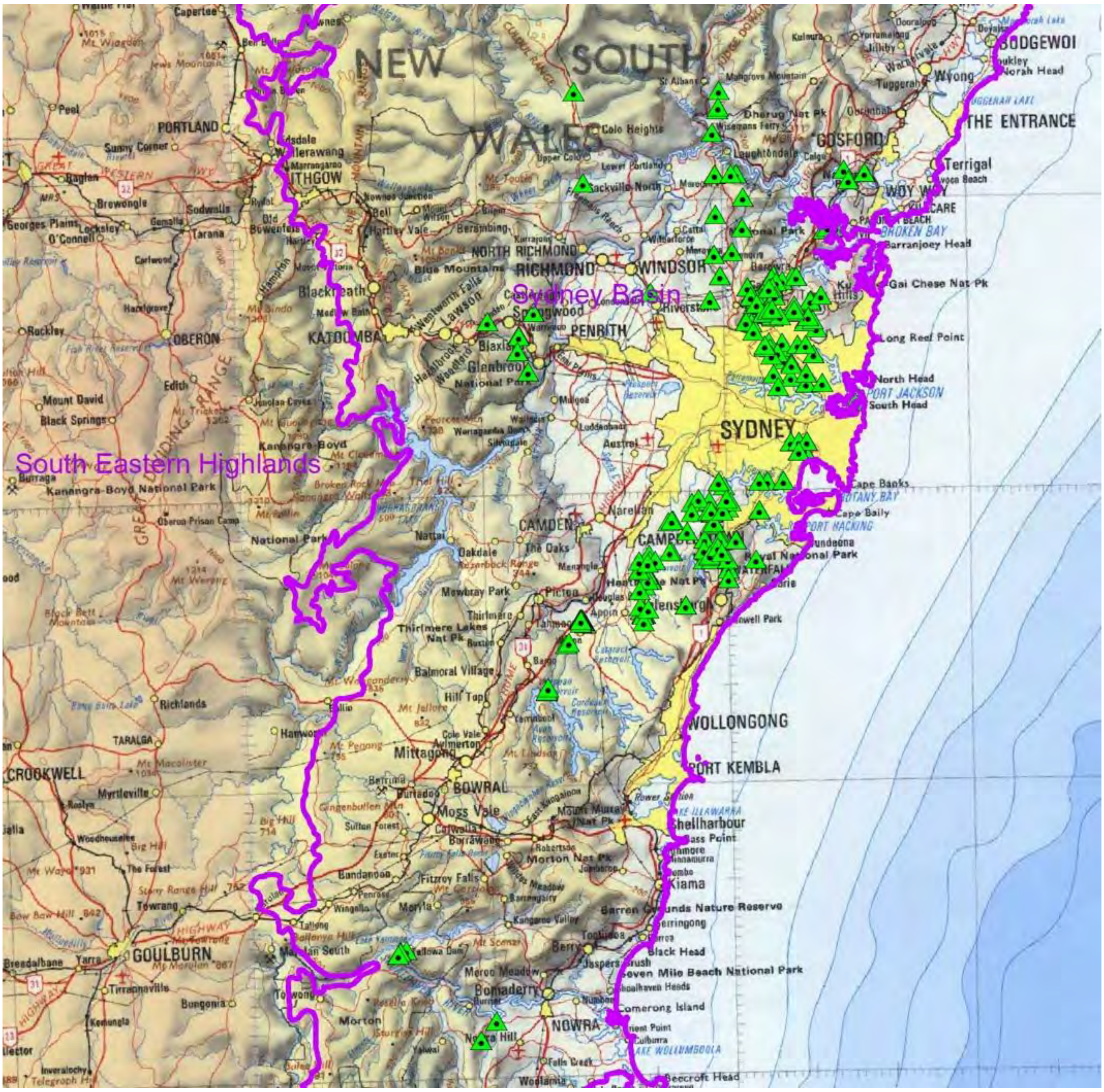
"It is likely that our understanding of the distribution of *M. deanei* is incomplete" (DECCW, 2010). It is feasible that populations are yet to be documented between the Upper Nepean record and the Shoalhaven hinterland records, however, similar to the situation in metropolitan Sydney, these populations will still be separated by the substantial area of unsuitable and largely cleared habitat of the Wingecarribee Plateau between Morton National Park, Meryla State Forest (now largely a Flora Reserve) and Budderoo National Park in the south, and Macquarie Pass National Park and Upper Nepean State Conservation Area to the north. The prospective record at Hill Top may indicate that the species could occur in Nattai National Park, which may provide a link to the Lower Blue Mountains populations.

Several of the early collections of *M. deanei* were made from now-suburban areas where the species is considered locally extinct. These include Kogarah (1884), Arncliffe (1897), Tempe (1898), Oatley (1899), Cooks River (1901), and Earlwood (1912) (Fairley, 2004; DECCW, 2010). "In the last ten years, sites have also been lost to residential development and road construction in Hornsby Heights (J. Slaven, Hornsby Council, pers. comm.), Bangor, and Menai (I. Drinnan, Sutherland Council, pers. comm.)" (DECCW, 2010).

"The available habitat for *M. deanei* has been severely reduced and fragmented by urban development, quarrying, and associated disturbances. This is primarily a consequence of the species' distributional range being centred upon the Sydney region, and its apparent preference for ridge-top locations and sites with lateritic soils… Ongoing urban consolidation and expansion continues to threaten a number of populations. For example, undetected, though probably small, populations may be present in the rural-residential areas of Baulkham Hills (now The Hills) and Hornsby LGAs where the threat of clearing is substantial (S. Douglas, pers. comm.)" (DECCW, 2010). Hewitt et al. (2014b) also notes, "The species' naturally restricted distribution has been markedly reduced by urban development in the Sydney area, and many sites where it was previously recorded (Australia's Virtual Herbarium 2013) were visited and found to have been lost in the years since the records were made" (DECCW, 2010).

In the species' Recovery Plan, "*M. deanei* records within 500 metres of each other have been defined as belonging to the same population, as dispersal of the species is unlikely to exceed this distance (Felton 1993). Populations may consist of a number of sites, as sites have been determined on the basis of tenure… It is difficult to count individual plants within populations, because *M. deanei* is a clonal species. This means that an individual (or genet) may occur as a number of stem clumps (or ramets), which may appear as different plants (Myerscough 1998)... Research by Felton (1993) suggests that for every 10-15 *M. deanei* ramets counted, two to three individuals may be present, while the NSW Scientific Committee (1999) notes that for this species 'ramet counts may overestimate population size by two or three times'. This difficulty with identifying genetically distinct plants needs to be considered when discussing the size of populations based on ramet counts. It also explains why no attempt has been made to determine the size of 28% of all populations. Generally, it is likely that the number of genetically distinct plants is lower than the number of ramets counted… At least 52% of the populations contain less than 50 ramets, and thus most likely even less (*sic*) individual plants. Only four populations contain more than 500 ramets. Of these four, only one occurs in the northern part of the species' range, the other three are in the southern part" (DECCW, 2010).

The latest research in this field is bey Hewitt *et al*. (2019) who undertook genetic analysis of selected *M. deanei* populations and determined that "Multiple stems were found to comprise single genets up to ~10m diameter on the ground, and (that) molecular evidence points to an outcrossing breeding system. Genetic diversity was positively correlated with population size, and significant genetic differentiation was shown between northern and southern regions using clustering analyses." Of particular importance is that they also found that estimates of population size given in DECCW (2010) are likely to be a least 6 times higher than what is now supported by molecular analysis.



Map 2. BioNet records (26/11/18) for whole of species' range

The above map was generated from BioNet data and gives a generally accurate indication of the species' known range, but not the extent of potential habitat. Large areas of NPWS estate and Water NSW catchment lands have not been subject to the same level of survey effort as areas where pressure for land clearing is high or where activities such as mining have funded surveys. The map shows an absence of records of the species between the lower Blue Mountains and the Southern Highlands, despite there being extensive areas of potential habitat present. Similarly, there are very few records north from the Blue Mountains villages through to those north of Colo Heights and near St. Albans. Again, that area contains significant areas of potential habitat.

2.3.1 Reservation status

As of 2010, more than 50% of all 'sites' of the species were known to occur in NPWS reserves (DECCW, 2010). "Holsworthy Military Reserve, contains 17 % of the known *M. deanei* population, including large populations that extend along the ridgelines in the central and western section of the area" (DECCW, 2010). That area is largely naturally vegetated but is subject to clearing and detrimental disturbance for military purposes and is not conservation estate. Two large populations occur on land managed by Water NSW for potable water catchment protection within the Nepean and Avon Dam catchments. Since the 2010 Recovery Plan, these populations have received additional protection through the gazettal of the large Upper Nepean State Conservation Area. Whilst this reserve permits subsurface mining and some surface infrastructure for mining and water management purposes, the two populations are close to dams, and unlikely to be threatened by mining activities. Additionally, gazettal of Dharawal National Park in place of and beyond the scope of most of the former Dharawal State Conservation Area has protected numerous occurrences of the species. The now much smaller portion that remains a State Conservation Area does not contain records of this species, based on BioNet data.

Berowra Valley Regional Park, which according to DECCW (2010) was known to contain 17% of the sites of *M. deanei* at that time, has since been gazetted as a National Park, increasing the emphasis on conservation in this area, and affording the species some additional protection, subject to resourcing.

The north-western populations on the fringes of metropolitan Sydney, primarily in The Hills Shire, remain unreserved in terms of NPWS estate. These extend from Kenthurst through Middle Dural, Glenorie, the former Maroota State Forest, to north-nor-west of the locality of Maroota. Most are on Crown land or former Crown land where there are conflicts between grants or claims under the NSW Aboriginal Land Rights Act and competing claims under the Commonwealth Native Title Act. These areas are not known to be actively managed for conservation but may be increasingly protected through biodiversity stewardship agreements / biobanking.

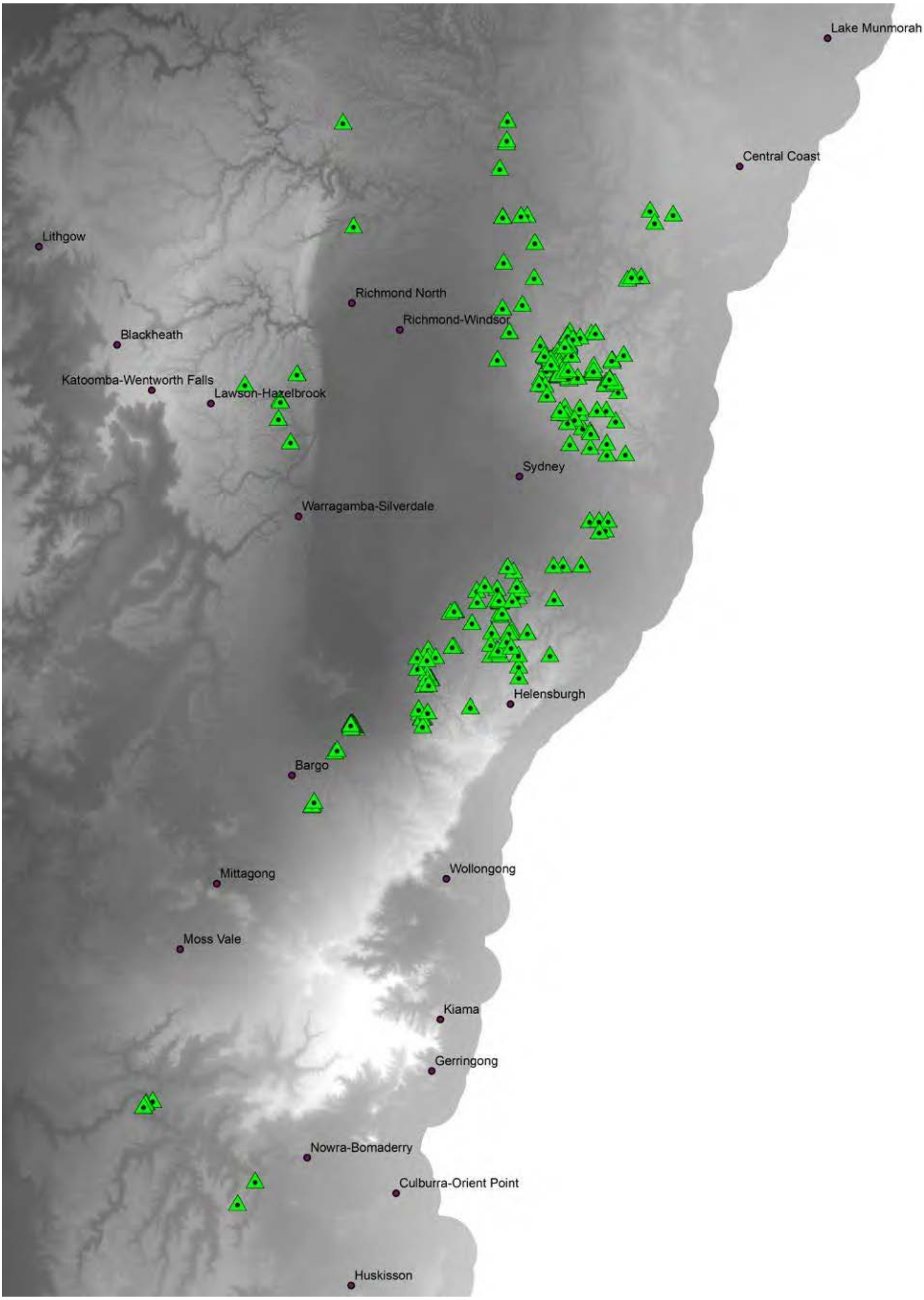
The outer northernmost populations are within Parr State Conservation Area and Yengo National Park. A 1933 record 'near Hawkesbury Punt' (ferry) plots in unsuitable habitat can could be in Dharug National Park north of the River, in Wisemans Ferry Historic Site south of the River, or on unreserved freehold nearby.

2.4 Habitat

2.4.1 Geology, soil, climate

"*Melaleuca deanei* mostly occupies broad flat ridgetops, dry ridges and slopes (Benson & McDougall 1998). In southern Sydney, the species is most often found on flat broad ridge tops more than 100 metres wide (Travers Morgan 1990). The altitudinal range of *M. deanei* is between 20 and 410 metres above sea level, and annual rainfall in the species' distribution ranges from 1,000 to 1,400 mm (Benson & McDougall 1998)" (DECCW, 2010). However, more recent distribution and rainfall data obtained from OEH indicates that the species' minimum average annual rainfall tolerance is considerably lower: ~830 mm (Wilton), with several occurrences in areas with 900 -950 mm in western and north-western Sydney and environs. Notably, the species has a very narrow range of annual average temperature tolerance based on current BioNet distribution data: ~14 to ~16 C.

"*Melaleuca deanei* is strongly associated with sandy loam soils that are low in nutrients, sometimes with ironstone present (Benson & McDougall 1998). In a study of ten populations in southern Sydney, Travers Morgan (1990) found that the species most frequently occurred on deep and well-developed lateritic soils, i.e. soils where an indurated iron-rich layer usually overlies a mottled clay and a pallid clay (Murphy 1993)." (DECCW, 2010).



Map 3. *M. deanei* locations shown over average annual rainfall (lightest shading shows highest rainfall)

Analysis of BioNet records and mapped Soil Landscapes indicates that the species is strongly associated with the Lucas Heights Soil Landscape, especially south of metropolitan Sydney. The northern Sydney records are mainly associated with Hawkesbury and Lucas Heights Soil Landscapes, with some occurring on Gymea and Lambert Soil Landscapes. Most of these are associated with the upper Hawkesbury Group, principally Hawkesbury Sandstone, though the Lucas Heights Soil Landscape is associated with the Mittagong Formation. This is a transitional bed between the Wianamatta Group (mostly shale) and the Hawkesbury Group (mostly sandstone) (*sensu* Martyn, 2018) and is very strongly associated with several threatened plant species, and at least one threatened ecological community.

A very small number of records occur on the Glenorie and Blacktown Soil Landscapes, which are derived from Wianamatta Shale. When reviewed, most of these records were very vaguely located, with very low spatial Accuracy scores. The exception is recent, spatially accurate records near Wilton, which plot on the Blacktown Soil Landscape. The apparent explanation in this case is that the Soil Landscape mapping is very coarse on the Wollongong 1:100,000 sheet, and that the Lucas Heights Soil Landscape is under-mapped. This is supported by recent vegetation mapping. In this area, the map shows the Blacktown landscape directly adjoining the Hawkesbury landscape – a situation that effectively does not occur in Nature, as there is almost always some transition between the purely shale terrain and the purely sandstone terrain.

2.4.2 Associated vegetation communities and NSW TECs

"M. deanei occurs in a wide range of vegetation communities but is most often found in Coastal Sandstone Ridgetop Woodland (Tindall *et al.* 2004). Several authors state that there seems to be no obvious association between *M. deanei* and any particular components of the ridgetop flora (Specht 1981; Travers Morgan 1990; Felton 1993; Benson & McDougall 1998)" (DECCW, 2010).

The OEH Threatened Biodiversity Data Collection lists the following Keith Vegetation Classes as being associated with *M. deanei*:

- Coastal Valley Grassy Woodlands;
- South East Dry Sclerophyll Forests;
- Sydney Coastal Dry Sclerophyll Forests;
- Sydney Coastal Heaths;
- Sydney Hinterland Dry Sclerophyll Forests; and
- Sydney Montane Dry Sclerophyll Forests.

The Threatened Biodiversity Data Collection indicates that *M. deanei* is potentially associated with 20 Plant Community Types (PCTs) across its range. Two of these are also associated with State and/or Commonwealth-listed Threatened Ecological Communities (TECs). Within the Growth Areas, relevant communities and NSW-listed TECs, excluding apparent errors, are shown in Table 4. The associated PCTs are treated by OEH as *potential* habitat, and the species may not actually occur in all of those communities.

Associations between a species and Vegetation Classes and PCTs in the Threatened Biodiversity Data Collection represent *potential* habitat, not actual habit. Given the limitations of vegetation mapping and that in most cases, survey effort for threatened species is incomplete across their range, such an approach is understandable.

The listed association between *M. deanei* and Coastal Valley Grassy Woodland is a consequence of the association with PCT 1395. Ordinarily, *M. deanei* would not be considered to be associated with this Vegetation Class as the vast majority of occurrences are in heathy/shrubby habitats. However, PCT 1395 is legitimately associated with this species, even though such occurrences are atypical across the species' range.

An assessment of the association between *M. deanei* and PCTs was undertaken to better understand the potential habitat for this species in terms of plant communities. The information is used to generate 'species polygons' (maps of potential habitat) as required under the BAM. Whilst DPE required habitat associations to be graded i.e. strong to weak association with particular PCTs, only ungraded PCT association data was used to generate the 'species polygons'. The assessment is constrained by limitations of BioNet data and available vegetation maps. The assessment of the species' relationship with PCTs in and near the Cumberland Subregion used publicly available OEH vegetation maps and did not use the updated vegetation maps produced by Biosis within the Growth Areas. There are now known to be significant differences between Biosis' updated and finer-scale map and OEHs earlier maps. These have a bearing on the results presented in Table 2. However, the effect on the modelling of habitat for *M. deanei* is likely to be far smaller for *M. deanei* than for species that are strongly associated with the Cumberland Subregion.

Some of the records of the species are not spatially associated with a PCT. This may be because:

- the record occurs in a site now cleared of native vegetation or too degraded to be captured by mapping;
- because the record is too spatially uncertain, so has been assigned generic co-ordinates, usually in a named town or suburb, and such settled areas often lack native vegetation; and/or
- the record plots just outside an area of mapped vegetation because it is on a road verge, and even most GPS records are only accurate to 5m, meaning it could plot on the road, not on the verge.

To overcome this latter problem, those records were assigned a 10m buffer so that they would associate with the nearest mapped vegetation polygon up to 10m from the plotted location.

A further consideration is that survey effort for the species is not evenly distributed across the area subject to analysis. Some sites of potential habitat have had very little or no effort, often due to tenure constraints, yet others have had every apparent plant recorded (mostly in reserves or as part of ecological impact assessments). This creates very substantial biases in the data, which can create misleading weightings of association between the species and particular PCTs. Furthermore, most records do not include population data, such that a record might be for one plant or many. In short, this analysis is best used only for presence/absence i.e. whether the species has been recorded at a point that is mapped as a particular PCT, or not. Analysis beyond that is very constrained by deficiencies and biases in the datasets, especially in BioNet data.

The analysis of association with PCT in Table 2 below deals only with records in the Cumberland Subregion plus a 10 km buffer. Records that associate with a PCT when a 10 m buffer is used are included in the counts of sightings below and are not shown separately. Two analyses were undertaken: All records in the target area without regard to spatial Accuracy score; and only records in that area with Accuracy score of 100 m or better. The latter analysis is considered more reliable, but both sets of figures are provided. Sightings with Accuracy <=100 m are shown in square brackets **[ ]** and in bold text. Where available, the combined count of individuals associated with the records is provided in parentheses { }. Those counts relate only to records with Accuracy <=100 m. Where a record doesn't contain population data, it is assumed to relate to a single plant.

Only PCTs mapped in the Growth Areas are dealt with in the table below. For PCTs outside the Growth Areas but within the 10 km buffer, 1777 (63 **[49]** {1641}) and 1787 (24 **[11]** {14}) are significantly associated with *M. deanei*. Those PCTs are more typical of the species' habitat across its range.

Because there are very few records of *M. deanei* from the Cumberland Subregion, a 10 km buffer (which mostly comprises incompatible geology and soils for this species) has been used to broaden the dataset. Even with this buffer, the analysis in Table 2 is unrepresentative of the species' association with PCTs across its range, as the species primarily occurs outside the Cumberland Subregion. Additionally, the recent records of the species from the Bingara Gorge housing development skew the analysis in favour of PCT 1395 because it is over-mapped by OEH where this population occurs. The more recent and accurate map by Biosis designated as 1181 much of what OEH maps at that site as 1395. The boundary between these communities is unlikely to be as clear as either map indicates, and it is likely that unmapped, transitional areas related to PCT 1081 are present.

A pattern of PCT 849 on shale, 1395 on the high-shale part of the transition, 1081 on the low-shale part of the transition, then 1181 on the predominantly sandstone terrain is evident just to the north of the Bingara Gorge site but 1081 is not mapped at this latter location. It is likely that 1081 is a more strongly associated PCT for this species than is 1181, despite what the basic analysis of association suggests. It is also very likely that the apparently Very High association with 1395 is primarily an artefact of the dataset and is unrepresentative. All such biases are dealt with in the column, Adjusted relative significance.

In my Expert Report for *Persoonia nutans*, I compensated for the fact that vegetation mapping of the Growth Areas is arguably affected by the fact that two different OEH PCT maps cover this area, and they don't seem to be as aligned as they might be in terms of PCT allocations – at least not where they adjoin in some cases. For *P. nutans*, two PCTs that are clearly very similar to PCT 1081 but that do not occur in the Growth Areas were treated as 1081 for the purpose of analysing the association of that species with PCTs. Were a similar approach taken in relation to *M. deanei*, the number of sightings and the population sizes associated with PCT 1081 would significantly increase because most of the records of this species in the 10 km buffer come from PCTs that are similar to or at least closest to 1081. That PCT is present in parts of the Wilton and Greater Macarthur Growth Areas but absent further east.

It is important to note that the ranking of relative significance of PCTs for this species does not infer that the species will occur where any of these PCTs are present in the two relevant Growth Areas. It only indicates the relative probability of occurrence and of associated population size in the context of this limited analysis.

TABLE 2. Species records relative to mapped PCTs and their relative significance for the species in the Growth Areas

PCT	PCT Name	Associated TECs (NSW BC Act)	% Cleared (VCD)	Sightings & Population	Relative association	Adjusted relative association#
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Not a TEC but some areas may be within Shale Sandstone Transition Forest (CE)	40	20 **[13]** {561}	Moderate	High
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney	Not a TEC	20	23 **[16]** {587}	Moderate	Moderate
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (CE)	80	41 **[40]** {1192}	Very High	Moderate

Figures for the % Cleared column were obtained from the OEH BioNet Vegetation Classification Database (VCD).

2.4.1 Description of PCTs associated with *Melaleuca deanei* in each Growth Area

PCT 1081

This community is a form of 'shale/sandstone transition forest' that was previously within the scope of the now circumscribed Shale/Sandstone Transition Forest TEC. It has been independently assessed as a prospective threatened community, that whilst significantly reserved, is suffering on-going losses around Sydney, largely due to urban and peri-urban land use. It is a very significant habitat for *M. deanei* and several other threatened plant species.

This PCT is absent from GPECGA and WSAGA due to the lack of suitable geology. It is a present but as a very minor component of the GMGA (one site and three polygons) and as a moderate component of the WGA. It is likely to have been naturally uncommon to rare in those areas and has probably not been heavily cleared there. It is not readily mapped with high reliability because of the broad ecotone with PCT 1395. Consequently, a precautionary approach is particularly necessary when dealing with areas mapped as PCT 1081, as some may be better classified as 1395 and therefore a Critically Endangered Ecological Community. It is also highly likely that 1081 is present but unmapped in areas that show 1395 immediately adjoining 1181, as the transition zone between the associated geologies is rarely as simple as most maps indicate.

No areas mapped as PCT 1081 are within the proposed urban footprint in either of the two relevant Growth Areas.

PCT 1181

This community is mapped within the WGA and GMGA, but is largely outside the proposed areas of urbanisation, being associated with sandstone soils in gullies, valleys and slopes. It is associated with often-protected habitat along watercourses, and with relatively high bushfire risk and with steep, often rocky terrain.

This PCT is highly associated with *M. deanei* habitat within the study area but this is probably amplified by limitations of the vegetation mapping, which tend to simplify the shale/sandstone transition and over-map PCTs 1395 and 1181 by under-mapping PCT 1081. This PCT is not present in the GPECGA or the WSAGA due to the absence of associated geology.

PCT 1395

This community is the principal PCT of the Shale Sandstone Transition Forest TEC and has a significant though atypical association with *M. deanei* in and beyond the study area. This community occurs on flat to gently sloping terrain, usually bordering cleared or highly modified rural land. This PCT is absent from the GPECGA and the WSAGA due to the lack of associated geology.

Most mapped occurrences are excluded from the proposed urban footprint in the two relevant Growth Areas. However, even where proposed urbanisation does not involve clearing, habitat can be increasingly threatened by urban encroachment in the form of bushfire hazard reduction works, recreational pressures, urban pollution e.g. nutrient-laden runoff, increased weed invasion from inappropriate landscaping/gardening, and increased predation of fauna by domestic pets.

2.4.2 Associated Commonwealth TECs

As of November 2018, there was not an Approved Conservation Advice for this species. The Commonwealth Department of Environment & Energy appears to defer to the Recovery Plan (DECCW, 2010) in this regard.

GIS analysis indicates that *M. deanei* is associated with the nationally listed Shale Sandstone Transition Forest (this is essentially the same entity as the NSW TEC of the same name, though it permits greater inclusion of PCT 1081 / DSFp146 of Tozer *et al*., 2010).

2.4.3 Habitat condition

Degraded and significantly modified areas of the above-described PCTs can still be habitat for this species due to its ability to persist as woody rootstock and in the soil seed bank. Such modified sites may have reduced or no canopy and/or midstorey, and/or reduced understorey and some weed invasion. The species could persist in highly modified sites such as slashed bushfire Asset Protection Zones, and road and trail verges. Some forms of disturbance, even relatively severe forms that would be considered clearing of vegetation, could be beneficial to this species, within limits. This situation is recognised for numerous threatened plant species in and beyond the Sydney Basin Bioregion. It is believed to be related to the fact that modern fire regimes are likely to be significantly different to those prior to 1788. *M. deanei* is known to be disadvantaged by prolonged absence of fire because reproduction is promoted by, though not dependent on plants and habitat being burnt. Conversely, too frequent fire would be detrimental because seedlings would not have sufficient time to develop post-fire recovery functions such as a lignotuber and epicormic buds, so would likely be killed.

The condition of potential habitat for this species is not, in itself, a reliable indicator of the species' presence, and accordingly, **all condition states except derived grassland are considered in determining suitable habitat** i.e. intact, thinned, scattered, and derived shrubland.

3. Description of the study area

3.1 Landscape context and land use history

All of the Growth Areas have been significantly cleared for earlier activities, primarily timber production associated with opening areas for agriculture and pastoralism, minor areas of surface resource mining, and to varying degrees, for urban and commercial/industrial use. They are proposed to accommodate phased increases in urban land use, primarily within existing cleared or highly modified lands. Increased urban use is planned as a response to population growth.

3.1.1. Greater Macarthur Growth Area (GMGA)

The GMGA extends from Glenfield in the north to Appin in the south. It is largely within the Campbelltown LGA with the southernmost section within the Wollondilly LGA. The northern half comprises an urban renewal corridor centred on the Sydney to Main Southern railway line. It encompasses the existing industrial and residential suburbs of Glenfield, Macquarie Fields, Minto, Leumeah and Campbelltown. The GMGA is associated with extensively cleared, gently undulating shale terrain typical of the Cumberland Plain, and contrasts the sandstone gorges of the Woronora Plateaus across the Georges River to the east. The northern portion of the GMGA is already substantially urbanised, with remnant vegetation largely restricted to creek-lines or small patches associated with designated open space. Vegetated creek-lines include Bunbury Curran Creek, Bow Bowing Creek, Leumeah Creek, Fishers Ghost Creek and Spring Creek.

The more extensive southern half of the GMGA, south of Rosemeadow, comprises proposed urban land releases at Menangle Park, Mount Gilead and Appin. Menangle Park and Mount Gilead are subject to separate planning processes, so are not within the scope of this biocertification. In the north-west, Mount Sugarloaf (213 m AHD) forms the southern end of a hilly ridge on the Luddenham Soil Landscape above the Menangle floodplain that extends north to Denham Court, then to Cecil Hills and Prospect Hill. Some native vegetation persists, although it is often invaded by African Olive. The floodplain is dissected by Menangle Creek and its tributaries, including Nepean Creek, Woodhouse Creek and Leafs Gully.

The southern GMGA is primarily semi-rural and agricultural land, with creek corridors and some larger patches of remnant vegetation located between the Nepean and Georges Rivers. Geologically, the area comprises gently undulating hills on Wianamatta Shale intergrading via a shale sandstone transitional zone (can include the Mittagong Formation) with steeper and infertile terrain on Hawkesbury Sandstone along the rivers. Transitional and sandstone geologies are sometimes exposed along the smaller creek lines.

3.1.2. Wilton Growth Area (WGA)

The WGA is a relatively smaller area that occurs to the south of the GMGA, extending from the vicinity of Douglas Park in the north, Maldon in the north-west, and beyond Wilton in the southeast. The boundaries closely follow the Nepean River in the north and west, a tributary Allens Creek in the east, and the Cordeaux River in the south. Away from the Nepean River and gullies, a higher, gently undulating zone has been largely cleared for agriculture. The Woronora Plateau forms the southern boundary and includes the northernmost section of the large Upper Nepean State Conservation Area, with unreserved but closed areas of the Water NSW Special Area (Sydney water supply catchment) extending to the east and southeast. The Hume Highway dissects the WGA roughly north to south, and Picton Road traverses it roughly northwest to southeast.

The WGA includes both shale, shale sandstone transition and sandstone environments. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The flatter shale terrain has soils of the Blacktown Soil Landscape, which is derived from Ashfield Shale (a member of the Wianamatta Group), and typically supported the now Critically Endangered Cumberland Plain Woodlands. Much of this area is cleared or modified for agriculture and hobby farms. It comprises native/exotic grassland with smaller areas of Derived Native Grasslands in relatively better condition. Areas above the gullies feature soils of the Lucas Heights Soil Landscape derived from the Mittagong Formation (a transitional bed between the Wianamatta and Hawkesbury Groups). These support variable shale sandstone transition woodlands and forest, some of which are also Critically Endangered. In the steeper gullies, the Hawkesbury Soil Landscape dominates, and supports Hawkesbury Sandstone Gully Forest types with Ridgetop Woodlands on some of the upper slopes.

3.1.3. Penrith to Eastern Creek Growth Area (GPECGA)

The GPECGA is a relatively large area that extends from Rooty Hill, Minchinbury and Hassell Grove in the east, across the Cumberland Plain to the Hawkesbury-Nepean River in the northwest, then south through Jamisontown, Glenmore Park, to the intersection between The Northern Road and the Warragamba Water Supply Pipelines in the far south-west. The predominant geology is Wianamatta Shale on flat to gently undulating terrain that has been extensively cleared for agriculture, and later for housing and industrial use, with some remnant vegetation on current and former Defence holdings. The shale soils support(ed) Cumberland Plain Woodlands. Overlying the extensive shale deposits are small areas of weathered Paleogene-Neogene alluvium e.g. Shalvey and Willmot, that are much more common to the north. These support(ed) the Castlereagh Forests & Woodlands complex of vegetation types, which is strongly associated with several threatened plant species. More common are broadly linear deposits of Quaternary alluvium along watercourses such as South Creek and Eastern Creek, and on the flood terraces of the Hawkesbury-Nepean River. Other lithologies occur but are very rare and of very small extent.

Very little of the GPECGA is reserved in NPWS estate. Wianamatta Regional Park (which emphasises recreational uses) encloses small areas of former Defence land in the far north. Adjacent to the southwestern boundary is the small Mulgoa Nature Reserve (emphasises biodiversity values). Two Biobanking sites adjacent to the Nature Reserve have increased the area under conservation.

3.1.4. Western Sydney Aerotropolis Growth Area (WSAGA)

The WSAGA abuts the GPECGA's southernmost border near the locality of Sovereign (east of Mulgoa), then extends south past Greendale, northeast to the locality of Badgerys Creek, east to Kemps Creek, and northward to the vicinity of Mount Vernon, excluding Twin Creeks Golf Course and associated settlement.

The lithology and soils are broadly similar to that of the GPECGA, being effectively just an extension of that area to the south to incorporate the developing Badgerys Creek Airport and environs. The area is even more severely cleared of native vegetation, except along some streams and on rare occurrences of steeper terrain. It contains no NPWS reserves, with the nearest being the small Kemps Creek Nature Reserve, outside the Area to the southeast. Gulguer Nature Reserve and Bents Basin State Conservation Area occur to the southwest of Greendale.

3.2 Geology and remnant vegetation

All of the Growth Areas are within the Cumberland Subregion. The dominant lithology across all of the Growth Areas is Wianamatta Shale (Ashfield and Bringelly Shales), with much smaller areas of Paleogene-Neogene alluvium occurring largely outside these boundaries, and much larger areas of Quaternary alluvium associated with floodplains of the many watercourses (*sensu* Martyn, 2018).

The terrain varies from almost flat through to steeply hilly areas associated with minor volcanism and more often, in association with shale ranges. In the far south, the more elevated shale landscapes have been eroded down to the underlying Hawkesbury Sandstone in a series of gullies and gorges. A transition zone between the shale and the sandstone is discernible in some areas.

On the dominant shale geology, the associated Critically Endangered Cumberland Plain Woodlands are still present in all of the four Growth Areas but have been disproportionately cleared for rural and later urban and allied uses. Much of what remains of this ecological community occurs as paddock trees and areas of remnant native ground-layer vegetation in pastoral and other contexts, with the exception of some substantial, though fragmented and isolated remnants. Remnant vegetation in these relatively fertile and arable landscapes is often in poor condition. In the most heavily cleared areas, it can be restricted to strips along watercourses. Some forms are dominated by *Casuarina* species. Weeds are common and sometimes severe in the moister situations. Weeds often extend into higher and drier terrain, especially in the form of African Olive and African Love Grass, both of which can occur on a landscape scale.

Small areas of the biodiverse Castlereagh Forests and Woodlands persist in all but the Wilton Growth Area on often-laterised Paleogene-Neogene alluvium. These variable woodlands and open forests support a particularly high number of threatened plant species, and because their soils are less suitable for agriculture and grazing, are better conserved than the Cumberland Plain Woodlands. Nonetheless, they are all listed as threatened ecological communities.

In the two southern Growth Areas, vegetation of the shale sandstone transition zone is relatively common and tends to remain in less arable areas adjoining the largely cleared former Cumberland Plain Woodlands. It is often found fringing the largely uncleared sandstone-based terrain, and ranges from highly intact to significantly modified and degraded, largely due to grazing and weed invasion. The associated Shale Sandstone Transition Forest is recognised as Critically Endangered due to extensive clearing across its substantial range, and because of the severity of other threats. Very little is present in formal conservation areas.

In the two southern Growth Areas, diverse, sandstone-based vegetation persists in association with most of the many incised watercourses. This vegetation is broadly the same as what occurs in extensive conservation estate around urban Sydney, but some communities adjoining current or former Shale Sandstone Transition Forest are not well-conserved and are threatened by further clearing and degradation.

3.2.1 Plant Community Types

The following section lists the Plant Community Types mapped in each Growth Area with brief notes about their distribution in those Areas. The list is not restricted to PCTs associated with *M. deanei*.

3.2.1.1 Greater Macarthur Growth Area (GMGA)

The predominant ecological communities in the GMGA are or were Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), all of which are Threatened Ecological Communities. All have been extensively cleared and degraded, primarily by agriculture and weed invasion, but also by urban and allied uses. There are no NPWS reserves in this Growth Area. However, the very small Leacock, Edmondson and William Howe Regional Parks occur just outside the border and are managed primarily for recreation rather than conservation. Dharawal State Conservation Area and National Park border the southern portion of the Growth Area to the east.

A summary of the mapped ecological communities is found in Table 3. The maps are based on OEH products that have been updated by Biosis for DPE.

Table 3. Summary of all ecological communities within the Greater Macarthur Growth Area

PCT	PCT Name	Distribution & notes
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Small patch at Menangle Sugarloaf on SE slopes.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Along creek lines in shale areas in northern and central parts of GMGA.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Small patches on shale soils throughout GMGA but mostly in northern and central parts.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches on shale soils throughout GMGA, more common in southern parts on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	4 polygons, Macquarie Fields, most of which have long been historically mown (Milton Park Softball Complex). They are now subject to regeneration.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	One small occurrence mapped around the margins of bushland associated with Smiths Creek at Leumeah.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Nepean River north from Menangle Bridge.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Narrow zone along Nepean & Georges Rivers and tributary gullies and a small zone along Smiths Creek at Leumeah.
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Restricted to parts of the riparian zones of the more incised and larger watercourses. Very restricted extent in this Area.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Relatively small remnants extend from Glenfield into the far south where it is extensive on transitional soils mostly south from Rosemeadow. Can intergrade with 849 and 1081.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Only mapped to a very minor extent as highly linear remnants between Glenfield and Macquarie Fields (along the railway) and at Ingleburn (adjoining roads).

3.2.1.2 Wilton Growth Area (WGA)

The predominant ecological communities in the WGA are or were Cumberland Plain Woodland (CPW) and Shale Sandstone Transition Forest (SSTF) both of which are Threatened Ecological Communities. Sandstone-based communities occur in and surrounding the more incised watercourses. There are no NPWS reserves in this Growth Area, though Upper Nepean State Conservation Area occurs immediately to the south. There is a Biobanking site on the northern side of the river near Douglas Park (within the WGA), and three more such properties to the immediate north (including St Marys Towers) and those associated with coal mines (Steenbeeke, pers. comm.).

Table 4. Summary of all ecological communities within the Wilton Growth Area

PCT	PCT Name	Distribution & notes
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	On shale soils of higher, gently undulating terrain of northern and central areas. Small patches with scattered trees (farming properties) adjoining more extensive exotic and native grasslands.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	One patch in a derived grassland (treeless) condition in the west, and a much larger portion in the far north.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Limited to a few patches in the north between 1395 on plateau edges and 1181 in sandstone gullies.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Common on slopes and plateau edges above and around incised sandstone-based watercourses that surround most of the Area.
1292	Water Gum – Coachwood riparian scrub along sandstone streams	Restricted to a very narrow riparian strip along the Nepean River.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	The most extensive community on shale sandstone transition soils between 849/850 and sandstone communities along gullies. Variable floristics.

3.2.1.3 Greater Penrith to Eastern Creek Growth Area (GPECGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Shale Gravel Transition Forest and Castlereagh Forests & Woodlands. River-flat Eucalypt Forest was previously much more extensive along the Hawkesbury-Nepean River and adjoining primary floodplain, and it remains to varying degrees along many watercourses such as Eastern Creek, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. There is one NPWS reserve in this Growth Area: Wianamatta Regional Park, however it is already significantly fragmented and may be required to potentially accommodate a large transport corridor. The small Mulgoa Nature Reserve and associated Biobanking sites occur near the south-western border of this Growth Area. Yarramundi SCA occurs on the western boundary but across the Nepean River, and Wianamatta NR occurs near the NW corner.

Table 5. Summary of all ecological communities within the GPECGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Scattered as small remnants and one larger remnant in the central portion, but with greater extent in the central north, mainly in the western ungazetted portion of Wianamatta Regional Park.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	A few very small remnants present south of the M4, with larger remnants within and near the gazetted and ungazetted portions of Wianamatta Regional Park.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northwest, with some small remnants in the southwest, often associated with watercourses.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Present to a very minor extent on the southwestern edge adjoining Mulgoa Nature Reserve
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains through the south and central areas.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Common in and near Orchard Hills in the south, and former ADI lands in the central north, with some areas in the ungazetted portion of Wianamatta Regional Park. Other scattered remnants, particularly in the east.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches in the south west, primarily in pastoral settings and on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Restricted to one linear polygon in the eastern portion of Wianamatta Regional Park.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Hawkesbury-Nepean River, primarily near Penrith Lakes.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Present as mostly-linear remnants along South Creek and Eastern Creek and tributaries, with some scattered occurrences, including along the M4.

3.2.1.4 Western Sydney Aerotropolis Growth Area (WSAGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Castlereagh Forests & Woodlands near the localities of Kemps and Badgerys Creeks, and potentially in the vicinity of the water pipeline crossing of Luddenham Road. Riverflat Eucalypt Forest remains to varying degrees along most watercourses, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. Swamp Oak Forest occurs mainly along South Creek and some tributaries. There are currently no NPWS reserves in this Growth Area. The small Kemps Creek Nature Reserve occurs just outside the south-eastern corner and Gulguer Nature Reserve and Bents Basin State Conservation Area are near the south-western corner.

Table 6. Summary of all ecological communities within the WSAGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Restricted to the Kemps and Badgerys Creek area as three patches of remnants.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	As above: two patches with smaller remnants nearby and on slightly higher ground than 724.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northeast, with one remnant in the centre.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains but very little remains, and most occurrences are linear.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	The most common PCT in this Area, with remnants throughout on the dominant shale terrain.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Only very small patches in the far south.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain and Hunter valley	Present as mainly very linear remnants along most watercourses but largely absent from the southernmost portion.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principal source of threatened flora records in NSW is the OEH BioNet database, which includes most records held by the NSW Herbarium (specimen-based), as well as sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may not have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet are original – most are simply replicate records based on specimens held in other herbaria.

The preliminary assessment of threatened species records undertaken for the preparation of this Expert Report reiterated the merit of reviewing BioNet data and resolving a range of errors, rather than simply using data 'as held'. *Melaleuca deanei* records within BioNet were reviewed, and numerous corrections were made, though the majority of these relate to the assigned spatial accuracy scores and to clarifying or correcting location placements and descriptions. Not all records were able to be checked in that stage, and a second review for records in or near the Growth Areas was conducted to further improve data quality. The reviews eliminated a range of errors and allowed many records that were otherwise too spatially vague, to be refined such that they were suitable for habitat modelling and for general reference. Not all records were reviewed, and inaccuracies remain in the dataset, but records within the Cumberland Subregion are now far more accurate in terms of their identification of the species, their location, and their spatial accuracy score.

BioNet data should only be treated as indicative, not least because there has not been comprehensive survey of all of the Growth Areas or environs, and surveys have been variously constrained. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate.

Field survey undertaken by consultancy firms engaged by DPE (Biosis and Ecoplanning) did not add any records of *M. deanei*.

The preliminary assessment of threatened species records undertaken for the preparation of this and three other Expert Reports reiterated the merit of reviewing BioNet data and resolving a range of errors, rather than simply using data 'as held'.

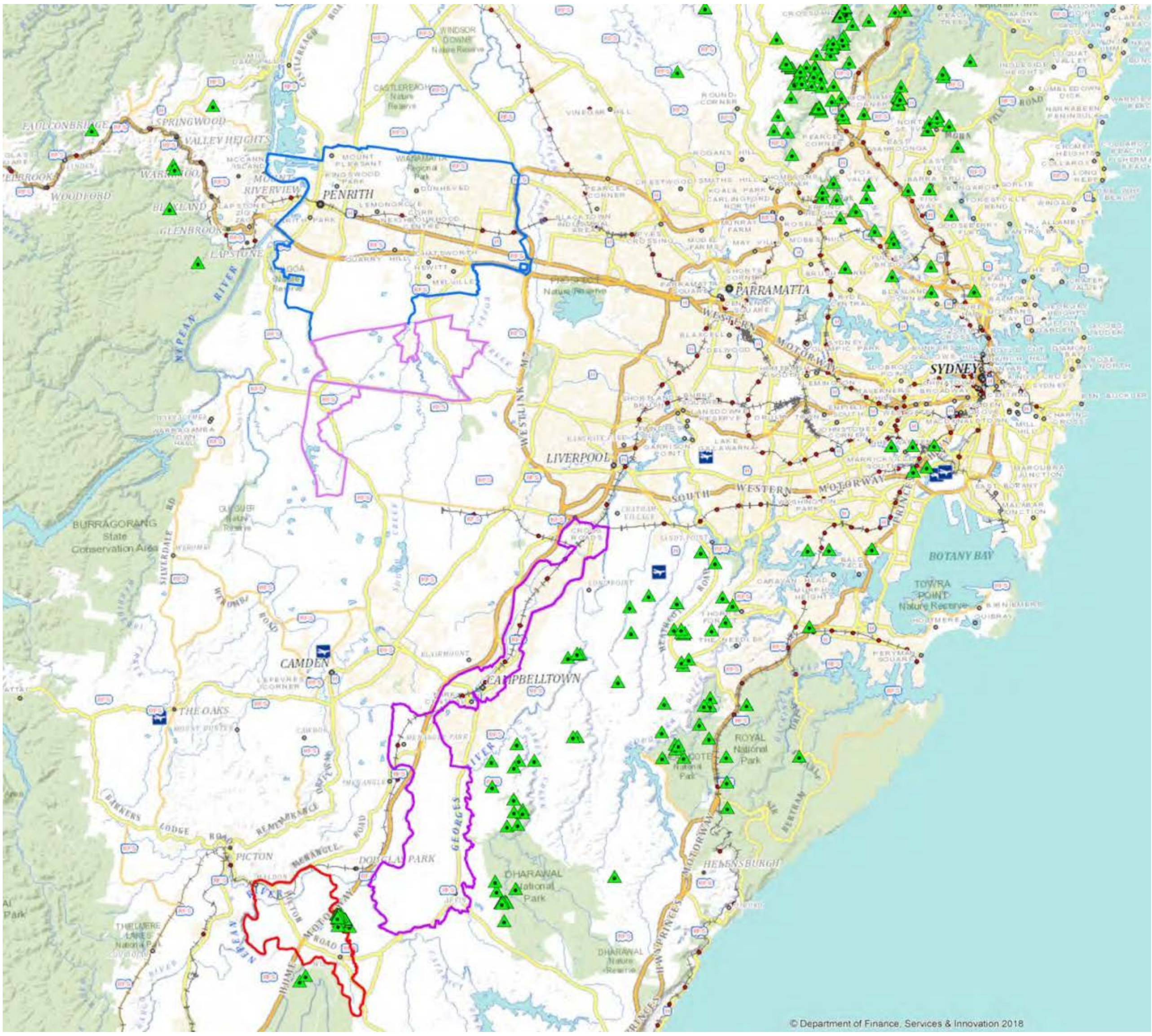
The preparation of this Report entailed detecting and notifying OEH about the correction of several records of *M. deanei* that were errors of some form. One record from the Cumberland Plain near Vineyard was determined to be a data entry error (wrong species). Another record plotted in the GMGA from an experienced botanist had a 1 km spatial accuracy and sparse notes: "north of Appin" and "in swampy area". The plotted location of the record was highly arbitrary and in a cleared paddock in the southern half of Appin village on unsuitable geology. The observer of the record was contacted about the inconsistency and was able to supply information confirming its proper location. BioNet staff have since moved this record. There is no longer a record of this species from the GMGA.

4.1.1 Existing records by Growth Area

There are no BioNet records of *M. deanei* from either the GPECGA or the WSAGA. There is no suitable habitat for this species in those areas.

There are no records of *M. deanei* in the GMGA, but there are numerous valid records to the east on the Woronora Plateau. Equivalent habitat extends into the GMGA and is identified in this Report.

M. deanei is known from numerous spatially accurate records of a population within and just outside the WGA. Other threatened flora species are present in the same area e.g. *Epacris purpurascens* var. *purpurascens*, *Acacia bynoeana*, *Persoonia bargoensis*, *Grevillea parviflora* ssp. *parviflora*. The records are dated 2015 and are from flora assessments for the Bingara Gorge housing project, which is outside the scope of the WGA.



Map 4. BioNet records (as of 26/11/18) relative to Growth Areas

Each point on Map 3 may not designate a collection or observation at that location, as most very old records lacked any co-ordinates, or only supplied coarse co-ordinates, and may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

4.1.2 Prior surveys within each Growth Area

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods and findings across the study area.

The OEH Authorised Officer for *M. deanei* was contacted in this regard. She provided information in the form of two 2014 publications by Alison Hewitt *et al*. (Western Sydney University) and mentioned a site in Sutherland Council area (outside the Growth Areas) that may have been subject to rehabilitation. She also mentioned a report that was seen to be of potential relevance (c.f. Cumberland Ecology, 2011).

The aforementioned surveys associated with the Bingara Gorge housing project have been considered in the preparation of this report.

4.2 Summary of survey work undertaken for the biocertification assessment

4.2.1 Vegetation mapping

Vegetation mapping of the Cumberland Subregion was completed in stages by OEH in 2013 and 2016. These two vegetation layers have been used as the base to compile an updated vegetation community layer for each of the Growth Areas. This updated work has been completed by Biosis under contract to DPE. The mapping update includes checking plant community types and confirming the accuracy of boundaries to account for clearing or regrowth that may have occurred since the original mapping was completed. Field verification of the mapping was undertaken by Biosis and Ecoplanning, both of whom undertook vegetation surveys where access was permitted.

Vegetation in the Growth Areas was mapped and assessed based on five vegetation condition classes:

- Intact;
- Non-offsettable Grassland;
- Offsettable Grassland;
- Scattered Trees;
- Thinned.

4.2.2 Field survey effort

The information in section 4.2.2 has been provided by DPE but has been edited here to only deal with threatened flora where feasible. Further details are provided separately by DPE:

An initial 726 letters were sent to landholders within the Wilton and Greater Macarthur Growth Areas in late 2017 with a second letter following in March 2018. To increase the response rate, Biosis commenced targeted door-knocking in May 2018. From this, just under 20% of landholders within these Growth Areas allowed access to their property. However, this included access to large parcels of land owned by major developers, which allowed a reasonable amount of access, particularly for the Wilton Growth Area.

Floristic plot data collected:

- Wilton (86 plots across 6 PCTs)
- Greater Macarthur (82 plots across 9 PCTs)

Approximately 150 of the plots required to meet BAM requirements were obtained by supplementing Biometric plots from various recent assessments. This involved locating the previous plots and collecting additional data on stem classes, number of large trees, and litter cover to meet BAM requirements. The ecologists had no trouble locating the original survey sites and found that the additional data was quick and easy to collect (approximately 30 minutes per site).

The remaining plots in Wilton and Greater Macarthur, and all of the plots in Western Sydney Aerotropolis and Greater Penrith to Eastern Creek consisted of new plots surveyed for this project. All plots were sampled according to the methods prescribed by the BAM Manual (OEH 2017). This includes collecting information on species cover and abundance from 20 x 20 m or equivalent configuration plots within each vegetation zone.

A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Growth Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council.

Floristic plot data collected:

- Western Sydney Aerotropolis (53 plots across 6 PCTs)
- Greater Penrith to Eastern Creek (26 plots across 7 PCTs)

Targeted survey for threatened species

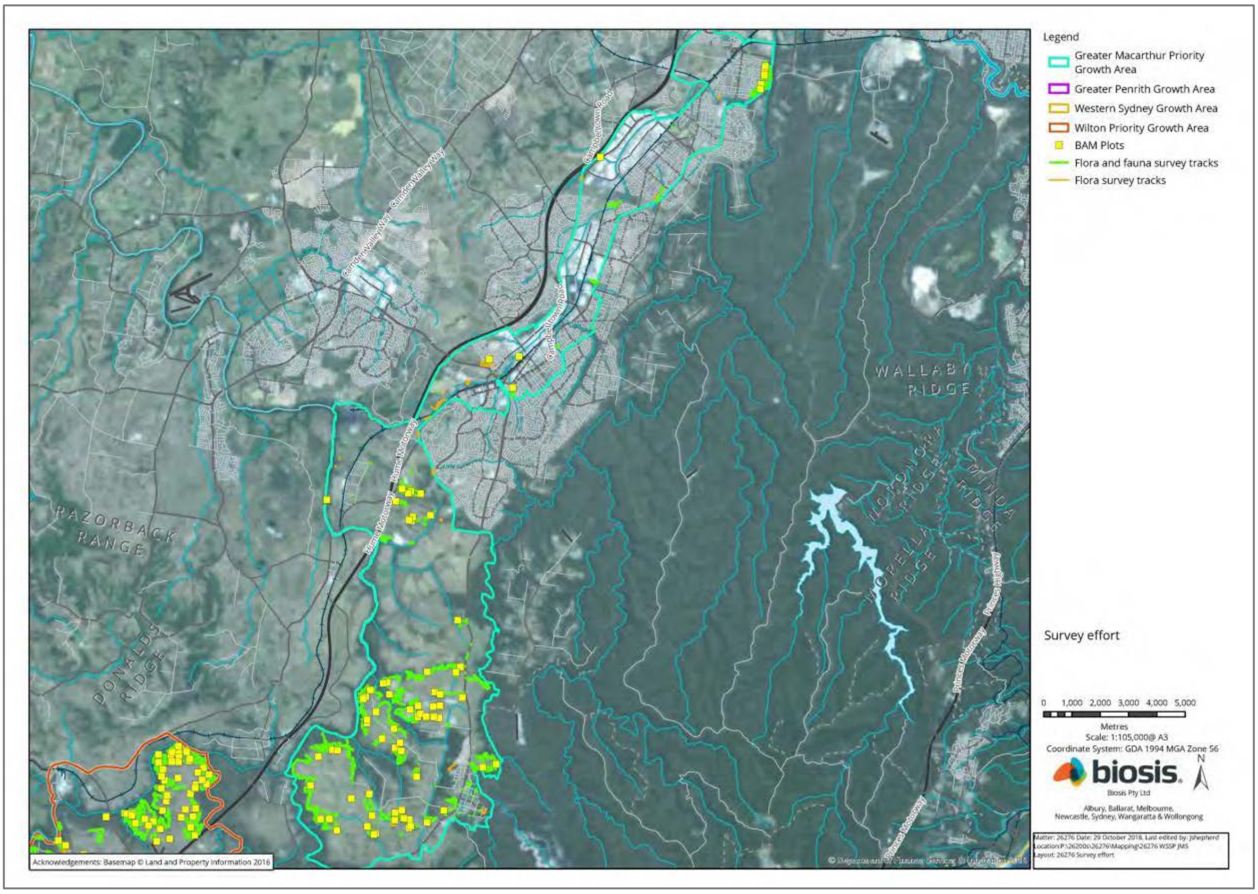
Targeted survey for threatened plant species has been conducted on lands where access has been granted. Vegetation transects and random meanders for threatened flora was conducted by Ecoplanning and Biosis in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey has included effort through each PCT and vegetation zone and has extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m).

Likely habitat for most threatened flora species comprised areas of lower disturbance. This includes areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora.

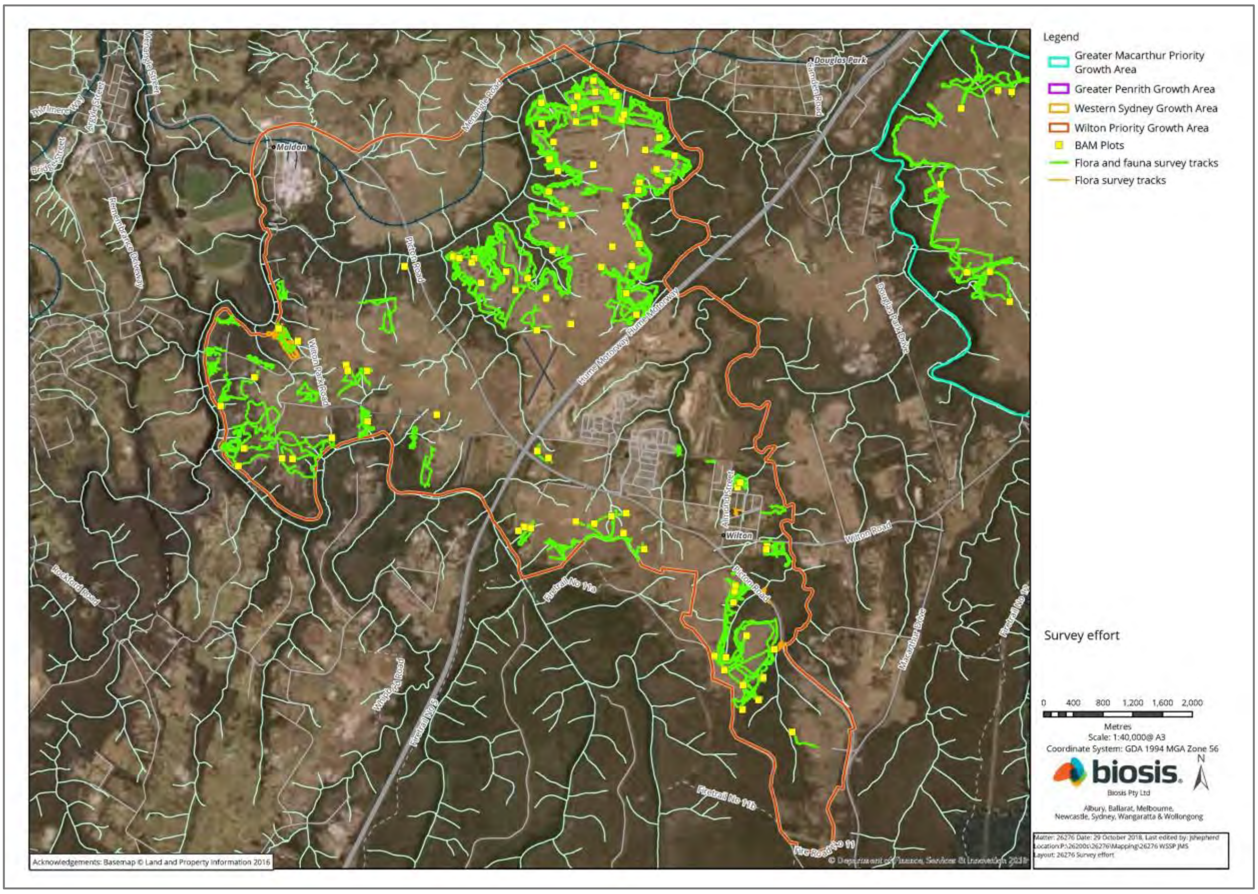
Table 9. Survey effort for threatened plant species *and* fauna habitat by PCT

PCT No.	Area of PCT in Growth Area (ha)	Area of PCT in urban zone (ha)	Field survey area (ha)	Percent of PCT surveyed within Growth Area (%)	Percent of PCT surveyed relative to urban zone (%)
724	191.3	57.0	12.1	6.3%	21.2%
725	167.4	51.4	6.9	4.1%	13.4%
781	68.9	5.6	0.9	1.4%	16.8%
830	21.6	0.8	1.7	7.8%	206.5%
835	1175.8	287.3	30.5	2.6%	10.6%
849	3078.3	637.6	125.0	4.1%	19.6%
850	522.9	294.3	36.1	6.9%	12.3%
883	7.4	0.0	0.5	6.8%	
1081	74.2	0.0	0.2	0.3%	
1105	138.6	0.0	0.0	0.0%	
1181	780.7	0.2	39.6	5.1%	19794.4%
1292	39.8	0.0	0.3	0.7%	
1395	3326.6	486.9	483.4	14.5%	99.3%
1800	232.6	20.2	7.3	3.1%	36.2%
TOTAL	**9826.1**	**1841.3**	**744.5**	**7.6%**	**40.4%**

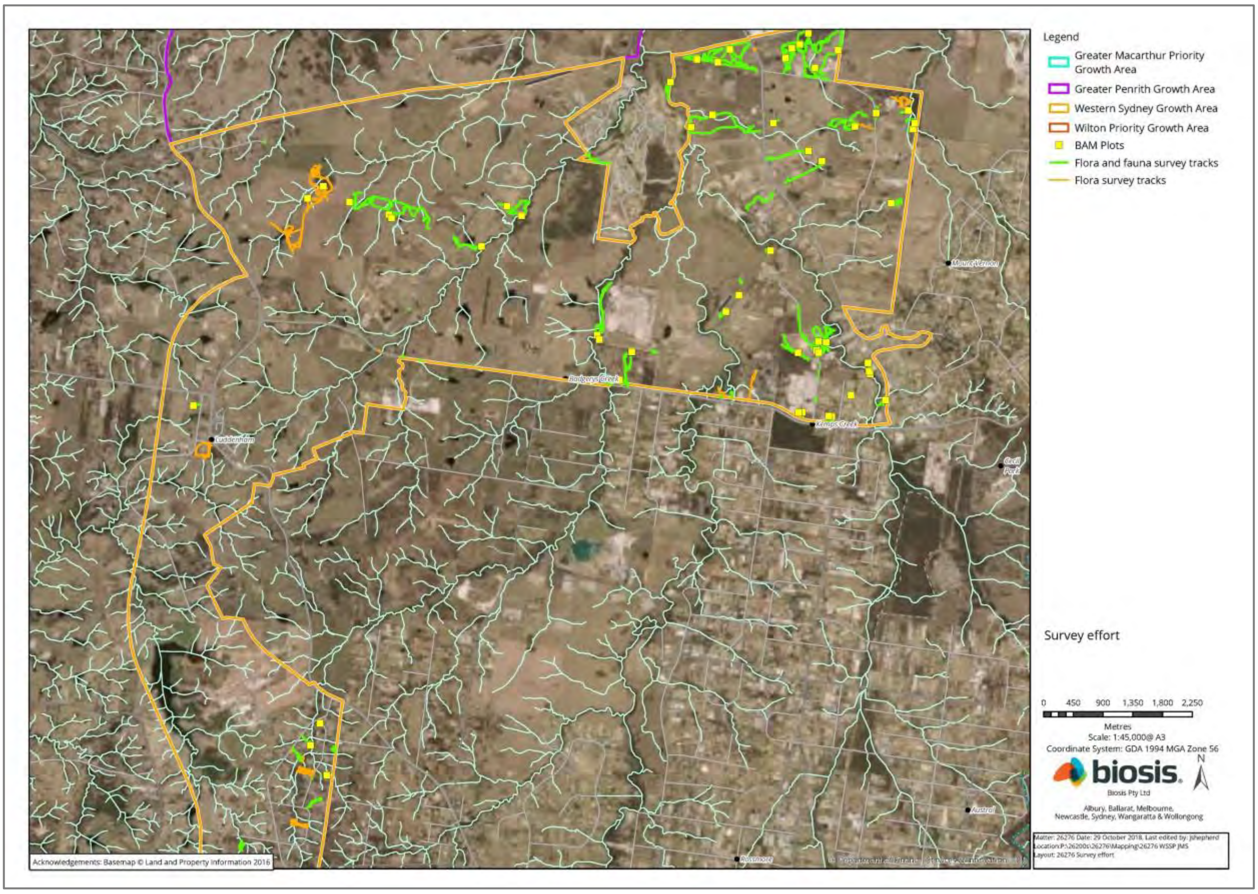
Field survey effort was not confined to the urban zone. Surveys occurred into nearby vegetation zoned for conservation. The urban zone has been revised over time and some areas where survey had already occurred were later removed. For these reasons, comparison of the survey area to the urban zone is indicative only. Survey effort has been calculated using a 20-metre buffer either side of GPS survey tracks. For the purposes of this analysis, the urban zone includes land zoned for future urban development plus transport corridors within the growth areas. It does not include any transport corridors outside the growth areas.



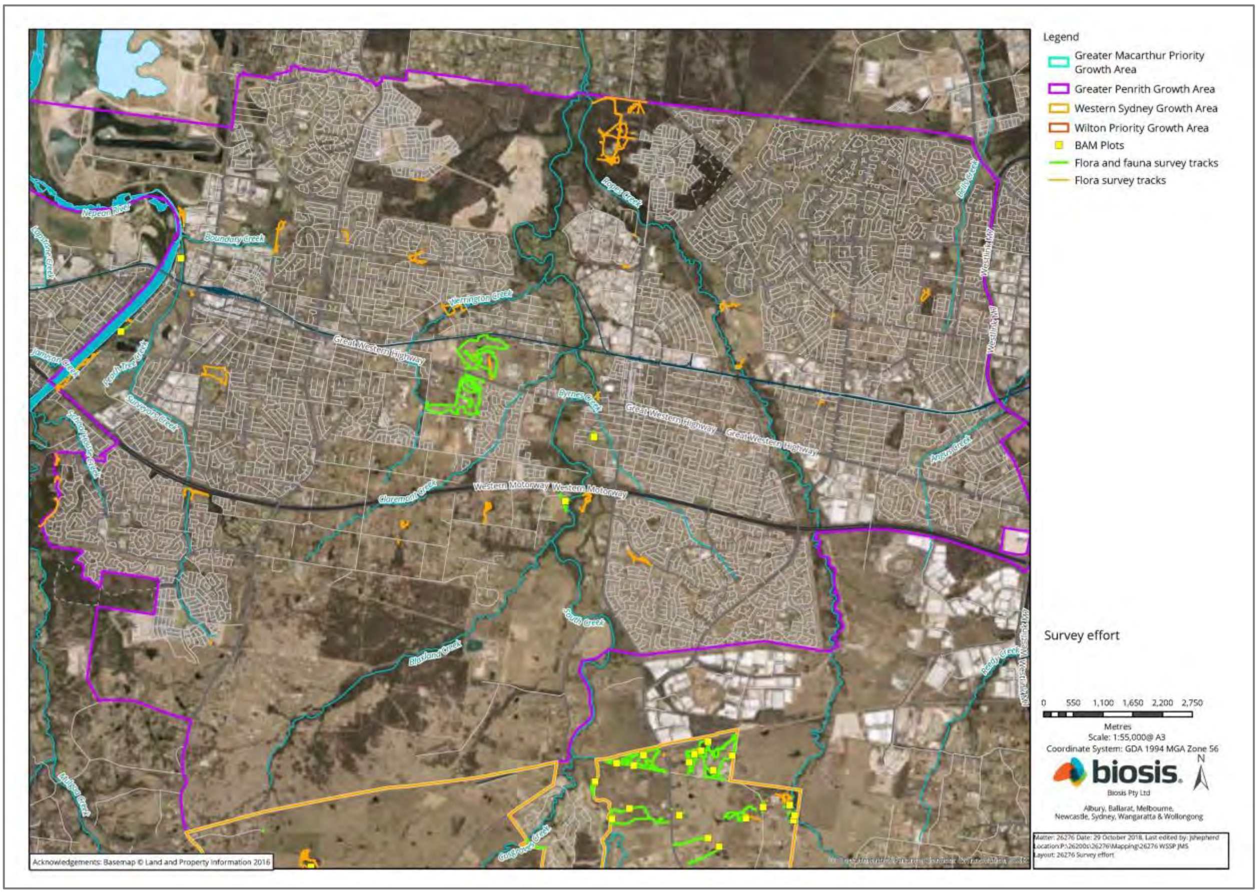
Map 5. GMGA survey effort (Biosis & Ecoplanning)



Map 6. WGA survey effort (Biosis and Ecoplanning)



Map 7. WSAGA ('Western Sydney') survey effort (Biosis and Ecoplanning)



Map 8. GPECGA survey effort (Biosis and Ecoplanning)

4.2.3 Survey constraints –timing / site conditions

As noted earlier, severe drought affected all of the study areas for some or all of the survey period. The Wilton and Greater Macarthur GAs were only surveyed during drought, whereas the Penrith & Eastern Creek and the Aerotropolis GAs were surveyed both during intense drought and the subsequently slightly wetter conditions that followed in the Spring of 2018. Whilst wetter, drought remained present, and fellow Expert, Robert Miller, reported that vegetation was evidently drought-affected across all of the Growth Areas into November.

Drought, combined with increased intensity and extent of total grazing pressure, meant that affected surveys may have under-recorded the target species compared to normal conditions. Whilst drought alone is unlikely to cause *M. deanei* to die back to rootstock or die and only remain as seedbank, when combined with increased herbivory due to drought, this is a far more likely outcome. The extent to which herbivory of any kind affects this species is unknown. It is unlikely to be palatable to livestock because of the high volatile oil content, and that it is not likely to be nutritious, but native browsers may consume it e.g. Swamp / Black Wallaby or Brushtail Possum under harsh conditions.

Irrespective of drought, surveys for this species are constrained by consideration of fire ecology, in that this species can be suppressed and potentially rendered apparently extinct at a site if the area has not been burnt for many years and shrub growth is thick. Prolonged absence of fire is a constraint in some of the surveyed areas. Conversely, the species could be undetectable or not readily distinguished and identified in areas burnt very recently.

4.2.4 Survey constraint – surveys undertaken by generalists / non-experts

M. deanei is not a cryptic species and it is not easily missed when suitable conditions are present. However, it is more likely to be present but not recorded when surveyed by personnel not very familiar with the species, and more so in situations such as restricted visibility and access due to dense scrub cover as a result of prolonged absence of fire and/or regrowth after earlier clearing or intense grazing etc. Those situations are more likely in some of the areas surveyed i.e. between grazed lands and ungrazed bushland.

4.3 Surveys completed specifically for this Report

I did not undertake any surveys for this species in either of the two Growth Areas in which it is either known or likely to occur. Reasons for this include:

- Consultants who detected the Bingara Gorge population had earlier surveyed some of the nearby equivalent habitats, but did not detect this species or the other associated threatened plant species present at that site (G. Steenbeeke, pers. comm.);
- Surveys by other consultants on behalf of DPE traversed some additional areas of potential habitat, and also did not detect the species;
- There were constraints in terms of ready access to properties other than those that DPE's consultants had already surveyed or were scheduled to survey, and some sites of potential habitat were inaccessible due to the land owner not providing permission to enter;
- Relatively little time was available given the timeframes that had been specified for the provision of the four Expert Reports that I was commissioned to complete;
- *M. deanei* is naturally rare and patchily distributed, and the species appears to be at its low rainfall limit of distribution in the WGA and GMGA. Most of the more westerly populations are at higher elevations with greater orographic rainfall and/or less rain-shadow than the WGA and GMGA (both of these Areas experience rain-shadow from the Woronora Plateau to the east, and the Greater Blue Mountains to the west);

Having regard to the above, there seemed to be relatively little merit in my undertaking additional surveys, especially given that my work in this Expert Report is intended to cover gaps in survey effort, so would necessarily take a precautionary approach when dealing with the prediction of potential habitat. This decision has been further supported by the fact that the majority of potential habitat for this species has been excluded from the proposed urban footprint.

4.4 Assessment of species' presence

The following section deals with known occurrences of the species in the context of the four Growth Areas.

4.4.1 Greater Macarthur Growth Area

Most of the northern half of the GMGA is not likely to support the species based on the extent of land clearing and/or the scarcity of suitable habitat parameters such as plant communities and soil types. Were the species found in the highly urbanised northern GMGA, it is likely that unless on public land able to be managed for conservation, any such occurrence may not be viable in the long-term terms because of threats including fragmentation / isolation of habitat, and ability to maintain ecological processes.

In contrast, the southern half of the GMGA contains significant areas of potential habitat. This habitat mainly occurs around the upper slopes and ridges associated with gullies and valleys of incised watercourses, and some other remnants that appear to have escaped clearing and grazing due to their relative infertility or other constraints. Some potential habitat is present within and on some edges of the biocertification area (urban footprint). However, potential habitat within the proposed urban footprint is likely to be of lower condition and less viable due to historic and current land uses.

4.2.2 Wilton Growth Area

The species is known to be present in this Growth Area, and nearby to the south, with both populations being substantial in extent and the number of apparent individuals. The only occurrences in the Growth Area are on a site outside the proposed urban footprint, within the separately approved Bingara Gorge housing project. A significant area of similar habitat occurs largely outside but occasionally on the margins of or adjoining the proposed urban footprint. However, surveys of some nearby sites supporting apparently suitable habitat by the same personnel who found the documented population did not detect any further occurrences. This may be a result of the areas having different disturbance histories, particularly in terms of fire. This situation does not preclude the species being present in those sites, as it may be restricted to the seed bank or to rootstock, or in areas with thick scrub cover.

The species is unlikely to occur within the majority of the proposed urban footprint as it is not suitable habitat or has been too heavily modified. Potential habitat within the proposed urban footprint is likely to be of lower condition and less viable due to historic and current land uses.

4.2.3 Greater Penrith & Eastern Creek Growth Area

The species is not known to be present in this Growth Area, nor immediately nearby. This Area does not contain suitable habitat for this species.

4.2.4 Western Sydney Aerotropolis Growth Area

The species is not known to be present in this Growth Area, nor nearby. This Area does not contain suitable habitat for this species.

4.5 Assessment of suitable habitat for *Melaleuca deanei*

4.5.1 Description and relative significance of potential habitat

The species' ecology and distribution are now sufficiently known to be confident in predicting the Plant Community Types, associated Threatened Ecological Communities and landscapes in which it is likely to occur, both in general, and within the Growth Areas. DECCW (2010) indicates that there is not a clear association between the species and particular habitat. However, this may refer to the fact that the species is not specific to a *single* habitat. At that time, vegetation maps were not as developed as they are now over much of the species' range, which likely constrained DECCW's ability to perceive and describe habitat associations.

Potential habitat for *M. deanei* has been determined based on the species' known affinity with particular geology, soils, and vegetation communities, with some regard to habitat condition. Additionally, the species is not associated with watercourses, so graded riparian exclusion buffers have been applied in the creation of the required 'species polygons' that map potential habitat. All vegetation condition classes are included except Derived Native Grassland.

As per the findings presented earlier, combined with expert knowledge, the following vegetation communities are regarded as potential habitat for *M. deanei* across the **two southern Growth Areas** in which it is either known or considered likely to occur:

Table 8.

PCT	PCT Name	Relative significance
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	High to potentially Very High when compensating for limitations of datasets
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney	Moderate to Low when compensating for limitations of datasets
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain, Sydney Basin Bioregion	Very High to High when compensating for limitations of datasets

Again, it is important to note that the relative significance of these PCTs for this species should only be seen in the context of the Greater Macarthur and Wilton Growth Areas. Across the species' range, the relative strength of association for these PCTs will likely drop, not least because other PCTs, particularly more coastal heathy woodlands, are strongly associated with this species.

Greater Macarthur Growth Area

The vegetation mapping provided for use in the project indicates that there are **1645.0 ha** of potential habitat for this species in this Growth Area based only on the extent of relevant PCTs. However, significant portions of some components are of lesser habitat significance due to persistent disturbance, particularly intensive pastoralism (sewing of introduced pasture species, addition of fertiliser, commercial stocking rates), and are less likely to retain this species in any form. This is particularly the case for PCT 1395, which is the most likely to be directly degraded by rural land uses. PCT 1181 is more likely to be compromised by rural and urban run-off and associated weed invasion but only along riparian zones in which *M. deanei* does not occur.

Table 9. Potential habitat in the GMGA

PCT	Distribution	Relative habitat value of local occurrences
1081	Very rare in this GA – just one site and three polygons above a drainage line in an established urban area.	Moderate to high depending on condition (mapped as Intact but likely to suffer from urban pressures, particularly weeds and altered fire regime). Site has very high edge to area ratio, further reducing general habitat value.
1181	Common within sandstone gullies and gorges, mainly on or near WGA boundaries, primarily in the southern portion. Only one small example in the northern portion (urban bushland).	Low to moderate depending on sandstone influence – high sandstone and no shale influence is of lower habitat value. Not suitable habitat close to watercourses. Areas degraded by adjoining rural and urban land uses are likely to be of less habitat value.
1395	Common in the far south from around Menangle Park through Gilead to Appin area; between cleared shale landscapes and sandstone gullies	High to moderate depending on shale content: high shale content is of lower habitat value. Unlikely habitat when near other than low order watercourses

Wilton Growth Area

There is a substantial area of potential habitat in the WGA, with several recent records within one population mapped as part of the Bingara Gorge housing project. Similar habitat extends along the upper slopes of many remnant vegetation areas associated with larger watercourses. The updated vegetation map indicates that there are **1162.2 ha** of potential habitat for this species in this Growth Area.

Table 10. Potential habitat in the WGA

PCT	Distribution	Relative habitat value of local occurrences
1081	Uncommon and restricted to three substantial patches above sandstone gorges, mainly on or near edges of WGA.	High to moderate even when considering that the nearby records are not mapped in this PCT (likely due to limitations of that mapping).
1181	Common within sandstone gullies and gorges, mainly on or near WGA boundaries.	Low to moderate depending on sandstone influence – high sandstone and no shale influence is of lower habitat value. Not suitable habitat close to watercourses.
1395	Common in the far south from around Menangle Park through Gilead to Appin area; between cleared shale landscapes and the upper margins of sandstone gullies	High to moderate depending on shale content and site condition: high shale content is of lower habitat value. Unlikely habitat when near anything other than low order watercourses

4.5.2 Species habitat polygons

Species habitat polygons generated by this report relate to the extent of potential habitat that is proposed to be cleared for urbanisation or related purposes, such as transport corridors. The polygons were generated to inform biodiversity offset assessments. The data presented in this section does not deal with species habitat outside proposed urban zones as those areas are treated as conservation zones or are excluded from urban and associated transport zones for a range of reasons.

The habitat polygons include all relevant condition classes of relevant PCTs as identified in this Report. In this case, all condition classes are included except Derived Native Grassland. However, that class was apparently accidentally included in the calculations, but the effect of this is trivial.

Species habitat polygons have been generated based on DPE's project-specific PCT maps and the application of graded riparian buffers. The riparian buffer distances used to generate the polygons increase with the Strahler stream order as shown below. The buffer is applied either side of the mapped stream centreline. The distances have been determined based on observations of spatially accurate records of the species in relation to relevant stream orders. Riparian exclusion buffers are used for this species as *M. deanei* is primarily associated with ridge tops, plateau margins, spurs, and upper slopes with relatively exposed aspects. It is not associated with lower slopes or sheltered aspects, and not with riparian habitats. Note that these riparian buffer distances are a different concept and serve a different purpose to those applied by DPE for the purposes of protecting streamside vegetation and watercourses in its planning within the Growth Areas.

Spatially reliable records of this species do not occur near streams, but can occur closer than would otherwise be expected, simply because of steep terrain. This factor is partly why a simplistic linear GIS-based assessment has not been used to determine the optimal buffer distances. The distances used here err in accordance with the precautionary principle. Many spatially reliable records occur considerably more than 20 m from first order streams. A simple linear relationship between stream order and buffer distance was not evident because higher order streams in elevated areas tend to be deeply incised such that ridgetop habitat can be relatively close to the stream but over very steep, sometimes vertical terrain. The distance can be relatively short, but the altitude difference can be dramatic.

Table 11.

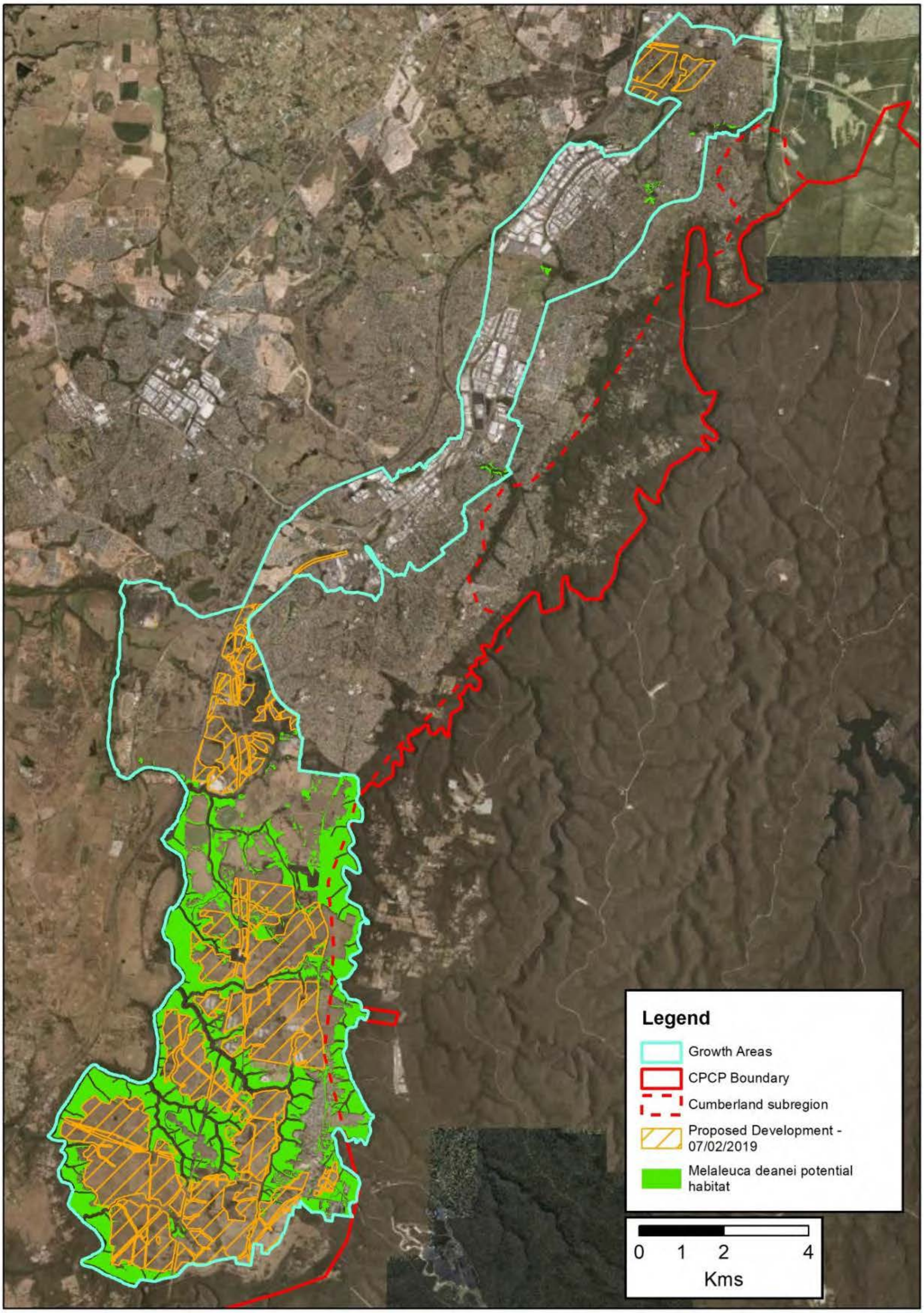
Stream order	Buffer distance (m)
1	20
2	30
3	40
4	60
5	70
6	80
7	90

Species polygons in the form of GIS shape files were provided to the Biodiversity and Sustainability Branch of DPE in November 2018. A summary of the analysis of these shape files is presented in Table 12. These figures are based on precautionarily modelled *potential* habitat, and do not necessarily equate with *actual* habitat, nor do they provide any information of potential population sizes or population viability. It is unlikely that a large percentage of the potential habitat identified in this Report would actually support *M. deanei* because this species is naturally rare and patchily distributed, even though it can be locally abundant in favourable conditions.

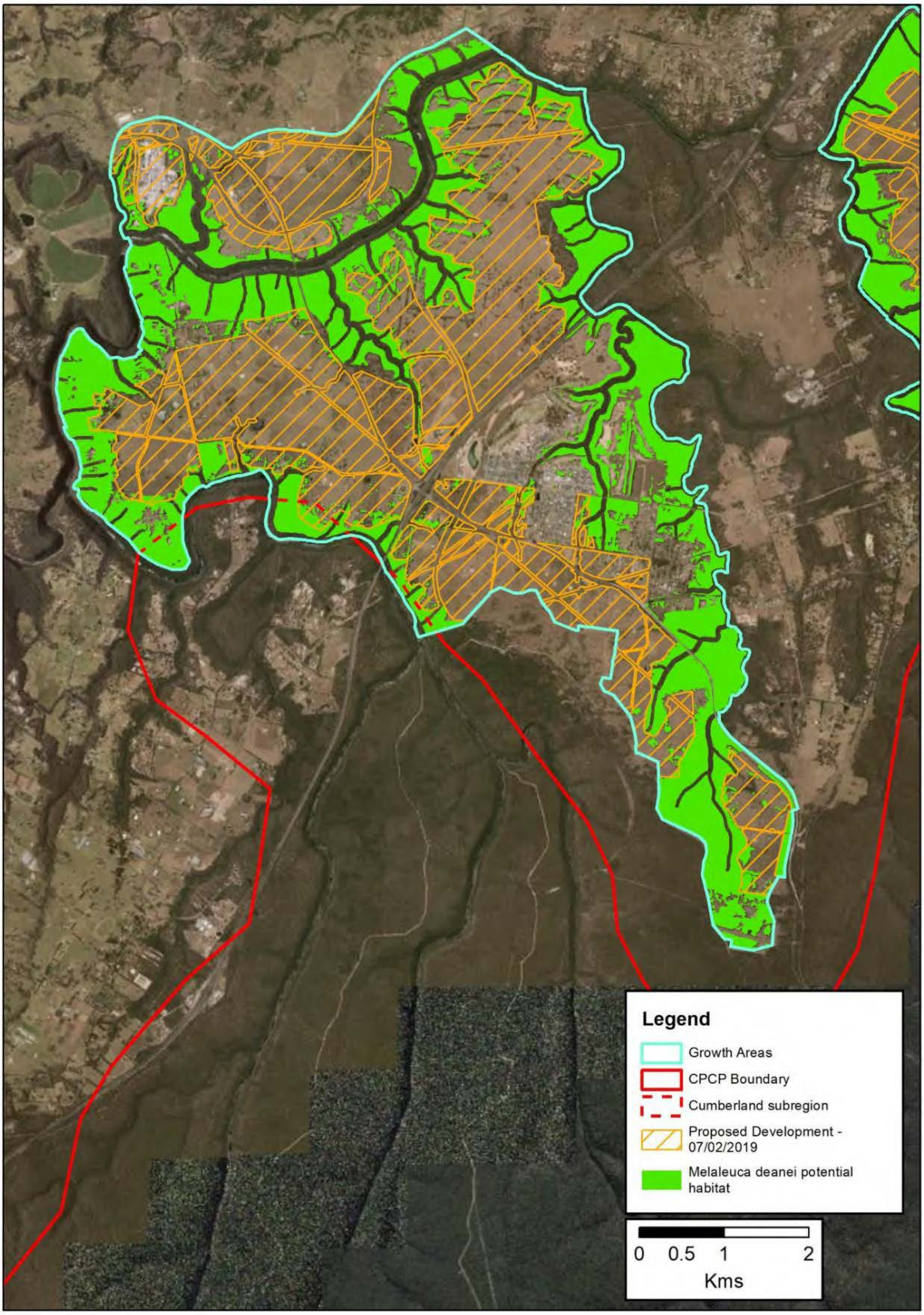
Table 12. Area of PCT-based potential habitat proposed for removal in each Growth Area

Growth Area	Area of potential habitat (ha)	Area of potential habitat removal (ha)	% area of potential habitat removal by GA
Greater Macarthur	1645.0	102.3	6.2
Wilton	1162.2	114.6	9.9
Transport corridors **(all GAs)**	-	0.0	0.0
TOTAL	**2807.2**	**216.9**	**7.7**

Map 9 Greater Macarthur - Potential habitat and proposed urban/transport habitat removal



Map 10 Wilton - Potential habitat and proposed urban/transport habitat removal



5. Summary and conclusion

Within the four Growth Areas, *Melaleuca deanei* is currently only known from the Wilton Growth Area, and that occurrence is outside the biocertification area. Potential habitat for this species exists in other parts of the WGA and in the GMGA, though in the latter case, the vast majority of that habitat is in the southern section. The species is not known or likely to occur in the GPECGA or WSAGA, and no potential habitat is identified in those Growth Areas in this Report.

Based on current information, the proposed urban footprint and associated transport corridors across the two relevant Growth Area would destroy 216.9 hectares of potential habitat for *M. deanei*. This equates to 7.7% of the area of potential habitat as defined in this Report. The actual extent of conflict between habitat for the species and proposed clearing for urbanisation is likely to be much smaller as the species is naturally rare and patchily distributed. Not all of the area proposed for removal is of equal value as potential habitat, and different PCTs and condition classes have different probabilities of supporting *M. deanei*.

Because this species is relatively tolerant of some types of disturbance, and it can persist in the soil seedbank, as well as surviving for some time as rootstock, it may occur in areas that might otherwise be disregarded as habitat. It may even persist in areas not mapped as native vegetation. It is likely that some modified sites might support the species in some form, but in general, these are of relatively low significance in the context of the much larger areas of more intact potential habitat that is excluded from urbanisation and associated clearing. It is also feasible that some forms of disturbance associated with urbanisation, particularly the creation of bushfire Asset Protection Zones (APZs) between bushland conservation areas and housing, could advantage this species, especially where the habitat has not burnt for many years. Thinning of the shrub layer by fire or mechanical means could favour the species. More frequent, moderate intensity burning of bushland that represents known or likely habitat for this species, may, within limits, also advantage it compared to low frequency and/or very cool burning.

The positioning of the bushland / urban interface and associated infrastructure such as APZs, should have appropriate regards to this species' habitat and ecology. Appropriate buffers and other strategies are required to prevent direct and indirect harm to this species as a result of the urbanisation of adjoining lands. For example, potential habitat should not be compromised by the placement of housing nearby as might prevent that habitat being managed for conservation, especially in terms of bushfire risk management. DPE has informed me that the intention is for APZs to be accommodated within the proposed urban footprint, not in the non-biocertified bushland areas that may adjoin it.

The absence of records of this species from areas of potential habitat does not mean it could not be present. This is because:

- not all areas have been surveyed historically or recently;
- all surveys have a range of limitations;
- not all discoveries of threatened species are disclosed; and
- large areas of potential habitat are highly likely to have fire regimes that do not favour this species, meaning it may currently occur in very low numbers or as seedbank, yet could appear in substantial numbers after an appropriate fire or equivalent disturbance.

These factors have been considered in the preparation of the species habitat polygons that will inform DPE in relation to biodiversity offset obligations.

6. Information used in the assessment

6.1 DPE or OEH resources

- BioNet data (internal access provided under license for use in this Expert Report and associated dataset cleaning for the purposes of species habitat modelling to meet EPBC Act requirements)
- Atlas of Living Australia on-line (partial use to check for records not in BioNet)
- EMU data (NSW Herbarium specimen database, provided by OEH)
- OEH on-line threatened species profile
- OEH Threatened Species Data Collection on-line
- OEH BioNet Vegetation Classification Database (previously known as VIS)
- EPBC Act Listing/Conservation Advice
- OEH PCT (vegetation) maps for Sydney Metropolitan and Cumberland Plain
- Field data from Biosis and Ecoplanning consultancies engaged by DPE
- GIS layers and maps provided by DPE and its contractors, or by OEH

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7. Acknowledgements

I acknowledge the contributions of DPE staff, particularly Dayle Green, Greg Steenbeeke and Christian Marando (GIS), and DPE contractor Darren James (GIS) in the preparation and refinement of this document and associated maps. My contractor, Rhys Grogan, also assisted with GIS output in the form of drafts of the 'species polygons'.

Consultant botanist, Robert Miller assisted with fieldwork at Kemps Creek, and provided information about field observations associated with searches for his target species and with opportunistic sitings of my target species.

OEH staff assisted with some aspects of data availability and with the processing of many amendments to BioNet records.

8. Statement of professional independence

Whilst I was engaged and funded by DPE to prepare this Expert Report, and series of draft reports and maps were reviewed by DPE staff, I was not coerced by DPE to amend my work in any manner that I did not otherwise agree with. I believe that I had appropriate professional independence in the preparation of this document and associated maps.

I also declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses with property in the Growth Areas, nor do I have other active clients with real estate or associated commercial interests in the Growth Areas.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for a large number of private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation.

I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields.

I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management.

I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections, and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps, and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy-making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Founding member of the Ecological Consultants Association of New South Wales (did not renew due to my relocating to Victoria and later to the ACT).
- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honey Bee.

Species / population	Work conducted
Acacia bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset.
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA
Callistemon linearifolius	Fieldwork, research, successful nomination, advice to RMS and NPWS, PAS2 review
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going)
Callistemon purpurascens	Described new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going)
Calotis glandulosa	Fieldwork (new and extended populations, Kosci NP), CAM review
Calotis pubescens	Fieldwork (new population, Kosci NP), CAM review
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records

Species / population	Work conducted
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council and OEH, CAM reviews
E. aquatica	Fieldwork, advice to Council and Forestry Corporation
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel
E. kartzoffiana	Fieldwork, research, expert witness
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination and advice to NSWSC – listing pending
Gyrostemon thesioides	Successful nomination
Helichrysum calvertianum	Fieldwork, research, nomination, advice to NSWSC – listing pending
Hibbertia fumana	Research, minor fieldwork, expert witness
*H. incana (*syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review

Species / population	Work conducted
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset.
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable - listing pending
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All of the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DEE re Cwlth listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DEE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DEE Recovery Plan update, advice to OEH
Elderslie Banksia Scrub Forest	Major review for DEE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DEE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping, advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping, advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping, and advice about revised listing, advice to DEE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent)
Robertson Basalt Tall Open-forest	Modelling and mapping, advice to NSW SC
Robertson Rainforest	Modelling and mapping
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters research. Formally published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping
Southern Highlands Shale (Forest &) Woodland	Major contributor to DEE listing, drafting of Listing and Conservation Advices, advice to OEH about revision of NSW listing, modelling and mapping. Contracted to prepare listing for upgrade to CE.
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)

Ecological community	Nature of engagement
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils and to OEH/SC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping, advice to OEH
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to DEE listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advices
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy,* 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Edited but not refereed publications

Douglas, S.M. 2014. "When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum". *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. "Black Gum: a threatened tree of upland New South Wales and Victoria." *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. "Species profile and monitoring of Dampiera fusca". *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. "Endangered plant discovered" (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. "Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong". News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. "Phoenix flora: a post-fire discovery in the ACT". *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. "Phoenix flora" (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. "Mysteries of the Megalong Valley: another rare plant for the Blue Mountains." *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. "Land of the living dead – tree decline in urban areas". *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. "Bushland weeds – more on native weeds". *Environment NSW*, December

Douglas, S.M. 2000. "Regional Parks". *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. "Community biodiversity surveys". *National Parks Journal,* 40(3)

Douglas, S.M. 1996. "Mapping our urban bushland". *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. "Healing the Hawkesbury: start with bushland protection". *National Parks Journal*. 38(4)

Public media coverage

2004, November 6. "Bright flowering spot after fire" - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran
- Supervisor for undergraduate dissertation, "Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve" (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation "Riparian Vegetation of upper Cattai Creek" (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**

- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**
- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report – *Persoonia nutans*

Expert report for *Persoonia nutans* (Nodding Geebung), Dr Steven Douglas, February 2019

Expert Report For

Persoonia nutans

(Nodding Geebung)

Strategic Assessment for the
Cumberland Plain Conservation Plan

Greater Macarthur, Greater Penrith to Eastern Creek,
Wilton, and Western Sydney Aerotropolis Growth Areas

Prepared for NSW Department of Planning & Environment, February 2019

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1. Introduction

1.1 Purpose of the Expert Report

An Expert Report may be prepared under s.6.5 of the Biodiversity Assessment Method (BAM) in place of undertaking a threatened species survey of sufficient extent, intensity and duration as would otherwise be necessary to comply with the BAM. Use of an Expert Report may be beneficial where it is highly unlikely that a species may occur within a study area; where survey cannot meet BAM specifications; and/or the reliability of detecting the species is low. In respect of *Persoonia nutans*, insufficient survey extent; constraints on the effectiveness of survey; and unreliability of detection due to aspects of the species' ecology are the primary reasons for preparing an Expert Report.

The purpose of this Report is to provide an assessment of the current status and conservation requirements of *Persoonia nutans* within the four priority growth areas of Greater Macarthur (GMGA); Wilton (WGA); Greater Penrith to Eastern Creek (GPECGA); and Western Sydney Aerotropolis (WSAGA)to determine whether:

a) The species is unlikely to be present and would thus require no further assessment; or
b) The species is known or likely to be present, and the Expert Report must provide estimates of potential habitat within growth areas and development footprints as part of the biocertification process.

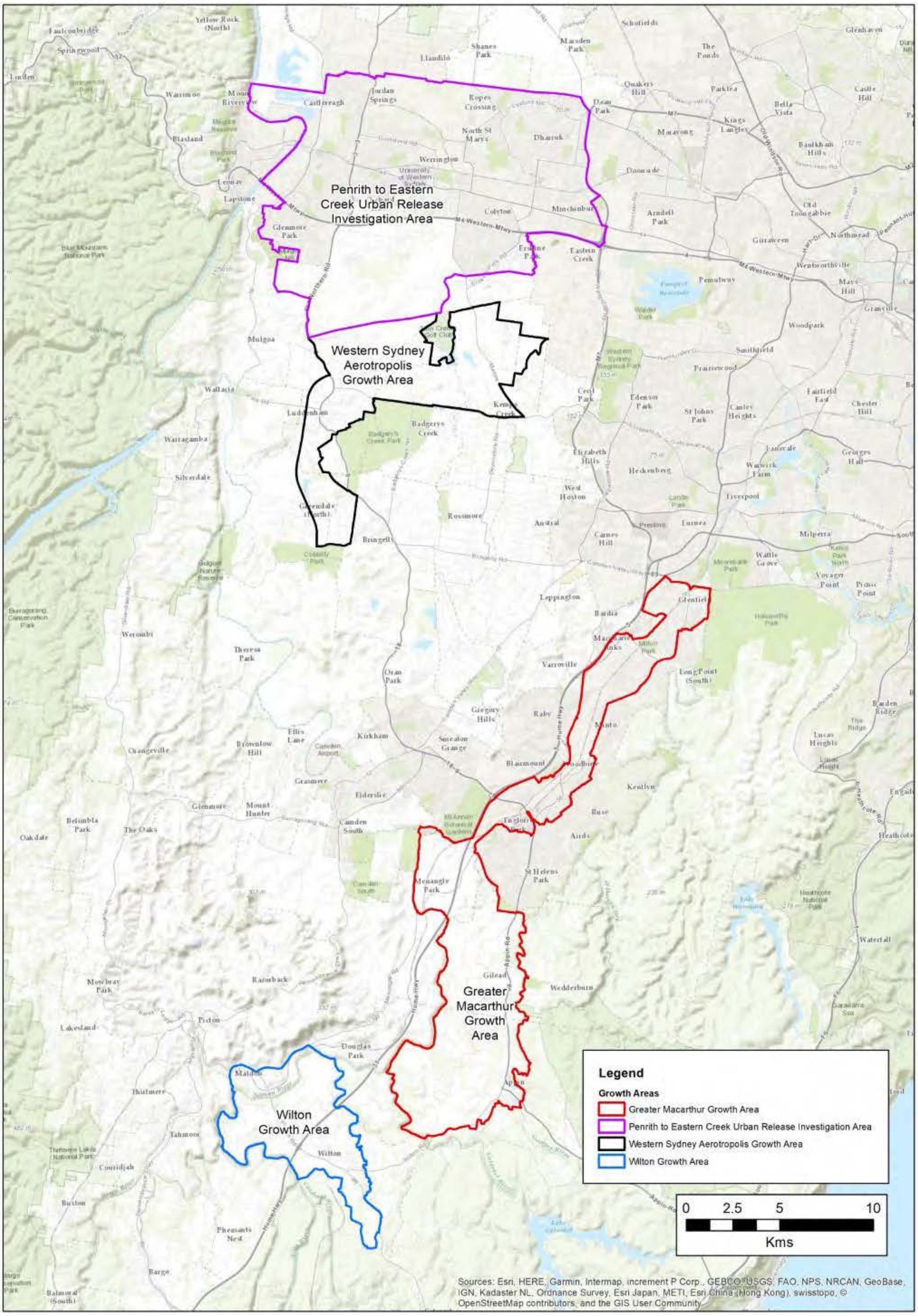
1.2 Project context

The NSW Government is identifying areas for future urban land use and associated infrastructure in western Sydney. The four priority growth areas are all located in the Cumberland Subregion under the Interim Biogeographic Regionalisation for Australia (IBRA) (SEWPaC, 2012).

As part of the planning for these areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify land use outcomes. A strategic assessment of this Plan is underway, and this Expert Report will assist in determining the extent and quantum of impacts of the proposed urban growth on *Persoonia nutans*.

Persoonia nutans (Nodding Geebung) with flower buds. © S. Douglas

1.3 Study area



Map 1. Growth Areas subject to this Expert Report

Greater Penrith to Eastern Creek Growth Area (GPECGA)

A large portion of this Growth Area is already urbanised, with several areas of industrial land use. Significant rural and peri-urban areas remain in the central north, the centre, and the southwest. Large areas of remnant vegetation are present in the far north (former Australian Defence Industries site, now in part Wianamatta Regional Park), and the Orchard Hills Defence facility. Mining of alluvium for sand and soil continues in the far northwest of the area in the Penrith Lakes locality.

The area has been extensively cleared because of its relatively arable terrain, based mainly on shale and alluvium. Some of the remaining vegetation is associated with the much less arable to infertile Castlereagh Forests & Woodlands and its older, leached and mineralised alluvium and shale-derived soils. Strips of remnant vegetation are present along some of the larger watercourses such as Eastern and South Creeks. Significant parts of the study area are or were flood-prone, and this has influenced the retention of vegetation in some affected areas.

Western Sydney Aerotropolis Growth Area (WSAGA)

This Growth Area adjoins the Greater Penrith to Eastern Creek area, extending south to the locality of Greendale, west of Bringelly. It is currently largely rural, with villages at Luddenham and Kemps Creek. Most rural areas are pastoral, but there are significant areas of more intensive rural use, including poultry and egg production, a large dairy and associated fodder cropping, and some market gardens and enclosed fruit and vegetable production. Quarrying occurs at the localities of Badgerys Creek and Kemps Creek.

This Growth Area is extensively cleared but retains native vegetation in areas where rural uses were constrained by steeper terrain, flooding along streams, or unsuitable soils.

Greater Macarthur Growth Area (GMGA)

The GMGA occurs in southwestern Sydney on predominantly shale soils that have been heavily cleared for agriculture and urban or industrial use. The northernmost section has long-established urban and commercial / industrial land use, while the southern section is largely rural (pastoral, minor cropping), with some villages and primarily subsurface mining (e.g. coal and coal seam gas). It extends from urban Glenfield in the north, to the rural village of Appin in the south.

In the southernmost section, geological uplift and erosion have exposed infertile sandstone terrain along gullies and valleys. Much of that terrain remains naturally vegetated because it is unsuited to agriculture, however it occupies only a small percentage of the total area of this heavily-cleared region. Between the infertile sandstone valleys and the relatively arable shale plateau and hills is a geological and ecological transition zone. Whilst much of the vegetation of the shale terrain has been cleared, a greater area of vegetation remains on the transition zone, primarily in the south. Both the shale and transition zones support Critically Endangered ecological communities that are potential habitat for some threatened plant and animal species.

Wilton Growth Area (WGA)

The Wilton Growth Area is the most southerly of the four Western Sydney Growth Areas dealt with in this Report. It extends from the village of Douglas Park in the north, to the village of Wilton in the south. It is primarily rural (pastoral) area with some more intensive agriculture, significant but mostly underground mining (primarily coal), and some long-established villages. The Hume Motorway dissects this Growth Area.

The pattern of clearing and vegetation retention is broadly similar to that of Greater Macarthur, with the majority of remnant vegetation associated with infertile but biodiverse sandstone gullies and the Nepean River gorge, and with associated transition into the heavily cleared shale landscapes.

1.4 Justification for the use of an Expert Report

An Expert Report for *Persoonia nutans* is required as part of the threatened biota assessment for the Cumberland Plain Conservation Plan because:

1) Survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH, 2016) for field traverses due to limitations on land access, particularly in the GMGA;
2) Survey quality was constrained by drought conditions. Whilst this species is perennial, under sufficiently severe drought and associated total grazing pressure (livestock, if relevant; native species; feral species), it can be reduced to surviving as seed bank. Drought was a major limitation on survey effectiveness in this instance. A known location of another threatened species that can occur with *P. nutans* was visited by fellow botanist, Robert Miller, but could not be detected, even though the habitat was still in place. This suggests that the surveys for both species will have under-detected them because of drought and associated increased grazing/browsing pressures;
3) Survey effectiveness was further constrained by parts of the study area having been long-unburnt. This can create an unnaturally dense shrub layer that limits access and that also creates conditions likely to suppress the species such that it may retreat to the seedbank until favourable conditions return (post-fire or equivalent disturbance).

Surveys associated with biocertification of the study areas and earlier projects in those areas have been insufficient to reliably determine the presence and extent of the species. An Expert Report is required to provide an assessment of the likely presence, location, and significance of occurrences of the species in those areas.

1.5 Credentials of expert

I have worked as an ecologist since the mid-1990s, primarily in the Greater Sydney region, but also in the ACT, Central Coast, southern NSW (coast, tablelands and slopes), throughout Victoria and into eastern South Australia. I have primarily been self-employed, with a mix of government, private, and corporate clients, and have also worked as a subconsultant to larger firms, including two university-based consultancies. I have also worked directly for the NSW NPWS, and more recently for OEH (Native Vegetation Information Science). I was approved by OEH as a species expert for *Persoonia nutans* in November 2018. A summary of my credentials as required under the BAM is provided below as Table 1. I was approved by OEH as a species expert for *Persoonia nutans* under s.6.5 of the BAM in November 2018.

Table 1. Credentials of Dr Steven Douglas as Expert in relation to *Persoonia nutans*

BAM section	BAM requirement	Details
s.6.5.2.8 (g)	Name of expert	Dr Steven Douglas
s.6.5.2.3 (a)	Expert's qualifications	Bachelor of Science (Plant Ecology, Land Management, Resource & Environmental Management), Macquarie University, 1993. Master of Environmental Planning, Graduate School of Environment, Macquarie University, 1996. Doctor of Philosophy, Australian National University, 2008. Graduate Certificate of Information Literacy, ANU, 2006. BAM Accredited Ecologist, 2018.
s.6.5.2.3 (b)	History of experience in ecological research and survey method for the relevant entity	Review of BioNet and incorporated NSW Herbarium database records of *P. nutans* (DPE, 2018). Provision of expert witness evidence in relation to *P. nutans* (QUBE proposal, Moorebank; included assessment of adequacy of biobanking arrangements) L&EC 2017/81889 (2017-18). Fieldwork and advice to NPWS in relation to the species' management profile (c. 1997). Review of historic outlying collection record of the species from Hornsby Shire as part of Hornsby Shire Threatened Biota Management Plan (record deemed to be a result of taxonomic changes not reflected in BioNet/Atlas at that time, subsequently reassigned) (1999). Contributed to the update of the 1996 Draft Recovery Plan. Research and/or successful nominations of allied *Persoonia* species (*acerosa*, *hirsuta*, *glaucescens*, *bargoensis*, *oxycoccoides*, *marginata*), under TSC Act and EPBC Act (1998-onwards). Some work commissioned by NPWS / DECCW / OEH. Plot-based monitoring of allied *P. acerosa* (Blue Mountains City Council for OEH) (2015 on-going). Numerous historic surveys in northwest and western Sydney including Hawkesbury, Blacktown, Liverpool and Penrith LGAs (1994-2000) as evidenced by BioNet and NSW Herbarium records. Particular attention paid to Castlereagh, Agnes Banks and Windsor Downs Nature Reserves and associated proposed extensions (1994-6). Project Manager, Urban Bushland Biodiversity Survey (Western Sydney), including surveys and reporting (1995-7).
s.6.5.2.3 (c)	Resumé detailing projects pertaining to the survey of the relevant entity	See Appendix 1. Relevant surveys and works listed above. Minor survey of predicted habitat at locality of Kemps Creek for DPE Expert Report. Meandering transect used.

s. 6.5.2.3 (d)	Employer's name and period of employment (if relevant)	Self-employed ecological consultant, 1996 to present (continuous other than for periods of study). Employed by OEH as contracted staff from November 2015 to July 2018 (Wingecarribee Shire vegetation map, South Coast Regional vegetation map, Review of mapping issues for TECs).
s.6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant entity	Consulted by OEH Authorised Officer regarding prospective surveys and review of conservation status for *Persoonia nutans* (2017). Consulted by OEH in major review of numerous threatened flora and communities as part of an update of BioBanking Tool (2006). Approved as a BAM species expert for *Persoonia nutans* by OEH in November 2018. Recruited by IUCN to assist in the Eastern Australia conservation status review of *Proteaceae* for the Red List publication of threatened species (February 2019)

2. Species information

2.1 Description

Persoonia nutans is "An erect to spreading shrub to 2.5 m high [rarely to 3.0 m] with hairy young branches. Leaves are well separated on mature stems, linear, 1 - 3 cm long, 1 - 1.8 mm wide, usually flat, with recurved margins. They are sparsely hairy when immature, and hairless when mature. Flowers are yellow, pendant to drooping on a stalk to 12 mm long… The species is similar to *P. bargoensis*, which is found in the [far] southern part of the Cumberland Plain and nearer the Southern Highlands" (OEH, 2017).

The plant is quite variable in height depending on the time since fire. In long unburnt habitat, it is a substantial but spindly shrub to 3 m high and ~ 2 m wide. More often, it is seen at ~ 1 m high and 0.5, 0. 75 m wide. Some variation in form is also likely as a result of different habitats e.g. how sandy, rocky or clayey the substrate.

2.2 Ecology

Emery & Offord (2018, Table 1) show that *P. nutans* has not been studied for breeding system, fruit set and/or seed germination. However, some information is available through earlier research. Flowering typically occurs from November to March (peak from December to January, NPWS, 2004), with sporadic flowering all year. Flowering is likely to be suppressed during drought, then intensified when drought breaks. The species is an obligate seed regenerator (NPWS, 1996; 2002a; 2004; DEC, 2005). Although listed as a short-lived species, much of the ecology is poorly known. Maturity is expected to be about 10 years. Plants appear to set abundant fruit. Seed is likely to be dispersed, after consumption of the fruit, by large birds such as currawongs and parrots, and large mammals such as wallabies, kangaroos and possums (OEH, 2017; DEC, 2005; Douglas, pers. obs.; McDougall, pers. comm., 2018; Weston, 2003, Auld et al., 2007, Barker & Vestjans, 1990). The introduced Honey Bee (*Apis mellifera*) may be a threat to the long-term viability of at least some *Persoonia* species because it is able to collect floral resources without pollinating the flower (Paton, 2000).

"Nothing is known of the longevity of the soil-stored seed bank of *P. nutans*. It appears germination is promoted, not only by fire, but also by physical disturbance (NPWS 1996; *sensu* Burcher *et al*., 2016). It is not known whether the seed bank is completely exhausted by a single fire. The extent to which germination occurs in the absence of disturbance is unknown, although observations during the 1996 survey (NPWS 1996) indicate such germination is likely to be rare" (DEC, 2005).

"Abundance at a site appears to be related to disturbance history. Sites with higher abundance also appear to be more disturbed" (OEH, 2017; *sensu* Burcher *et al*., 2016). However, too severe or too frequent disturbance would compromise or prevent one or more of germination, maturation, and reproduction, potentially resulting in local extinction. Too frequent fire has earlier been assessed as a significant threat to the species' viability (NPWS, 1996), and was consider the likely explanation for a low number of the species throughout much of the reserve (Burcher *et al*., 2016).

Similar to the Endangered *Persoonia hirsuta* mentioned by Emery & Offord (2018: 91), *P. nutans* can be found on disturbance margins such as edges of roads and trails, in former gravel (laterite) quarries, and in infrequently slashed perimeters of habitat, but is not restricted to them. Myerscough *et al*. (2000) suggest that soil disturbance may be a surrogate for the effects of fire, particularly in areas with low fire frequency. It also occurs in long-undisturbed habitat, but population demographics will be skewed to mature or senescent plants, as recruitment is strongly linked to fire or equivalent factors. Very long-unburnt sites will entail population decline as plants senesce and die, with recruitment being absent or minimal until suitable conditions return. Drought and subsequent return to average or above-average rain may have a similar, though likely weaker effect in this regard, as drought can suppress competing understorey species, with rains promoting recruitment in areas that have a reduced understorey cover.

Mature *Persoonia nutans*. © Ben Ford

2.3 Distribution and abundance

Persoonia nutans is restricted to western Sydney between Grose Wold in the northwest (apparently only 1 plant, collected twice); adjacent to the Georges River at Macquarie Fields in the south (Simmos Beach Reserve and environs); with the most easterly populations being near the Georges River at Pleasure Point, Voyager Point and East Hills (some in Council reserves), and at an industrial site in Villawood (very small and isolated). A naturally isolated, central population occurs at the locality of Kemps Creek, along with several other threatened plant species and ecological communities.

"The species has a disjunct distribution, with the majority of populations (and 99% of individuals) occurring in the north of the species range in the Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs areas. Core distribution occurs within the Penrith, and to a lesser extent, Hawkesbury local government areas, with isolated and relatively small populations also occurring in the Liverpool, Campbelltown, Bankstown and Blacktown local government areas" (OEH, 2017; DEC, 2005; NPWS, 2004). Most of the outlying populations occur in distinctly different habitat to the others. "This species is restricted to part of the Sydney metropolitan area and most remaining populations are threatened by development for housing and mining" (Weston & Johnson, 1991).

As part of DPE's obligations to assess the impact of proposed Growth Areas on threatened biota at State and Federal levels, I was commissioned by DPE to do a review of BioNet records for a subset of species deemed suitable for the modelling of potential habitat. This entailed addressing, where possible, a range of errors and inaccuracies. As part of this review, three records of *Persoonia nutans* were noted as being outside its accepted range. Two of these records plotted in the upper Cataract River catchment inland of the Illawarra Escarpment, west and southwest of Bulli, and were associated with upland swamps and at an elevation far higher than this species is known to occur. They were assessed as unlikely to be valid based on habitat, and they were unvouchered, meaning there was no specimen to support the identifications. They were determined to be a result of a data entry error (wrong species entered into the dataset). The third record was another unvouchered entry from incompatible habitat in Royal National Park, much further east than the species is known to occur. This record has since been invalidated, and likely relates to a common species that was misidentified or more likely, the wrong species code was entered into the dataset.

Persoonia nutans was probably never widespread across the Cumberland Plain, as it is largely confined to comparatively rare and localised Paleogene-Neogene age perched aeolian and alluvial sediments. In the north of its range, where the species can be locally abundant, these deposits are relatively extensive, though the aeolian deposits are much less so and have been extensively mined. Whereas in its central and southern habitats, the species occurs as relatively small and isolated populations because the associated deposits are far smaller in extent. Most of the outlying populations are associated with the quite different geology on the Wianamatta Shale / Hawkesbury Sandstone transition zone, usually near occurrences of Paleogene-Neogene alluvium. The Georges River (east) sites occur on a mix of Paleogene-Neogene alluvium and shale sandstone transition. The now extremely small Villawood population appears to be associated with an unmapped occurrence of Paleogene-Neogene alluvium based on descriptions of the associated vegetation. The Soil Landscape map shows that site as occurring on Wianamatta Shale, but the species is only associated with the edges of that geology where it adjoins Paleogene-Neogene alluvium or the Hawkesbury Group. Geology and Soil Landscape maps are produced at a coarse scale so are only ever indicative. Other ecological surveys in that vicinity have confirmed the presence of vegetation and geology indicative of Paleogene-Neogene alluvium (e.g. Ecological Surveys & Planning, 2013; Colin Gibson, pers. comm., 2018).

It is likely that the species' extent of occurrence prior to European settlement was broadly similar to its current extent, although there has very likely been some habitat removal in the north of the species' range due to mining (Agnes Banks area), rural and rural-residential land use (Londonderry area), and urbanisation (St Marys area). Habitat has been removed and degraded / fragmented in the central population due to clearing for schools, a sports field, rural and rural-residential uses, and some industrial uses. Habitat loss in the south is associated with industrial and housing activities, and potentially with military and infrastructural uses. The southernmost and much of the easternmost occurrences are partly within Council reserves but are threatened by the effects of adjacent urbanisation (*sensu* DEC, 2005; Douglas, pers. obs.). The isolated and tiny occurrence at Villawood is on an industrial site surrounded by long-established urban land use. It is conceivable that there were once other occurrences of the species between that location and the nearest populations near the Georges River to the south, but these were likely patchily distributed on small, unmapped occurrences of Paleogene-Neogene alluvium, and larger, mapped occurrences just to the west and southwest. There are no records of the species from those intermediate areas, but any associated populations could readily have been destroyed before any regard was given to the impacts of land uses on threatened flora.

Some habitat losses have been quantified in part by NPWS (2002b). Agnes Banks Woodland and Castlereagh Scribbly Gum Woodland are the vegetation communities that support the majority of *P. nutans*. These have been reduced to only 15.9% and 52.7% respectively of their pre-European settlement extent due mainly to mining and rural-residential land use. Assessment of more recent mapping by OEH (2013) indicates that these figures remain roughly correct. The mining of large areas that previously supported Agnes Banks Woodland would have resulted in the loss of considerable numbers of *P. nutans* (DEC, 2005).

NPWS (2002b) and DEC (2005) are now quite dated works, and more accurate vegetation maps now indicate that the PCT within the Threatened Ecological Communities with which the species is associated have been cleared as shown in Table 3 later in this Report. Data for the percentage of PCTs cleared is from the OEH BioNet Vegetation Classification Database (VCD, previously 'VIS') and relates to the extent of a PCT across its range, not just within the Cumberland Subregion. PCTs associated with *Persoonia nutans* are restricted to that area with the exception of 1081 and 1395 which extend to surrounding plateaux; and River-flat Eucalypt Forest, which extends along much of the coast and hinterland.

Known and inferred extinction of local populations are noted by DEC (2005). Further extinctions since 2005 are highly likely.

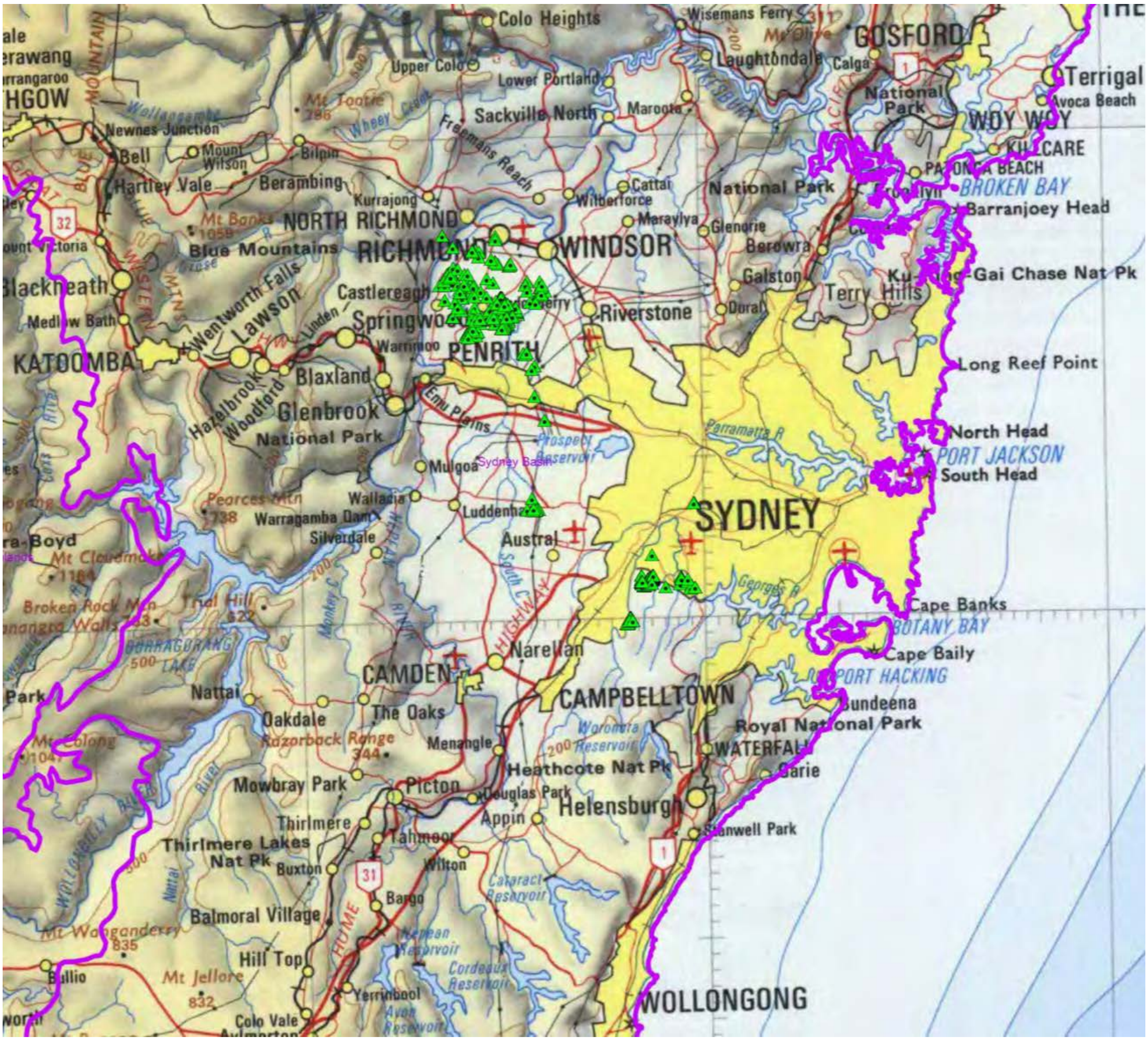
A small number of occurrences that are not documented in DEC (2005) are now known, including a substantial population just outside the far north of the GMGA at Moorebank. That area had been identified by DEC (2005) as potential habitat, but as it was then owned by the Department of Defence, it had not been surveyed. Most of that habitat is now set aside as a Biobanking reserve, but other parts of the site that included occurrences of *P. nutans* have been approved for clearing to accommodate an industrial facility. All of the Biobanking reserve was burnt severely in a suspected arson event in 2017. Whilst much of it was in need of fire to promote regeneration, the fire was extremely intense and extensive, and part of the habitat had been burnt only a few years earlier, meaning that some species would not have had time to regenerate and establish a new seed bank. The site remains at risk from too frequent fire as a result of it adjoining a main road, a railway, and suburban Wattle Grove, or conversely from too infrequent and/or too low intensity fire because of difficulties associated with fire management in such a compromised situation.

It seems likely that without significant intervention, the population at Villawood will not be viable in the long-term due to its isolation and very small population size, plus the nature of threats to what little remains of its habitat. Recent advice from botanists, Colin Gibson and Robert Miller (pers. comm., 2018), is that when the site was seen in 2014, only two plants remained – one healthy, one not, and two additional marked plants were dead – "nothing has been done to manage the site, which at that time, was in poor condition" – African Love Grass and Lantana are big problems. The associated and apparently contaminated ICI site was noted to "have been remediated [apparently in relation to chemical contamination] and bushland has been cleared."

The isolated Kemps Creek population occurs primarily on freehold tenure and is also apparently very small, though may prove to be larger were those habitats to be managed for conservation e.g. appropriately burnt then protected from weed invasion, feral animals, timber theft, and recreational damage. At present, the majority of habitat at this location is long unburnt, has an unnaturally dense regrowth tree layer, and is in slow decline. However, one young plant was recently observed north of the main habitat in an area disturbed by stocking with goats and then recent clearing for industrial land use. It occurs within a tiny linear remnant on that property's periphery and has some protection in the form of a s.88b covenant that sets aside this remnant to conserve threatened plant species and the threatened ecological community in which they occur. A Vegetation Management Plan was prescribed for that area as part of the development assessment, but the extent of threats from weeds and potential nutrient leachate from mulch stockpiled immediately adjoining the conservation area suggests that this Plan is not being implemented or is otherwise ineffective.

Across its range, the estimated area of potential habitat (i.e. suitable vegetation community and suitable soil type) for *P. nutans* is currently 5300 ha in the north of the species' range and 573 ha in the south of the species' range (DEC, 2005). "These values considerably overestimate the 'Area Of Occupancy' of *P. nutans* given that the species will not occupy all of these areas at a particular point in time, and some of this potential habitat may not be suitable habitat (e.g. may be subject to high fire frequency)" (DEC, 2005). These calculations also rely on the accuracy of regional-scale vegetation maps, which are themselves constrained by coarse scale geology and soil maps, inherently conferring a significant margin of error. There has also likely been considerable removal and degradation of habitat since 2005, both legal and illegal.

Persoonia nutans is an obligate seeder, and in the event of a fire, all affected *P. nutans* plants are killed and regeneration is dependent upon recruitment from a soil stored seed bank. *Persoonia nutans* populations are therefore relatively dynamic, particularly where fire is frequent. Fluctuations in space and time of above ground individuals is a natural occurrence. Consequently, the number of individuals and populations is difficult to estimate. Current information suggests there are 27 populations of *P. nutans* supporting greater than 5500 individuals in total. Only seven of these populations occur within conservation reserves, with the majority of populations occurring on private property and unoccupied Crown land" (DEC, 2005). Since 2005, further survey effort has documented some additional populations or at least extensions to known populations, and whilst an estimate of individuals is of relatively little merit because of the species' ecology, an updated estimate may be at least 50% greater than that given in DEC (2005).



Map 2. Cleaned BioNet occurrence data (extracted 26/11/18)

NB, each point may not designate a collection or observation at that location, as most very old records lacked any co-ordinates, or only supplied coarse co-ordinates, and may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

2.3.1 Reservation status

OEH has not published an updated estimate of *Persoonia nutans'* reservation status since that in DEC (2005). The work of Burcher *et al*. (2016) was not required to remedy this.

The species is known to occur in Castlereagh, Agnes Banks and Windsor Downs Nature Reserves, all in the north of its range (Table 2). More recently, it is known from the relatively new Wianamatta Nature Reserve and Wianamatta Regional Park. The security and even the boundaries of the latter reserve are unclear, as some official maps show it as an eastern and larger western portion, but one OEH map only shows the eastern portion. Reportedly, only the eastern portion is gazetted as reserve, and the western portions remain freehold. The currently proposed DPE urban footprint in the GPECGA shows a large transport corridor passing through the western portion, and this includes locations of two *P. nutans* records. Of the very few records of the species from that area, most are on or just outside the eastern portion's boundary.

The Kemps Creek population remains unreserved and is only known from freehold tenure and some Council-owned or managed land. It is not managed for conservation other than to a minor and fairly ineffective degree on Council land fringing a sports oval. It is partially and incidentally conserved on a freehold property on Clifton Avenue, which is ~1 km north of where the species was previously known in that locality. This currently occurs as a single young plant that was found in what is part of a small s.88b covenanted conservation area associated with an approved industrial land use. The species was not known from that site until found during fieldwork associated with the preparation of this Expert Report. The conservation area is very thin and vulnerable to edge effects, including weed invasion from that property and nearby. It was designated to conserve the threatened plant species, *Dillwynia tenuifolia* and *Pultenaea parviflora*, and the threatened ecological community in which they occur. It is now known to also contain the threatened plant, *Hibbertia puberula* ssp. *puberula* (dealt with in an Expert Report by Robert Miller), which had also not previously been detected on the site. The area is required to be managed in accordance with a Vegetation Management Plan prepared for the property, but the Plan did not appear to be adequately enacted when the site was visited in November 2018.

Part of the Moorebank population is now afforded some protection as a Biobanking offset site. The western records that formed a minority of the population at that site have now been destroyed, with most of the eastern records retained within the reserve. However, the reserved area was burnt in a very intense fire in 2017 during severe drought, and at this stage, the status of the *P. nutans* population there has not been documented. Part of the area had been burnt only 2-3 years prior to the fire, which could result in extinction of this species in the affected area. Conversely, other parts of the site may experience a large increase in numbers of *P. nutans* because fire will have removed over-mature and dense shrub growth and facilitated germination of seed bank.

Further information about other reserved populations of the species in Biobanking sites cannot be provided here because of confidentiality constraints governing that information.

OEH advised of another potential future reserve of this species in the north of its range where ~3000 individuals have been recently documented on land owned by the NSW Government and adjacent to Castlereagh Nature Reserve. Even if this area is conserved, the vast majority of the species' habitat and occurrences in the northern population remain unprotected and unmanaged on former Crown land in the Castlereagh/Londonderry area where threats are considerable e.g. recreational vehicle use, refuse dumping, arson and otherwise inappropriate fire regimes, weed invasion, timber theft, and feral animals. It is understood that an unresolved Native Title Act claim and competing land use intentions are factors in the former Crown land having uncertain status and an absence of protective management.

Counts of individuals are based on BioNet data plus Robert Miller's new records and information from DEC (2005). *Records with no value for the attribute, 'Number of Individuals' were assigned a count of 1. Most records that have population data are for a single plant, sometimes ranging to two or three plants and rarely to <10. Records in Agnes Banks NR were counted using GIS no allowance was made for records that may be within the Reserve but plot outside it due to minor spatial errors in GPS co-ordinates or inaccuracies in the actual Reserve boundary.

Table 2. Numbers of *P. nutans* within conservation reserves

Reserve	Records	Individuals*
Agnes Banks NR	582	825
Castlereagh NR	274	274 - 1500
Wianamatta NR	26	36
Wianamatta RP east portion	2	2
Wianamatta RP west portion	4	13
Windsor Downs NR	48	48 - 500

The species is not adequately reserved across its range. It is best reserved in the largest, northern occurrences where all of the NPWS reserves that contain it occur. These are vulnerable to arson, recreational misuse, and climate change. The central population at Kemps Creek is very much at risk. The southernmost population at Simmos Beach appears to be threatened by trail proliferation and a compromised fire regime due to it adjoining an urban area. It may also be at risk of inbreeding depression, as the population is small and relatively isolated.

2.4 Habitat

2.4.1 Geology and soil

Persoonia nutans occurs in a range of open forest and woodland communities on the Cumberland Plain and some of its margins. Most occurrences are associated with Paleogene-Neogene aeolian and alluvial sediments and the Castlereagh Forests and Woodlands group of vegetation communities, and with the Agnes Banks and Berkshire Park Soil Landscapes. However, the southernmost population at Simmos Beach is associated with the Wianamatta Shale/Hawkesbury Sandstone transition (incorrectly mapped as Blacktown Soil Landscape and edges of the alluvial South Creek Soil Landscape, but better mapped as Lucas Heights Soil Landscape, which is mapped nearby).

To the east, the composite site (likely a metapopulation) at Pleasure Point, Voyager Point and East Hills is variously mapped on the Berkshire Park and Lucas Heights Soil Landscapes.

The Villawood population is mapped on the Blacktown Soil Landscape (Wianamatta Shale) but apparently occurs on an unmapped occurrence of the Berkshire Park Soil Landscape.

The northwestern outlying population is mapped as occurring on the junction of the Luddenham (shale) and Gymea (sandstone) Soil Landscapes. Only one plant has been recorded there to-date on two occasions. At a finer scale, it could be mapped as a strip of Lucas Heights Soil Landscape between the shale and the sandstone lithologies.

The spatial accuracy of Soil Landscape and geology maps is coarse (often at best 1:100,000 scale) and is only useful for broad assessments. In many instances, the transition between Wianamatta Group and Hawkesbury Group-derived soils is not mapped because the transition zone is relatively small and can be difficult to define in coarse maps. Similarly, the boundary between the Paleogene-Neogene deposits and Wianamatta Shale can be complex and too difficult to map, even at a fine scale.

2.4.2. Associated vegetation communities and NSW TECs

Vegetation types associated with *P. nutans* include Castlereagh Scribbly Gum Woodland, Cooks River/Castlereagh Ironbark Forest, Shale Gravel Transition Forest, Castlereagh Swamp Woodland and/or Agnes Banks Woodland, and Shale Sandstone Transition Forest. The latter is only associated with one of the outlying populations, but two others occur in association allied communities. All of these vegetation types are Threatened Ecological Communities (TECs) ranging from Vulnerable to Critically Endangered.

The OEH Threatened Biodiversity Data Collection (July 2018) listed the following Keith Vegetation Classes as being associated with *P. nutans*:

- Coastal Valley Grassy Woodlands;
- Cumberland Dry Sclerophyll Forests; and
- Sydney Sand Flats Dry Sclerophyll Forests

The Threatened Biodiversity Data Collection indicates that *P. nutans* is potentially associated with 8 Plant Community Yypes (PCTs) across its range. Some of these are also associated with State and Commonwealth-listed Threatened Ecological Communities (TECs). Within the Growth Areas, relevant communities and NSW TECs, excluding apparent errors, are shown in Table 3. The associated PCTs are treated by OEH as *potential* habitat, and the species may not actually occur in all of those communities.

Associations between a species and Vegetation Classes and PCTs in the Threatened Species Data Collection were determined by the species' Accountable Officer within OEH some years ago, and staff were required to take a relatively inclusive approach in accordance with the precautionary principle (Steenbeeke, pers. comm.). This may mean that for some species, Vegetation Classes and PCTs have been associated with them even though there is little or no empirical evidence to support that, but where the officer believed that these attributes credibly represent *potential* habitat. Given the limitations of vegetation mapping and that in most cases, survey effort for threatened species is incomplete across their range, such an approach is understandable.

It appears that in some cases, the associations with Vegetation Class and PCTs in the Threatened Species Data Collection may have been amended after the assignments described above, and that some more recent associations may be influenced by spatial errors in species' records and/or errors in or limitations of vegetation maps. The apparent association between *Persoonia nutans* and Coastal Valley Grassy Woodlands is one example, and any association of this kind is weak when reviewed.

An assessment of the association between *P. nutans* and PCTs was undertaken to better understand the potential habitat for this species in terms of plant communities. The assessment is constrained by limitations of BioNet data and available vegetation maps. The assessment of the species' relationship with PCTs in and near the Cumberland Subregion used OEH vegetation maps that were publicly available at the time and did not use the updated vegetation maps produced within the Growth Areas by the biocertification process.

Some records of the species were seen to not be spatially associated with a PCT. This may be because:

- the record occurs in a site now cleared of native vegetation or too degraded to be captured by mapping;
- because the record is too spatially uncertain, so has been assigned generic co-ordinates, usually in a named town or suburb, and such settled areas often lack remnant native vegetation; and/or
- the record plots just outside an area of mapped vegetation because it is on a road verge, and even most GPS records are only accurate to 5m, meaning it could plot on the road, not on the vegetated verge.

To overcome this latter problem, those records were assigned a 10 m buffer so that they would associate with the nearest mapped vegetation polygon up to 10 m from the plotted location.

A further consideration is that survey effort for the species is not evenly distributed across the area subject to analysis. Some sites of potential habitat have had very little or no effort, often due to tenure constraints, yet others have had every apparent plant recorded (mostly in reserves or as part of ecological impact assessments). This creates very substantial biases in the data, which can create misleading weightings of association between the species and particular PCTs. Furthermore, most records do not include population data, such that a record might be for one plant or many. In short, this analysis is best used only for presence/absence i.e. whether the species has been recorded at a point that is mapped as a particular PCT, or not. Analysis beyond that is very constrained by deficiencies and biases in the datasets, especially in BioNet data.

The analysis of association with PCT in Table 3 deals only with records in the Cumberland Subregion plus a 10 km buffer. Records that associate with a PCT when a 10 m buffer is used are included in the counts of sightings below and are not shown separately. Two analyses were undertaken: All records in the target area without regard to spatial Accuracy score; and only records in that area with Accuracy score of 100 m or better. The latter analysis is considered more reliable, but both sets of figures are provided. Sightings with Accuracy <=100 m are shown in square brackets **[ ]** and in bold text. Where available, the combined count of individuals associated with the records is provided in parentheses { }. Those counts relate only to records with Accuracy <=100 m. Where a record doesn't contain population data, it is assumed to relate to a single plant.

Only PCTs mapped in the Growth Areas are dealt with in Table 3. Two PCTs mapped outside the Growth Areas: 958 (Agnes Banks Woodland) and 1067 (Castlereagh Swamp Woodland) were seen to be significantly associated with the species. Both are mapped north of the GPECGA by OEH. The updated vegetation map for this project did not identify either of these PCTs within any of the Growth Areas.

Some PCTs can appear to have a greater or lesser association than is actually the case. This is evident for this species in that an uncritical review of the raw data would associate this species with PCT 835*, which is a type of grassy riverflat forest on Quaternary alluvium that is not considered habitat for this species in any of the literature. In this case, there are very few records of the species associating with this PCT, and they are reasonably spatially accurate, but the vegetation map against which they have been assessed is inaccurate at that scale. The records plot in riverflat forest but the vegetation is most likely a unit with which the species is accepted to be associated - probably Shale Gravel Transition Forest.

Similarly, the apparently stronger association with PCT 849, a form of Cumberland Plain Woodland, is likely to be an artefact of spatial errors in the species' records and/or spatial or other inaccuracies of the vegetation map. The species is not accepted to occur in Cumberland Plain Woodland. The records that appear to be associated with that vegetation were more likely in Shale Gravel Transition Forest or Shale Sandstone Transition Forest, both of which can have a broad and indistinct ecotone with Cumberland Plain Woodland such that mapping of the boundary can be very difficult, even at quite a fine map scale.

Conversely, the species has a stronger, though still low and very tightly confined association with PCT 1081 than is indicated by the raw data in Table 3. The table shows that there are no records of the species with spatial accuracy of 100 m or better known from this PCT, and that there are only five records with lesser accuracy that are associated with this PCT. This is substantially an artefact of the fact that the native vegetation at the Simmos Beach population is assigned to PCTs 1787 and 1790 which are more prevalent on the Sydney Metropolitan vegetation map than the adjoining Cumberland Plain vegetation map. The latter is by far the most relevant to all of the Growth Areas. The OEH Threatened Species Data Collection report for *P. nutans* does not list PCTs 1787 or 1790 as being habitat for this species. However, availability of the associated vegetation map post-dates the last period in which OEH sought to ensure correlations between PCTs and threatened species were correct and current (Steenbeeke, pers. comm.).

Additionally, the two PCTs mapped at Simmos Beach Reserve are strongly allied with PCT 1081 (being confusingly described in the BioNet VCD as variously derived from or a parent unit of 1081), which occurs primarily on the Cumberland Plain map and is present in the Greater Macarthur and Wilton Growth Areas. Descriptions of vegetation at this site by Miller (pers. comm.), Steenbeeke (pers. comm.) and some of the observers of the species' BioNet records, along with the presence of PCT 1395 in close proximity, suggest that much of that habitat could be sensibly mapped as 1081.

On that basis, PCT 1081 goes from having no meaningful association with this species, to having a Low relative association based on the number of records with <=100m spatial accuracy and the number of plants recorded or assumed (one record = one plant unless other data provided) at the Simmos Beach site. Alternative figures for those parameters are provided as a second row for that PCT in Table 3.

PCT 1395 also shows no credible association with *P. nutans* in the raw data, irrespective of the spatial accuracy of the records. Yet there are records that describe the species as occurring in 'shale sandstone transition forest'. One such site is at East Hills Park, but the vegetation is mapped as a form of coastal shale sandstone transition forest that is quite distinctive from the PCTs that comprise the Shale Sandstone Transition Forest TEC (principally 1395). Assuming that the OEH vegetation map is correct, this site is not informative for the purposes of determining PCT associations with this species in the Growth Areas, as it does not occur in any of them. However, there are two other records (duplicate collections of the one plant) that also mention the species occurring in Shale Sandstone Transition Forest. Once moved to the correct location based on information from the first collector (Wotherspoon, 2002), they plot in credibly mapped PCT 1395, which is informative for this Report, as this community occurs in two of the Growth Areas. Whilst the relative association with 1395 is Very Low, and relates to a single outlying site, this PCT is included as potential habitat for the species within its accepted range, plus a precautionary buffer (south to Narellan Road). Alternative 'Sightings & Populations' figures for PCT 1395 are provided as a second row in Table 3[#].

2.4.2 Associated Commonwealth TECs

The Commonwealth Department of Environment & Energy (DEE) Species Profile and Threats Database website for *Persoonia nutans* shows that as of November 2018, the Department has not released an Approved Conservation Advice for this species. It relies on the joint NSW/Commonwealth Recovery Plan for this purpose, though that Plan is now quite dated (2005), and also references the NPWS (2004) EIA Guidelines and on-line profile (OEH, 2017) for this species. Consequently, there is not an official document that clearly shows which Commonwealth TEC are associated with *P. nutans*.

However, in this case, the NSW TECs with which the species is accepted to be associated are equivalent to or components of Commonwealth TECs.

2.4.3 Habitat condition

Degraded and significantly modified areas of the PCTs that are known or likely habitat for *P. nutans* can still support it due to its ability to persist in the soil seed bank. Modified sites may have reduced or no canopy and/or midstorey, and/or reduced understorey and some weed invasion. Some may be dominated by shrubs in areas of regrowth after earlier clearing or 'under-scrubbing'.

This species is known to occur in highly modified sites such as slashed bushfire Asset Protection Zones, and road and trail verges, and in former small-scale quarries (DEC, 2005, Burcher *et al*., 2016). Some forms of disturbance, even relatively severe forms that would be considered clearing of vegetation, appear to be beneficial to this species, within limits. This situation is recognised for numerous threatened plant species in and beyond the Sydney Basin Bioregion. It may be related to the fact that modern fire regimes are likely to be significantly different to those prior to 1788, and that some native animal species that had a role in seed dispersal and understorey modification are now extinct.

The condition of potential habitat for this species is not, in itself, a reliable indicator of the species' presence, and accordingly, **all condition states except derived grassland are considered in determining potential habitat** i.e. intact, thinned, scattered, and derived shrubland. Derived grassland is not included, as in large part, PCTs that are known habitat for *P. nutans* are not subject to pastoralism, so have generally not been cleared of trees to support grazing. However, the species can survive grazing depending on the livestock type and stocking rate, and because it can survive as seedbank. Sites with long and intensive grazing history will be unlikely to retain the species in any form, especially given that fertiliser is likely to be used to promote and maintain fodder cover on the low fertility soils that this species prefers. Fertiliser use alone could suppress or eliminate this species. Only sites with relatively recent grazing history or very low stocking rates may retain the species as plants and/or seed.

Table 3. BioNet records of *P. nutans* and counts of individuals relative to mapped PCTs

PCT	PCT Name	Associated TECs (NSW BC Act)	% Cleared (VCD)	Sightings & Population	Relative association	Adjusted relative association#
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Shale Gravel Transition Forest (E)	75	71 **[64]** {101}	Moderate	Moderate
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Cooks River/Castlereagh Ironbark Forest (E)	95	51 **[43]** {61}	Moderate	Moderate
808	Derived shrubland on Tertiary Gravels of the Cumberland Plain	Shale Gravel Transition Forest (E) Cooks River/Castlereagh Ironbark Forest (E)	75-95 inferred from 724/725	Not mapped, no empirical data	Moderate (inferred)	Moderate (inferred)
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	River-flat Eucalypt Forest of Coastal Floodplain (E)	93	8 **[4]** {4}	Very Low	Nil
849	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CE)	93	34 **[13]** {15}	Low	Nil
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland (V) Castlereagh Swamp Woodland (E)	50	670 **[641]** {3626}	Very High	Very High
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Not a TEC but some areas may be within Shale Sandstone Transition Forest (CE)	40	5 **[0]** {0} 37 **[27]** {34}*	Nil	Low – one atypical occurrence
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (CE)	80	5 **[0]** {0} 5 **[2]** {2}#	Nil	Very Low – one atypical occurrence

3. Description of the study area

3.1 Landscape context and land use history

All of the Growth Areas have been significantly cleared for earlier activities, primarily timber production associated with opening areas for agriculture and pastoralism, minor areas of surface resource mining, and to varying degrees, for urban and commercial/industrial use. They are proposed to accommodate phased increases in urban land use, primarily within existing cleared or highly modified lands. Increased urban use is planned as a response to population growth.

3.1.1. Greater Macarthur Growth Area (GMGA)

The GMGA extends from Glenfield in the north to Appin in the south. It is largely within the Campbelltown LGA with the southernmost section within the Wollondilly LGA. The northern half comprises an urban renewal corridor centred on the Sydney to Southern Highlands railway line. It encompasses the existing industrial and residential suburbs of Glenfield, Macquarie Fields, Minto, Leumeah and Campbelltown. The GMGA is associated with extensively cleared, gently undulating shale terrain typical of the Cumberland Plain, and contrasts the sandstone gorges of the Woronora Plateaus across the Georges River to the east. The northern portion of the GMGA is already substantially urbanised, with remnant vegetation largely restricted to creek-lines or small patches associated with designated open space. Vegetated creek-lines include Bunbury Curran Creek, Bow Bowing Creek, Leumeah Creek, Fishers Ghost Creek and Spring Creek.

The more extensive southern half of the GMGA, south of Rosemeadow, comprises proposed urban land releases at Menangle Park, Mount Gilead and Appin. Menangle Park and Mount Gilead are subject to separate planning processes, so are not within the scope of this biocertification. In the north-west, Mount Sugarloaf (213 m AHD) forms the southern end of a hilly ridge on the Luddenham Soil Landscape above the Menangle floodplain that extends north to Denham Court, then to Cecil Hills and Prospect Hill. Some native vegetation persists, although it is often invaded by African Olive. The floodplain is dissected by Menangle Creek and its tributaries, including Nepean Creek, Woodhouse Creek and Leafs Gully.

The southern GMGA is primarily semi-rural and agricultural land, with creek corridors and some larger patches of remnant vegetation located between the Nepean and Georges Rivers. Geologically, the area comprises gently undulating hills on Wianamatta Shale intergrading via a shale sandstone transitional zone (can include the Mittagong Formation) with steeper and infertile terrain on Hawkesbury Sandstone along the rivers. Transitional and sandstone geologies are sometimes exposed along the smaller creek lines.

3.1.2. Wilton Growth Area (WGA)

The WGA is a relatively smaller area that occurs to the south of the GMGA, extending from the vicinity of Douglas Park in the north, Maldon in the north-west, and beyond Wilton in the southeast. The boundaries closely follow the Nepean River in the north and west, a tributary Allens Creek in the east, and the Cordeaux River in the south. Away from the Nepean River and gullies, a higher, gently undulating zone has been largely cleared for agriculture. The Woronora Plateau forms the southern boundary and includes the northernmost section of the large Upper Nepean State Conservation Area, with unreserved but closed areas of the Water NSW Special Area (Sydney water supply catchment) extending to the east and southeast. The Hume Motorway dissects the WGA roughly north to south, and Picton Road traverses it roughly northwest to southeast.

The WGA includes both shale, shale sandstone transition and sandstone environments. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The flatter shale terrain has soils of the Blacktown Soil Landscape, which is derived from Ashfield Shale (a member of the Wianamatta Group), and typically supported the now Critically Endangered Cumberland Plain Woodlands. Much of this area is cleared or modified for agriculture and hobby farms. It comprises native/exotic grassland with smaller areas of Derived Native Grasslands in relatively better condition. Areas above the gullies feature soils of the Lucas Heights Soil Landscape derived from the Mittagong Formation (a transitional bed between the Wianamatta and Hawkesbury Groups). These support variable shale sandstone transition woodlands and forest, some of which are also Critically Endangered. In the steeper gullies, the Hawkesbury Soil Landscape dominates, and supports Hawkesbury Sandstone Gully Forest types with Ridgetop Woodlands on some of the upper slopes.

3.1.3. Greater Penrith to Eastern Creek Growth Area (GPECGA)

The GPECGA is a relatively large area that extends from Rooty Hill, Minchinbury and Hassell Grove in the east, across the Cumberland Plain to the Hawkesbury-Nepean River in the northwest, then south through Jamisontown, Glenmore Park, to the intersection between The Northern Road and the Warragamba Water Supply Pipelines in the far south-west.

The predominant geology is Wianamatta Shale on flat to gently undulating terrain that has been extensively cleared for agriculture, and later for housing and industrial use, with some remnant vegetation on current and former Defence holdings. The shale soils support(ed) Cumberland Plain Woodlands. Overlying the extensive shale deposits are small areas of weathered Paleogene-Neogene alluvium e.g. Shalvey and Willmot, that are much more common to the north. These support(ed) the Castlereagh Forests & Woodlands complex of vegetation types, which is strongly associated with several threatened plant species. More common are broadly linear deposits of Quaternary alluvium along watercourses such as South Creek and Eastern Creek, and on the flood terraces of the Hawkesbury-Nepean River. Other lithologies occur but are very rare and of very small extent.

Very little of the GPECGA is reserved in NPWS estate. Wianamatta Regional Park (which emphasises recreational uses) encloses small areas of former Defence land in the far north. Adjacent to the southwestern boundary is the small Mulgoa Nature Reserve (emphasises biodiversity values). Two Biobanking sites adjacent to the Nature Reserve have increased the area under conservation.

3.1.4. Western Sydney Aerotropolis Growth Area (WSAGA)

The WSAGA abuts the GPECGA's southernmost border near the locality of Sovereign (east of Mulgoa), then extends south past Greendale, northeast to the locality of Badgerys Creek, east to Kemps Creek, and northward to the vicinity of Mount Vernon, excluding Twin Creeks Golf Course and associated settlement.

The lithology and soils are broadly similar to that of the GPECGA, being effectively just an extension of that area to the south to incorporate the developing Badgerys Creek Airport and environs. The area is even more severely cleared of native vegetation, except along some streams and on rare occurrences of steeper terrain. It contains no NPWS reserves, with the nearest being the small Kemps Creek Nature Reserve, outside the Area to the southeast. Gulguer Nature Reserve and Bents Basin State Conservation Area occur to the southwest of Greendale.

3.2 Geology and remnant vegetation

The dominant lithology across all of the Growth Areas is Wianamatta Shale (Ashfield and Bringelly Shales), with much smaller areas of Paleogene-Neogene alluvium occurring largely outside these boundaries, and much larger areas of Quaternary alluvium associated with floodplains of the many watercourses.

The terrain varies from almost flat through to steeply hilly areas associated with minor volcanism and more often, in association with shale ranges. In the far south, the more elevated shale landscapes have been eroded down to the underlying Hawkesbury Sandstone in a series of gullies and gorges. A transition zone between the shale and the sandstone is discernible in some areas.

On the dominant shale geology, the associated Critically Endangered Cumberland Plain Woodlands are still present in all of the four Growth Areas but have been disproportionately cleared for rural and later urban and allied uses. Much of what remains of this ecological community occurs as paddock trees and areas of remnant native ground-layer vegetation in pastoral and other contexts, with the exception of some substantial, though fragmented and isolated remnants. Remnant vegetation in these relatively fertile and arable landscapes is often in poor condition. In the most heavily cleared areas, it can be restricted to strips along watercourses. Some forms are dominated by *Casuarina* species. Weeds are common and sometimes severe in the moister situations. Weeds often extend into higher and drier terrain, especially in the form of African Olive and African Love Grass, both of which can occur on a landscape scale.

Small areas of the biodiverse Castlereagh Forests and Woodlands persist in all but the Wilton Growth Area on often-laterised Paleogene-Neogene alluvium. These variable woodlands and open forests support a particularly high number of threatened plant species, and because their soils are less suitable for agriculture and grazing, are better conserved than the Cumberland Plain Woodlands. Nonetheless, they are all listed as threatened ecological communities.

In the two southern Growth Areas, vegetation of the shale sandstone transition zone is relatively common and tends to remain in less arable areas adjoining the largely cleared former Cumberland Plain Woodlands. It is often found fringing the largely uncleared sandstone-based terrain, and ranges from highly intact to significantly modified and degraded, largely due to grazing and weed invasion. The associated Shale Sandstone Transition Forest is recognised as Critically Endangered due to extensive clearing across its substantial range, and because of the severity of other threats. Very little is present in formal conservation areas.

In the two southern Growth Areas, diverse, sandstone-based vegetation persists in association with most of the many incised watercourses. This vegetation is broadly the same as what occurs in extensive conservation estate around urban Sydney, but some communities adjoining current or former Shale Sandstone Transition Forest are not well-conserved and are threatened by further clearing and degradation.

3.2.1 Plant Community Types

The following section lists the Plant Community Types mapped in each Growth Area with brief notes about their distribution in those Areas. The list is not restricted to PCTs associated with *P. nutans*. Biobanking reserves are not dealt with fully here due to confidentiality constraints relating to their location and attributes.

3.2.1.1 Greater Macarthur Growth Area (GMGA)

The predominant ecological communities in the GMGA are or were Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), all of which are Threatened Ecological Communities. All have been extensively cleared and degraded, primarily by agriculture and weed invasion, but also by urban and allied uses. There are no NPWS reserves in this Growth Area. However, the very small Leacock, Edmondson and William Howe Regional Parks occur just outside the border and are managed primarily for recreation rather than conservation. Dharawal State Conservation Area and National Park border the southern portion of the Growth Area to the east.

A summary of the mapped ecological communities is found in Table 4. The maps used here are based on OEH products that have been updated by Biosis for DPE.

Table 4. Summary of all ecological communities within the Greater Macarthur Growth Area

PCT	PCT Name	Distribution & notes
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Small patch at Menangle Sugarloaf on SE slopes.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Along creek lines in shale areas in northern and central parts of GMGA.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Small patches on shale soils throughout GMGA but mostly in northern and central parts.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches on shale soils throughout GMGA, more common in southern parts on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	4 polygons, Macquarie Fields, most of which have long been historically mown (Milton Park Softball Complex). They are now subject to regeneration.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	One small occurrence mapped around the margins of bushland associated with Smiths Creek at Leumeah.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Nepean River north from Menangle Bridge.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Narrow zone along Nepean & Georges Rivers and tributary gullies and a small zone along Smiths Creek at Leumeah.
1292	Water Gum - Coachwood riparian scrub along sandstone streams, Sydney Basin Bioregion	Restricted to parts of the riparian zones of the more incised and larger watercourses. Very restricted extent in this Area.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Relatively small remnants extend from Glenfield into the far south where it is extensive on transitional soils mostly south from Rosemeadow. Can intergrade with 849 and 1081.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Only mapped to a very minor extent as highly linear remnants between Glenfield and Macquarie Fields (along the railway) and at Ingleburn (adjoining roads).

3.2.1.2 Wilton Growth Area (WGA)

The predominant ecological communities in the WGA are or were Cumberland Plain Woodland (CPW) and Shale Sandstone Transition Forest (SSTF) both of which are Threatened Ecological Communities. Sandstone-based communities occur in and surrounding the more incised watercourses. There are no NPWS reserves in this Growth Area, though Upper Nepean State Conservation Area occurs immediately to the south. There is a Biobanking site on the northern side of the river near Douglas Park (within the WGA), and three more such properties to the immediate north (including St Marys Towers) and those associated with coal mines (Steenbeeke, pers. comm.).

Table 5. Summary of all ecological communities within the Wilton Growth Area

PCT	PCT Name	Distribution & notes
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	On shale soils of higher, gently undulating terrain of northern and central areas. Small patches with scattered trees (farming properties) adjoining more extensive exotic and native grasslands.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	One patch in a derived grassland (treeless) condition in the west, and a much larger portion in the far north.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Limited to a few patches in the north between 1395 on plateau edges and 1181 in sandstone gullies.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Common on slopes and plateau edges above and around incised sandstone-based watercourses that surround most of the Area.
1292	Water Gum – Coachwood riparian scrub along sandstone streams	Restricted to a very narrow riparian strip along the Nepean River.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	The most extensive community on shale sandstone transition soils between 849/850 and sandstone communities along gullies. Variable floristics.

3.2.1.3 Greater Penrith to Eastern Creek Growth Area (GPECGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Shale Gravel Transition Forest and Castlereagh Forests & Woodlands. River-flat Eucalypt Forest was previously much more extensive along the Hawkesbury-Nepean River and adjoining primary floodplain, and it remains to varying degrees along many watercourses such as Eastern Creek, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. There is one NPWS reserve in this Growth Area: Wianamatta Regional Park, however it is already significantly fragmented and may be required to potentially accommodate a large transport corridor. The small Mulgoa Nature Reserve and associated Biobanking sites occur near the south-western border of this Growth Area. Yarramundi SCA occurs on the western boundary but across the Nepean River, and Wianamatta NR occurs near the NW corner.

Table 6. Summary of all ecological communities within the GPECGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Scattered as small remnants and one larger remnant in the central portion, but with greater extent in the central north, mainly in the western ungazetted portion of Wianamatta Regional Park.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	A few very small remnants present south of the M4, with larger remnants within and near the gazetted and ungazetted portions of Wianamatta Regional Park.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northwest, with some small remnants in the southwest, often associated with watercourses.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Present to a very minor extent on the southwestern edge adjoining Mulgoa Nature Reserve
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains through the south and central areas.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Common in and near Orchard Hills in the south, and former ADI lands in the central north, with some areas in the ungazetted portion of Wianamatta Regional Park. Other scattered remnants, particularly in the east.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Very small patches in the south west, primarily in pastoral settings and on steeper terrain.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Restricted to one linear polygon in the eastern portion of Wianamatta Regional Park.
1105	River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion	Only mapped along the Hawkesbury-Nepean River, primarily near Penrith Lakes.
1800	Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley	Present as mostly-linear remnants along South Creek and Eastern Creek and tributaries, with some scattered occurrences, including along the M4.

3.2.1.4 Western Sydney Aerotropolis Growth Area (WSAGA)

The native vegetation of this Growth Area has been extensively cleared, with what remains classified as Threatened Ecological Communities. The majority of the Area formerly supported Cumberland Plain Woodlands, with a much smaller area supporting Castlereagh Forests & Woodlands near the localities of Kemps and Badgerys Creeks, and potentially in the vicinity of the water pipeline crossing of Luddenham Road. Riverflat Eucalypt Forest remains to varying degrees along most watercourses, though frequently in poor condition, due largely to extensive weed invasion and a long interface with unsympathetic land uses. Swamp Oak Forest occurs mainly along South Creek and some tributaries. There are currently no NPWS reserves in this Growth Area. The small Kemps Creek Nature Reserve occurs just outside the south-eastern corner and Gulguer Nature Reserve and Bents Basin State Conservation Area are near the south-western corner.

Table 7. Summary of all ecological communities within the WSAGA

PCT	PCT Name	Distribution & notes
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Restricted to the Kemps and Badgerys Creek area as three patches of remnants.
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	As above: two patches with smaller remnants nearby and on slightly higher ground than 724.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion	Very limited extent, primarily in the far northeast, with one remnant in the centre.
835	Forest Red Gum – Rough- barked Apple grassy woodland on alluvial flats of the Cumberland Plain	Common along creek lines and associated floodplains but very little remains, and most occurrences are linear.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	The most common PCT in this Area, with remnants throughout on the dominant shale terrain.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Only very small patches in the far south.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain and Hunter valley	Present as mainly very linear remnants along most watercourses but largely absent from the southernmost portion.

4. Assessment of species' presence and suitable habitat

4.1 Existing records and surveys

The principle source of threatened flora records in NSW is the OEH BioNet database, which includes most records held by the NSW Herbarium (specimen-based), as well as sightings, including those associated with vegetation sampling for the purposes of mapping. Other databases, such as Atlas of Living Australia, largely mirror BioNet data within NSW, but are not used in this Report due to their having lower data quality control, and because they do not allow even a registered user to access data that may not have been generalised to obscure the exact location of a record. Very few flora records that are in ALA but not in BioNet are original – most are simply replicate records based on specimens held in other herbaria.

The preliminary assessment of threatened species records undertaken for the preparation of this Expert Report reiterated the merit of reviewing BioNet data and resolving a range of errors, rather than simply using data 'as held'. *Persoonia nutans* records within BioNet were reviewed, and numerous corrections were made, though the majority of these relate to the assigned spatial accuracy scores and to clarifying or correcting location placements and descriptions. Not all records were able to be checked in that stage, and a second review for records in or near the Growth Areas was conducted to further improve data quality. The reviews eliminated a range of errors and allowed many records that were otherwise too spatially vague, to be refined such that they were suitable for habitat modelling and for general reference. Not all records were reviewed, and inaccuracies remain in the dataset, but records within the Cumberland Subregion are now far more accurate in terms of their identification of the species, their location, and their spatial accuracy score.

BioNet data should only be treated as indicative, not least because there has not been comprehensive survey of all of the Growth Areas or environs, and surveys have been variously constrained. The absence of records from an area does not necessarily mean the species is absent, as it may not have been surveyed there, or survey conditions and methods may have been inadequate.

Field survey undertaken by consultancy firms engaged by DPE (Biosis and Ecoplanning) did not add any records of this species. Fellow botanist, Robert Miller and I undertook very limited survey in the Kemps Creek locality. Robert detected, and I recorded, one juvenile *Persoonia nutans* at a site on which it had not been previously recorded in two earlier consultancy assessments on behalf of the land owner and in a more recent vegetation mapping survey for DPE. The plant was likely not present during the earlier consultancy assessments, as it is clearly a young specimen that likely arose after threatening processes were removed from that habitat relatively recently. I believe that had I been given access to more freehold land in that area, I would have been able to record additional occurrences of this species. DPE made considerable and repeated efforts to obtain such access, but with very little success. However, all areas of known or potential habitat for *P. nutans* in that locality have been excluded from the proposed urban footprint / biocertified area.

4.1.1 Existing records by Growth Area

Persoonia nutans records in Greater Macarthur Growth Area

There are no records of the species from the GMGA, but there are several records associated with a population to the east at Simmos Beach on the edge of Macquarie Fields. There are a large number of records further to the northeast on an approved industrial development site on former Defence Department land at Moorebank, part of which is now within a Biobanking offset reserve.

Persoonia nutans records in Wilton Growth Area

The species has been never been recorded within the WGA. This is credible on the basis that this Area occurs at higher elevation and further south than the species is known to occur, and only one of the PCTs with which it is associated is present in this Area. That PCT, 1395, is only known to be habitat for this species at the edges of its distribution, and this Area is substantially beyond that distribution. Weston & Johnson (1991) indicate that *P. nutans*, which has a southern limit at Simmos Beach Reserve, is replaced by the allied and highly range-restricted *P. bargoensis* in the Wollondilly region in which the WGA occurs.

Persoonia nutans records in Greater Penrith to Eastern Creek Growth Area

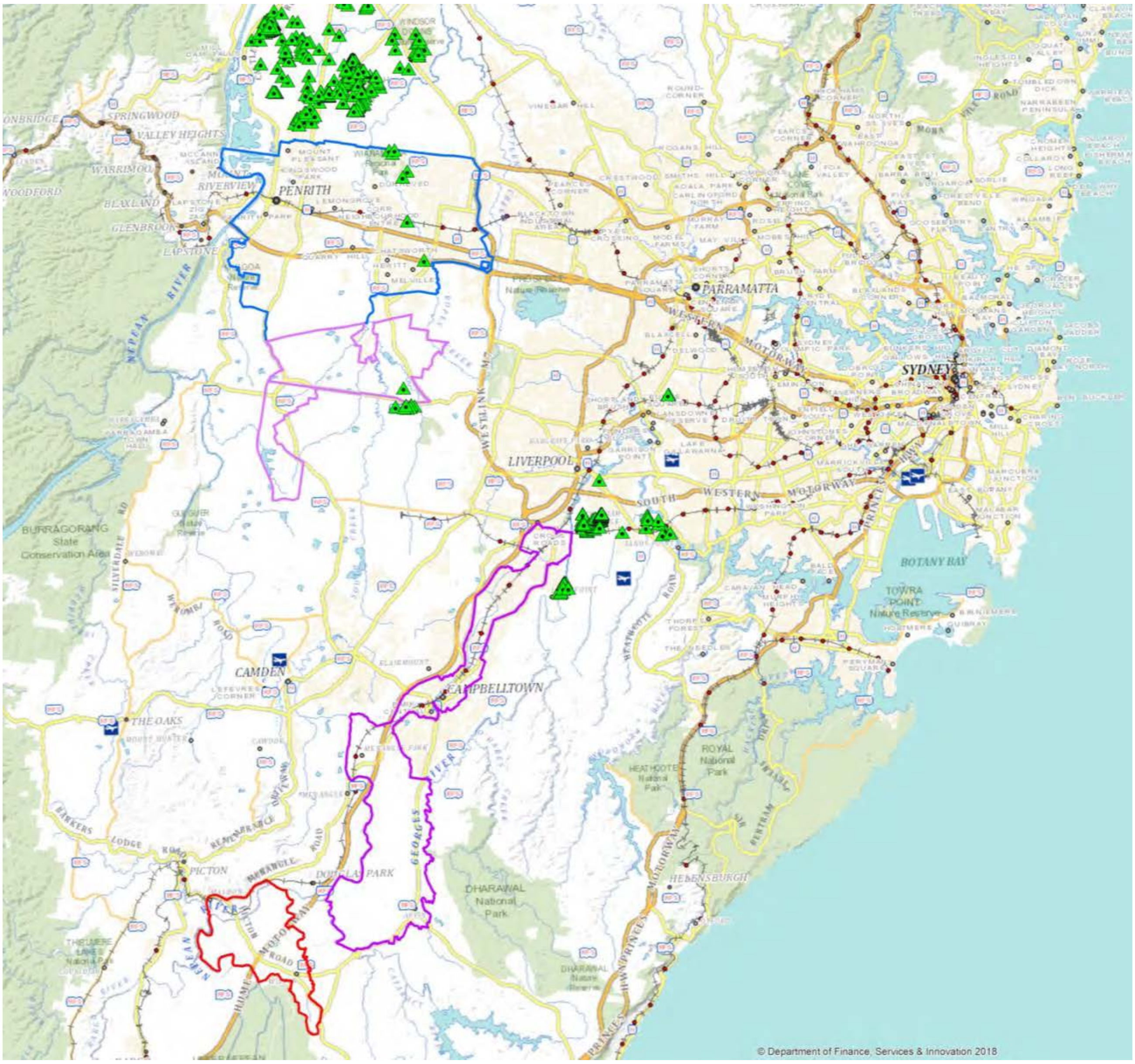
The species is known from this Growth Area in the form of both vaguely located historic records and spatially accurate recent records. Recent records occur in the central north of the Area in and near the eastern extent of the former ADI lands that are now partially urbanised and partially reserved (e.g. Wianamatta Regional Park). In the central section of this Growth Area, the very few records that exist are old or very old, and if they have any locational information, this only refers to "St Marys" or "east of St Marys", so are arbitrarily located. As part of the review of BioNet records, these were further consolidated and moved to a small strip of remnant vegetation where seedbank may remain. There are no records from the vicinity of St Marys since 1955, and the area is now extensively urbanised.

In the southeast of this Area, a single, modern record exists in a tiny patch of remnant bushland along the M4 Motorway, with records of the threatened *Acacia pubescens* nearby.

There was always relatively little habitat for this species in this Area, and even less remains today. Most of the remaining mapped potential habitat in this Area is restricted to the gazetted and proposed portions of Wianamatta Regional Park.

Persoonia nutans records in Western Sydney Aerotropolis Growth Area

There are several records of the species just outside the south east corner of this Growth Area in the locality of Kemps Creek. They are a mix of relatively old, spatially vague records; and modern, more spatially reliable records. All are associated with an isolated remnant of Paleogene-Neogene alluvium. The one record within this Growth Area was added during surveys to support this Report, and it occurs approximately 1 km north of the earlier records. Equivalent habitat remains between these records but has been progressively degraded and removed in recent years. Much of what little habitat remains is threatened by a range of legal and illegal land uses, and the fact that this species can be present in seed bank on long-unburnt sites but is too often disregarded if it is not detected during ecological assessments.



Map 3. BioNet records (cleaned as of 26/11/18) relative to Growth Areas

Each point on Map 3 may not designate a collection or observation at that location, as most very old records lacked any co-ordinates, or only supplied coarse co-ordinates, and may only have mentioned a town or locality. Such records will generally have a relatively poor Accuracy score (10-25 km) to indicate that the actual location of the species could be within a considerable distance of the designated point. Many such records are assigned the same indicative co-ordinates such that one point on a map may relate to several old records that were supplied with very little locational information.

4.1.2 Prior surveys within each Growth Area

There is no central or local registry of surveys and survey effort for threatened biota, and a large proportion of survey reports are not made public or only made public when lodged with a planning consent authority. This makes it extremely difficult, if not impossible to compile a list of surveys, methods and findings across the study area.

The OEH Authorised Officer for *P. nutans* was contacted in this regard. He advised that he does not hold a record of this information but did note some relevant results of a recent survey on public land (records now in BioNet) and referred me to the manager of threatened biota matters in the Greater Sydney OEH office for further assistance. She committed to providing the relevant information by consulting key staff. I was included in the associated emails. No additional information about this species was provided.

I separately became aware of some earlier surveys of threatened flora that OEH had commissioned for areas of NPWS estate near the GPECGA. With approval from the NPWS, the lead ecologist who undertook those surveys provided information about his work, which entailed targeted searches for *P. nutans* and the provision of a very brief report. The associated records were confirmed to have been lodged in BioNet.

Whilst seeking to obtain access to properties for fieldwork, DPE located and provided three ecological assessments relating to project proposals in the locality of Kemps Creek, north of Elizabeth Drive, within the WSAGA. These revealed that two consultants involved at one site has misidentified the PCT and TEC being assessed and had not detected all relevant threatened plant species. Those assessments did not find *P. nutans* on the site, but it was later detected during fieldwork for this Report. The third assessment relates to an adjoining development project that also reported that no threatened flora species were present. Part of that site was observed through a wire fence during fieldwork for this Report, and was seen to support a threatened *Hibbertia* species, with a very high likelihood that several other threatened plant species are present.

4.2 Summary of survey work undertaken for the biocertification assessment

4.2.1 Vegetation mapping

Vegetation mapping of the Cumberland Subregion was completed in stages by OEH in 2013 and 2016. These two vegetation layers have been used as the base to compile an updated vegetation community layer for each of the Growth Areas. This updated work has been completed by Biosis under contract to DPE. The mapping update includes checking plant community types and confirming the accuracy of boundaries to account for clearing or regrowth that may have occurred since the original mapping was completed. Field verification of the mapping was undertaken by Biosis and Ecoplanning, both of whom undertook vegetation surveys where access was permitted.

Vegetation in the Growth Areas was mapped and assessed based on five vegetation condition classes:

- Intact;
- Non-offsettable Grassland;
- Offsettable Grassland;
- Scattered Trees;
- Thinned.

4.2.2 Field survey effort

The information in section 4.2.2 has been provided by DPE but has been edited here to only deal with threatened flora where feasible. Further details are provided separately by DPE:

An initial 726 letters were sent to landholders within the Wilton and Greater Macarthur Growth Areas in late 2017 with a second letter following in March 2018. To increase the response rate, Biosis commenced targeted door-knocking in May 2018. From this, just under 20% of landholders within these Growth Areas allowed access to their property. However, this included access to large parcels of land owned by major developers, which allowed a reasonable amount of access, particularly for the Wilton Growth Area.

Floristic plot data collected:

- Wilton (86 plots across 6 PCTs)
- Greater Macarthur (82 plots across 9 PCTs)

Approximately 150 of the plots required to meet BAM requirements were obtained by supplementing Biometric plots from various recent assessments. This involved locating the previous plots and collecting additional data on stem classes, number of large trees, and litter cover to meet BAM requirements. The ecologists had no trouble locating the original survey sites and found that the additional data was quick and easy to collect (approximately 30 minutes per site).

The remaining plots in Wilton and Greater Macarthur, and all of the plots in Western Sydney Aerotropolis and Greater Penrith to Eastern Creek consisted of new plots surveyed for this project. All plots were sampled according to the methods prescribed by the BAM Manual (OEH 2017). This includes collecting information on species cover and abundance from 20 x 20 m or equivalent configuration plots within each vegetation zone.

A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Growth Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council.

Floristic plot data collected:

- Western Sydney Aerotropolis (53 plots across 6 PCTs)
- Greater Penrith to Eastern Creek (26 plots across 7 PCTs)

Targeted survey for threatened species

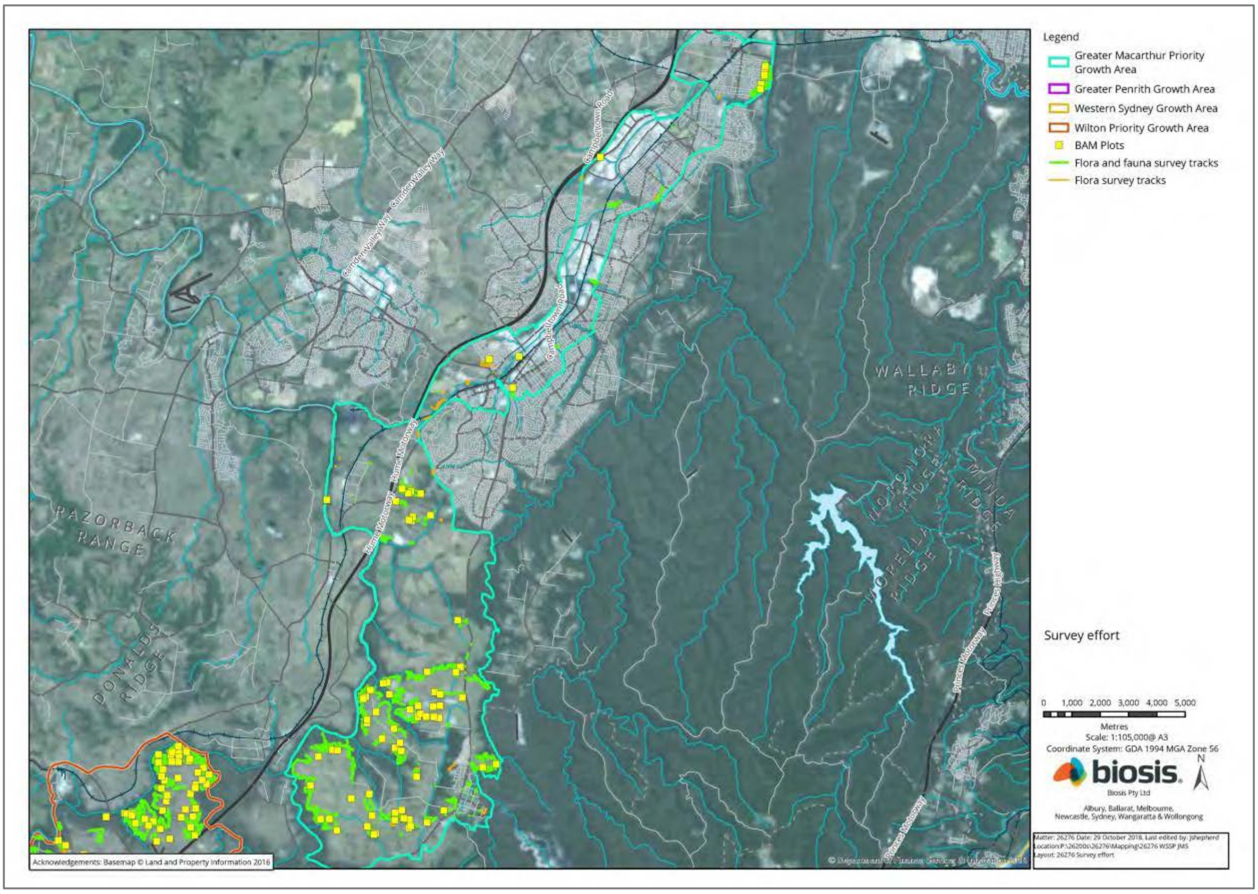
Targeted survey for threatened plant species has been conducted on lands where access has been granted. Vegetation transects and random meanders for threatened flora was conducted by Ecoplanning and Biosis in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey has included effort through each PCT and vegetation zone and has extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m).

Likely habitat for most threatened flora species comprised areas of lower disturbance. This includes areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora.

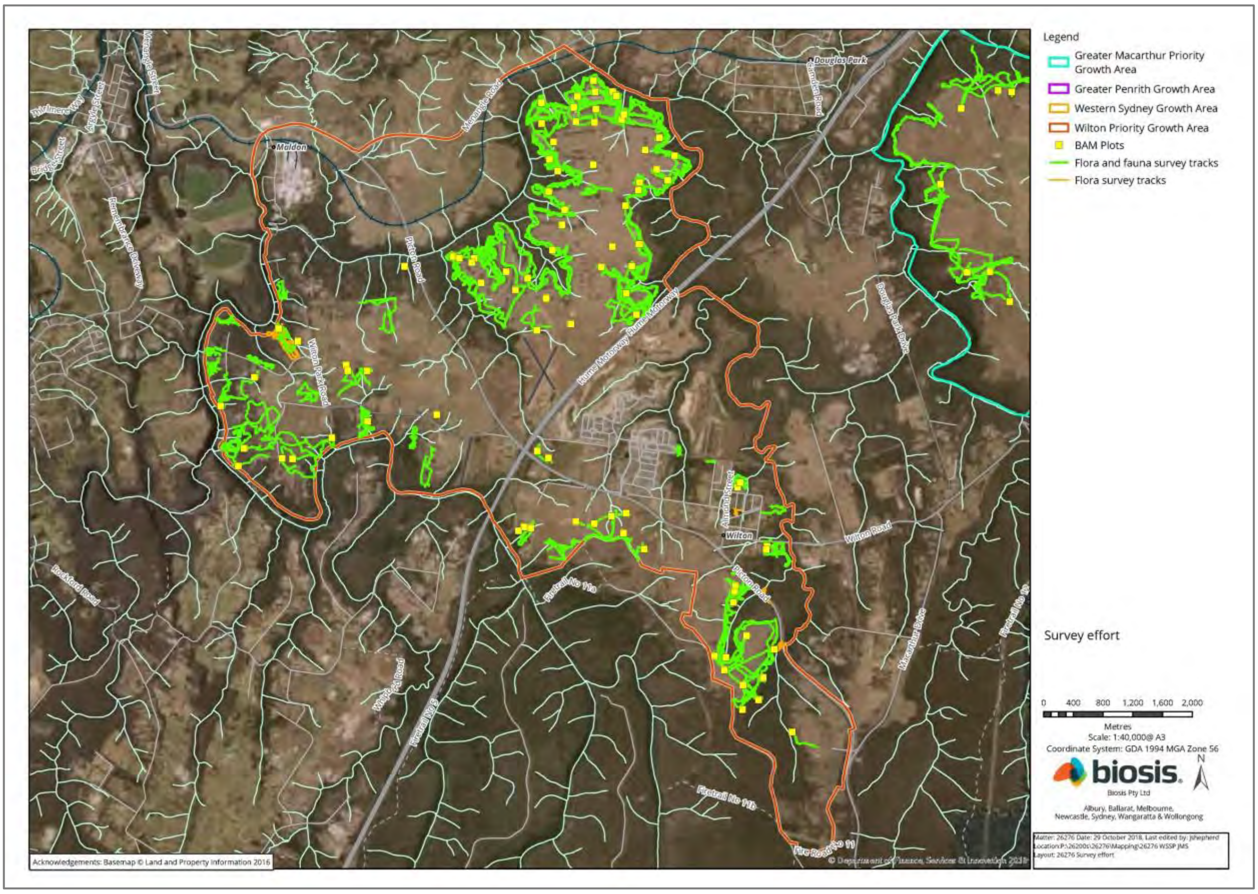
Table 8. Survey effort for threatened plant species *and* fauna habitat by PCT

PCT No.	Area of PCT in Growth Area (ha)	Area of PCT in urban zone (ha)	Field survey area (ha)	Percent of PCT surveyed within Growth Area (%)	Percent of PCT surveyed relative to urban zone (%)
724	191.3	57.0	12.1	6.3%	21.2%
725	167.4	51.4	6.9	4.1%	13.4%
781	68.9	5.6	0.9	1.4%	16.8%
830	21.6	0.8	1.7	7.8%	206.5%
835	1175.8	287.3	30.5	2.6%	10.6%
849	3078.3	637.6	125.0	4.1%	19.6%
850	522.9	294.3	36.1	6.9%	12.3%
883	7.4	0.0	0.5	6.8%	
1081	74.2	0.0	0.2	0.3%	
1105	138.6	0.0	0.0	0.0%	
1181	780.7	0.2	39.6	5.1%	19794.4%
1292	39.8	0.0	0.3	0.7%	
1395	3326.6	486.9	483.4	14.5%	99.3%
1800	232.6	20.2	7.3	3.1%	36.2%
TOTAL	**9826.1**	**1841.3**	**744.5**	**7.6%**	**40.4%**

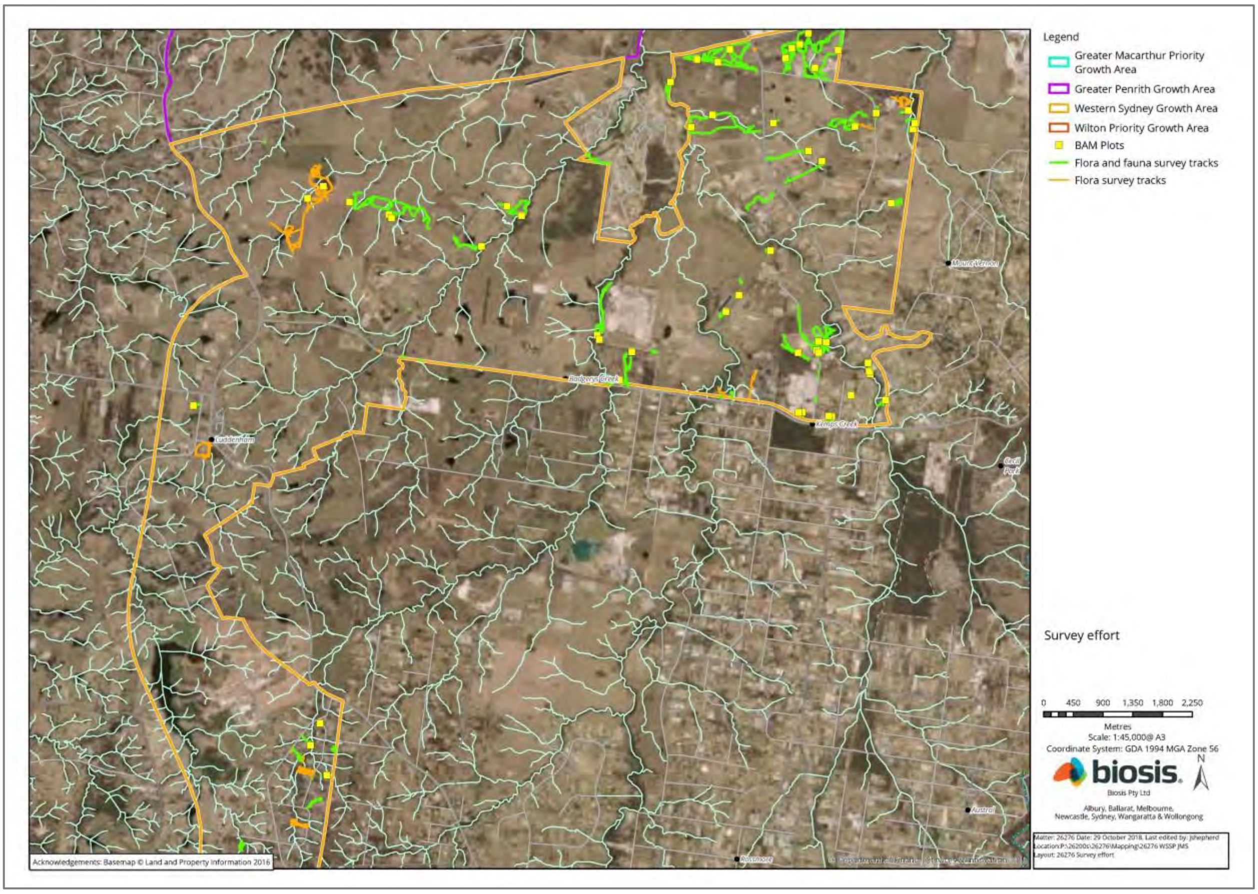
Field survey effort was not confined to the urban zone. Surveys occurred into nearby vegetation zoned for conservation. The urban zone has been revised over time and some areas where survey had already occurred were later removed. For these reasons, comparison of the survey area to the urban zone is indicative only. Survey effort has been calculated using a 20-metre buffer either side of GPS survey tracks. For the purposes of this analysis, the urban zone includes land zoned for future urban development plus transport corridors within the growth areas. It does not include any transport corridors outside the growth areas.



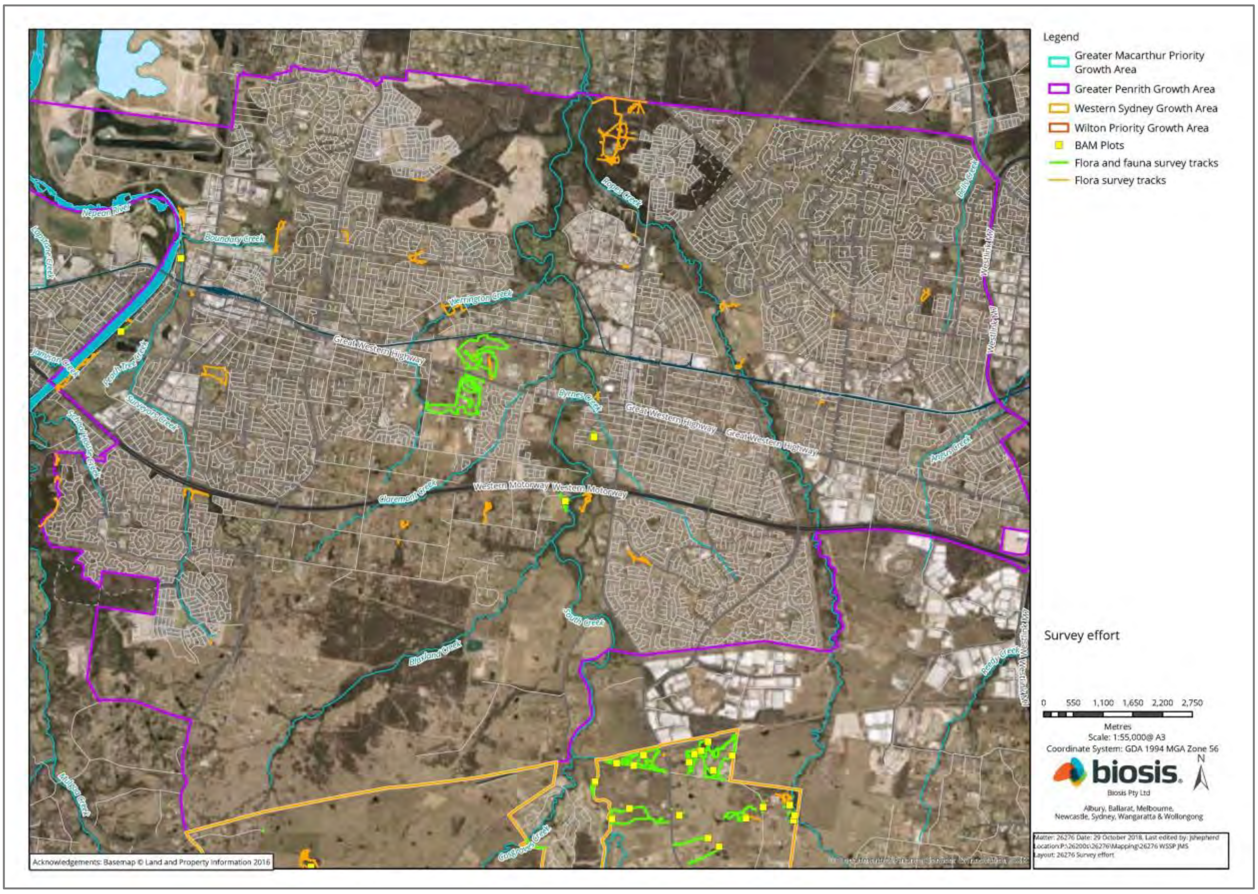
Map 4. GMGA survey effort (Biosis & Ecoplanning)



Map 5. WGA survey effort (Biosis and Ecoplanning)



Map 6. WSAGA ('Western Sydney') survey effort (Biosis and Ecoplanning)



Map 7. GPECGA survey effort (Biosis and Ecoplanning)

4.2.3 Survey constraints –timing / site conditions

As noted earlier, severe drought affected all of the study areas for some or all of the survey period. The Wilton and Greater Macarthur GAs were only surveyed during drought, whereas the Greater Penrith to Eastern Creek and the Aerotropolis GAs were surveyed both during intense drought and the subsequently slightly wetter conditions that followed in the Spring of 2018. Whilst wetter, drought remained present, and fellow Expert, Robert Miller, reported that vegetation was evidently drought-affected across all of the Growth Areas into November.

Drought, combined with increased intensity and extent of total grazing pressure, meant that affected surveys are likely to have under-recorded the target species compared to normal conditions. Whilst drought alone is unlikely to cause *P. nutans* to die back to rootstock or die and only remain as seedbank, when combined with increased herbivory due to drought, this is a far more likely outcome.

Irrespective of drought, surveys for this species are constrained by consideration of fire ecology, in that this species can be suppressed and even rendered apparently extinct at a site if the area has not been burnt for many years. Prolonged absence of fire is a constraint in some of the surveyed areas. Conversely, the species could be undetectable or not readily distinguished and identified in areas burnt recently. Areas burnt too often may also see the species suppressed or even eliminated. This is a factor in some of the survey sites closer to urban areas where a mix of hazard reduction burning and arson occur.

4.2.4 Survey constraint – surveys undertaken by generalists / non-experts

Whilst *P. nutans* is not regarded as a cryptic species, juveniles are small and infertile such that they could be missed, even by expert observers. It is more likely to be present but not recorded when surveyed by personnel not very familiar with the species and its ecology, particularly in terms of micro-habitat features. As an example, at least one young *Persoonia nutans* plant that was detected by fellow botanist, Robert Miller during survey for this Report had not been detected by consultants working for DPE, and who had recently been on that site.

Even when the prescribed OEH survey methods are used, a combination of site-based constraints, the species' ecology (e.g. dies back to seedbank without suitable disturbance), and a lack of familiarity with this species creates a situation where it is likely that it can present in plant form, but not recorded, or present only as seedbank, but not considered present because no plants were seen. *P. nutans* is one of several threatened plant species that should not be treated as absent, simply because it was not observed in plant form. If suitable habitat occurs, the species should be considered present unless there are clear reasons to rule otherwise. That approach is taken in this Report in relation to the designation of 'species polygons' (i.e. maps of where the plant is known or likely to occur).

4.3 Surveys completed specifically for this Report

I undertook a very brief survey of potential habitat for *P. nutans*, *A. bynoeana* and *A. pubescens* in the locality of Kemps Creek in mid-November 2018. Fellow botanist, Robert Miller was also present to survey for his target species. He examined some sites that I did not. He is very familiar with *P. nutans* and did not report its presence other than where he detected it and I subsequently reported it to the north of the previously documented occurrences.

The main remnant habitat in this locality is just to the south of the WSAGA but was checked by Miller for reference purposes (i.e. is the plant still present, is it still detectable during drought, what condition is the habitat in, etc.). That remnant was seen to be largely unmanaged and degrading due to several threats, and it is feasible that the species is now restricted to seed bank at that location, though it could be present on disturbance margins that were not traversed.

Relatively little potential habitat remains for this species in the WSAGA, and whilst little of this was available to be surveyed by me or by consultants engaged by DPE, all such habitat has been excluded from the proposed urban footprint.

Map 8. GPS track logs (purple lines)

I did not survey for any of my target species in the GPECGA because there is very little known and potential habitat for it there, and most of what remains is either reserved, or proposed for reservation by OEH. Surveying such areas would have added little or no information. Robert Miller did detect three new records of *P. nutans* in that area, one of which apparently duplicates an existing record. These were useful additions but do not alter my understanding of the species' ecology or distribution, and all are close to known occurrences. DPE offered access to a large area of remnant bushland in this Growth Area, but it is not mapped as suitable habitat for any of the species that I am addressing in Expert Reports, so I did not take up that offer.

I did not survey the WGA, as the species is not known from or likely to occur there.

I did not survey the GMGA, as only one small remnant of potential habitat exists there, and it was examined on my behalf by a Campbelltown Council officer familiar with the two relevant target species. A detailed survey was not undertaken and was not warranted given the nature of the habitat (highly modified and degraded, with much of it having a long history of being mown). Neither *P. nutans* or *Acacia bynoeana* was reported, but both were unlikely to be observable due to site conditions, though they may remain as seedbank. That habitat is on Council-managed parkland outside DPE's proposed urban footprint, so will not be biocertified. Having been alerted to the presence of a Threatened Ecological Community and potential habitat for these two threatened plant species, Council has recently commenced preliminary conservation work at this site.

4.4 Assessment of species' presence

4.4.1 Greater Macarthur Growth Area

The species is not known to be present in this Growth Area but may occur in or near four small patches of PCT 883 in Macquarie Fields, all of which is outside the proposed urban footprint. Other low-probability potential habitat occurs in the form of PCTs 1395 and 1081 north of Narellan Road. 1081 only occurs at one site in urban bushland associated with Smiths Creek in Leumeah. 1395 is more common but appears to be restricted primarily to generally small, often linear and likely degraded urban remnants from Glenfield, through Macquarie Fields, Ingleburn to Minto. It is unlikely to occur within the majority of this Growth Area because it was never suitable habitat or has been too heavily modified.

4.2.2 Wilton Growth Area

The species is not known nor likely to be present in this Growth Area due to it being outside the species' known geographic range by at least 20 km. The closely related *P. bargoensis* occurs in this Growth Area instead. Those species are separated by 40 km (Weston & Johnson, 1991). As of 2018, BioNet records for these species are separated by 24-28 km depending on the spatial accuracy of a record from Appin.

4.2.3 Greater Penrith to Eastern Creek Growth Area

The species is present in this Growth Area, but both known and likely habitat comprise a relatively small area in the central north, primarily with the gazetted or proposed sections of Wianamatta Regional Park. However, the proposed western addition appears to be at risk from further clearing and fragmentation to accommodate a large transport corridor. Potential and known habitat also occurs as patches along or near the M4 Motorway, roughly in the centre of this Area and to the east. The majority of this Growth Area was never suitable habitat for this species.

4.2.4 Western Sydney Aerotropolis Growth Area

The species is now known in this Growth Area from a single young plant, added during surveys associated with this Report. The extent of known and potential habitat is limited to a few patches of remnant vegetation in the localities of Kemps Creek and Badgerys Creek. Most of the WSAGA was always unsuitable habitat for this species based on geology, soil and plant community associations.

4.5 Assessment of suitable habitat for *Persoonia nutans*

4.5.1 Description and relative significance of potential habitat

As per the findings presented earlier in Table 3, combined with expert knowledge, the following PCTs are regarded as potential habitat for *P. nutans*. Not all of these PCTS are present in all Growth Areas, and not all occurrences or parts of these communities are likely to support the species in plant or seedbank forms. Wetter and sometimes more thickly vegetated areas associated with drainage lines are unlikely habitat, as this species prefers drier, more open conditions. Riparian buffer exclusions will be used as a component of the 'species polygons' discussed later. All vegetation condition classes are included except Derived Native Grassland:

Table 9. PCTs known or likely to be habitat for *P. nutans*

PCT	PCT Name	Relative significance
724	Broad-leaved Ironbark - Grey Box - *Melaleuca decora* grassy open forest on clay/gravel soils of the Cumberland Plain	Moderate
725	Broad-leaved Ironbark - *Melaleuca decora* shrubby open forest on clay soils of the Cumberland Plain	Moderate
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Very High
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	Low
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain	Very Low

The following sections describe the relative habitat value and local occurrences of each PCT mapped in each Growth Area.

Greater Macarthur Growth Area

The vegetation mapping provided for use in the project indicates that there is **1903.97 ha** of potential habitat for this species in this Growth Area based only on the extent of the relevant PCT.

Table 10. Potential habitat in the GMGA

PCT	Distribution	Area (ha)	Relative habitat value of local occurrences
883	Four very small polygons in low condition at Macquarie Fields.	0.91	Very low to low. The species may regenerate here if issues of mowing, absence of fire, and intense weed invasion are remedied. Any resultant population would be isolated from core habitat and surrounded by unsympathetic land uses. However, there is some scope to improve the quality and quantity of habitat on this public land.
1081	Restricted to one remnant urban bushland surrounding Smiths Creek in Leumeah.	7.52	Low, as this PCT is only associated with this species at the atypical but nearby Simmos Beach population. The proximity of housing likely makes it difficult to burn this site with sufficient intensity to support this species in the long-term.
1395	Several remnants in the north of the Area from Glenfield to Minto. Other areas to the south are outside the species' accepted range.	1895.54	Very Low, as this PCT is also only associated with the species at an outlying site in the far north of its range. There are no records of the species from this PCT in or near any of the Growth Areas.

Wilton Growth Area

The species is not known or likely to occur in this Growth Area, which is outside its known or likely distribution, even though at least one of the associated PCTs is present here. That niche is occupied by the closely related *P. bargoensis* in this Area.

Greater Penrith to Eastern Creek Growth Area

The vegetation mapping provided for use in the project indicates that there is **272.35 ha** of potential habitat for this species in this Growth Area based only on the extent of the relevant PCTs. There was always very limited scope for the species to occur in this Area, and much less so as a result of historic and on-going land clearing.

Table 11. Potential habitat in the GPECGA

PCT	Distribution	Relative habitat value of local occurrences
724	Present primarily in the far central north but extending south in association with Eastern Creek, with very small patches near the M4 Motorway.	Moderate to High, and most of the spatially accurate records in this Growth Area are associated with this PCT.
725	Mapped only in the far north as small to medium patches that are largely within the gazetted and proposed parts of Wianamatta Regional Park	Moderate, though very small patches in urban areas are likely to be less viable.
883	Mapped to a very small extent only in the far central north. Only 1 polygon in Biosis map, and entirely within Wianamatta Regional Park's eastern portion.	Very High as a PCT, and there are records of the species nearby.

Western Sydney Aerotropolis Growth Area

The vegetation mapping provided for use in the project indicates that there is **92.80 ha** of potential habitat for this species in this Growth Area based only on the extent of the relevant PCT. Only a small area of habitat ever existed in this Area, and even less remains due to historic and on-going land clearing.

Table 12. Potential habitat in the WSAGA

PCT	Distribution	Relative habitat value of local occurrences
724	Present as several patches in the localities of Kemps and Badgerys Creeks, mainly surrounded by pastoral or industrial land use.	Moderate to High. Some areas have been degraded by overstocking of grazing livestock. Others have been cleared or largely-so.
725	Present as several small patches in the localities of Kemps and Badgerys Creeks, mainly surrounded by pastoral or industrial land use.	Moderate, though very small patches adjoining unsympathetic land uses are likely to be less viable. All remnants in this area appear to be degraded by earlier clearing, grazing and weeds.
883	No longer present in the revised PCT map but habitat intermediate with 725 is present.	Very High, if this PCT or similar vegetation is present in this Growth Area. Recent record nearby.

4.5.2 Species habitat polygons

Species habitat polygons generated by this report relate to the extent of potential habitat that is proposed to be cleared for urbanisation or related purposes, such as transport corridors. These habitat polygons and associated calculations were generated to inform biodiversity offset requirements. The data presented in this section does not deal with species habitat outside proposed urban zones as those areas are treated as conservation zones or are excluded from urban and associated transport zones for a range of reasons. For this species, species polygons (proposed clearing of habitat) are only recognised in Greater Penrith to Eastern Creek and Western Sydney Aerotropolis Growth Areas because the species is not predicted to occur in the Wilton Growth Area, and potential habitat in the Greater Macarthur Growth Area is outside the scope of proposed urban impacts.

The habitat polygons include all relevant condition classes of relevant PCTs as identified in this Report. In this case, all condition classes are included except Derived Native Grassland.

Graded riparian exclusion buffers were used in recognition that *P. nutans* does not occur in riparian vegetation or close to watercourses. The buffer distances used here increase with the mapped Strahler stream order as shown in Table 13. The accuracy of the buffers is limited by available data, including the mapped location of streams. The buffer is applied either side of the mapped stream centreline. Note that these riparian buffer distances are a different concept and serve a different purpose to those applied by DPE for the purposes of protecting streamside vegetation and watercourses in its planning within the Growth Areas.

Table 13. Stream exclusion buffers

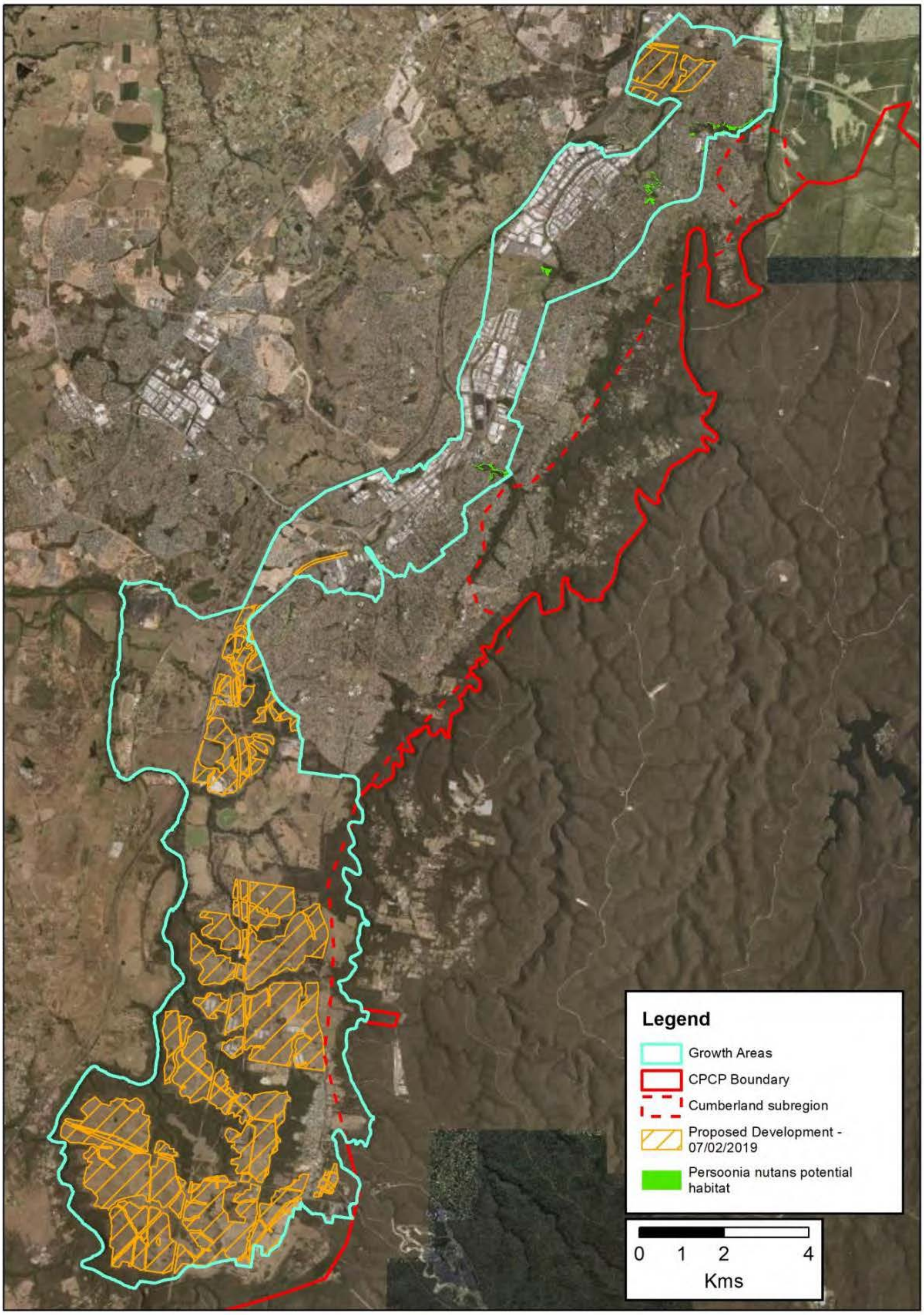
Stream order	Buffer distance (m)
1	5
2	10
3	20
4	30
5	40
6	50
7	70

Species habitat polygons in the form of GIS shape files were provided to the Biodiversity and Sustainability Branch of DPE in November 2018. The analysis of these shape files is presented in Table 14. These figures are based on precautionarily modelled *potential* habitat, and do not necessarily equate with *actual* habitat, nor do they provide any information of potential population sizes or population viability. It is unlikely that a large percentage of the potential habitat identified in this Report would actually support *P. nutans* because this species is naturally rare and patchily distributed, even though it can be locally abundant in favourable conditions.

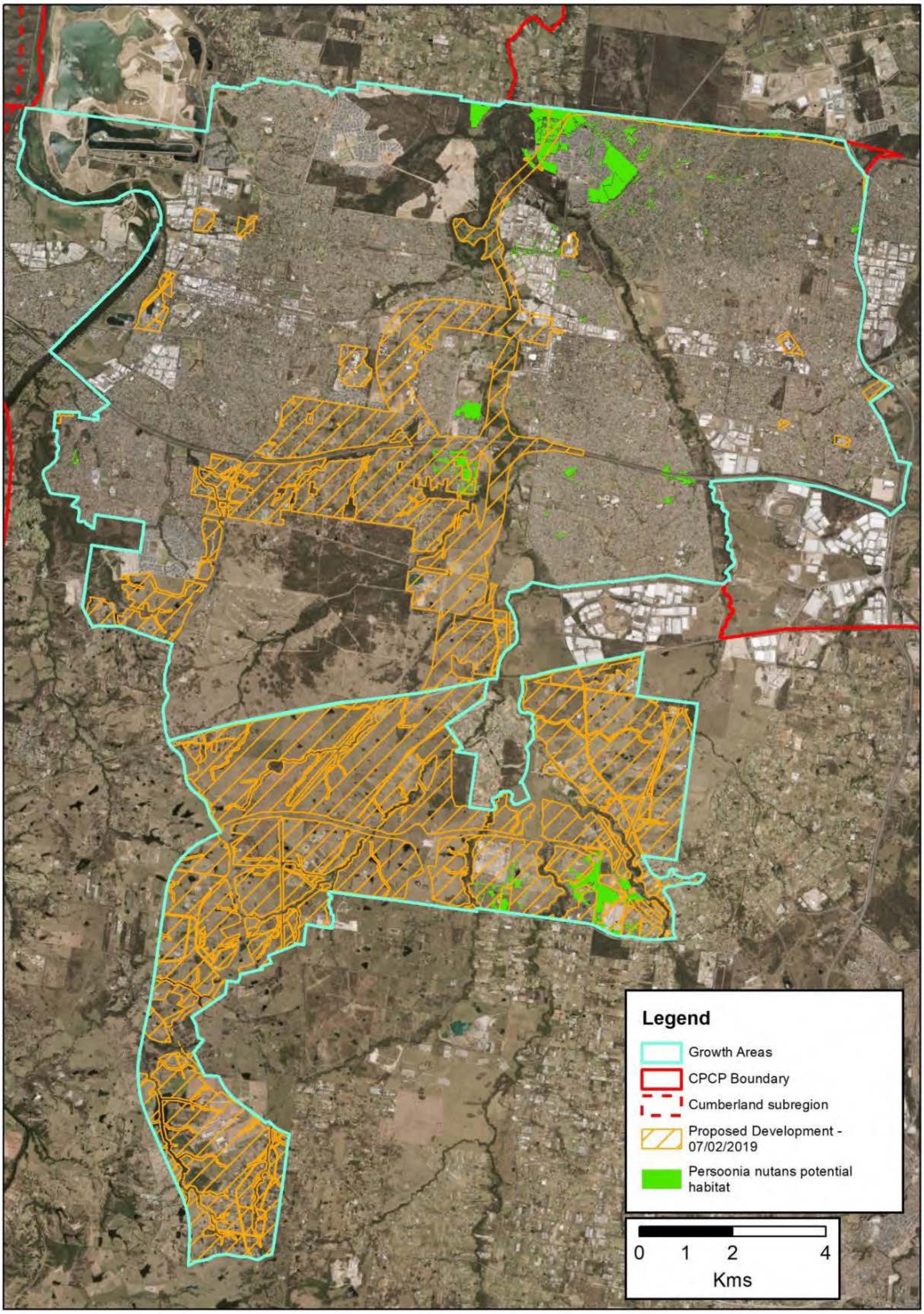
Table 14. Total of potential habitat and proposed removal of potential habitat

Growth Area	Area of potential habitat (ha)	Area of potential habitat removal (ha)	% area of potential habitat removal by GA
Greater Penrith to Eastern Creek	272.6	9.9	3.6
Western Sydney Aerotropolis	92.8	34.0	36.6
Greater Macarthur	23.6	0.0	0.00
Transport corridors **(all GAs)**	-	49.8	12.8
TOTAL	**389.0**	**93.7**	**24.1**

Map 9 Greater Macarthur - Potential habitat and proposed urban/transport habitat removal



Map 10 Greater Penrith & Eastern Creek plus Western Sydney Aerotropolis
– potential habitat and proposed urban/transport habitat removal



5. Summary and conclusion

Within the four Growth Areas, *Persoonia nutans* is currently only known from the Western Sydney Aerotropolis and Greater Penrith to Eastern Creek Growth Areas, with all currently known records outside the proposed urban areas, including transport corridors. Potential habitat for this species exists in all but the Wilton Growth Area, based on the species' known association with specified Plant Community Types, with other threatened plant species, and with Soil Landscapes, geologies, climate, etc. The most likely occurrences are within a subset of the Castlereagh Forests & Woodlands on Paleogene-Neogene alluvium. Atypical outlying populations are possible in habitat associated with the shale sandstone transition and the Mittagong Formation within the northern section of the Greater Macarthur Growth Area.

Based on current information, the proposed urban footprint and associated transport corridors of the three relevant Growth Areas would destroy 93.7 hectares of potential habitat for *P. nutans*. This equates to 24.1% of the area of potential habitat identified in those three Growth Areas. The actual extent of conflict between habitat for the species and proposed clearing for urbanisation is likely to be smaller as the species is naturally rare and patchily distributed. Not all of the area proposed for removal is of equal value as potential habitat, and different PCTs and condition classes have different probabilities of supporting *P. nutans*.

The greatest area of conflict between proposed urbanisation and the best quality / highest probability of occurrence potential habitat for this species is in the form of a proposed transport corridor through the western (apparently ungazetted) portion of Wianamatta Regional Park in the Greater Penrith to Eastern Creek Growth Area. Other significant conflicts arise in the form of the 'Urban Development Management Zone' of that Growth Area and to a greater extent, in the Western Sydney Aerotropolis Growth Area. Most such conflicts entail removal of vegetation condition classes below the Intact class. There is no conflict between potential habitat and proposed urbanisation in the Greater Macarthur Growth Area.

Because *P. nutans* is relatively tolerant, arguably dependent on some types of disturbance, and that it can persist in the soil seedbank, it may occur in areas that might generally be disregarded as potential habitat, and that may not be mapped as native vegetation. It is likely that highly modified sites that might support the species in some form are of relatively low significance for it in the context of the larger areas of more intact potential and known habitat that are excluded from urbanisation and associated clearing. It is also feasible that disturbance associated with urbanisation, particularly the creation of bushfire Asset Protection Zones (APZs) between bushland conservation areas and housing, could advantage this species, especially where the habitat has not burnt for many years. Thinning of the shrub layer by fire or mechanical means could favour the species, as may soil disturbance associated with fire trail construction. More frequent, moderate intensity burning of bushland that represents known or likely habitat for this species, may, within limits, also advantage it compared to low frequency and/or very cool burning.

The positioning of the bushland/urban interface and associated infrastructure such as APZs should have regard to this species' habitat and ecology, and appropriate buffers and other strategies are required to prevent direct and indirect harm to this species as a result of the urbanisation of adjoining lands. For example, potential habitat should not be compromised by the placement of housing nearby as might prevent that habitat being managed for conservation, especially in terms of bushfire risk management. DPE has informed me that the intention is for APZs to be accommodated within the proposed urban footprint, not in the non-biocertified bushland areas that may adjoin it.

The absence of records of this species from areas of potential habitat does not mean it could not be present because: not all areas have been surveyed historically or recently; all surveys have a range of limitations; not all discoveries of threatened species are disclosed or accurately mapped; and large areas of potential habitat are highly likely to have fire regimes that do not favour this species, meaning it may currently occur in very low numbers in dense and inaccessible habitat, or as seedbank, yet could appear in substantial numbers after an appropriate fire or equivalent disturbance. These factors have been considered in the preparation potential habitat maps and the associated generation of species habitat polygons that will inform DPE in relation to biodiversity offsetting obligations.

6. Information used in the assessment

6.1 DP&E or OEH resources

- BioNet data (internal access provided under license for use in this Expert Report and associated dataset cleaning for the purposes of species habitat modelling to meet EPBC Act requirements)
- Atlas of Living Australia on-line (partial use to check for records not in BioNet)
- EMU data (NSW Herbarium specimen database, provided by OEH)
- OEH on-line threatened species profile
- OEH Threatened Species Data Collection on-line
- OEH BioNet Vegetation Classification Database (previously known as VIS)
- EPBC Act Listing/Conservation Advice
- OEH PCT (vegetation) maps for Sydney Metropolitan and Cumberland Plain
- Field data and associated analyses from Biosis and Ecoplanning (consultancies engaged by DPE)
- GIS layers and maps provided by DPE and its contractors

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7. Acknowledgements

I acknowledge the contributions of DPE staff, particularly Dayle Green, Greg Steenbeeke and Christian Marando (GIS), and DPE contractor Darren James (GIS) in the preparation and refinement of this document and associated maps. My contractor, Rhys Grogan, also assisted with GIS output in the form of drafts of the species potential habitat polygons. OEH staff assisted with some aspects of data availability and with the processing of many amendments to BioNet records.

Consultant botanist, Robert Miller assisted with fieldwork at Kemps Creek, and provided information about field observations associated with searches for his target species and with opportunistic sitings of my target species. Consultant ecologist, Paul Burcher of AES, kindly provided access to his targeted survey data and associated report to OEH / NPWS; and provided images of the species taken by Ben Ford. Botanist and bush regenerator, Colin Gibson, provided important information about the history and current status of the Villawood population, and the exact location of associated plants. The latter enabled refinement of the associated BioNet data. Consultant ecologist, Danny Wotherspoon provided information about the species' northwestern outlier, which also allowed the NSW Herbarium records and BioNet entries to be spatially corrected.

8. Statement of professional independence

Whilst I was engaged and funded by DPE to prepare this Expert Report, and a series of draft reports and maps were reviewed by DPE staff, I was not coerced by DPE to amend my work in any manner that I did not otherwise agree with. I believe that I had appropriate professional independence in the preparation of this document and associated maps.

I declare that I do not have any personal or commercial conflict of interest in the preparation of this Report. I do not own real estate or businesses with property in the Growth Areas, nor do I have other active clients with real estate or associated commercial interests in the Growth Areas.

9. Appendix 1. Author's *Curriculum Vitae*

Dr Steven Douglas (BSc., MEnv. Plan., PhD.)

I have over twenty years of experience as an ecologist and environmental planner, primarily in New South Wales, with some experience in the ACT, Victoria and South Australia. I have worked for all levels of government, for environmentalist non-government organisations (NGOs), and for a large number of private clients ranging from individuals to multinational firms, directly and as a subcontractor. I have often worked as a sole consultant but have also collaborated with other specialists and have sometimes been part of large teams involved in large-scale, even interstate projects.

I specialise in the detection, management and conservation of rare and threatened flora species and communities, and in associated ecological impact assessment and mitigation. I have qualifications and experience in a range of general and specific ecological, social, organisational and 'sustainability' fields. I have served on environment-related ministerial committees and have held other ministerial appointments in NSW, including those dealing with bushfire management. I have published in journals dealing with plant conservation, environmental law and policy, social science, and ecological ethics. Aspects of my work have been published by government, prominent NGOs, and in the popular press and other media.

This CV only contains content directly related to my botanical expertise.

Employment summary

1996 to present:

Self-employed, trading as *Ecological Surveys & Planning* (www.ecologicalsurveys.net)

Through this enterprise, I have undertaken a large number of consultancies for public and private sector clients including environmental impact assessment and mitigation; threatened biota research, profiling and management; vegetation mapping; preparing management plans for conservation estate; providing environmental planning and catchment management advice; advising on bushfire risk management; acting as an expert witness in Land & Environment Court proceedings; and developing organisational sustainability policies and practices.

July 2017 to July 2018:

Senior Ecologist, NSW Office of Environment & Heritage (NVIS, Science Division)

My work on the project below led to OEH retaining my services to research and document problems with the description, interpretation and mapping of Threatened Ecological Communities (TECs) statewide. This project provides advice to OEH, the NSW Threatened Species Scientific Committee, and through those agencies, to the Commonwealth Threatened Species Scientific Committee. It identifies technical issues with the description of TECs and their mapping, as well as wider problems of how TECs are defined. It draws on a major project undertaken by OEH for the NSW EPA and Forestry Corporation, in which TECs of the east coast and ranges were assessed and mapped for regulatory purposes on forestry estate. However, my work includes many more TECs and recent information emerging from Save Our Species project panels.

November 2015 to July 2017:

Team Leader, NSW Office of Environment & Heritage (NVIS, Science Division)

This project in Wingecarribee Shire is the first in which OEH's vegetation mapping team has worked at a very fine scale for a single local government area. The project entails auto-segmentation of digital aerial photography; supervising contract vegetation sampling; conducting strategic sampling; modelling of most vegetation communities; describing new communities; and extensive remote and on-ground map validation. I was hired partly because of my extensive familiarity with much of the vegetation of this geodiverse and biodiverse region. The role included supervision of two staff; liaison with consultants; and substantial networking with OEH and Wingecarribee Council staff. An update of vegetation classification will occur from mid 2019 onwards, and I have drafted a peer-reviewed journal article about the project that will be submitted for publication.

1995/6:

Project consultant, then Project Manager, Urban Bushland Biodiversity Survey (NPWS)

The Urban Bushland Biodiversity Survey was undertaken by the NPWS to compile comprehensive data on indigenous flora and fauna in twelve local government areas in Western Sydney. Contracted initially as a consultant to design and scope the project, I was later employed as Project Manager. Responsibilities involved an extensive literature review, preparation of a project plan and a background paper for the Survey and the overall management of the project including up to twelve staff and several consultants. The major focus was on coordinating research work, fauna and flora field surveys, and a community liaison and media campaign. Extensive flora survey work and scientific data analysis was undertaken. I provided a tour of important vegetation sites for the South Creek Catchment Management Committee. I also wrote media releases and conducted various media events including a live-to-air interview on ABC Radio National, and filming of a story in the field for the Totally Wild program.

1994:

Catchment Environment Officer (*Hawkesbury City Council*).

The project was funded by a grant from the former Hawkesbury-Nepean Catchment Management Trust and had the objective of identifying land uses on riverside properties to assess their potential to generate water pollution. The information on land use and riparian vegetation was primarily gained from aerial photo interpretation, limited land-based inspections and several water-based inspections, and was recorded in a GIS. Work site inspections, pollution control on agricultural lands, community meetings, site visits with landowners, and facilitating the formation of a Landcare group in the Sackville area.

1993/4:

Technical Officer (*Hawkesbury-Nepean Catchment Management Trust*).

Work included assisting with the preparation of a vegetation management strategy for the Trust and the outline of a revegetation strategy for South Creek. Other responsibilities involved providing scientific advice for development assessments, the preparation of hard copy and computer-based catchment maps, and advising on the implementation of revegetation projects in the catchment.

Ministerial appointments

- Appointed a member of the **National Parks & Wildlife Service Regional Advisory Committee** (South Coast) (2010-mid 2018). I opted not to reapply for this role after serving two terms. The restructure of the NPWS meant that the Committee would operate from Wollongong to the Victoria border and inland to the Tablelands. This was logistically fraught, and the role of RACs was evidently being diminished, with larger areas to manage but less meetings held.
- Appointed a member of the **NSW Sustainability Network** (2001), part of the Sustainability Advisory Council reporting to the Minister for Planning. I did not take up this position due to my relocating to Victoria.
- Nature Conservation Council representative on the former NSW **Native Vegetation Advisory Council** (1999-2001) reporting to the Minister for Land & Water Conservation under the Native Vegetation Conservation Act. I served as a member of the Regional Vegetation Planning Subcommittee, which amongst other matters, reviewed draft Regional Vegetation Management Plans and Codes of Practice for activities such as native forestry and timber plantations. I was particularly involved in reviewing and recommending amendments to the Code of Practice for plantation forestry. I resigned due to my relocating to Victoria.
- Nature Conservation Council representative on the former **Southern Catchment Management Board** (June 2000 - March 2001). I resigned due to relocating to Victoria. I expressed my dissatisfaction with the design of the catchment boards and recommended to the Minister that they be replaced with the Catchment Management Authority model used in Victoria. The Boards were later replaced with such Authorities.
- Nature Conservation Council representative on Baulkham Hills and Hornsby-Ku-ring-gai **District Bushfire Management Committees** (1995-2001).
- Australian Conservation Foundation representative on the former **Environmental Works Community Audit Committee** reporting to the Minister for Environment in relation to the Special Environment Levy imposed by the then Water Board (1993-5). I completed my term when the Committee concluded its business and dissolved upon acceptance of its final report by the Minister.

Tertiary qualifications & titles

Adjunct Research Fellow

School of Philosophical, Historical & International Studies, Monash University, 2014-16

Doctor of Philosophy

Fenner School of Environment & Society, The Australian National University, 2004-7

The research was undertaken in the transdisciplinary Human Ecology Program and covered fields such as ecological philosophy, ecotheology, environmental policy-making, policy evaluation, organisational change, and critical systemic analysis. My thesis was passed unanimously and unamended by one Australian and two USA-based professors. I was awarded a $10,000 Publication Fellowship by the Fenner School and have since published aspects of my research.

Master of Environmental Planning

Macquarie University Grad. Sch. Env., 1994-96

This course included environmental law and politics, community involvement in planning, environmental education, development approval processes, urban planning, EIA, environmental science/fieldwork and heritage management. The dissertation component involved a pioneering report on the significant flora of the Greater Cattai Region (Cattai subcatchment) in north-western Sydney and led to my being offered employment with the NSW NPWS to design and manage a biodiversity survey of western Sydney.

Bachelor of Science

Macquarie University, 1990-93

My degree majors are Resource and Environmental Management, Land Management, and Plant Biology/Ecology.

Graduate Certificate of Research Information Literacy

The Australian National University, 2004-7

This course included advanced word processing, citation management, literature gathering (including on-line literary databases and other Internet sources), on-line publishing, presentation software, and thesis production.

Professional memberships

- Founding member of the Ecological Consultants Association of New South Wales (did not renew due to my relocating to Victoria and later to the ACT).
- Member of the NSW Environmental Defenders Office (EDO) Scientific Advisory Service (continuing).

Threatened biota experience

The following threatened plant species and populations and threatened ecological communities (TECs) have been engaged with in the various forms and processes listed below. The list is not complete, and some processes are on-going. I also successfully nominated three Key Threatening Processes under the TSC Act: Bushrock Removal; Clearing of Native Vegetation; Competition from European Honey Bee.

Species / population	Work conducted
Acacia bynoeana	Fieldwork, research, successful nomination, monitoring, advice to authorities, expert witness, rediscovered lost population, documented new population near range limit, PAS2 review, SOS review panel, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
A. gordonii	Fieldwork, successful nomination, advice to NPWS, PAS2 review, SOS research and monitoring program (fire ecology, BMtns NP), review and amendment of BioNet dataset.
A. prominens	Successful nomination of Endangered Population
A. pubescens	Fieldwork, contribution to Recovery Plan, confirmed disjunct southern populations, nominated population, PAS2 review, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Ancistrachne maidenii	Fieldwork, research, successful nomination, advice to NPWS, CAM review
Asterolasia elegans	Fieldwork, species profile, advice to Council and NPWS
Baloskion longipes	Research linked to *Carex klaphakei*, review of BioNet records, advice to OEH
Boronia deanei	Research, SOS review, CAM review, advice to OEH
Bossiaea oligosperma	SOS fieldwork, review of records (NW population), report to OEH, establishment of monitoring plots in Yerranderie SCA
Callistemon linearifolius	Fieldwork, research, successful nomination, advice to RMS and NPWS, PAS2 review
Callistemon megalongensis	Co-described new species, successful nominations (listing then upgrade), fieldwork, advice to Council and OEH, PAS2 review, SOS monitoring program (OEH, BMCC, on-going)
Callistemon purpurascens	Described new species, fieldwork, successful nominations, advice to Council and OEH, SOS monitoring project (2018 on-going)
Calotis glandulosa	Fieldwork (new and extended populations, Kosci NP), CAM review
Calotis pubescens	Fieldwork (new population, Kosci NP), CAM review
Carex klaphakei	SOS research project and recommendation for monitoring; resolved errors in BioNet records

Species / population	Work conducted
Commersonia prostrata	PAS2 / PKF research, fieldwork, advice to NPWS and OEH, documentation and monitoring of new and known populations for Forestry Corp, designed recovery actions for populations in Wingello and Penrose SFs
Cullen parvum	Fieldwork, located new NE population, report to NPWS
Dampiera fusca	Research, fieldwork, successful nominations, monitoring program for ACT Parks & Conservation, advice to NPWS and OEH, CAM review
Darwinia biflora	Fieldwork, research, contributor to Recovery Plan, PAS2 review, review and amendment of BioNet dataset.
Darwinia glaucophylla	Fieldwork, research, successful nomination, advice to NPWS, PAS2 review
Darwinia fascicularis ssp. *oligantha*	Fieldwork, research, successful nomination of population
Darwinia peduncularis	Research, successful nomination, CAM review
Dillwynia tenuifolia	Fieldwork, research, successful population nominations, advice to OEH
Epacris purpurascens var. *purpurascens*	Fieldwork, research, nomination, new SW range limit (Nattai NP), advice to NPWS/OEH
Eucalyptus aggregata	Research, successful nomination of species and population, fieldwork (Wingecarribee Shire) and advice to Council and OEH, CAM reviews
E. aquatica	Fieldwork, advice to Council and Forestry Corporation
E. sp. *Cattai*	Successfully argued for recognition of this entity as a new species, successful nomination, fieldwork, PAS2 review, advice to OEH, SOS project panel
E. kartzoffiana	Fieldwork, research, expert witness
E. macarthurii	Fieldwork, research, successful nominations, advice to Council and OEH
E. parvula	Fieldwork (Wadbilliga NP), CAM review
E. pulverulenta	Fieldwork (Bredbo Hills), CAM review
Galium australe	PAS2 research, recommended taxonomic review of most records in NSW based on Herbarium assessment, advice to OEH, CAM review
Grevillea juniperina ssp. *juniperina*	Fieldwork, research, advice to OEH (Colebee NR offset site)
Grevillea molyneuxii	Fieldwork, advice to OEH for CAM review
Grevillea parviflora ssp. *parviflora*	Fieldwork, research, expert witness, review and amendment of BioNet dataset.
Grevillea parviflora ssp. *supplicans*	Fieldwork, research, nomination, advice to NPWS
Grevillea raybrownii	Fieldwork, research, nomination and advice to NSWSC – listing pending
Gyrostemon thesioides	Successful nomination
Helichrysum calvertianum	Fieldwork, research, nomination, advice to NSWSC – listing pending
Hibbertia fumana	Research, minor fieldwork, expert witness
*H. incana (*syn. *superans)*	Successful nomination of population then species
H. praemorsa	ROTAP, researched, fieldwork (informal)
H. puberula ssp. *furcatula*	Fieldwork (incidental) documenting new occurrence, advice to OEH/NPWS
H. puberula ssp. *puberula*	Research, minor fieldwork with R. Miller, expert witness
Homoranthus binghiensis	CAM review (recommended changing to CE)
Keraudrenia corrolata var. *denticulata*	Successful nomination of population
Lasiopetalum joyceae	Fieldwork, research, successful nomination, species profiling for Council and NPWS, PAS2 review

Species / population	Work conducted
Leptospermum deanei	Fieldwork, research into hybridization with *L. trinervium*, advice to RBG, Council, OEH
Leucopogon fletcheri ssp. *fletcheri*	Fieldwork, research, successful nomination, advice to OEH and NPWS
Melaleuca deanei	Research, fieldwork, successful nominations, advice to NPWS/OEH and species profile for Council, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Olearia cordata	Fieldwork and report to NPWS, PAS2 review
Persoonia acerosa	Fieldwork, PAS2 review, SOS monitoring plots, advice to Council and OEH
Persoonia bargoensis	Fieldwork, research, successful nomination, PAS2 review, CAM review, review and amendment of BioNet dataset.
Persoonia hirsuta	Fieldwork, research, nominations of species and population, PAS2 review, review and amendment of BioNet dataset.
Persoonia glaucescens	Fieldwork, nomination, report to NPWS, PAS 2 review, CAM review, review and amendment of BioNet dataset.
Persoonia marginata	Fieldwork and report to OEH, CAM review
Persoonia mollis ssp. *revoluta*	Fieldwork, research, advice to OEH and Forestry Corp., nomination as Vulnerable - listing pending
Persoonia nutans	Fieldwork, nomination, advice to OEH, review and amendment of BioNet dataset. Nominated by DPE and recognised by OEH as a species expert under BC Act (Nov 2018).
Phyllota humifusa	PAS2 fieldwork and research; advice to NPWS, OEH, Council, Forestry Corp (monitoring plots, reduced APZ width), review of BioNet dataset.
Pimelea curviflora var. *curviflora*	Fieldwork, research, successful nomination, advice to OEH
Pomaderris brunnea	Incidental fieldwork and documentation of new populations and range extension; review and amendment of BioNet dataset.
P. cotoneaster	Fieldwork, research, advice to Council, NPWS, OEH, liaise with ANBG seed collectors, CAM review
P. sericea	PAS2 research (review of records and habitat), recommended consideration of Presumed Extinct or at least CE
Pultenaea elusa	PAS2 research (review of records and habitat), recommended Presumed Extinct
P. glabra	SOS fieldwork and monitoring plots. Review of Mts Wilson/Irvine records resulted in these being reallocated to an undescribed species given the interim name, *P. monticola*.
P. parviflora	SOS fieldwork and report to OEH (Colebee NR offset site); review and amendment of BioNet dataset.
P. pedunculata	Fieldwork, research, expert witness, CAM review
Solanum armourense	PAS2 fieldwork, research, report, advice to OEH, CAM review
S. celatum	Fieldwork, research, new populations (new range limit and habitat), advice to OEH, CAM review
Tetratheca glandulosa	Fieldwork, PAS2 review, advice to OEH and Cwlth DEE re conservation status
Triplarina nowraensis	SOS fieldwork, review of BioNet records, advice to OEH/NPWS, establishment of monitoring plots
Zieria involucrata	Fieldwork, input to Recovery Plan, CAM review
Zieria murphyi	Liaise with ANBG, fieldwork, advice to OEH

Threatened Ecological Communities (TECs)

My work for OEH in reviewing all NSW and EPBC Act TECs in the State has given me at least some familiarity with most of these entities and builds on already-strong knowledge of some. I have also been an expert witness in cases involving some of these communities – some entailing basic reviews and advice, and others involving in-depth considerations. All of the EPBC Act parallel listings are not included here unless I was involved in a particular nomination:

Ecological community	Nature of engagement
Blue Gum High Forest	Successful nomination, expert witness
Blue Mountains Basalt Cap Forest	SOS panel
Blue Mountains Shale Cap Forest	Successful nomination, SOS panel
Blue Mountains Swamps	Fieldwork, mapping, advice to BMtns Council, modelling
Castlereagh Scribbly Gum Woodland	Successful nomination, advice to DEE re Cwlth listing, expert witness
Cooks River / Castlereagh Ironbark Forest	Advice to DEE for EPBC Act listing
Cumberland Plain Woodland	Correction of OEH mapping, fieldwork, assessments, advice to Councils and NPWS
Eastern Suburbs Banksia Scrub	Major review for DEE Recovery Plan update, advice to OEH
Elderslie Banksia Scrub Forest	Major review for DEE Recovery Plan, SOS panel
Illawarra Lowlands Grassy Woodland	DEE review panel for EPBC Act listing
Lowland Grassy Woodland & Forest of SE Corner Bioregion	Successful nomination
Maroota Sands Swamp Forest	Successful nomination, SOS panel
Melaleuca armillaris Tall Shrubland	fieldwork, mapping, advice to OEH
Montane Peatlands & Swamps	Fieldwork, modelling and mapping, advice to OEH
Mount Gibraltar Forest	Detailed review for modelling and mapping, and advice about revised listing, advice to DEE re Upland Basalt Eucalypt Forest inclusion of NSW TECs
O'Hares Creek Shale Forest	Research and review for modelling and mapping
Pittwater & Wagstaffe Spotted Gum Forest	Successful nomination
Riverflat Eucalypts Forest on Coastal Floodplains	Successful nomination (component), research, modelling and mapping (limited extent)
Robertson Basalt Tall Open-forest	Modelling and mapping, advice to NSW SC
Robertson Rainforest	Modelling and mapping
Shale/Gravel Transition Forest	Mapping, TEC review
Shale/Sandstone Transition Forest	First to describe this concept c. 1996 based on Masters research. Formally published as a concept in NPWS (1997, UBBS). Successful nomination, research, major review and advice to DEE for EPBC Act listing, modelling and mapping
Southern Highlands Shale (Forest &) Woodland	Major contributor to DEE listing, drafting of Listing and Conservation Advices, advice to OEH about revision of NSW listing, modelling and mapping. Contracted to prepare listing for upgrade to CE.
Subtropical & Temperate Coastal Saltmarsh (EPBC Act)	Funded to prepare successful nomination
Sun Valley Cabbage Gum Forest	Successful nomination, mapping, advice to Council, SOS project panel
Swamp Sclerophyll Forest on Coastal Floodplains	Allied major research project cited in the Final Determination, TEC review (gap analysis)

Ecological community	Nature of engagement
Sydney Turpentine Ironbark Forest	Successful nomination, mapping, advice to Councils and to OEH/SC about revision
Tablelands Basalt Forest	Research, expert witness, advice to OEH about revision, modelling and mapping
Tablelands Snow Gum…Grassy Woodland	Fieldwork documenting new occurrences, modelling and mapping, advice to OEH
Upland Basalt Eucalypt Forest (EPBC Act)	Major contributor to DEE listing of this composite community that includes several NSW TECs. Draft Listing and Conservation Advices
Western Sydney Dry Rainforest and Moist Shale Woodland	SOS panel, TEC review

Publications / presentations / media

Ecology / conservation / environmental law & policy / ecological ethics

Refereed journal articles

Douglas, S.M. and Wilson, P.G. 2015. "Callistemon purpurascens (Myrtaceae): a new and threatened species from the Blue Mountains region of New South Wales, Australia". *Telopea* 18: 265-272

Douglas, S.M. 2000. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link". *Australasian Journal of Natural Resources Law & Policy,* 6(2)

Conference proceedings

Douglas, S.M. 2003. "Ecological offsets – what's the idea?" in Morrison, C. (Ed.) *Urban bushland and remnant vegetation: toolkits for a sustainable future – conference proceedings*. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 2001. "Local Government & the Threatened Species Conservation Act: the greatest potential; the weakest link"; in Newton, S. (Ed.) *Bushland or buildings? The dilemma for biodiversity conservation in urban areas* – conference proceedings. Nature Conservation Council of NSW, Sydney

Douglas, S.M. 1998. "The Threatened Species Conservation Act; a consultant's perspective" in *On the brink; your bush, their habitat, our Act.* Threatened Species Network, Nature Conservation Council of NSW, and Environmental Defenders Office, Sydney

Book chapters

Douglas, S.M. 1999. "Development & Sydney's threatened biota" in *Greenprint for Sydney: an environmental strategy for the 21st Century*. Total Environment Centre, Sydney, NSW

Professional reports

Douglas, S.M. & Anderson, J.R.B. 2002. Eucalyptus robusta *(Swamp Mahogany) communities and their conservation status in New South Wales*. Swamp Mahogany Project, Central Coast Community Environment Centre, Newcastle University Campus, Ourimbah

Douglas, S.M. 1997. "Local Government Area Reports: Baulkham Hills Shire", in James, T. (Ed.) *Urban Bushland Biodiversity Survey* (Stage 1, Western Sydney) Flora Appendices Vol. 2. NSW National Parks & Wildlife Service, Hurstville

Edited but not refereed publications

Douglas, S.M. 2014. "When biosecurity is threatened from within: the case of the native environmental weed, Pittosporum undulatum". *Australasian Plant Conservation*, 23(2)

Douglas, S.M. 2009. "Black Gum: a threatened tree of upland New South Wales and Victoria." *Australasian Plant Conservation*, 17(4)

Douglas, S.M. 2009. "Species profile and monitoring of Dampiera fusca". *Australasian Plant Conservation*, 17(3)

Douglas, S.M. 2006. "Endangered plant discovered" (St. Clements Retreat, Galong). *Biodiversity Research Newsletter*, 20, p.4, July, NSW Department of Environment & Conservation, Hurstville.

Douglas, S.M. 2006. "Endangered plant discovered (*Cullen parvum*) at St. Clements Retreat, Galong". News of Friends of Grasslands, November-December, p7

Douglas, S.M. 2005. "Phoenix flora: a post-fire discovery in the ACT". *Australasian Plant Conservation*, 13(3)

Douglas, S.M. 2004. "Phoenix flora" (re Dampiera fusca). *Journal of the Australian Native Plant Society Canberra Region*, 14(2), December

Douglas, S.M. 2003. "Mysteries of the Megalong Valley: another rare plant for the Blue Mountains." *Australasian Plant Conservation*, 12(1)

Douglas, S.M. 2001. "Land of the living dead – tree decline in urban areas". *Environment NSW* (newsletter of the Nature Conservation Council of NSW), September

Douglas, S.M. & Newton, S. 2000. "Bushland weeds – more on native weeds". *Environment NSW*, December

Douglas, S.M. 2000. "Regional Parks". *National Parks Journal* Vol. 44 (5 & 6) (journal of the National Parks Association of NSW)

Douglas, S.M. 1996. "Community biodiversity surveys". *National Parks Journal,* 40(3)

Douglas, S.M. 1996. "Mapping our urban bushland". *The Gardens*, Spring (journal of the Royal Botanic Gardens, Sydney)

Douglas, S.M., Bolesic, T. and Ware, K. 1994. "Healing the Hawkesbury: start with bushland protection". *National Parks Journal*. 38(4)

Public media coverage

2004, November 6. "Bright flowering spot after fire" - discovery of Dampiera fusca – a new genus and nationally significant species for the ACT and a new northern limit for the species. *Canberra Times*

2004. Live-to-air interview re discovery of *Dampiera fusca* in Namadgi NP, *ABC 666* AM Radio, Canberra

1996. Live to air interview re NPWS Urban Bushland Biodiversity Survey, *ABC 2BL* AM Radio, Sydney

1996. Pre-recorded TV segment re discovery of several nationally threatened plants in the one location during surveys for NPWS UBBS. *Totally Wild* program, Channel 10, Sydney

Consultancy projects

Short descriptions of the many larger projects that I have been involved in are available at http://ecologicalsurveys.net/?page_id=10, and a list of smaller projects is at http://ecologicalsurveys.net/?page_id=14

Voluntary and other works

- Assist **International Union for the Conservation of Nature (IUCN)** with a review of the conservation status of *Proteaceae* in eastern Australia (Melbourne, 2019).
- Assist **NSW Environmental Defenders Office** with a review of NPWS monitoring proposals to assess the effects of permitting horse riding in declared Wilderness areas (Kosciusko National Park) (2014).
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Noxious Weeds Act 1993 (in 2011)
- Assist **NSW Environmental Defenders Office** in the preparation of its submission to the NSW Government's review of the Threatened Species Conservation Act 1995 (in 2010)
- Assist discoverers (**Blue Mountains Bushcare**) of a previously undescribed *Epacris* species (*E. apungens* Coleby & Brown) in south Leura to prepare an article for the journal, *Telopea*, describing this species and its ecology
- Assist **NPWS** with a search for the ultra-endemic and rare rainforest plant, *Thismia clavarioides*, in Morton National Park (2010)
- Expert panel member assisting **Hawkesbury-Nepean CMA** with its Draft Climate Change Vulnerability Assessment for selected threatened ecological communities of the NSW Southern Highlands (2010)
- Assist PhD student, David Field (**University of Wollongong and CSIRO**) with information about the ecology, distribution, and conservation status of *Eucalyptus aggregata* (Black Gum) (2007)
- Fieldwork assisting with group preparation of vascular plant species lists in numerous NPWS and ACT Parks reserves in the Southern Tablelands area. **Australian Native Plants Society** (2003-2007)
- Searches for *Euphrasia scabra* (critically endangered) in Packers Swamp and Nunnock Swamp. Discovered new population (3rd in NSW) in unnamed swamp, SE Forests National Park. **Friends of Grasslands** (2004)
- Assistant part-time editor of "*Danthonia*" (now *Australasian Plant Conservation*), the journal of the **Australian Network for Plant Conservation** Inc., Canberra (2002-2003)
- Assist PhD student, David Clunas (**University of Wollongong**) with review of his research in the ecology of the nationally Rare, *Pultenaea villifera* var. *villifera* (2002)
- Provide technical assistance to four final year undergraduate Environmental Science students (**Australian Catholic University**) working in Marramarra National Park, (c. 2000)
- Discovery of and subsequent surveys for *Persoonia hirsuta* ssp. nov. 'Yengo NP'. **NPWS/RBG**
- Vascular flora and fauna (microchiropteran bats) surveys within Pilliga Nature Reserve. **NPWS** Coonabarabran
- Supervisor for undergraduate dissertation, "Environmental rehabilitation of Peats Crater and Peats Bight in Muogamarra Nature Reserve" (D. Maestri), **Southern Cross University** (1997)
- Co-supervisor for undergraduate dissertation "Riparian Vegetation of upper Cattai Creek" (D. Buckle). **Southern Cross University** (1997)
- Preliminary flora assessment for proposed subdivision and development; Red Gum Avenue, Pennant Hills. The bushland area was subsequently added to Berowra Valley Regional Park. **Friends of Berowra Valley Bushland**

- **NSW National Parks Association** (NPA) Biodiversity Audit, proposed Bargo River National Park. Team Leader, Vegetation - threatened flora
- Guided interpretive walk of Fred Caterson Reserve. **Cattai Catchment Management Committee**
- **NSW NPA** audit of Greater Sydney proposed conservation reserves and additions - assistant and author of NW Sydney reserve proposals
- **NSW NPA** Biodiversity Audit of the proposed Dyarrabin Nature Reserve (~2000 ha) - Project Co-ordinator
- **NSW NPA** Proposal for the creation of Dyarrabin Nature Reserve; revised submission and report of the second NPA Biodiversity Audit
- Preliminary flora study of Crown lands (Functional Area 1), Cattai Ridge Road, Halcrows Road, Hillside/Glenorie; submission to Director NPWS and to Baulkham Hills Council. **NSW NPA**
- Flora survey of Morans Rock Crown lands for proposed addition to Wollemi National Park. **NSW NPA**
- Proposed Welcome Reef Dam (Shoalhaven River north of Braidwood) - assist with flora and fauna surveys. **NSW NPA**. Much of the area is now within Nadgigomar Nature Reserve
- Flora survey of surplus Department of Education lands at Ellerman Park, Round Corner. The local community proposed that the area become a reserve to protect a critically endangered plant community present on the site. **Friends of Ellerman Park**
- Flora survey of Crown lands at South Maroota for proposed Crescent Reach Nature Reserve (later declared as the Maroota Ridge State Conservation Area), **NSW NPA**
- Calangara Nature Reserve Proposal in Kenthurst. Survey and report to **NSW NPA**
- Preliminary Survey of bushland in Holland Reserve, Glenhaven
- Survey of Crown Reserve (now part Scheyville NP), Pitt Town; report to **NSW NPA**

Expert report – *Pimelea spicata*

Expert report for *Pimelea spicata* Spiked Rice-flower – GMAC and Wilton, Teresa James, August 2018

Expert report for *Pimelea spicata* Spiked Rice-flower – GPEC and WSA, Teresa James, April 2019

Strategic Assessment for Cumberland Plain Conservation Plan

Greater Macarthur and Wilton Growth Areas

Expert Report for *Pimelea spicata* Spiked Rice-flower

Prepared for NSW Department of Planning & Environment

Teresa James August 2018

Contents

Introduction

1.1 Purpose of the expert report

An expert report may be prepared under section 6.5 of the Biodiversity Assessment Method (OEH 2017) in place of undertaking a threatened species survey. Use of an expert report may be beneficial where it is highly unlikely that a species may occur within the study area, survey effort is inadequate and/or the reliability of detecting the species through survey is low. In respect of *Pimelea spicata*, low survey effort and unreliability of survey are the primary reasons for preparing an expert report.

The purpose of this report is to provide scientific assessment of the current status and conservation needs of *Pimelea spicata* within the Greater Macarthur and Wilton priority growth areas of western Sydney. Specifically, the report is to determine whether:

- The species is unlikely to be present and in this case no further assessment is required, or
- The species is likely to be present and in this case the expert report must provide estimates of habitat area both within the growth and biocertified or development footprint areas.

1.2 Project context

The NSW Government is identifying areas for future urban development and associated infrastructure in western Sydney. There are four priority growth areas: Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These new growth areas are all located within the Cumberland Interim Biogeographic Regionalisation for Australia (IBRA) sub-region.

As part of the planning for the priority growth areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify development and conservation outcomes for the growth areas. A strategic assessment of this plan is underway and this expert report will assist the biodiversity assessment to assess the conservation benefits and development impacts of the Plan in respect of *Pimelea spicata*.

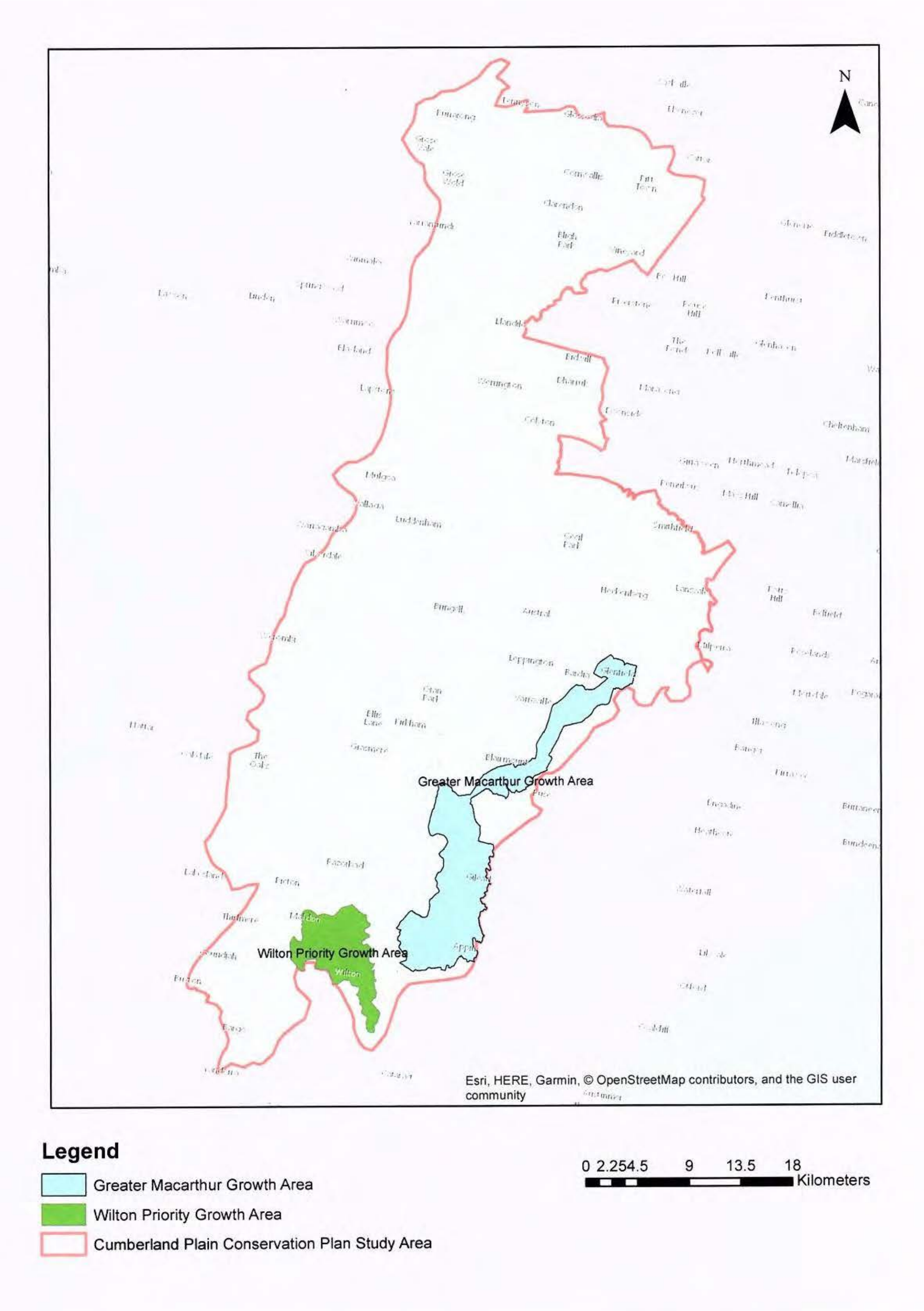
1.3 Study area

The study area for this report comprises the growth areas of Greater Macarthur (Campbelltown and Appin) and Wilton (see Figure 1). It is located within the Cumberland subregion on Triassic Wianamatta Group Shales and transitional shale/sandstone areas in south-eastern parts of the Cumberland Plain, western Sydney. The eastern and southern margins are within the Sydney Cataract subregion defined by the Triassic Hawkesbury Sandstone plateau. The study area is within the Hawkesbury-Nepean and Georges River catchments.

<u>Greater Macarthur Growth Area</u>
The Greater Macarthur PGA extends from Glenfield in the north to Appin in the south. The northern zone is already well developed with remnant vegetation largely restricted to creek-lines or small patches associated with open space reserves. Southern parts of the area, south of Rosemeadow, comprise primarily agricultural lands with larger patches of remnant vegetation associated with the Nepean and Georges Rivers, and associated tributaries.

<u>Wilton Growth Area</u>
The Wilton PGA occurs to the south of the Greater Macarthur Growth Area extending from Douglas Park in the north to south of Wilton. The boundaries closely follow the Nepean River in the north and west, and a tributary Allens Creek in the east. Away from the river and creeks the higher areas are largely cleared for agriculture and hobby farms. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The Woronora sandstone plateau (within the Upper Nepean State Conservation Area) forms the southern boundary. The Hume Highway dissects the growth area.

Figure 1. Greater Macarthur and Wilton Priority Growth Areas



1.4 Credentials of expert - Teresa James (BSc Combined Honours)

I am a botanist/ecologist with over forty years of experience in vegetation survey, plant identification, conservation assessment and threatened species, particularly in western Sydney. I have worked within the NSW government (National Herbarium of NSW, NSW National Parks & Wildlife Service) and for the last twenty years as a consultant (sole trader). A summary of my credentials as required under the Biodiversity Assessment Methodology (2014, 2016) is provided in Table 1.

Table 1. Credentials of Teresa James

BAM section	BAM requirement	Details
BAM s 6.5.2.8 (g)	Name of expert	Teresa James
BAM s 6.5.2.3 (a)	The expert's qualifications	Bachelor of Science (Honours), University of Exeter 1978 Accredited BioBanking Assessor (awarded 2008, renewed 2013)
BAM s 6.5.2.3 (b)	History of experience in ecological research and survey method, for the relevant species	Field surveys and other relevant studies: • Populations of *Pimelea spicata* across western Sydney e.g. Denham Court Road, Campbelltown (1999, 2012), Alpha Road Park, & Grey Box Reserve, Holroyd (2011), Cobham Road Reserve & Power Street Reserve, Fairfield (2016-17), Greendale (near Wallacia), private property (2016-7), Cranebrook Reserve, Penrith (2017). • Threatened community and threatened species (including *Pimelea spicata*) roadside surveys through Campbelltown LGA for Campbelltown City Council (2013) • Targeted survey for *Pimelea spicata* along Denham Court Road, near Camden Valley Way for SMEC (2012) • Expert report to DECCW: Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland at a property on Appin Road, Gilead (2011). • Targeted survey for *Pimelea spicata* at Menangle Park Offset Strategy for GHD (2009, 2010) • Biobanking Pilot Project at Wilton (2007). • Survey & monitoring of Cumberland Plain Woodland and *Pimelea spicata* at Faulkland Crescent Reserve, Blacktown (2004, 2007) for Blacktown City Council.
BAM s 6.5.2.3 (c)	A resume detailing projects pertaining to the survey of the relevant species	Resume attached at Appendix 1. Relevant field surveys listed above.
BAM s 6.5.2.3 (d)	Their employer's name and period of employment (where relevant)	Self-employed ecological consultant Teresa James Flora Consultant 1998 to present
BAM s 6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant species to which the survey relates	1. Author of several botanical guides to the flora of Western Sydney: • James, T.A., McDougall, L & Benson, D. (1999). Revised edition. *Rare Bushland Plants of Western Sydney.* Royal Botanic Gardens, Sydney. • James, Teresa (2013) Flora of Cumberland Plain Woodland – an identification guide. • James, Teresa (2015) Threatened Flora of the Fairfield LGA.

		• James, Teresa (2016) Native Flora of Shale Soils of the Cumberland Plain Woodland – An Identification Guide. 2. Author of flora component of Urban Bushland Biodiversity Survey of Western Sydney (1997). Included compilation of information on *Pimelea spicata* and its habitat across western Sydney local government areas. 3. Contributed information to the *Pimelea spicata* Approved Recovery Plan (2006). 4. Has acted as Expert witness in NSW Land and Environment Court in relation to threatened communities in western Sydney including: • Expert advice to OEH and Land & Environment Court in relation to alleged clearing of endangered ecological communities (Cumberland Plain Woodland and Shale Sandstone Transition Forest) at Gilead, western Sydney. Proceedings 50604 of 2011. • Expert advice to Liverpool City Council ats Muslim League of NSW – 264 Wilson Road, Green Valley. Land & Environment Court Proceedings No 10394 of 2005. Issues relating to Cumberland Plain Woodland. • Expert advice to Liverpool City Council ats AV Jennings – Stage 24 Dalmeny Drive, Prestons. Land & Environment Court Proceedings No 10395 of 2006. Issues relating to Cumberland Plain Woodland. 5. PAS2 Expert Interviews for several NSW threatened species with OEH (February-August 2012) including a range of Cumberland Plain species 6. Member of SOS Project Panel (2018) – Cumberland Plain Woodland, Western Sydney Dry Rainforest, Moist Shale Woodland, River-flat Eucalypt Forest, Agnes Banks Woodland and Castlereagh Ironbark Forest 7. Member of NPWS Cumberland Plain Recovery Team (1998)

Through this experience I have developed a good knowledge and understanding of the life history and habitat requirements of *Pimelea spicata* and associated habitats within the growth areas.

1.5 Justification for use of expert report

An expert report for *Pimelea spicata* is required as part of the threatened species assessment for the Cumberland Plain Conservation Plan for the following reasons:

1. The survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH 2016) for field traverse surveys due to limitations imposed by land access particularly within the Greater Macarthur Growth Area. Around 69% of total potential habitat for *Pimelea spicata* has been able to be accessed for survey with only 56% in the Greater Macarthur Growth Area.
2. Inadequate survey timing. *Pimelea spicata* is difficult to detect particularly when not in flower. Flowering is unpredictable and considered dependant on good rains (Environmental Impact Assessment Guidelines NPWS 2004, and personal knowledge). During dry periods the species is often invisible above ground but may persist in the soil as rootstock and seed. Dry, hot spring/summers have been a particular feature of the western Sydney environment in the last few years.

3. The cryptic nature of the species and extent of disturbance across the growth areas significantly reduces the likelihood of detecting the species. Many populations have only been recorded once the disturbance factor e.g. mowing, grazing or weed infestation has been removed. Many of the sites surveyed have been heavily grazed or mown.

Survey for *Pimelea spicata* has been insufficient to reliably determine the presence and extent of the species within the growth centres. An expert report is necessary to provide a more comprehensive and reliable level of scientific assessment.

1.6 Species surveys

1.6.1 *Summary of survey work undertaken*

To assess the impacts of development within the growth areas both existing and new biometric data has been used together with general and targeted survey. Extensive field sampling has been undertaken with assessment based on vegetation zones consistent with the Biodiversity Assessment Methodology (BAM 2017). Quantitative plot data has been collected to sample variability within each vegetation zone (Ecoplanning, Biosis 2017-18). More general flora and fauna survey has also been undertaken including targeted survey for threatened species including *Pimelea spicata* (Biosis). Surveys have been undertaken by Ecoplanning and Biosis.

Survey effort has varied across the study area. The northern extent of the Greater Macarthur growth area has been well surveyed by Biosis (general and targeted survey) reflecting the small areas and easy access. The only plot sampling (Ecoplanning), however, was in Georges River Reserve at Glenfield. The southern extent of the Greater Macarthur growth area has been less well surveyed with around 50% of habitat polygons surveyed (due primarily to limited access) and again mostly through general/targeted survey by Biosis. Many of the areas surveyed were reported to be heavily grazed (Bruce Mullins pers. comm.). The Wilton Growth Area has been relatively well-surveyed particularly in the north-eastern plateau area with both general and targeted survey (Biosis) and plot sampling (Ecoplanning).

The location of survey areas, tracks and plots are shown in Figures 9-11.

1.6.2 Land access

An initial 726 letters were sent to landholders within the Growth Areas in late 2017 followed by a second letter in March 2018, and targeted door knocking in May 2018 (DPE *pers.comm*.). Just under 20% of landholders responded. Surveys were undertaken on all areas of land where landowners granted access. Of the 14,984 hectares within the Wilton and Macarthur Growth Areas, of which 5,385 ha is potential native vegetation that could be impacted by development, DPE has completed surveys across 3,360 hectares (62% of the total survey area).

There is 765 hectares of total potential habitat (Cumberland Plain Woodland only) available for *Pimelea spicata* across the Wilton and Greater Macarthur Growth Areas. Of this area 530 hectares or 69% has been able to be accessed for survey. While nearly all available habitat was surveyed in the Wilton Growth Area, only 56% of potential habitat was able to be accessed in the Greater Macarthur Growth Area. Table 2 summarises the total area of habitat for *Pimelea spicata* that was surveyed.

1.6.3 Survey timing

Surveys for *Pimelea spicata* should be undertaken when flowering. Flowering is sporadic throughout the year and is likely to be in response to climatic conditions, particularly rainfall (DEC 2006). At other times plants are difficult to see or may only be present as rootstock or seed. Surveys have occurred between November 2017 to May 2018 and no sighting of this species has been recorded within the growth areas. Spring/summer was hot and dry with unfavourable conditions. Many of the Cumberland Plain Woodland sites surveyed were also heavily grazed.

Table 2. Total area of *Pimelea spicata* habitat surveyed (data provided by Dept. Planning & Environment)

Growth Area	Vegetation community	Total area (ha)	Survey area (ha)	Percent surveyed %
Greater Macarthur	849	293	204	70
	850	206	73	35
Sub-total		499	277	56
Wilton	849	236	222	94
	850	31	31	100
Sub-total		267	253	95
TOTAL		**766**	**530**	**69**

2. Species Information

2.1 Species description

A small, slender to spreading shrub or sub-shrub to c. 50 cm high; stems 1-several, glabrous. Older stems are often seen intertwining with grasses and herbs. *Pimelea spicata* has an underground carrot-like tap root recorded up to 18 cm in length that gives plants the ability to re-sprout after defoliation and periods of drought stress (NSW NPWS 1997). The leaves are mostly opposite, narrow-elliptic to elliptic in shape, to 20 mm long and 8 mm wide, spreading, soft and often bluish-green. Inflorescence is a raceme, dense when young, elongated and interrupted at maturity, bracts absent. Flowers tubular, white to pink tinged, 7-10 mm long with four spreading lobes. Fruit is a narrow-ovoid nut, c. 3 mm long, 1-seeded, mostly green.

Pimelea spicata leaves & flowers (left)
fruit (above)

2.2 Biology/ecology

Pimelea spicata is incapable of effective vegetative spread (Benson and McDougall 2001) although more recent observations suggest that mature individuals can spread over short distances through underground rhizomes (OEH 2017). Seed production, however, is the primary means of recruitment. Flowering is sporadic throughout the year and is likely in response to climatic conditions, particularly rainfall (DEC 2006). Flowering and fruiting has been observed in plants 1.5-2 years old (NPWS 1997); flowers continue to be produced as fruits mature. Native bees are known pollinators and moths may also contribute to pollination (DEC 2006). The species may also be capable of spontaneous self-pollination (DEC 2006). Fruiting is highly variable depending on environmental conditions. Seed viability has been recorded as relatively high ranging from 83% - 86% (Nash & Matthes 1995, Willis et al. 2003 cited in DEC 2006). Seed dispersal is highly localised with the majority of seedlings observed within 30 cm of adult plants following fire (Hogbin pers. obs. cited in DEC 2006). *Pimelea spicata* maintains a long-lived soil-stored seed bank resulting in potential for considerable recruitment following disturbance. The soil seed bank can survive under infestations of invasive weeds (Willis et al cited in DEC 2006).

Seed germination can be triggered by disturbance including fire, slashing/mowing, grazing and soil disturbance (NPWS 1997, Willis et al 2003 cited in DEC 2006). Monitoring of seedlings following fire revealed 80% survival in the first year (NPWS 1997 cited in DEC 2006). Ex-situ trials found that smoke application increased seed germination (Tozer & Robertson 1998), however, Willis et al. (2003) cited in DEC (2006) found only a 20-30% germination rate for seed in any trial.

Re-sprouting from the taproot occurs following defoliation caused by fire, drought or physical damage (NPWS 1997). The species can survive periods of drought stress or weed infestation by dying back to the tap root and re-sprouting when favourable conditions return. It is unknown at what age the tap root has to be of a sufficient size to facilitate re-sprouting.

2.3 Distribution and abundance

Pimelea spicata occurs in two disjunct regions of the Sydney Basin IBRA bioregion, the Cumberland Plain in western Sydney and the coastal region of the Illawarra, south of Sydney.

<u>Cumberland Plain</u>
On the Cumberland Plain *Pimelea spicata* is found on clay soils derived from Wianamatta Group Shales. The current known distribution extends from Freeman's Reach in the north to Douglas Park in the south and west from Penrith to Georges Hall in the east. *Pimelea spicata* has been recorded in the following vegetation communities:

PCT 849 – Grey Box – Forest Red Gum grassy woodlands on flats of the Cumberland Plain
PCT 850 - Grey Box – Forest Red Gum grassy woodlands on shale of the southern Cumberland Plain
PCT 806 & 807 – Derived grasslands on shale hills and shale plains of the Cumberland Plain
PCT 830 – Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain

These communities are equivalent to the Cumberland Plain Woodland and Moist Shale Woodland threatened ecological communities.

The recovery plan for *Pimelea spicata* (DEC 2006) identified 25 populations on the Cumberland Plain. Currently there are approx. 70 sites (Bionet Atlas records, June 2018). The main concentration of sites is found in the Blacktown, Prospect, Bankstown and Narrellan districts. More recent records (post 2014) are from near Wallacia and Horsley Park - Cecil Park. Populations in Campbelltown and Wollondilly LGAs are close to the south-eastern limit of the specie's geographical range.

<u>Coastal Illawarra</u>
In the Illawarra *Pimelea spicata* is associated with coastal headlands and hill tops from Mount Warrigal south to just north of Kiama. The recovery plan for *Pimelea spicata* (DEC 2006) identified 5 populations in the Illawarra.

In 2006, the total population of *Pimelea spicata* across 30 known populations was estimated to be around 4300. Populations varied from a few individuals to >500 plants although larger populations were rare with over half with <50 individuals and small habitat areas of less than 0.5 ha (DEC 2006, Dept. Environment & Heritage 2016*)*. Since 2006 several populations are likely to have been lost to development or habitat modification. At several sites survey has failed to re-locate plants including at Menangle and along Denham Court Road near Camden Valley Way (*James* 2009, 2010, 2012). Prolonged periods of drought, increased weed invasion and heavy grazing are likely to be the main causes. Counterbalancing losses are several new records and increased abundance at some existing sites. There have been new records within Fairfield, Liverpool and Penrith LGAs (mostly <50 individuals). Increased population sizes are noted at Narellan and Prospect.

2.4 Habitat

Pimelea spicata is found in grassy woodlands on shale on the Cumberland Plain and on grassy coastal headlands in the Illawarra.

<u>Cumberland Plain</u>
On the Cumberland Plain *Pimelea spicata* occurs in Cumberland Plain Woodland, Moist Shale Woodland and derived grasslands. Associated canopy trees are Grey Box *Eucalyptus moluccana*, Forest Red Gum *E. tereticornis,* Narrow-leaved Ironbark *E. crebra* and Spotted Gum *Corymbia maculata*. The mid-storey typically contains *Acacia parramattensis, A. decurrens, Bursaria spinosa*, *Acacia implexa, A. falcata, Dillwynia sieberi* and *Indigofera australis*. Common groundcover grasses and herbs associated with occurrences include Kangaroo Grass *Themeda triandra,* Weeping Grass *Microlaena stipoides,* Kidney Weed *Dichondra repens*, Woodruff *Asperula conferta* and Blue Trumpet Flower *Brunoniella australis*.

Pimelea spicata prefers moist soil and often occurs on gentle lower slopes where groundwater seepage maintain soils damper for longer (*T. James pers. obs.*). A relatively open groundcover maintained by occasional disturbance e.g. fire or infrequent/low intensity grazing/slashing provides favourable habitat. Although the species can survive (and flower) among taller grasses and perennial weeds (e.g. at Cobham Street Road, Horsley Park) it is likely to disappear above ground under dense weed infestations. The Denham Court Road population in 2003, for example, was estimated to be hundreds yet in 2011 no plants were found where plants were previously plentiful (*T. James pers. obs.)*. The road reserve had become increasingly degraded with weed infestation in both the mid-storey layer (African Olive, Box Thorn and Lantana) and the ground-layer (Bridal Creeper, Prickly Pear, Blackberry & Mother-of Millions). The species was likely still present in the soil seed-bank.

Frequent or intensive grazing, slashing or mowing will restrict the growth of plants with re-sprouting controlled by the frequency of disturbance and environmental conditions. Frequent cutting creates open, dry and hot conditions at the soil surface resulting in die-back of plants above ground. The species can persist for many years under such a regime as a tap root and seed in the soil. There are many examples of regeneration following cessation of mowing and slashing in council reserves e.g. Faulkland Crescent Reserve and Melrose Park in Blacktown and Power Street Reserve in Fairfield.

Habitat of *Pimelea spicata* along unformed road reserve (Cobham Road, Horsley Park)

Illawarra
In coastal habitat of the Illawarra *Pimelea spicata* occurs in a wider range of geologies and soils derived from the Permian Shoalhaven (sandier than the clay soils of western Sydney). The favoured sites are on grassy headlands and hilltops with Kangaroo Grass *Themeda triandra*, Mat-grass *Lomandra longifolia* and Blady Grass *Imperata cylindrica*, often with Coast Banksia *Banksia integrifolia*. Woodland is also often dominated by Forest Red Gum *Eucalyptus tereticornis* and Thin-leaved Stringybark *E. eugenioides* above Kangaroo Grass, species also occurring in *Pimelea* habitat in western Sydney. Habitat in the Illawarra includes the endangered ecological community *Themeda Grasslands on Seacliffs and Coastal Headlands* (PCT 898).

3. Description of the study area

3.1 Landscape context and land use history

3.1.1 Greater Macarthur Growth Area (GMGA)

The Greater Macarthur PGA extends from Glenfield in the north to Appin in the south. It is largely within the Campbelltown LGA with the southernmost section within the Wollondilly LGA. The northern half of the growth area comprises an urban renewal corridor centred on the Sydney to Southern Highlands railway line. It encompasses the existing industrial and residential suburbs of Glenfield, Macquarie Fields, Minto, Leumeah and Campbelltown. The Growth Area is associated with extensively cleared, gently undulating shale terrain typical of the Cumberland Plain and contrasting with the sandstone gorges and plateaus along the Georges River to the east. The northern zone is already well developed with remnant vegetation largely restricted to creek-lines or small patches associated with open space lands. Vegetated creek-lines include Bunbury Curran Creek, Bow Bowing Creek, Leumeah Creek, Fishers Ghost Creek and Spring Creek. Bushland reserves containing Cumberland Plain Woodland and River-Flat Eucalypt Forest TECs include Bunburry Curran Reserve, Pembroke Park and John Kidd Reserve (Blair Athol).

The more extensive southern half of the PGA, south of Rosemeadow, comprises proposed land release areas at Menangle Park, Mount Gilead and Appin. In the north-west Mount Sugarloaf (213 m asl) forms the southern end of a hilly ridge on the Luddenham soil landscape above the Menangle floodplain that extends north up to Denham Court. Some native vegetation persists although invaded by African Olive. The floodplain is well dissected by Menangle Creek and its tributaries including Nepean Creek, Woodhouse Creek and Leafs Gully. These are primarily semi-rural and agricultural land, with creek corridors and some larger patches of remnant vegetation, located between the Nepean and Georges Rivers. Geologically the area comprises gently undulating hills on shale intergrading via a shale/sandstone transitional zone with steeper terrain on Hawkesbury sandstone along the rivers. Transitional and sandstone geologies are sometimes exposed along the smaller creek lines.

3.1.2 Wilton Growth Area (WGA)

The Wilton PGA occurs to the south of the Greater Macarthur PGA extending from Douglas Park in the north, Maldon in the north-west and to south of Wilton. The boundaries closely follow the Nepean River in the north and west, a tributary Allens Creek in the east and the Cordeaux River in the south. Away from the Nepean River and gullies a higher gently undulating zone has been largely cleared for agriculture. The Woronora sandstone plateau (within the Upper Nepean State Conservation Area) and part of the Sydney Water Catchment forms the south-western boundary. The Hume Highway dissects the PGA north to south and Picton Road NW to SE.

The WPGA includes both shale, shale/sandstone transitional and sandstone environments. Remnant vegetation occurs predominantly along the watercourses and on associated slopes. The flatter shale terrain has soils of the Blacktown soil landscape, which is derived from Ashfield Shale and typically support shale woodlands. Much of this area is cleared or modified for agriculture and hobby farms. It comprises native/exotic grassland with smaller areas of better condition Derived Native Grasslands. Steeper slope areas above the gullies are comprised of soils of the Lucas Heights soil landscape derived from the Mittagong Formation (located between the Ashfield Shale and Hawkesbury Sandstone). The Lucas Heights soils are a mix of clays and sands and occur within the shale/sandstone transition zone, they support variable transitional woodlands and forest. In the steeper gullies the Hawkesbury soil landscape dominates and supports Hawkesbury Sandstone Gully Forest types.

3.2 Native Vegetation

3.2.1 Greater Macarthur Growth Area

The predominant vegetation communities are Cumberland Plain Woodland (CPW), Shale Sandstone Transition Forest (SSTF) and River-flat Eucalypt Forest (RFEF), all threatened ecological communities. A summary of mapped communities based on maps provided by NSW Planning & Environment is found in Table 3.

Table 3. Summary of vegetation communities within the Greater Macarthur Growth Area

PCT No	PCT Name	TEC / Non-TEC	Distribution & notes
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Moist Shale Woodland (MSW)	Small patch at Menangle Sugarloaf on SE slopes (map 4)
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	River-flat Eucalypt Forest (RFEF)	Along creek lines in shale areas in northern and central parts of GMGA (maps 1-5)
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CPW)	Small patches on shale soils throughout GMGA but mostly in northern and central parts
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Cumberland Plain Woodland (CPW)	Very small patches on shale soils throughout GMGA, more common in southern parts
806	Derived grasslands on shale hills of the Cumberland Plain	Cumberland Plain Woodland (CPW)	On shale soils in central and southern parts on agricultural & semi-rural lands.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (SSTF)	Most extensive community on shale /sandstone transition soils mostly south from Rosemeadow (maps 5-7) intergrading with CPW. Along smaller creek-lines and upper slopes of Nepean River & Georges River.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	SSTF – higher shale influence examples otherwise not a TEC (Sydney Hinterland Transition Woodland)	One small patch mapped e.g. along Smiths Creek at Leumeah (map 3). Higher shale influenced forms are consistent with SSTF TEC.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Not a TEC, (Hinterland Sydney Sandstone Gully Forest)	Narrow zone along Nepean & Georges Rivers and tributary gullies (maps 5-7) and small zone along Smiths Creek at Leumeah (map 3)

3.2.2 Wilton Growth Area

The predominant vegetation communities within the growth area are Cumberland Plain Woodland (& Derived Grasslands) on the shale and Shale Sandstone Transition Forest in shale/sandstone transitional areas, both listed as critically endangered ecological communities in NSW. Cumberland Plain Woodland and Shale Sandstone Transition Forest are also listed under the EPBC Act (1999). A summary of mapped communities based on maps provided by NSW Planning & Environment and Cumberland Ecology (2016) is found in Table 4.

Table 4. Summary of vegetation communities within the Wilton Growth Area

PCT No	PCT Name	TEC / Non- TEC	Distribution & notes
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CPW)	On shale soils of higher gently undulating terrain of northern central parts of WGA (mostly map 2). Small patches with scattered trees (farming properties) adjoining more extensive exotic and native grasslands.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Cumberland Plain Woodland (CPW)	Small patch in western part of WGA (map 1).
806	Derived grasslands on shale hills of the Cumberland Plain	Cumberland Plain Woodland (CPW) (NSW)	On shale soils of higher gently undulating terrain of northern central parts of WGA (mostly map 1 & 2).
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (SSTF)	The most extensive community on shale/sandstone transition soils between CPW and sandstone communities along gullies in the WGA (maps 1-3). Variable floristics.
1081	Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain	SSTF - high shale examples only otherwise not a TEC (Sydney Hinterland Transition Woodland)	Few patches restricted to flatter land (often spurs) downslope of SSTF & above gully. Higher shale influenced forms are consistent with SSTF TEC.
1181	Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of west & south Sydney	Non-TEC Hinterland Sydney Sandstone Gully Forest	Narrow zone along Nepean River and tributary gullies (maps 1-3)
1292	Water Gum – Coachwood riparian scrub along sandstone streams	Non-TEC Riparian Forest	Very narrow zone along Nepean River (maps 1 & 2).
862	Grey Gum – Hard-leaved Scribbly Gum woodland of the Cox's Valley	Non-TEC Burragorang-Nepean Hinterland Woodland	Small patches mapped by Cumberland Ecology (2016) in NE of WGA above Allens Creek. These patch are included in SHTW in the DPE mapping.

3.3 Potential habitat for *Pimelea spicata*

Pimelea spicata is known to occur in the following vegetation communities:

PCT 849 – Grey Box – Forest Red Gum grassy woodlands on flats of the Cumberland Plain
PCT 850 - Grey Box – Forest Red Gum grassy woodlands on shale of the southern Cumberland Plain
PCT 806 & 807 – Derived grasslands on shale hills and shale plains of the Cumberland Plain
PCT 830 – Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain

Potential habitat may also occur in low sandstone forms (at the shale end of the transition) of Shale Sandstone Transition Forest, *Narrow-leaved Ironbark – Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain* (PCT 1395) which is structurally and floristically very similar to Cumberland Plain Woodland at the shale end of the transition (see Section 4.3.1).

Degraded examples of these communities (i.e. reduced canopy and/or mid-layer cover or weedy areas) can still provide habitat for the species due to its long-term persistence as woody rootstock (tap root) and in the soil seed bank. The communities identified above are equivalent to the Cumberland Plain Woodland, Moist Shale Woodland and Shale Sandstone Transition Forest threatened ecological communities.

3.3.1 Greater Macarthur Growth Area

Cumberland Plain Woodland (including Derived Grasslands) comprises >50% of remnant vegetation mapped in northern parts of the GMGA (south to around Rosemeadow) and around 20% (may be higher depending on extent of derived grasslands) in the southern section. There is around 70 ha of Moist Shale Woodland mapped in the vicinity of Mount Sugarloaf. High and low sandstone influenced SSTF has not been mapped separately (can be useful) in the mapping provided, however, SSTF occurring adjacent to CPW or in shale areas away from creek-lines may provide potential habitat.

Table 5. Potential habitat in the Greater Macarthur Growth Area

Vegetation community	Distribution	Habitat value
Cumberland Plain Woodland (all conditions including mowed or slashed as long as meet final determination)	Throughout but mostly in northern parts south to Rosemeadow.	High: most records from CPW both Shale Plains and Shale Hills
Moist Shale Woodland	Highly localised at Mount Sugarloaf	High: moist conditions favour the species
Shale Sandstone Transition Forest (low sandstone influence)	Throughout but mostly in southern parts	Moderate: not typically recorded from this community, however, at the shale end of the transition examples of CPW and SSTF are difficult to distinguish
Derived Native Grasslands (including mowed, slashed or grazed)	Throughout comprising grazing lands, roadsides & council reserves	Moderate to high: several records from over-cleared CPW or derived native grasslands

3.3.2 Wilton Growth Area

Due to the smaller area and reduced influence of shale with a corresponding increase in influence from sandstone at the edge of the Cumberland Plain, the extent of potential habitat for *Pimelea spicata* is less in the WPGA than the GMPGA.

Table 6. Potential habitat in the Wilton Growth Area

Vegetation community	Distribution	Habitat value
Cumberland Plain Woodland (all condition states)	Mostly in northern parts.	High, most records from CPW both Shale Plains and Shale Hills
Shale Sandstone Transition Forest (low sandstone influence)	Throughout	Moderate, not typically recorded from this community but at shale end of the transition examples of CPW and SSTF are difficult to distinguish.

Vegetation community	Distribution	Habitat value
Derived Native Grasslands (including mown, slashed or grazed)	Mostly northern areas comprising grazing lands, roadsides & council reserves	Moderate to high. Several records from over-cleared CPW or derived grasslands with varying levels of native species

4. Assessment of species presence and suitable habitat

4.1 Species records, habitat assessments and prior surveys

4.1.1 Species records

Records used in this report have been sourced from the NSW Bionet Atlas. Only four records relating to two sites exist for the Greater Macarthur Priority Growth Area (GMPGA) and none for the Wilton Priority Growth Area (see Table 7). One record from Glenfield in the far north of the GMGPA is suspect. See Figures 2 & 3.

Table 7: *Pimelea spicata* records from within Greater Macarthur Growth Area

Location	Date of record	No. of individuals	Notes
Minto Industrial Estate	2004	?	CP2 of Recovery Plan (DEC 2006) - original population destroyed & plants translocated to buffer area
Minto Industrial Estate	12/07/2012 – 13/02/2013	1	Apparently location close to CP2, now also cleared & developed based on current imagery
Minto Industrial Estate	7/03/2013	28	Habitat 10 m x 10 m in outlying stand of *Eucalyptus crebra* (CPW)
Western end of Glenfield Waste Services site at northern edge of GMGA (based on coordinates) but location given on record is Catholic school grounds, Leacock Lane, Casula	01/03/1992	?	Coordinates likely inaccurate. The Glenfield location is not identified in the recovery plan.

The Minto population is located within a 30 m wide strip of Cumberland Plain Woodland along Pembroke Road near the intersection with Ben Lomond Road. This habitat is part of a conservation area connected to a 60 m wide strip along Ben Lomond Road. The conservation area comprises a total area of c. 2.3 ha and is subject to a Bushland Plan of Management (Anne Clements & Associates 2010). The long-term security of this population is doubtful considering the narrow vegetation zones subject to extensive edge effects and long-term health of the remnant will depend on ongoing management.

There are several records located just outside of the Greater Macarthur Growth Area within the Liverpool -Campbelltown & Camden LGAs at Casula, Denham Court, Narellan and Mt. Annan. Records in Wollondilly are limited to one site just north-east of Douglas Park (ref Appin Mine VS#6). Information relating to the closest and highest density of records is summarised in Table 8.

Table 8. *Pimelea spicata* records just outside of the Greater Macarthur Growth Area

Location	Date of record	No. of individuals	References/notes
Appin Mine VS#6 c. 1-2km west of GMGA	2012-14	c. 100	Many records within an area of c. 5 ha on SSW facing slope. Site was subject to grazing, slashing & weeds. In Shale Hills Woodland.
Mt Annan Botanic Garden & surrounds 2 km west	1991 - 1998	Locally abundant	Conservation Area Mt Annan Botanic Gardens. Population CD1 of recovery plan.
All Saints Catholic College school grounds, Leacock Lane, Casula c. I km to the north	1992	Scattered colonies in 0.5 sq. km area	Population L2 of the recovery plan. Dry hilltops. Current status unknown, no plants see in 2003 (recovery plan), no subsequent records.

The largest and most recently recorded population is located within a secure offset site for the Appin Mine No 6 Ventilation Shaft (Niche Environment & Heritage 2011). Populations at Mount Annan (and surrounding areas) are well documented, those within the Mt Annan Botanic Gardens conservation area are likely to be secure. Other sites at Casula and Denham Court occur on private land and current status is unknown.

4.1.2 Habitat assessments and prior surveys in Greater Macarthur Growth Area

Menangle Park – targeted survey for *Pimelea spicata* (James 2009, 2010). Three remnants of Cumberland Plain Woodland totalling an area of c. 7 ha were surveyed in 2009 & 2010. They form part of Map 4 of the GMPGA and occur within the proposed urban development footprint. Based on current imagery these remnants appear to be in similar condition to that observed in 2009-10 i.e. of similar size and landscape context with ongoing grazing pressure. All sites contained potential habitat for *Pimelea spicata* although no plants were recorded. The survey was limited by prolonged dry conditions (particularly in 2009) and heavy grazing from horses. Plants are unlikely to be visible if present until grazing ceases and groundcover improves. These conditions are likely typical of similar habitat within the growth areas. Details of the sites are provided in Table 9. These sites were re-surveyed by Biosis for the strategic assessment.

It is noted that these remnants of Cumberland Plain Woodland are mapped in the strategic assessment mapping as PCT 1395 (SSTF) and not Cumberland Plain Woodland vegetation. I disagree with the mapping.

Table 9. Menangle habitat assessment sites

Site Id	Location [GDA94 MGA56]	Size	Habitat details	Survey effort & findings
1	South of Menangle Road at junction with Cummins Road 292394E, 6223452N	2 ha	CPW Grey Box – Forest Red Gum Small patch surrounded by grazing land (horses); gentle south-facing slope. Saline often bare soils. Weed invasion at shrub and ground-layer. Heavy grazing pressure. Low condition.	• 1 hour 30 mins random meander • No plants found • Conditions dry, unsuitable for survey • Low potential habitat
2	Eastern side of Cummins Road 292468E, 6223863N	2.5 ha	CPW Narrow-leaved Ironbark Small patch surrounded by grazing land (horses); moderate west-facing slope. *Bursaria spinosa* in shrub layer with *Indigofera australis*, ground cover with mix of native & exotic species. Moderate condition. Moderate grazing pressure.	• 2 hours 45 mins random meander • No plants found • Conditions dry, unsuitable for survey • Potential habit present

Site Id	Location [GDA94 MGA56]	Size	Habitat details	Survey effort & findings
3	Eastern side of Cummins Road, just north of Station Road intersection	5 ha	CPW Forest Red Gum - Narrow-leaved Ironbark; small patch surrounded by grazing land; gentle north-west facing slope. Shrub layer dominated by African Olive & Box Thorn; ground cover with mix of native & exotic species & much bare ground. Low condition with heavy grazing pressure, horses & rabbits.	• 1hour random meander • No plants found • Conditions dry, unsuitable for survey • Low potential habit present

Mt Gilead Biodiversity Assessments – NPWS (1997), Eco Logical (2017)

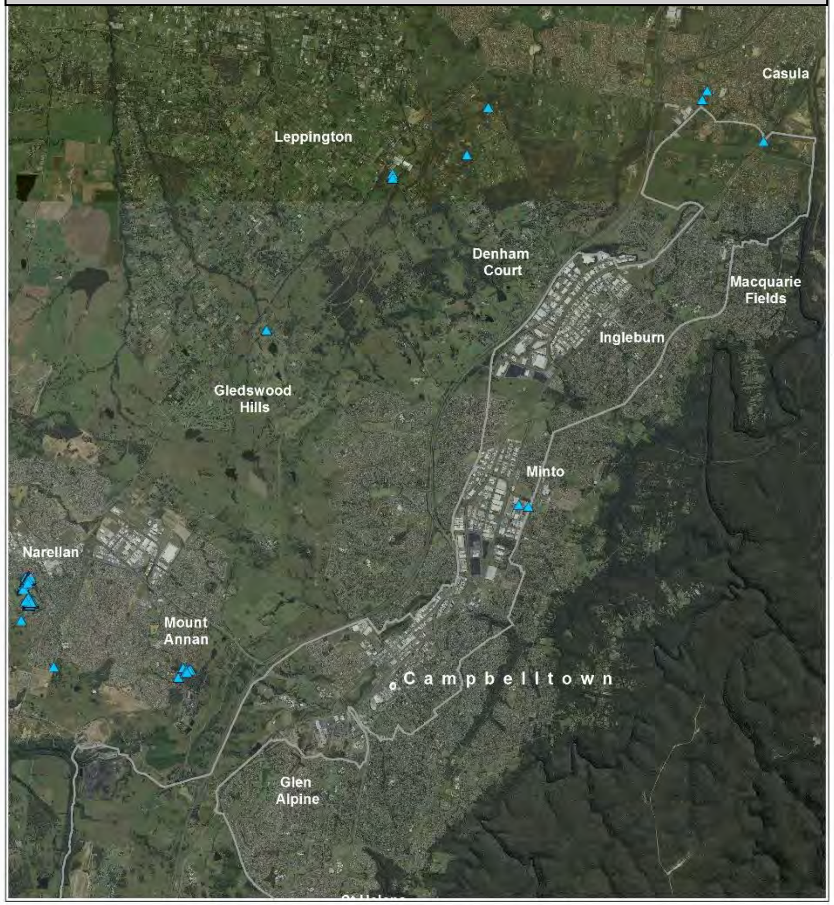
As part of the Mt Gilead *Biodiversity Certification Assessment & Biocertification Strategy* (2017) detailed survey and community verification was undertaken in 2015-2016 between Noorumba Council Reserve and Beulah Biobank Site (eastern boundary along Appin Road). Although these surveys were limited to the north-eastern section of Mt. Gilead, previous surveys had been undertaken in 2006 and 2013 across larger areas and over several months.

Table 10. Previous studies undertaken at Mt. Gilead

Previous study	Survey area	Effort (flora)	Results
ELA 2006	Mt Gilead (810 ha)	• 4-day survey Feb & March 2006 including flora, fauna & riparian health • Validation of vegetation communities, random meander • Threatened flora survey, random meander	• 4 vegetation communities (3 EECs – RFEF, CPW, SSTF) • No *Pimelea spicata* recorded
ELA 2014	Part of Mt. Gilead (210 ha)	• 4-day survey March, April, June, Sept 2013 including flora, fauna • Validation of vegetation communities, random meander & 18 Biometric plots • Threatened flora survey, random meander	• 3 EECs recorded RFEF, CPW, SSTF • No threatened flora species
ELA 2017	Part of Mt. Gilead (209 ha)	• Jan, Feb, April Sept, October 2015; Jan, Feb, Mar, August 2016 • 20 Biometric plots (9 same as in 2014) • Threatened flora survey, random meander	• 3 EECs recorded RFEF, CPW (8.75 ha), SSTF (20.62 ha) • No *Pimelea spicata* recorded

Although the land could not be accessed for the strategic assessment, survey effort has been comprehensive over several years in parts of the site. No plants of *Pimelea spicata* were recorded. Detection of plants, however, has and continues to be limited by ongoing clearing, slashing and grazing across much of the area. The extent of Cumberland Plain Woodland is also limited due to a higher sandstone influence particularly along creek-lines.

Figures 2 & 3. *Pimelea spicata* atlas records for GMGA & surrounding areas



Greater Macarthur Priority Growth Area (Northern Extent)

▲ Pimelea spicata - Bionet Records

Greater Macarthur Priority Growth Area (Southern Extent)

▲ Pimelea spicata - Bionet Records

Glenfield Waste Services (EPS 2015)
The Glenfield Waste Services site is located in the far north of the Greater Macarthur growth area along Cambridge Avenue at Glenfield. Known *Pimelea spicata* sites occur to the north and south at Casula and Minto. The location of a record just west of the site is considered dubious. Community verification and targeted survey was undertaken in 2012 and 2013. Suitable habitat occurs at the site but no plants were recorded.

Table 11. Glenfield flora survey

Previous studies	Survey area	Effort (flora)	Results
EPS (2015)	Glenfield Waste Services site (60 ha)	May & July 2012 random meander & 8 quadrats Dec 2013 – random meander targeted survey for Pimelea (12 hours, 1 hr per ha)	12 ha of Shale Plains Woodland & potential habitat No plants of Pimelea found. No details of conditions at time of survey.

Campbelltown LGA roadside habitat survey (James 2013)

Approximately 93 km of roadside habitat was surveyed over three weeks during September 2013. Sections of roadside surveyed relevant to this report are listed below:

- Glenfield – Cambridge Avenue (east of Railway Parade)
- Macquarie Fields – Victoria Road adjoining Bunbury Curran Reserve, Canterbury Road, Minto Road
- Menangle – Menangle Road (from Callaway Avenue to LGA boundary)
- Gilead – Appin Road (Noorumba Reserve to LGA boundary sign)

Pimelea spicata was targeted in remnants of CPW but no plants were found. The road reserves are typically closely mown preventing shrub regeneration except close to remnant trees and along fence-lines. Potential habitat in other areas is affected by dense woody growth of African Olive. Roads with mature habitat trees and patches of relatively intact native groundcover include Appin Road and Menangle Road. African Love Grass and Kikuyu are dominant invasive species along the roadsides in CPW resulting in loss of native species.

Based on these findings it is reasonable to expect potential habitat to exist along some of the more natural roadsides within the growth areas particularly in more rural environments of the central and southern parts. To realise this potential, however, will require appropriate protection and management. A summary of findings is provided in Table 12.

Table 12. Survey details for Campbelltown LGA roadside habitat survey

Previous studies	Survey area	Effort (flora)	Results
Campbelltown roadside survey T. James (2013)	Cambridge Avenue, Glenfield	Walking along roadsides with targeted search within patches of CPW	Confirm CPW on northern side of road adjoining Glenfield Waste Services site. Weedy. No *Pimelea spicata* recorded but potential habitat.
Campbelltown roadside survey T. James (2013	Canterbury Road Victoria Road Minto Road (Macquarie Fields)	Walking along roadsides with targeted search within patches of CPW	Small patch mapped as CPW is SSTF along Canterbury Rd. No potential PS habitat in this patch. SSTF along Victoria Rd, unlikely habitat. Minimal CPW potential habitat.

Campbelltown roadside survey T. James (2013	Menangle Road (Menangle Park)	Walking along roadsides with targeted search within patches of CPW	Small patches of CPW & derived grasslands, some mown, others with good native groundcover. Potential habitat in these patches south of Glen Alpine.
Campbelltown roadside survey T. James (2013	Appin Road (S. of Rosemeadow)	Walking along roadsides with targeted search within patches of CPW	Mostly CPW/very low sandstone influenced SSTF to just south of Mallaty Creek. Some good sections with larger remnant trees, native groundcovers/sparse shrubs & grasslands. Potential habitat.

4.1.3 Habitat assessments and prior surveys in the Wilton Growth Area

Wilton Junction New Town – Cumberland Ecology/SLR Consulting 2016

Surveys associated with the Wilton Junction/Bingara Gorge covered the eastern side of the WPGA. Comprehensive flora investigations were undertaken in 2013 and 2014 (see details below).

Table 13. Survey details for Wilton

Previous study	Survey area	Effort (flora)	Results
SLR **2013-14**	Wilton Junction /Bingara Gorge	• Walked and driven transects • Target searches for threatened species • 20 m x 20 m flora plots & 50 m transects • 68 *Over-The Fence* surveys	See below
Cumberland Ecology **2014-16**	Wilton Junction /Bingara Gorge	• Collection of biometric data within each plant community • Vegetation mapping	c. 60 ha of CPW identified c. 65 ha of SSTF (low sandstone) c. 8 ha of Derived native Grassland (CPW) No records of *Pimelea spicata*

4.2 Assessment of species presence and justification [BAM 6.5.2.8c, 6.5.2.5]

4.2.1 Greater Macarthur Growth Area

Based on atlas records and the extensive distribution of potential habitat (particularly Cumberland Plain Woodland and Moist Shale Woodland) within the GMGA it is confirmed that *Pimelea spicata* is present and could be present at other sites. The population at Minto Industrial Estate was confirmed in 2013 and is believed to be subject to some level of management. Although no known populations occur within the *biocertification* area, there are extensive areas of potential habitat and a reasonable likelihood that the species is present at other sites either as plants, rootstock or seed. The highest likelihood of occurrence is in central parts of the growth centre in the vicinity of Menangle Sugarloaf coinciding with the largest area of potential habitat in both particularly Cumberland Plain Woodland and Moist Shale Woodland.

4.2.2 Wilton Growth Area

There are no atlas records for *Pimelea spicata* within the Wilton Growth Area. The closest records are just north of Douglas Park on the western side of the Nepean River in similar undulating terrain within Cumberland Plain Woodland and on land largely cleared and used for grazing. In view of these records and presence of similar habitat within the WGA and *biocerification* area, there is a reasonable likelihood of the species being present. A significant proportion of the potential habitat comprises derived grasslands dominated by native species or a mix of native and exotic. It is noted that *Pimelea spicata* has been found in derived grassland dominated by exotics with occasional patches of native grasses and herbs e.g. at Cobham Road, Fairfield.

4.3 Assessment of suitable habitat

Suitable habitat for *Pimelea spicata* has been determined with reference to known sites, flora studies, scientific and personal knowledge. Important habitat attributes used to identify suitable habitat are discussed below.

4.3.1 Key habitat attributes & justification for use in determining suitable habitat

<u>Vegetation communities</u>
Pimelea spicata is primarily associated with *Cumberland Plain Woodland* (PCT's 849 & 850). Dominant canopy species are Narrow-leaved Ironbark *Eucalyptus crebra,* Grey Box *E. moluccana* and Forest Red Gum *E. tereticornis.* In southern parts of the Cumberland Plain, it also occurs in *Moist Shale Woodland* (PCT 830) with the same canopy species. Examples of populations occurring in Moist Shale Woodland include the following Atlas locations:

- Western Sydney Regional Park
- Denham Court (private property)
- Greendale near Wallacia (private property)
- Williamswood Biobank Site, Mount Hunter

The main occurrence of Moist Shale Woodland is at and in the vicinity of the Menangle Sugarloaf within the central zone of the GMPGA. In highly modified remnants it can be difficult to distinguish Moist Shale Woodland from Cumberland Plain Woodland with more resilient drier species replacing the moisture-loving ones until the canopy and understorey is restored.

Shale Sandstone Transition Forest (PCT 1395) may also provide suitable habitat at the shale end of the transition where it is structurally and floristically comparable to Cumberland Plain Woodland. The two communities adjoin each other extensively within the growth areas particularly in southern parts of the GMPGA and through the WPGA. Identification can be difficult particularly in modified remnants typical of these areas. Survey for alleged clearing of native vegetation at Gilead (James 2011) established that vegetation mapped as SSTF was partly Cumberland Plain Woodland. For these reasons some areas of SSTF are included within areas of identified suitable habitat.

Total habitat area of all mapped CPW (PCT's 849 & 850) and derived native grasslands within Wilton/Greater Macarthur priority growth areas is 765 ha.

<u>Physical environment</u>
Pimelea spicata is most often found on slopes in undulating low hilly terrain on Wianamatta Group shales including both Ashfield and Bringelly Shales. Within the GM and Wilton priority growth areas Ashfield Shale is the most widespread. To the south of the study area, particularly around Appin and Wilton it occurs as a capping over sandstone on ridges close to the Nepean and Georges Rivers. *Pimelea spicata* prefers moist soils (clay helps to retain the moisture) and is often found on protected south or east facing slopes close to drainage lines or seepage points. Growth and

flowering appears to be largely dependent on such moist soils with plants often not visible in dry periods and dying back to rootstock or persisting as seed in the soil seed bank.

Such conditions occur through most of the growth areas although protected slopes below ridges could be targeted as preferred habitat. The recent records from the Appin Mine location just west of the Nepean River are associated with such conditions and comparable to terrain within the southern part of the GMPGA and the WPGA.

<u>Habitat condition</u>
Optimal habitat for *Pimelea spicata* is intact woodland with an open, grassy understorey, however, it can survive in disturbed and degraded landscapes (see Section 2.4). Many of the known records are associated with regenerating native vegetation e.g. after a disturbance such as mowing or grazing has ceased. Records from many council reserves have been made in recent years as “no mow” zones have been established. Examples include:

- Faulkland Reserve, Kings Langley (Blacktown LGA)
- Melrose Park, Quakers Hill (Blacktown LGA)
- Power Street Reserve (Fairfield LGA)

Extensive areas of woody weeds such as African Olive occur within the growth areas, for example, at the Menangle Sugarloaf. These areas can still contain potential habitat (see Section 2.4) and are included. Examples of *Pimelea spicata* being recorded after removal of African Olive include a site at Greendale (Penrith LGA) and Mt. Annan.

The condition of habitat, therefore, is not a reliable indicator of species presence and accordingly **all condition states** are considered in determining suitable habitat i.e. intact, thinned, scattered, derived shrubland and grasslands.

4.3.2 Identification of habitat polygons

Areas of potential habitat are identified based on the attributes described in Section 4.3.1, landscape context and personal knowledge. Although *Pimelea spicata* is known to occur in degraded sites, very small patches within over-cleared landscapes where the soil is likely to have been modified are excluded.

Forty polygons containing a total of 542 ha of suitable habitat for *Pimelea spicata* are identified within the GMGA and six polygons with 405 ha in the WGA mostly comprising Cumberland Plain Woodland (including derived native grasslands) but also 187 ha of Moist Shale Woodlands and a total of 265 ha of CPW/low sandstone influenced SSTF (see Figures 4 & 5). The relative areas of vegetation communities are provided in Table 14.

Table 14. Areas (ha) of threatened communities identified as potential habitat for *Pimelea spicata* within the Greater Macarthur and Picton Growth Areas

Threatened Community	PCT	Area (ha) in Greater Macarthur	Area (ha) in Wilton
Cumberland Plain Woodland	850	121	0
Cumberland Plain Woodland	849	152	221
Native Grasslands (included in CPW areas)	608, 609	13	162
Moist Shale Woodland	830	187	0
River-flat Eucalypt Forest	835	0.2	0
Shale Sandstone Transition Forest (low sandstone)	1395	81.5	184

Figure 4. Habitat polygons for Greater Macarthur Growth Area Northern Zone

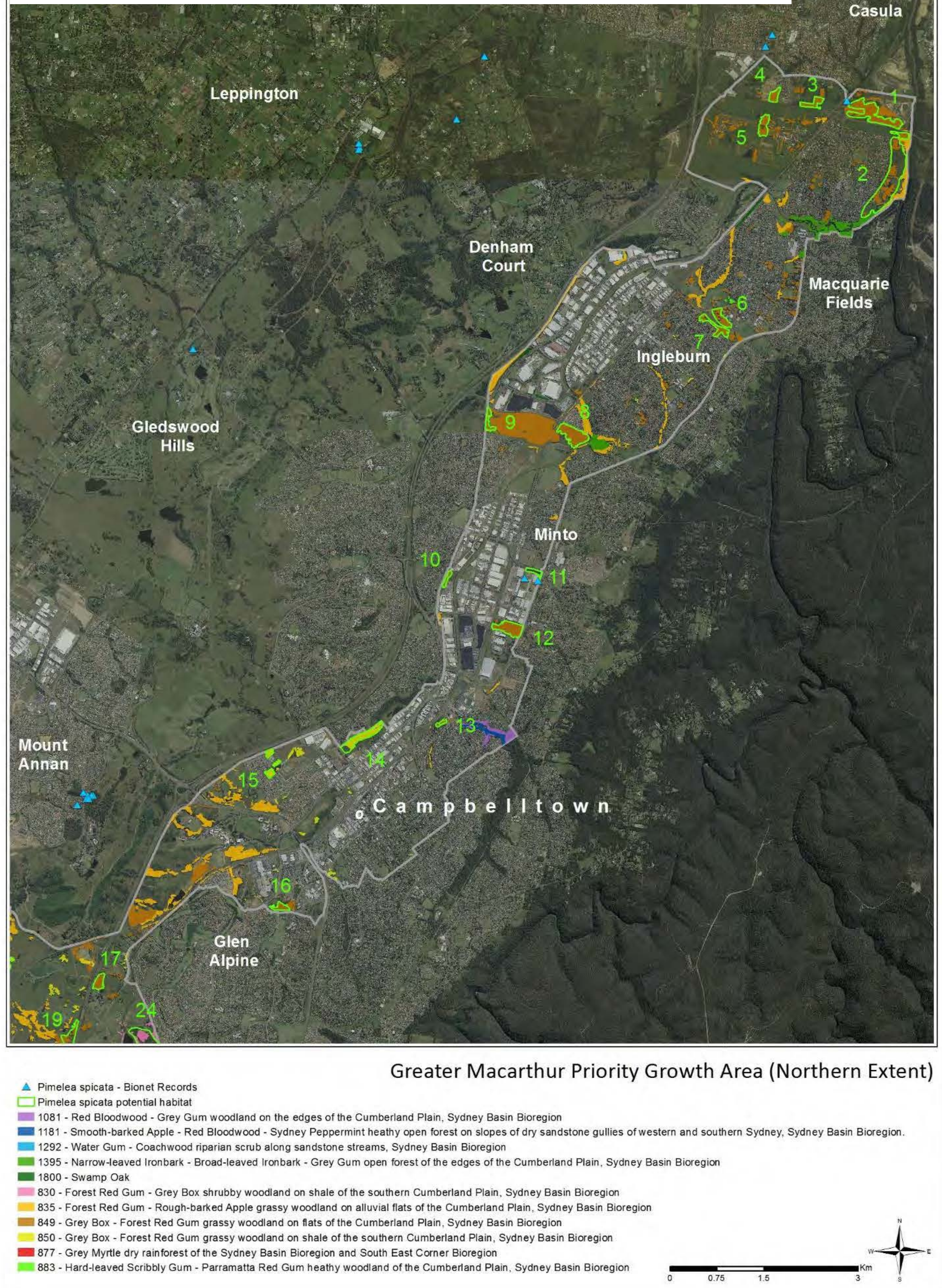


Figure 5. Habitat polygons for Greater Macarthur Growth Area Southern Zone

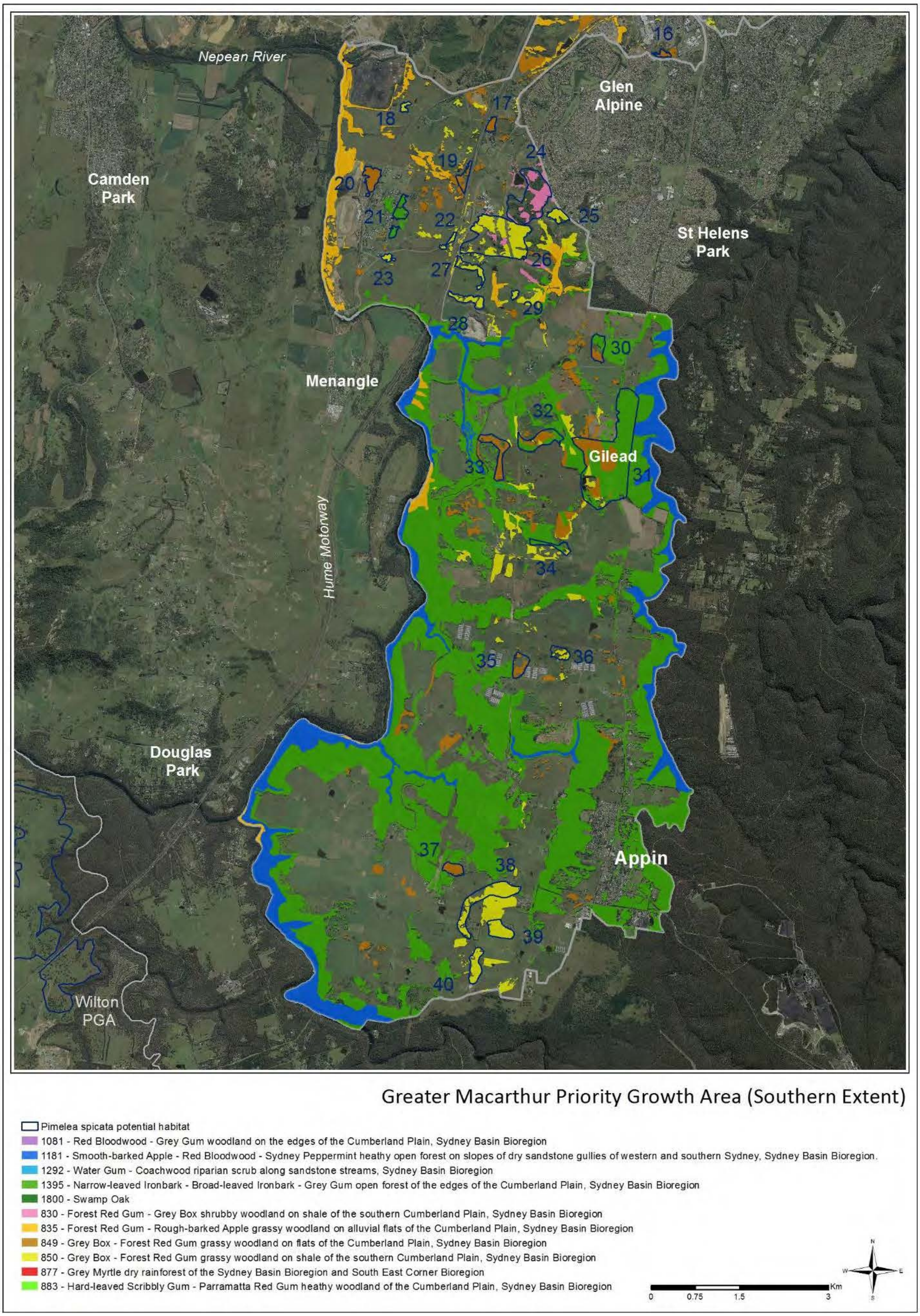


Figure 5a Habitat polygons for Greater Macarthur Growth Area Southern Zone in relation to Derived Native Grassland

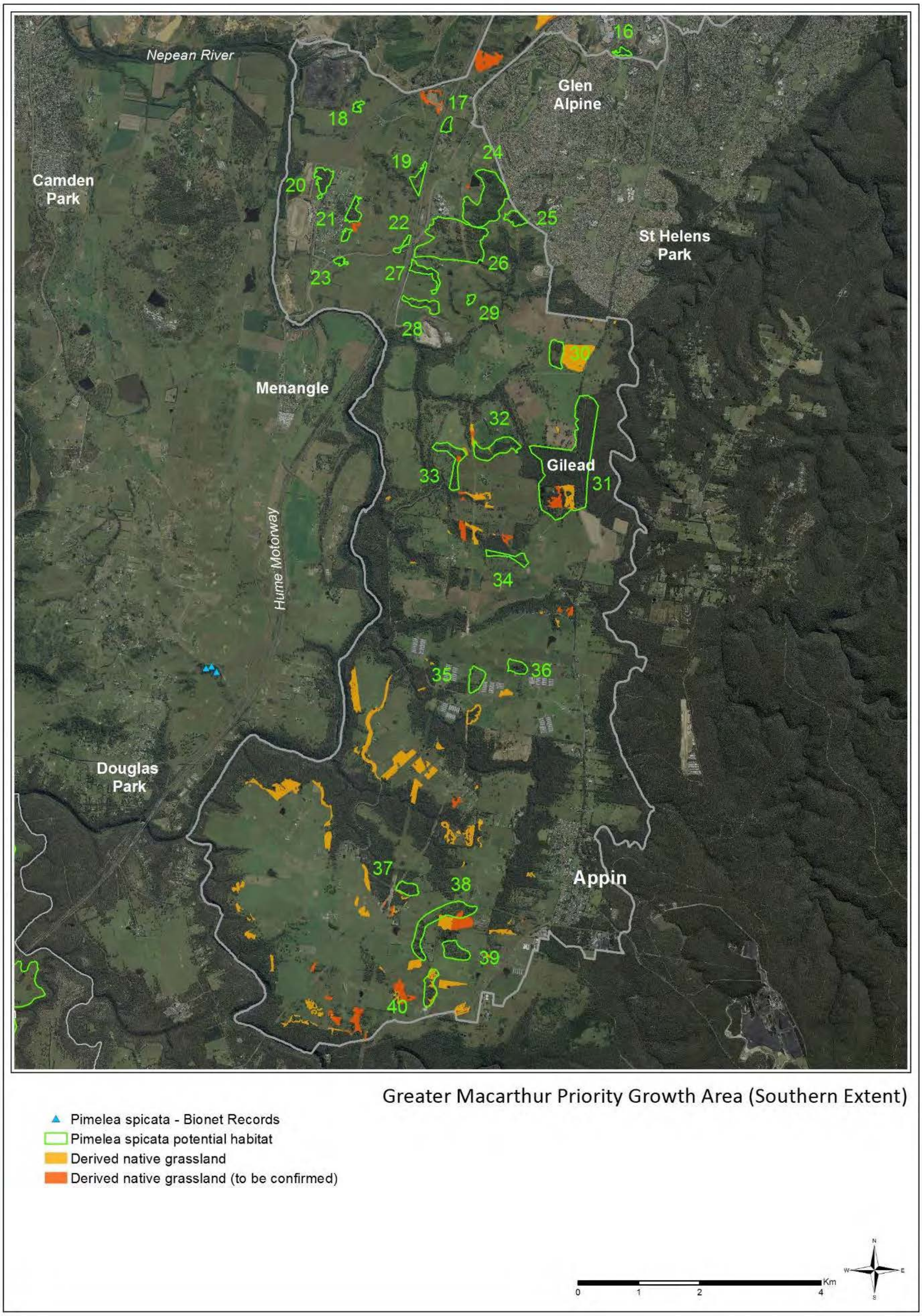


Figure 6. Habitat polygons for Wilton Growth Area

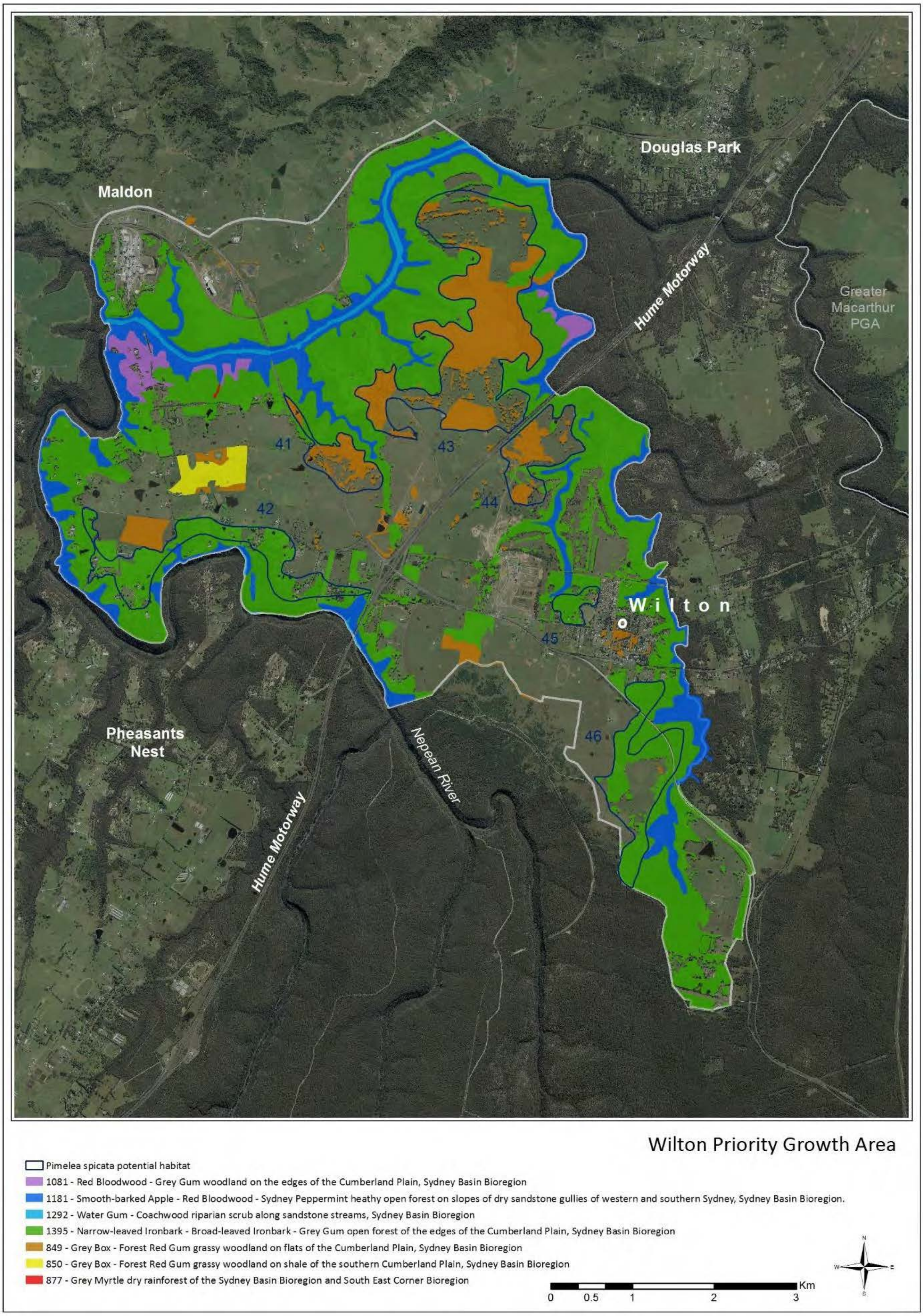
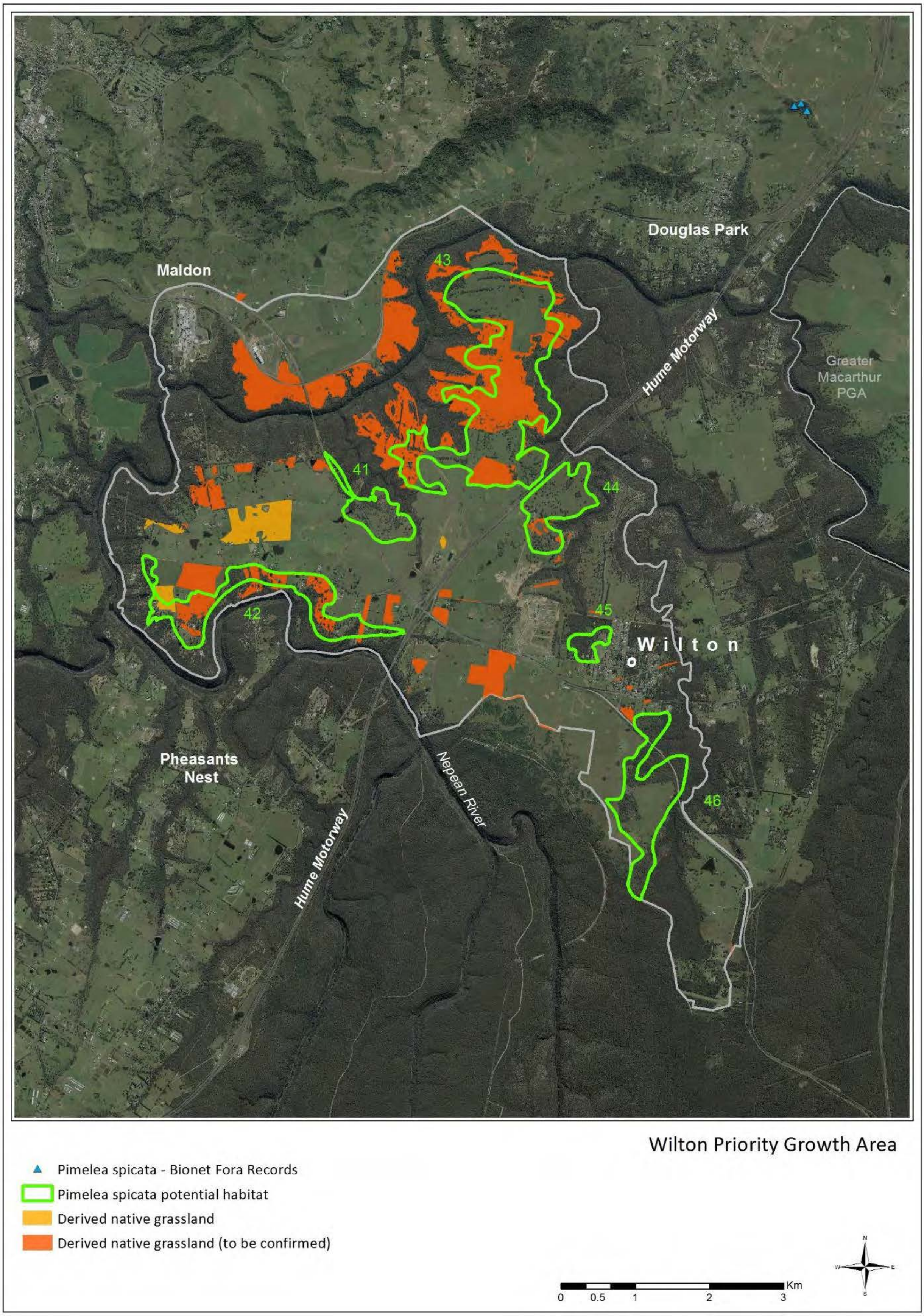
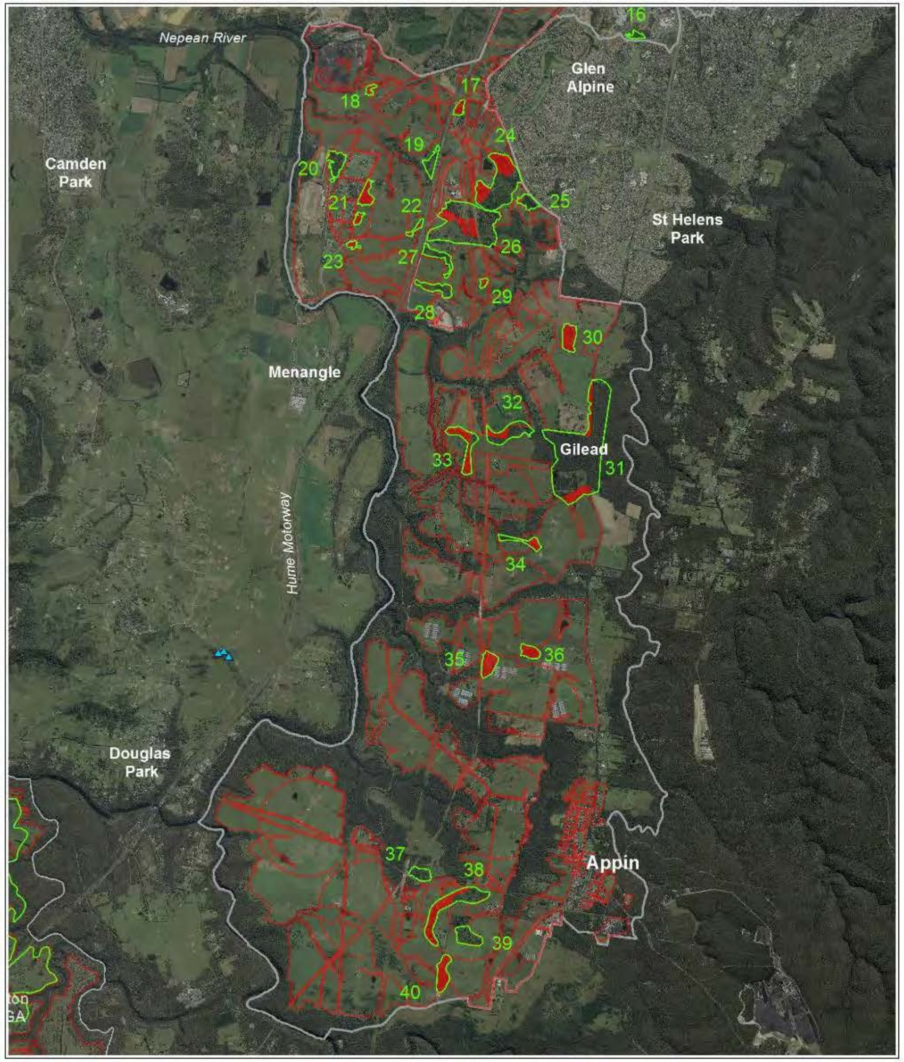


Figure 6a Habitat polygons for Wilton GA in relation to Derived Native Grassland

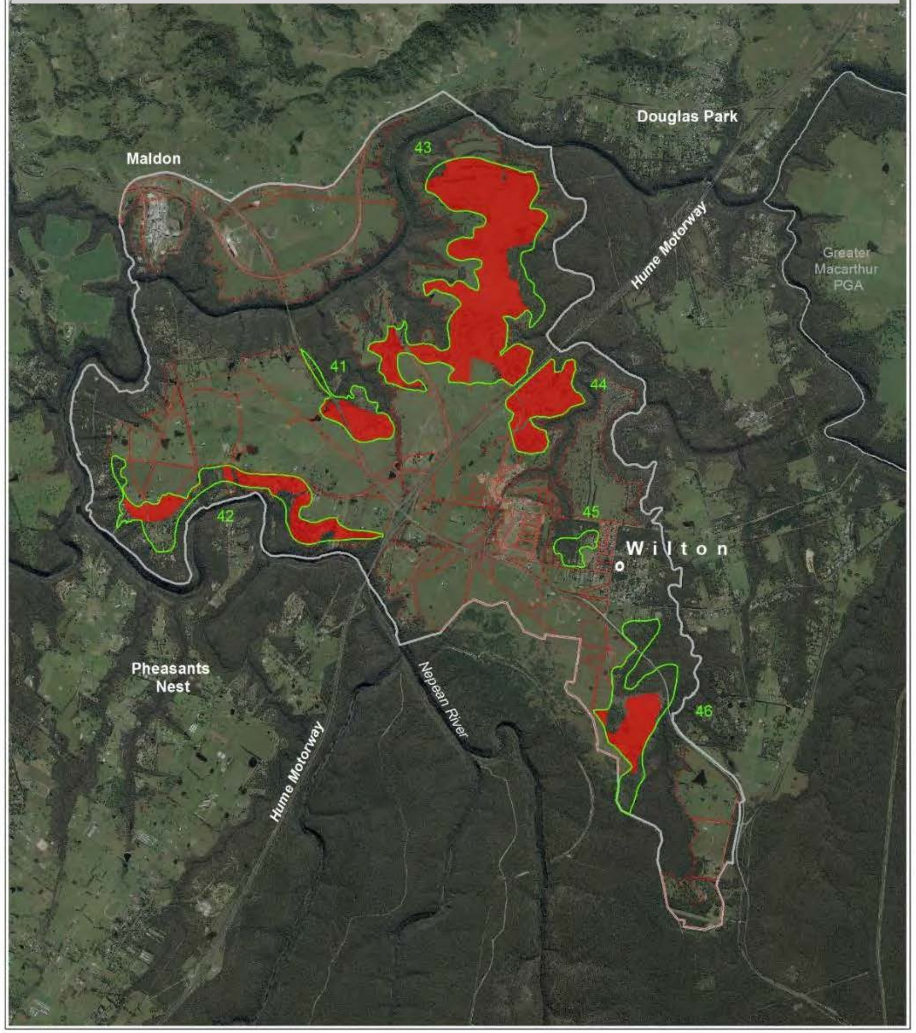


Figures 7 & 8 . Habitat polygons & overlap with biocertification area for GMGA



Greater Macarthur Growth Area (Southern Extent)

- Pimelea spicata - Bionet Records
- Pimelea spicata potential habitat
- Urban Development
- Urban development within potential habitat



Wilton Priority Growth Area

- Pimelea spicata - Bionet Fora Records
- Pimelea spicata potential habitat
- Urban Development Footprint/Biocertification Boundary
- Urban development within potential habitat

Biocertification area

Within the southern zone of the GMGA, the area of suitable habitat that is located within the development footprint is 113 ha or 21%. Within the PGA 468 ha or 82% occurs within the development zone.

4.3.3 Survey effort

Greater Macarthur GA
The nature and level of survey effort undertaken within the habitat polygons as part of the strategic assessment is a factor to consider in identifying potential habitat. Figures 9 - 11 show the overlap of surveys with areas of suitable habitat. This information is summarised in Table 15.

The northern extent of the Greater Macarthur growth area has been well surveyed reflecting the small areas and easy access. Except for polygon 2 where five Ecoplanning plots were sampled the remaining polygons were subject to general flora and fauna survey by Biosis that is reported to have included targeted survey for *Pimelea spicata* (Dayle Green *pers. comm*.). Details of the timing and conditions of surveys, however, are unknown. The spring/summer of 2017/18 was generally hot and dry, not providing suitable conditions for survey of this species (see Section 2). Many of the selected habitats are also currently subject to disturbance such as mowing in council reserves e.g. Georges River Reserve, Kanbyugal Reserve and along Bow Bowing Creek at Minto.

Table 15. Survey effort in suitable habitat polygons for *Pimelea spicata*

Growth area	No. of habitat polygons	No. of habitat polygons unsurveyed	No. of habitat polygons with plot survey	Details
Greater Macarthur (north)	16	2 12.5%	1	1 of the unsurveyed plots (No. 1) Glenfield Waste Services has been surveyed previously including plots – see Section 4.1.2. Except for plots 1 & 2 only general flora survey undertaken (Biosis)
Greater Macarthur (south)	24	12 50%	4	Low level of survey in areas with highest concentration of suitable habitat polygons.
Wilton	6	3 50%	3	Largest polygons with good level of plot survey (Ecoplanning)

The southern extent of the Greater Macarthur Growth Area has been less well surveyed with 50% of habitat polygons surveyed and again mostly through general/targeted survey by Biosis. Habitat occurring on semi-rural/grazing lands around Menangle Sugarloaf and Mount Gilead comprise some of the most potential habitat in Cumberland Plain Woodland and Moist Shale Woodland for *Pimelea spicata* within the growth areas but are among those least surveyed (both general, targeted and plot sampling). Many areas of suitable habitat in the southern extent are also still slashed and grazed or subject to African Olive infestation reducing the likelihood of the species being visible.

Wilton Growth Area
The Wilton GA has been well surveyed and although only 50% of the habitat polygons have been accessed and surveyed they are the largest ones. Reliability of these surveys in detecting *Pimelea,* however, is likely to be low in view of the hot dry conditions experienced during spring-autumn 2017-2018 and the extent of grazing. Figures 9-11 show the overlap of surveys with suitable habitat polygons with the priority growth areas.

Figure 9. Habitat polygons and survey effort for Greater Macarthur GA Northern Zone

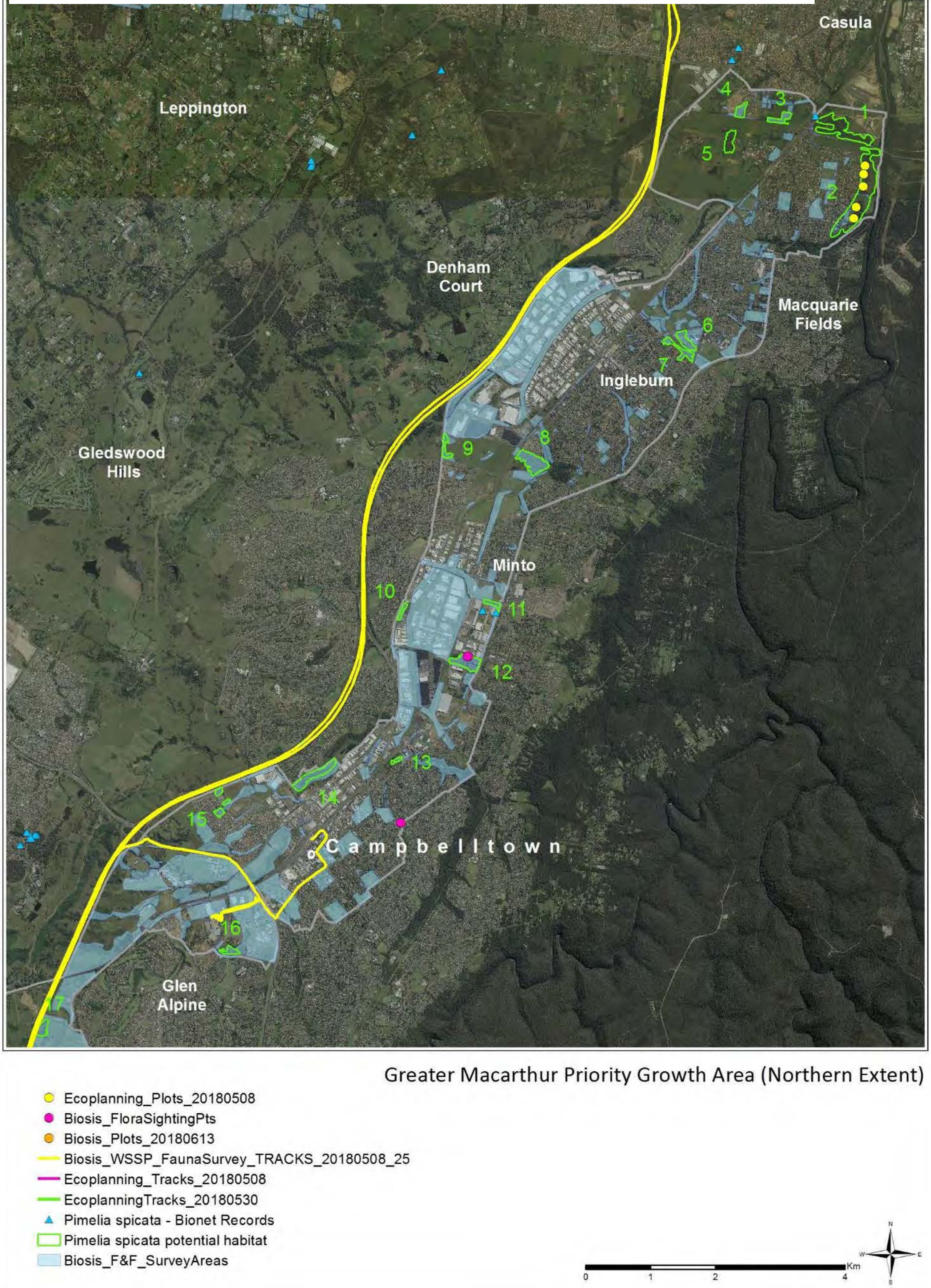


Figure 10. Habitat polygons and survey effort for Greater Macarthur GA Southern Zone

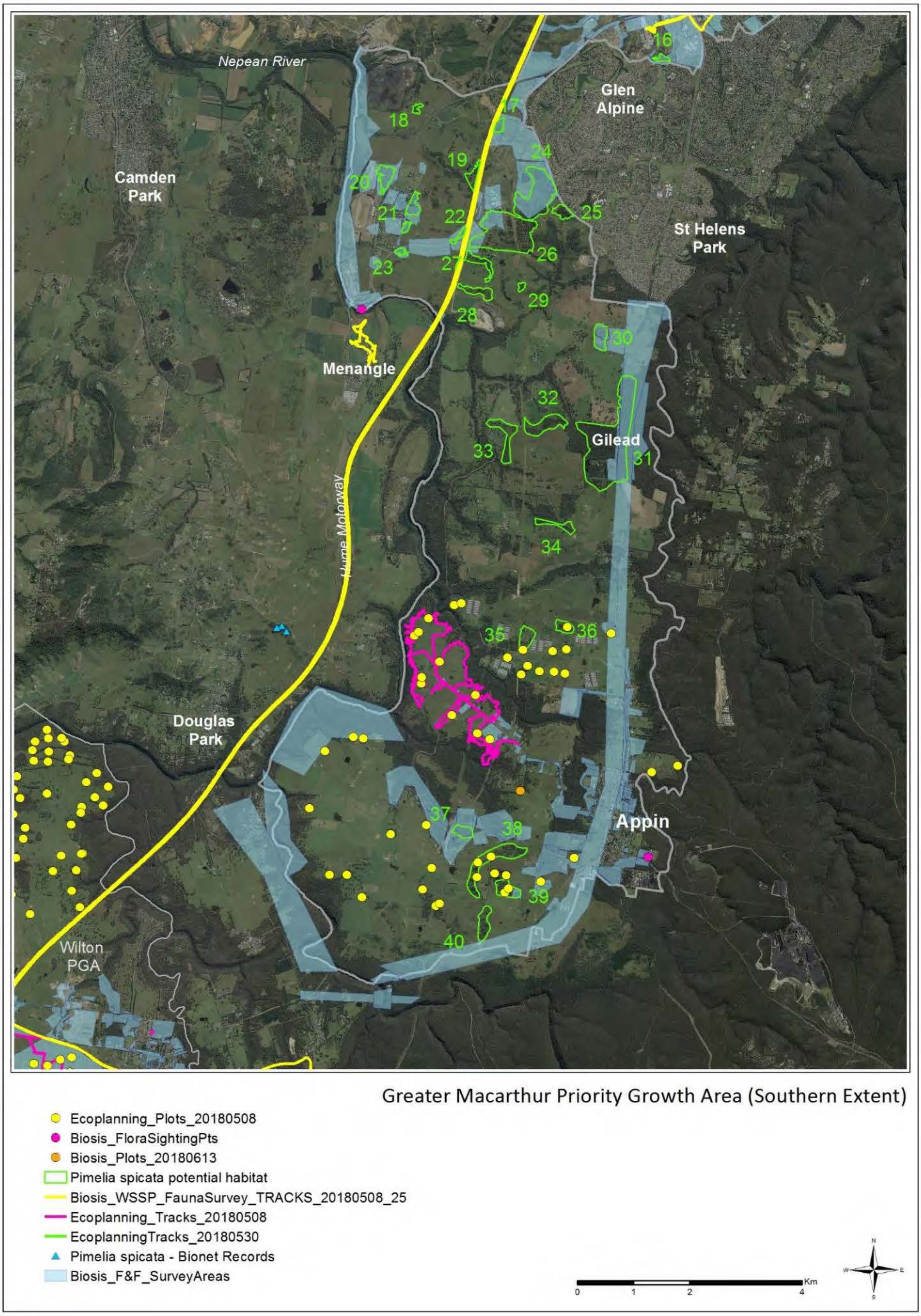
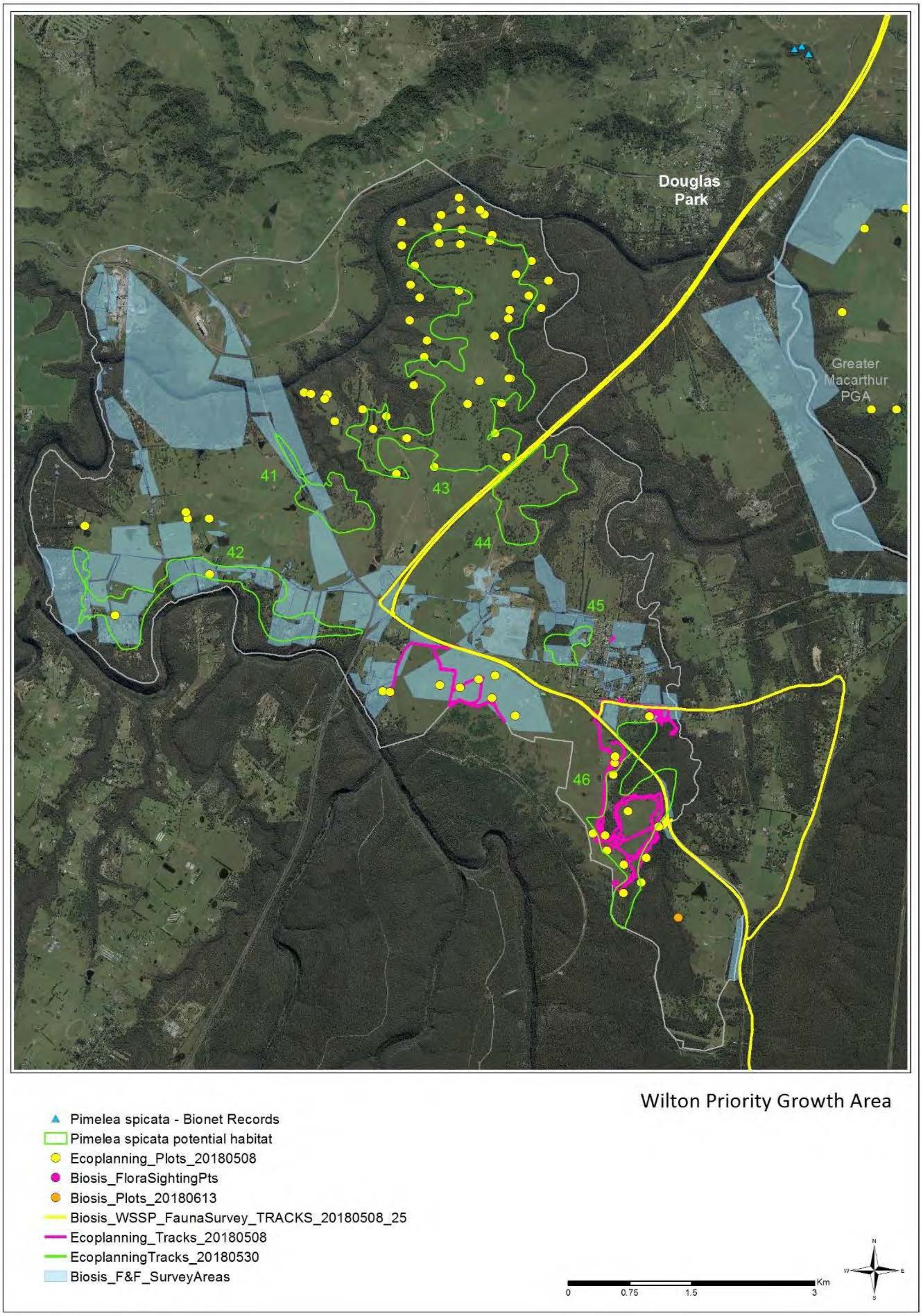


Figure 12. Habitat polygons and survey effort for Wilton GA



5 Summary and conclusion

Pimelea spicata is likely to be present within both the Greater Macarthur and Wilton Priority Growth Areas. Within the northern zone of the Greater Macarthur PGA one atlas record has been confirmed in recent years and has some short-term security. Several populations occur just to the north and west of the study area. The study area is considered important habitat for the species close to the south-eastern limit of its geographical range.

Likelihood of occurrence is based on the:

- Presence of local records;
- Presence of suitable habitat;
- Ability of the species to persist as rootstock and seed for long periods; and
- Ability of the species to easily regenerate when environmental conditions are suitable.

Extensive areas of suitable habitat are identified across the study area but particularly in the more rural lands of the southern extent of Greater Macarthur and the Wilton Growth Areas. A total area of 947 ha is identified within four vegetation communities (TECs) across the two growth areas (542 ha in GMGA & 405 ha in WGA). The condition of habitat is not a reliable indicator of species presence and all condition states were considered in determining suitable habitat.

Survey effort across the study area is variable. Areas with the highest potential for occurrence of *Pimelea spicata* are under-surveyed including Menangle Sugarloaf and Mt. Gilead. Throughout the study area, even where the level of survey is good, the reliability of detecting the species is low due to lack of targeted survey under suitable conditions for growth and flowering.

A high percentage of potential habitat occurs within the biocertification area or proposed development footprint and impacts on *Pimelea spicata* are expected to be high. Within the southern zone of the GMGA, the area of suitable habitat that is located within the development footprint is 113 ha or 21%. Within the WGA 468 ha or 82% occurs within the development zone.

In view of the low reliability of prior/recent surveys it is appropriate to assume the species presence and to reserve areas of suitable habitat across the study area that are protected and managed to protect the species long-term.

6. Information used in the assessment

6.1 NSW Planning & Environment resources

- Bionet sightings & other threatened species data
- Greater Macarthur & Wilton Vegetation Mapping
- Survey effort and land access details

Table 16. Sources for existing vegetation survey data used in the biodiversity assessment

Data collector	Client	Approx. no. plots	Survey year	Growth Area
Cumberland Ecology	Walker Corp	38	2014 - 2016	Wilton
Cumberland Ecology	Brad Corp	66	2014 - 2016	Wilton
Eco Logical Australia	Governors Hill	20	2015 - 2016	Wilton
Eco Logical Australia	Property NSW	None (mapping and assessment of trees only)	2016	Campbelltown

Data collector	Client	Approx. no. plots	Survey year	Growth Area
Eco Logical Australia	Lend Lease	Unknown	Unknown	Mt Gilead
OEH	OEH Koala Habitat Mapping	Around 18 within or bordering GAs (many others west of GAs)		Wilton and Appin

6.2 References

Anne Clements & Associates (2010) Flora study 395 Pembroke Road, Minto

Benson & McDougall (2001) Ecology of Sydney Plants *Cunninghamiana* 7(2)

Cumberland Ecology (2016) Wilton Junction New Town Project – Ecological Issues and Assessment Report

Cumberland Ecology (2017) Wilton Junction – Ecological Summary Report to Walker Corporation

DEC (2006) Approved Recovery Plan for *Pimelea spicata*

Dept. of Environment & Heritage online Spiked Rice-flower *Pimelea spicata* SPRAT profile www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=20834

Dept. of Environment & Heritage (2016) Conservation Advice *Pimelea spicata* Spiked Rice-flower

Eco Logical (2017) Mt Gilead *Biodiversity Certification Assessment & Biocertification Strategy*

Eco Logical (2015) Bingara Gorge Environmental Management Plan for EP & R Lands (Wilton) prepared for Lend Lease

Eco Logical (2017) Mt. Gilead EPS Environmental Property Services

(EPS 2015) Glenfield Ecological Assessment. Report to Glenfield Waste Services.

Harden, G.J. (ed) (1990). *Flora of New South Wales. Volume One*. Kensington, NSW: University of NSW Press

James, T (2009, 2010) Menangle Park Offset Strategy – targeted survey for *Pimelea spicata.* Unpublished report to GHD

James, T. (2011) Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland at a property on Appin Road, Gilead. Report to DEECW

James, T (2012) – targeted survey for *Pimelea spicata* along Denham Court Road for Camden Valley Way Upgrade. Unpublished report

James, T (2013) Campbelltown Roadside Survey – targeted survey for threatened species and EEC verification

Niche Environment & Heritage (2012). Appin Mine Ventilation Shaft No 6 Project. Biodiversity Management Plan

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NSW NPWS (1997) Urban Bushland Biodiversity Survey Stage 1 - Western Sydney

NSW NPWS (2004) Environmental Impact Assessment Guidelines

OEH (2016) NSW Guide to Surveying Threatened Plants

OEH (2017) Biodiversity Assessment Method http://www.environment.nsw.gov.au/resources/bcact/biodiversity-assessment-method-170206.pdf

OEH (2017) Spiked Rice-flower Profile http://www.environment.nsw.gov.au/ThreatenedSpeciesApp/profile.aspx?id=10632

Willis *et al.* (2003) Comparative seed ecology of the endangered shrub *Pimelea spicata* and a threatening weed Bridal Creeper. Ecological Management and Restoration Vol 4 Issue 1

7. Appendix 1. Curriculum Vitae for Teresa James

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Mailing address: PO Box 53 Forster NSW 2428

Telephone: Mobile: 04 282 18502.

Email: t.james@optusnet.com.au

Key positions:

- Botanist/ecological consultant specialising in vegetation survey, plant identification, conservation assessment and threatened species.
- Until October 1998 held position of Identifications Botanist, Plant Sciences, National Herbarium of New South Wales, Royal Botanic Gardens, Sydney.

Qualifications:

Bachelor of Science (Combined Honours in Biology and Geography) - University of Exeter, England. 1978.

Accreditation:

Accreditation awarded (2008) as a BioBanking Assessor under the Threatened Species Conservation Act 1995 (NSW); accreditation renewed 2013. Accreditation number 0017.

Current employment (1998-present):

Self- employed flora/ecological consultant (sole trader working as Teresa James Flora Consultant).

- Flora surveys, site/conservation assessments and monitoring projects.
- Preparation of environmental impact assessment reports (e.g. 7-part test, species impact statement & review of environmental factors).
- Biobanking and Biodiversity Offset assessments.
- Preparation of threatened species management plans.
- Expert witness in the Land & Environment Court.
- Botanical training for local councils and community groups.

Previous employment

1978 (3 months)	Technical Assistant, Biological and Chemical Research Institute, Rydalmere (Department of Agriculture).
1978-1998	Employed at the Royal Botanic Gardens, Sydney.
1978-1979	Temporary Herbarium Assistant
1980-1982	Technical Officer, Botanical Information Section
1982-1986	Acting Identifications Botanist, Botanical Information Section
1987-1991	Technical Officer, Botanical Information Section
1991-1994	Acting Identifications Botanist, Botanical Information Section
1994	Secondment 4 days/week to World Heritage Assessment of the Blue Mountains (consultancy for NSW National Parks & Wildlife Service).
1994	Permanent appointment as Identifications Botanist.
1994-	Appointed Botanical Information Section Co-ordinator.
1996-1997	Secondment to NSW National Parks & Wildlife Service as Flora Officer for Urban Bushland Biodiversity Survey. Stage 1: Western Sydney.

1994-1998	Identifications Botanist & Botanical Information Section Co-ordinator.

Selected longer-term projects:

1998-1999	Vegetation sampling for NSW National Parks & Wildlife Service - Western Sydney Vegetation Mapping Project.
1999	Flora consultant to Eastern Gas Pipeline (Duke Australia Operations).
2000	Preparation of Fire Ecology Manual for Rural Fire Service and UWS.
October 2000-2003	Flora consultant to Biosis Research for Penrith City Council – proposed developments & TSC Act issues at Erskine Park.
2001	Field sampling and truthing for vegetation community mapping project - Baulkham Hills LGA. Baulkham Hills Shire Council.
2001-2003	Qualitative and quantitative vegetation surveys (including rare plant species and ecological communities, weeds and other threats, environmental assessment) of Wingecarribee Swamp with Sainty & Associates for the Sydney Catchment Authority.
February 2002-May 2002	Review of wetland boundaries and general vegetation mapping and condition assessment within Baulkham Hills local government area (for Baulkham Hills Shire Council).
2003	Vegetation survey in the Hunter, Nattai & Bargo districts as part of the National Parks & Wildlife Service Vegetation Survey Program.
2002-2007	Flora survey/monitoring at Dr Charles McKay Reserve, Mt. Druitt for Blacktown City Council.
September 2005 –2006	Field validation for Foreshore Vegetation Mapping Project on Sydney Harbour for Botanic Gardens Trust and NSW Maritime Services.
September 2000-2008	Flora consultant to Liverpool City Council – provide review & advice relating to development applications, plans of management & special projects.
February -May 2007	Field survey for Sydney Metropolitan Catchment Management Authority/DECC vegetation mapping. Plot data recorded for 100 sites within SMCMA.
May 2008-2010	Vegetation mapping and assessment of Blue Gum High Forest and Turpentine Ironbark Forest in Ku-ring-gai local government area
August 2008-present	Flora advice to Ku-ring-gai Council - review of development applications, plans of management and mapping/biodiversity projects.
February-August 2012	PAS2 Expert Interviews for NSW threatened species with Office of Environment & Heritage.

*See consultant reports for complete list of projects/surveys.

Special projects:

Assessment of the World Heritage Values of the Blue Mountains and surrounding plateaus

An assessment of the natural and cultural values of the sandstone plateaus of the Blue Mountains and surrounding areas was funded by the Federal and State Governments to determine the potential for world heritage nomination. A team of people worked on the project from the Royal Botanic Gardens, Australian Museum (cultural values) and experts from local universities. I was project co-ordinator for the assessment, wrote much of the text for the natural values sections and was editor of the final report.

This report was used as a basis for the successful Blue Mountains World Heritage nomination (June 1998).

<u>NPWS Urban Bushland Biodiversity Survey. Stage 1: Western Sydney</u>

Documentation of biodiversity and conservation values in Western Sydney was the first priority project undertaken within the State Biodiversity Survey Program. The survey gave emphasis to threatened species, communities and habitats. The region was documented on a local government area basis. I co-ordinated the flora surveys and was principal author for the flora reports.

Particular expertise:

Plant Identification:

- New South Wales plants, native and naturalised (18 years of experience in the Botanical Information Section of the Royal Botanic Gardens, Sydney). Specimens received from all over state. Also cultivated plants.
- Specialist in Sydney flora.
- Prepared taxonomic treatments for various plant families in the publication Flora of New South Wales, volumes 1-4, produced by the Royal Botanic Gardens, Sydney.
- Conduct plant identification workshops both through the RBG and the University of Western Sydney.

Documentation and conservation/ impact assessment: plant communities and species

- Extensive range of sites surveyed with species lists compiled over the last twenty-five years, particularly in Western Sydney, the Blue Mountains and Southern Highlands. Plant specimens collected and incorporated into the National Herbarium of N.S.W. Information used in numerous reports and books e.g. World Heritage Assessment of the Blue Mountains, the NPWS Urban Bushland Biodiversity Survey, Rare Bushland Plants of Western Sydney and various papers.
- Prepare Tests of Significance and Species Impact Statements as required under current legislation (TSC Act, EPBC Act).
- Prepare Statements of Evidence & Affidavits for the Land & Environment Court.
- Provide advice to the community, developers, government agencies and councils concerning the identification of communities and species, impacts of proposed developments, the ecological effects of urbanisation, flood mitigation and management practices such as mowing, burning etc.

Peer review

Assessor services provided to government (all levels), consultancies and NGO's. Including the following:

- DA applications and associated reports e.g. REF's, SIS's, Tests of Significance
- BioBanking/Offset reports
- NSW Land & Environment Court reports

Education & training

- Involvement on committees or in groups providing technical advice and training eg. Greystanes Creek Management Committee, Upper Parramatta River Catchment Trust steering committees, Hawkesbury Rainforest Network.
- Presentations/talks e.g. National Parks Association, Society of Australian Plants, University of NSW, Landcare groups, local councils.
- Conduct plant community and species identification workshops/courses/tours through the Royal Botanic Gardens, the University of Western Sydney and privately.
- Prepared Fire Ecology Manual for Rural Fire Service (2000).

- Training for local government in threatened species, endangered ecological communities and biodiversity conservation.
- Publications e.g. primary author of revised edition of Rare Bushland Plants of Western Sydney (Royal Botanic Gardens 1999*),* contributor to Flora of New South Wales *(*Royal Botanic Gardens).

Courses/workshops & tours provided to local government/catchment management trusts/consultancies:

- Sept. 2004 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers & council staff
- October 2004 – Significant Plant Communities-of Baulkham Hills Shire Council – tour for council staff
- February 2005 – Community workshop in Cumberland Plain Woodland for Holroyd City Council
- July-August 2005 - Biodiversity training for Liverpool City Council – 3 workshops for council officers
- September 2005 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- August 2007 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2007 – Identification of plants in Cumberland Plain Woodland – for Hawkesbury Nepean CMA.
- April 2008 – Basic grass identification course for Baulkham Hills Shire Council (for bushcare volunteers).
- August 2008- Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- November 2008 to April 2009 – Weedy Grass Identification Workshop x 3 for Sydney Metro CMA.
- August 2009- Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2009 – EEC identification field day for Hawkesbury-Nepean CMA
- August 2010 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2010 – Cumberland Plain Woodland identification training for SMEC Australia
- April 2011- – Cumberland Plain Woodland identification training for SMEC Australia
- April 2011 – Field training in identification of communities & plants on the Cumberland Plain for Hawkesbury Nepean CMA.
- June 2011 – Presentation to council staff on threatened flora & fauna and biodiversity conservation within the Hills Shire.
- August 2011- Threatened Species Tour for Hills Shire Council bush care workers
- June 2012 – Eucalypt Identification workshop for Hills Shire Council.
- September 2014 - Threatened Species Tour for Hills Shire Council bush care workers
- September – November 2014 – Series of two-day workshops on threatened ecological communities in western Sydney.
- October 2014 – Plant identification training day held at Dr Charles Mckay Reserve, Mt. Druitt for Blue Tongue Ecosystems.
- March 2015 – Derived Grasslands Workshop (western Sydney) for government and community.
- May 2015 - Threatened Ecological Communities Workshop (western Sydney) for government and community.
- August 2015 – Shale Sandstone Transition Forest Workshop (western Sydney) for government and community.
- September 2015 – Northern Sydney Threatened Communities Workshop for government and community.
- April 2016 - Shale Sandstone Transition Forest Identification Workshop
- April 2016 – Introduction to Identifying Western Sydney Plants
- April 2016 – Grass Identification Workshop

- April 2016 – Cumberland Plain Woodland Workshop for Liverpool Council bushcarers
- August 2016 - Threatened Species Tour for Fairfield City Council.
- August 2016 - Threatened Species Tour for Hills Shire Council.
- April 2017 – Bushcare Training for Penrith Council
- Aug-Sept -Oct 2017 - Community bushland guided walks for Liverpool Council
- August 2017 - Threatened Species Tour for Fairfield City Council.
- August 2017 - Threatened Species Tour for Hills Shire Council.
- September 2017 – Flora workshops at Scheyville and Agnes Banks

Committee & community participation

- Member of NPWS Cumberland Plain Woodland Recovery Team (1998).
- Member of NPWS Acacia pubescens Recovery Team (1998 to 2002).
- Member, Green Corridors Strategy Steering Committee.Upper Parramatta River Catchment Trust. (1997-2000).
- Member, Water Quality Strategy Steering Committee. Upper Parramatta River Catchment Trust (1995-7).
- Member, State of the Environment Report Steering Committee for Holroyd City Council (1995-2002).
- Botanical Advisor for Management Committee, Greystanes Creek Restoration Project (1993-2000).
- Blue Gum High Forest Workshop / Advisory Committee – Ku-ring-gai Council. (2007).

Publications/booklets:

- Stepnell, K. & James, T. A. (1986). *Australia's Native Flowers*. Child & Henry Publishing Pty. Ltd.
- James, T.A. (1988). *Bertya ingramii* (Euphorbiaceae) a new species from New South Wales. *Telopea* 3(2): 285.
- Bedford, D. & James, T. (ed.) (1992). *Collection, Preparation & Preservation of Plant Specimens.* Royal Botanic Gardens, Sydney.
- Powell, J.M. & James, T.A. (1993) *Epacris sparsa* (Epacridaceae) reinstated. *Telopea* 5(2):375-380.
- James, T.A. (1990-1993) in *Flora of New South Wales*. Royal Botanic Gardens, Sydney
- Volume 1: Euphorbiaceae (part), Violaceae.
- Volume 2: Fabaceae (part).
- Volume 3: Celastraceae, Rubiaceae (part).
- Volume 4: Iridaceae (part), Poaceae (part).
- James, T.A. (1994). Observations on the effects of mowing on native species in remnant bushland, Western Sydney. *Cunninghamia* 3(3).
- Kodela, P.G. & James, T.A. & (1994) Aspects of the ecology and conservation status of the rare herb *Gentiana wingecarribiensis*. *Cunninghamia* 3(3).
- James, T.A. (1994) Review of a Key to Australian Grasses by B.K. Simon. *Australian Systematic Botany Society Newsletter* No.78.
- Contributor to Bowen Mountain Bushwalks (1994). Bowen Mountain Association.
- Kodela, P.G, James, T.A & Hind, P. (1996). Vegetation and flora of swamps on the Boyd Plateau, Central Tablelands, New South Wales. *Cunninghamia* 4(3).
- James, T.A. (1996). New combination in *Viola* (Violaceae). *Muelleria* Vol. 9 pp.35-36.
- James, T.A. NSW NPWS. (1997). Urban Bushland Biodiversity Survey. Stage 1: Native flora in Western Sydney.
- Hosking, R. J & James, T.A. (1998). An analysis of the native and exotic flora of the North Western Slopes upstream of the junction of the Peel and Namoi Rivers, New South Wales.

- James, T.A., McDougall, L & Benson, D. (1999). Revised edition. *Rare Bushland Plants of Western Sydney.* Royal Botanic Gardens, Sydney.
- James, T.A. (2009) Threatened plant species of Baulkham Hills Shire – unpublished booklet for Baulkham Hills Shire Council.
- James, T.A. (2009) Vegetation communities of Baulkham Hills Shire – unpublished booklet for Baulkham Hills Shire Council.
- James, Teresa (2013) Flora of Cumberland Plain Woodland – an identification guide.
- James, Teresa (2015) Threatened Flora of the Fairfield LGA.
- James, Teresa (2016) Native Flora of Shale Soils of the Cumberland Plain Woodland – An Identification Guide.

Reports

List of unpublished species lists and reports over the last 15 years.

- Kodela, P.G., James, T.A., Coveny, R.G. and Hind, P.D. (1992). Reconaissance survey of the vegetation at Long Swamp, near Penrose, Central Tablelands, N.S.W. Royal Botanic Gardens, Sydney. Unpublished report.
- James, T.A. & Kodela, P.G. (1992). Species list for Little Cattai Creek and tributary creeks. Royal Botanic Gardens, Sydney. Unpublished species list.
- James, T.A. & Kodela, P.G (1993). Plant species recorded from Butlers Swamp, Central Tablelands, N.S.W. Royal Botanic Gardens, Sydney. Unpublished species list.
- James, T.A. Coveny, R.G., Kodela P.G. and Hind, P.D. (1993). Plant species recorded from a wetland area on the northern side of Fitzroy Falls Reservoir, Central Tablelands, N.S.W. Royal Botanic Gardens, Sydney. Unpublished species list.
- James, T.A., Hind, P.D., Kodela, P.G. (1993). List of native species recorded for the Vale of Avoca Reserve. Royal Botanic Gardens, Sydney. Unpublished species list.
- Coveny, R.G. and James. T.A. (1993). Plant species recorded from the Dr. Charles McKay Reserve, Mt. Druitt, Western Sydney. Royal Botanic Gardens, Sydney. Unpublished species list.
- James, T.A. (1994) Native plant species recorded from Alpha Park Reserve, Greystanes. Unpublished report.
- James, T.A. (1994) Botanical Significance of the Lower Canal, Greystanes. Unpublished report.
- James, T.A. (2004 revised 2009). Rare and threatened plant species of Baulkham Hills Shire for Baulkham Hills Shire Council.
- Allen, CB, Benson, DH, James, T & Kelleway, J (2007). Vegetation map of the Sydney Harbour Foreshore, December 2006. Prepared for NSW Maritime and the Sydney Metropolitan CMA by Royal Botanic Gardens, Sydney.

Consultancies:

- James, T.A. (1992) Vegetation Survey of proposed pipeline and irrigation sites for Goulburn wool scour. Unpublished report for Gunninah Consultants.
- James, T.A. (1992). Survey of Vegetation along New Line Road at Cherrybrook. Unpublished report for Gunninah Consultants.
- James, T.A. (1993). Vegetation survey of the eastern section of the Australian Defence Industries site, St. Marys. Unpublished report for Gunninah Consultants.
- James, T.A. *et al.* (1994) Royal Botanic Gardens Assessment of the World Heritage Values of the Blue Mountains and surrounding plateaus.
- James, T.A & S. Mcune (1998a). Flora assessment for the proposed Highlands Resort development near Picton. Report prepared for DLWC.
- James, T.A. (1998b). Cumberland Plain Woodland Assessment, Claremont Meadows, Penrith. Report prepared for Biosis Research. Subsequent assessment of significance of Cumberland Plain Woodland at the site for Species Impact Statement (Dec. 1998).

- James, T.A. & S. Cook (1998d). Flora Survey of Domain Creek, Parramatta Park.
- Douglas, S.M. & James, T.A. (1998e). Report on the native flora and development potential of Lot72 DP661069 & Lot 75 DP 67236 Sirius Road, Voyager Point. Report to Liverpool City Council.
- James, T.A. (1999a). Species profiles and environmental impact assessment guidelines for the rare species *Epacris sparsa, Kunzea cambagei, Acacia baueri* subsp. *aspera, Euphrasia bowdeniae* and *Zieria covenyi.* Prepared for NSW NPWS.
- James, T.A. (1999b). 8 Part Test- proposed laying of underground electrical conduit at the Crest of Bankstown. Report to Bankstown City Council.
- James, T.A. (1999c). 8 Part Test for drainage works at the Crest of Bankstown. Report to Bankstown City Council.
- James, T.A. (1999d). Overview of vegetation and assessment of conservation significance at proposed Erskine Park Employment Area. Report prepared for Biosis Research.
- James, T.A. (1999e). Vegetation review and survey of Area 3, Chullora Industrial Estate. Report prepared for Mather & Associates and Business Land Group.
- James, T.A. (Sept 1999). Review of management plan for the Highlands Resort, Picton - report for DLWC.
- James, T.A. (Oct 1999). Field survey and 8-part test for *Acacia baueri* subsp. *aspera*. Report for the Illawarra Shooting Association.
- James, T.A. (Nov 1999). Flora assessment - proposed works at Oatlands Golf Course. Report to Oatlands Golf Club.
- James, T.A. (Dec 1999). Flora assessment - Bungarribee Creek, Blacktown. Report to Blacktown City Council.
- James, T.A. (Feb 2000). Norfolk Reserve, Greenacre - Plant Survey and 8 Part Test for proposed walking tracks. Report to Bankstown City Council.
- James, T.A. (March 2000). Flora survey along Clavering Road, Seaforth.
- James, T.A. (May 2000). Flora assessment and 8-part test for proposed high school development along York Road, Kellyville. Report to the Department of Public Works.
- James, T.A. (June 2000). Flora survey and assessment of remnant Cumberland Plain Woodland at Dr. Charles McKay Reserve, Mt. Druitt. Report to Dr. Charles McKay Reserve 271 Park Committee.
- James, T.A. (June 2000). Remnant bushland at Central Gardens, Merrylands - flora survey and assessment of conservation and educational values. Report to Holroyd City Council.
- James, T.A. (July 2000) Powell Park, Kurrajong Hills - flora survey and conservation assessment. Report to Hawkesbury City Council.
- James, T.A. (August 2000) Chullora Industrial Estate - bushland retention area (3) and adjoining lands - flora and fauna assessment and “eight part tests” of significance. Report to Business Land Group.
- James, T.A. (August 2000) Flora report for bushland along Ropes Creek, St. Marys with management guidelines. Report to National Trust.
- James, T.A. & S. Douglas (September 2000). Flora survey & 8-part test for Lower Prospect Canal.. Report to NSW NPWS.
- James, T.A. (November 2000). Flora inspection of proposed driveway across 181 Princes Highway, Sylvania.
- James, T.A. (November 2000) Preliminary flora & fauna survey - Arabella Street, Longueville - proposed subdivsion.. Report to City Plan Services.
- James, T.A. (January 2001) Flora survey and assessment for Dwyer Oval, Cabramatta for Liverpool City Council.
- James, T.A. (January 2001) Flora survey and assessment for Duncan Park, Seven Hills for Friends of Grantham
- James, T.A. & J. Anderson for Oculus Pty Ltd. (Feb-April 2001). Flora and fauna survey of reserves within Mosman Local Government Area for Mosman City Council.

- James, T.A. & J. Anderson (March 2001). Species Impact Statement - Lot 907 Narabang Way, Belrose. Report to Access Industrial Holdings Pty Ltd.
- (April-May 2001). Flora survey of Wingecarribbe Swamp. Field assistance provided to Sainty & Associates Pty. Ltd.
- James T.A. & Anderson, J. (May 2001). Preliminary flora and fauna survey for Public Reserve, Prestons. Report for Liverpool City Council.
- James, T.A. (March 2001). Species Impact Statement for Dendrobium Project (BHP) Woronora Plateau. Assistance provided to Biosis Research.
- James, T. A. (June 2001). Threatened flora assessment & survey – *Grevillea juniperina* subsp. *juniperina, Grevillea parviflora* subsp. *parviflora* and *Pultenaea pedunculata*. Report to NSW National Parks & Wildlife Service.
- James, T.A. & Anderson, J. (June 2001) Preliminary flora and fauna survey for Public Reserve south of Braidwood Avenue, Prestons. Report to Liverpool City Council.
- James, T.A. (July 2001). Flora survey - Scheyville National Park for NSW National Parks & Wildlife Service.
- James, T.A. (August 2001). 8 Part Test for proposed cycle track at Crest Reserve, Bankstown. Report to Bankstown City Council.
- James T.A. & Anderson, J. (August 2001). Preliminary flora & fauna survey of Chullora lands affected by proposed rail upgrade. Report to Rail Infrastructure Corporation.
- James, T.A. (Sept 2001). Inspection and assessment of current mowing/slashing activities at the St Marys ADI site. Report to Compliance and Enforcement Section, Environment Australia
- James, T.A. (Nov 2001). Flora survey for proposed drainage easement at Pleasure Point. Report to Liverpool City Council.
- Kodela, P.G., Bravo, F.J, James, T.A. & Sainty, G.R. (Dec 2001). Quantitative sampling of vegetation in Wingecarribee Swamp. Prepared for Sydney Catchment Authority.
- James, T.A. (March 2002). Moorebank Interchange - Threatened Flora Survey and Assessment. Report to Haliburton KBR and the Roads and Traffic Authority, New South Wales
- *James, T.A. (March 2002). Clearing of native vegetation – Lots 1 & 4 Cowlishaw Street, Redhead. Report to NSWNPWS and Lake Macquarie City Council.*
- James, T.A. (April 2002). Balmoral Road Land Release – Ecological assessment of Cumberland Plain Woodland. Report to Baulkham Hills Shire Council
- Kodela, P.G., Bravo, F.J, James, T.A & Olsen, A. (May 2002). Quantitative sampling for vegetation in Wingecarribee Swamp-Spring 2002 survey. Report for Sydney Catchment Authority.
- James, T.A. (May 2002). Post-fire survey for *Acacia baueri* ssp. *aspera* – proposed shooting range. Report to Illawarra Shooting Association.
- James, T.A. (May 2002). Eight-part test for Chullora siding proposal. Report to Rail Infrastructure Corporation.
- James, T.A. (August 2002). Ecological study of Castle Hill Cemetery. Report to Baulkham Hills Shire Council
- James, T.A. (August 2002). Flora survey and assessment for Precint A1, Judith Street, North Seaforth. Report to GHD for NSW Planning & RTA.
- James, T.A. (September 2002). Flora survey and assessment for Precint C North, Seaforth. Report to GHD for NSW Planning & RTA.
- James, T.A. (November 2002). Flora survey and assessment for proposed roadway and stormwater easement in vicinity of Clavering Road & Gurney Crescent, Seaforth. Report to GHD for NSW Planning & RTA.

- James, T.A. (December 2002). Flora survey and assessment for Lot 38A Boronia Lane, Seaforth. Report to GHD for NSW Planning & RTA.
- James, T.A. (January 2003). Flora survey and assessment (including 8 part-test) for proposed upgrade of Seaforth Oval. Report for Manly Council.
- James, T.A & Anderson, J. (February 2003). Flora and fauna survey and assessment (including 8 part-tests) for Lot 31 Muir Road, Chullora. Report to Landcom.
- James, T.A & Anderson, J. (February 2003). Flora and fauna survey and assessment for proposed re-zoning of creek-line in vicinity of 15-25 First Avenue, Hoxton Park. Report to Liverpool City Council.
- James, T.A. (March 2002). Flora survey of Heath Road Reserve. Report to Baulkham Hills Shire Council.
- James, T.A & Anderson, J. (April 2003). Review of Environmental Factors for proposed hazard reduction burn at the Kings School, North Parramatta.
- James, T.A & Anderson, J. (May 2003). Flora and fauna survey and assessment for Lot 11 Corner Hume Highway and Worth Street, Chullora. Report to Landcom.
- James, T.A. (June 2003). Chullora rail yard upgrade – targeted survey for Tadgell's Bluebell *Wahlenbergia multicaulis*, part of requirement for SIS. Report to Rail Infrastructure Corporation.
- James, T.A. (May-June 2003). Flora survey in Hunter district for NSW National Parks & Wildlife Service.
- James, T.A. (June 2003). Field survey in North West Sydney – for Eco Logical Australia and Planning NSW.
- James, T.A & Anderson, J. (September 2003). Flora and fauna survey of Caroll Park & surrounds, Casula. Report to Liverpool City Council.
- James, T.A. (October 2003). Flora survey in Nattai – Bargo district for NSW National Parks & Wildlife Service.
- James, T.A. (December 2003). Flora survey and assessment for rail corridor at Yagoona. Report to Report to Rail Infrastructure Corporation.
- James, T.A. (December 2003). Review of flora and fauna issues re proposed integrated housing development at Beames Road, Rooty Hill. Report to Dr. Charles McKay Reserve Committee.
- James, T.A. (February 2004). Flora survey and assessment for rail corridor at Birrong. Report to Report to Rail Infrastructure Corporation.
- James, T.A. (May 2004). Summary of flora surveys during 2003-4 in Dr Charles McKay Reserve, Mt. Druitt for Blacktown City Council.
- James, T.A. (May 2004). Conservation assessment of Cumberland Plain Woodland in Balmoral Road Land Release area, Kellyville. Report to Baulkham Hills Shire Council.
- James, T.A. (May-June 2004). Threatened flora assessment for proposed realignment of the Great Western Highway at Lawson. Report to Australian Museum Business Services and Roads & Traffic Authority.
- James, T.A. (July 2004). Yagoona cutting flora review. Report to Rail Infrastructure Corporation.
- James, T.A. & Anderson, J. (September 2004). Flora and fauna survey for proposed residential development at the Kings School, North Rocks. Shale Sandstone Transition Forest and threatened species. Report to the Kings School.
- James, T.A. (September 2004). Flora assessment for proposed construction of sewage effluent pipeline at Megarritys Creek, Warragamba. Report to Australian Museum and Sydney Water.
- James, T.A. (September 2004). Flora survey of Faulkland Crescent Reserve, Kings Park. Report to Blacktown City Council.

- James, T.A. (October 2004). Flora assessment for proposed construction of water quality basins at Henry Street and Waratah Street, Lawson. Report to Australian Museum and Roads & Traffic Authority.
- James, T.A. (October 2004). Clearing of native vegetation at Lot 102 DP 1027438, 238-258 Captain Cook Drive, Kurnell. Report to Dept. of Environment & Conservation.
- James, T.A. (November 2004). Review of flora and fauna assessment for proposed subdivision at Charcoal Road, South Maroota. Report to Baulkham Hills Shire Council.
- James, T.A. (January 2005). Birrong rail cutting - flora review. Report to Rail Infrastructure Corporation.
- James, T.A. (Feb 2005). Proposed construction of electricity transmission line west of Nowra – preliminary flora survey and assessment. Report to Parsons Brinckerhoff Australia Pty Ltd.
- James, T.A. & Anderson Ecological Surveys (March 2005). Amended Species Impact Statement for proposed development at 8 Narabang Way, Austlink Corporate Park, Belrose.
- James, T.A. (March 2005). Review of flora and fauna assessment for proposed subdivision at 48-52 Oratava Avenue, 11 Maralinga Place and 19-25 Timberline Avenue, West Pennant Hills. Blue Gum High Forest. Report to Baulkham Hills Shire Council.
- James, T.A. (May 2005). Flora assessment for proposed extensions at Chatswood High School. Report to NSW Dept. of Commerce (Government Architects Office).
- James, T.A. (September 2005). Review of flora and fauna assessment for proposed hotel complex at 314 Annangrove Road, Rouse Hill. Shale Sandstone Transition Forest. Report to Baulkham Hills Shire Council.
- James, T.A. (October 2005). Flora survey for proposed fire hazard burn at Lawson. Report to GIS Environmental Consultants.
- James, T.A. (November 2005). Flora survey and assessment of shale forest at Helensburgh. Report to J & Z. Erskine.
- James, T.A. (December 2005). Preliminary flora survey at 110 Hebron Road, Lower Portland.. Report to GIS Environmental Consultants.
- James, T.A. (February & March 2006). Flora surveys in BHP exploration areas (Appin district). Surveys undertaken for Biosis Research.
- James, T.A. (March 2006). Flora survey & assessment for proposed reconstruction of 32nd Avenue, Hoxton Park. Report to Liverpool City Council.
- James, T.A. (April 2006). Flora monitoring survey - Hartley Quarry. Survey for Biosis Research.
- James, T.A. (May 2006). Preliminary flora report – proposed Penrith Great River Walk. Report to Australian Museum Business Services for Penrith City Council).
- James, T.A. (May 2006). Autumn surveys in Dr Charles McKay Reserve, Mt. Druitt. Ongoing survey & monitoring for Blacktown City Council.
- James, T.A. (May 2006). Update of Species Impact Statement for proposed development at 8 Narabang Way, Belrose. Report to Access Industrial Holdings Pty Ltd.
- James, T.A. (May 2006). Review of Environmental Management Plan and site inspection for proposed stabilisation works along Birrong rail cutting. Advice to RailCorp.
- James, T.A. (July 2006). Flora investigation of alleged poisoning of vegetation on Lot 42 Warlands Creek via Blandford, Upper Hunter Valley. Report to Department of Environment & Conservation (Legal Branch).
- James, T.A. & Barker, C. H. (June-August 2006). Preliminary flora & fauna survey for Hyland Road Reserve (North), Greystanes. Report to Holroyd City Council.
- James, T.A. (September 2006) Threatened Flora Surveys – western Sydney. Targeted survey for Department of Environment & Conservation.

- James, T.A. (November 2006). Flora survey and assessment for proposed footbridge construction over Cabramatta Creek. Report to Liverpool City Council.
- November 2006. Targeted field survey for *Gentiana wingecarribiensis* at Wingecarribee Swamp, Southern Highlands. Assistance to Parsons Brincherhoff Australia.
- February-May 2007. Field survey of Sydney Metropolitan Catchment Management Authority area. Royal Botanic Gardens Trust and Sydney Metropolitan Catchment Management Authority.
- T.A. James (February 2007). Faulkland Crescent Reserve - flora survey and review. Report to Blacktown City Council.
- James, T.A. (April 2007). Upgrade of Great Western Highway at Wentworth Falls - proposed stockpile, compound and spill basin areas - Flora survey and assessment. Report to Australian Museum Business Services for RTA.
- James, T.A. (May 2007). Upgrade of Great Western Highway at Bullaburra – flora survey and assessment. Report to Australian Museum Business Services for RTA.
- BioBanking Pilot Program (May 2007). Field survey & assessment at three Sydney sites (Wilton, Camden & Cranebrook) to test draft assessment methodology. Undertaken with Australian Museum Business Services for Department of Environment & Conservation.
- James, T.A. (August 2007). Flora review – proposed re-zoning of land along Pacific Highway, Pymble with particular reference to Blue Gum High Forest. Report to Ku-ring-gai Council.
- James, T.A. & C. H. Barker (October 2007). Flora & Fauna Survey and Assessment – Castle Hill Cemetery. Report to Baulkham Hills Shire Council.
- James, T. A. (Nov 2007). Investigation of clearing of native vegetation at Lot 2 DP 559922, 280-282 Captain Cook Drive, Kurnell. Report to NSW Department of Environment & Climate Change (DECC).
- James, T.A. (Nov 2007). Review of flora assessment for proposed residential development at 216-220 New Line Road, Dural. Report to Hornsby Council.
- November 2007. Assistance to SMEC Australia with base-line ecological monitoring in Upper Nepean Special Area for SCA.
- James, T.A (Dec 2007-Feb 2008). Targeted survey for *Hibbertia superans.* Report to Indigenous Business Services.
- November 2007- January 2008. Targeted survey for *Gentiana wingecarribiensis* and *Prasophyllum uroglossum* at Wingecarribee and Hanging Rock Swamps. Report to NSW Department of Environment & Climate Change (DECC).
- March 2008. Flora survey for upgrade of Great Western Highway at Bullaburra. Report to nghenvironmental for RTA.
- James, T.A. (March 2008). Flora survey of Plumpton Park Reserve. Report to Blacktown City Council.
- James, T.A. (April 2008). Review of Water Street DA, Wahroonga. Report to Ku-ring-gai Council.
- James, T.A. (April 2008). Flora survey of Gum Tree Reserve, Guildford and Bolaro Avenue, Greystanes. Report to Holroyd City Council.
- May 2008-June 2009. Assistance to Ku-ring-gai Council to map and assess Blue Gum High Forest and Turpentine Ironbark Forest.
- James, T.A. (August 2008). Flora review of Species Impact Statement prepared for proposed industrial development at 37 Beaumont Road, Mt. Ku-ring-gai. Report to Hornsby Shire Council.
- James, T. A. (May 2009). Preliminary flora report for proposed residential development at 38-40 Grove Avenue, Narwee.
- James, T.A. & Barker, C. (2006-2009). Monitoring of flora and fauna at Hyland Road Reserve. Report to Holroyd City Council.

- James, T. A. (Sept 2009). Ecological issues relating to the Turramurra Deferred Area within Ku-ring-gai LGA. Report to Friends of Turramurra.
- James, T.A. (Sept 2009). Targeted survey for *Pimelea spicata* at Menangle Park. Assistance to GHD Pty Ltd.
- James, T.A. (Sept 2009). Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland - 561 Appin Road, Gilead. Report to Campbelltown City Council.
- James, T.A. (Nov 2009). Peer review of subdivision proposal at Kellyville. Shale Sandstone Transition Forest & threatened species present. Report to Hills Shire Council.
- James, T.A (2010). Field survey and ecological assessment for proposed park at Water Street, Wahroonga. Report to A. Parr.
- James, T.A. (March 2010). Survey of *Pimelea spicata* at Menangle Park for GHD.
- March-April 2010. Advice on threatened species for Growth Centres Strategic Assessment under EPBC Act to EcoLogical Australia.
- Lewis Ecological Surveys & James, T.A. (May –June 2010). Flora and fauna assessment for extension of Kirkwood Road, Tweed Heads. Report to Tweed Heads Shire Council.
- Lewis Ecological Surveys & James, T.A. (May –June 2010). Compensatory habitat assessment for the Kempsey to Eungai pacific highway upgrade.
- Joint project with Australian Museum (October 2010 - March 2011) – Flora & fauna survey for Stage 2 of the Narrabeen Lagoon Multi-use Trail.
- Joint project with Australian Museum (October 2010 - December 2011) – City of Sydney Biodiversity Survey & Strategy.
- James, T.A. (2011). Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland - 561 Appin Road, Gilead. Expert report to DECCW.
- James, T.A. (2011) Flora survey for three reserves in Holroyd LGA to document regeneration following the cessation of mowing. Report to Holroyd City Council.
- James, T.A. (2011) Flora survey of Grey Box Reserve, Greystanes. Report to Holroyd City Council.
- Douglas, S & James, T (2011) Review of listing advice and conservation advice for Shale Sandstone Transition Forest EEC under the EPBC Act – in progress.
- James, T.A. (2011) External Review of White Box – Yellow Box – Blakeley's Red Gum grassy woodlands and derived native grassland ecological community for the Mt. Pleasant Project (EPBC 2011/5795). Report to Dept. of Sustainability, Environment, Water, Population and Communities.
- Ecological advice to SMEC Australia (July-August, 2011). Impact assessment for *Pimelea spicata* – upgrade of Camden Valley Way, western Sydney.
- Ecological advice to SMEC Australia (August-September, 2011). Survey and assessment for Eastern Flame Pea – Trans Grid Dapto substation upgrade.
- Field assistance to SMEC Australia (February 2012) - Targeted survey for *Pimelea spicata* and general survey for RTA Camden Valley Way upgrade.
- PAS2 Expert Interviews for NSW threatened species with Office of Environment & Heritage (February-August 2012).
- Plot survey and ground verification of vegetation mapping within Hills Shire Council (June 2012).
- Threatened species management plans for several species prepared for Hills Shire Council (June 2012) – multi-species plan for Paulls Road (South Maroota), individual plans for *Persoonia hirsuta* and *Epacris purpurascens* at Fred Caterson reserve.
- Joint project with Australian Museum - Narrabeen Lagoon multi-trail (stage 2) Species Impact Statement (June 2012)

- Field assistance to SMEC Australia - Western Sydney Parklands vegetation monitoring project for WSP Trust (July – August 2012).
- Biodiversity/conservation assessment for 12-14 Cabernet Circuit Orchard Hills. Unpublished report to Wayne Olling of CCA (October 2012)
- PAS Reviews for selected NSW threatened species with Office of Environment & Heritage (November 2012).
- Vegetation Peer Review for the Northern Beaches Health Service Project. Report to Health Infrastructure (January 2013).
- Flora survey and assessment on private properties within the Balmoral Release Area, Kellyville (15, 16-20, 24, 26 & 28) for the Hills Shire Council (May-June 2013).
- Preparation of a Threatened Species Plan of Management for *Dillwynia tenuifolia* endangered population along Maquires Road, Maraylya for the Hills Shire Council (May-June 2013).
- Biobanking Assessment Report for the Northern Beaches Hospital Precinct development (a State Significant Development). July 2013. Report to SMEC Australia and Health Infrastructure.
- Threatened species roadside survey and verification of threatened ecological communities for Campbelltown City Council (September-October 2013).
- Peer Review of Species Impact Statement for 34-36 Britton Street, Smithfield for Holroyd City Council (November 2013).
- Flora survey and condition assessment for Pacific Highway Upgrade Woolgoolga to Ballina (Feb - April 2014). Assistance to Ecosure for Roads and Maritime Services.
- Matching of threatened entities occurring in the Greater Sydney Region area to newly mapped vegetation/community types in the Sydney Metro CMA and other parts of the Greater Sydney Region (May-June 2014) for Office of Environment and Heritage (Sydney).
- Parramatta Park baseline flora survey and report for Parramatta Park & Western Sydney Parklands Trust (September 2014).
- Assistance to SMEC with survey and biodiversity report for commonwealth-owned land at Badgerys Creek (Sept-Oct 2014). Report to Department of Infrastructure and Regional Development.
- Identification of Shale Sandstone Transition Forest in the Hills Shire – report to Hills Shire Council (July 2015).
- Assistance with field survey to SMEC Australia at the Holsworthy Training Area for Department of Defence (September 2015).
- Assistance with field survey (base line monitoring) to SMEC Australia at the Kapooka Biodiversity Offset Site near Wagga Wagga for Roads and Maritime Services (Sept-Oct 2015).
- Assistance to SMEC Australia in preparation of a Species Impact Statement for the Mona Vale Road upgrade for RMS (Nov 15-Jan16).
- Assistance to Ecosure in field survey/assessment for Mosman Flora and Fauna Bushland Audit (Jan-Feb 2016).
- Ecological Survey of Sackville Cemetery – report to The Hills Shire Council (May 2016)
- Field survey with 20 m x 20 m plot sampling for OEH Western Cumberland Plain and Bargo Gap Project (targeting transitional areas) – June 2016
- Field survey with 20 m x 20 m plot sampling for OEH Wingecarribee Shire Project – February 2017
- Field survey for vegetation management advice at Greendale property, western Sydney (April 2017)
- Vegetation Benchmark Values Project for the Hills Shire Council (June 2017)

NSW Land & Environment Court cases:

- Grand United Friendly Society v Minister for the Environment - 87A Hammers Road, Toongabbie. Land & Environment Court.Proceedings No. 40292 of 1997. Engaged as a consultant by NPWS. Issues relating to Cumberland Plain Woodland and Shale Sandstone Transition Forest.
- Australand v Penrith City Council, Erskine Park (Dec 1999-April 2000). Land & Environment Court Proceedings. Engaged as a consultant by Penrith City Council. Cumberland Plain Woodland and Sydney Coastal River-flat Forest.
- Penrith City Council v Norman Mathie & Others – 392-476 Luddenham Road, Luddenham. Land & Environment Court Proceedings No. 50080-82 of 1999. Engaged as a consultant by Penrith City Council. Issues relating to Cumberland Plain Woodland and Sydney Coastal River-flat Forest.
- Blacktown City Council v Megarry Excavations and Roadworks Pty Ltd. Land & Environment Court Proceedings No 40141 of 2000. Engaged as a consultant by Blacktown Council. Issues relating to Cumberland Plain Woodland and Shale Gravel Transition Forest.
- Mark Topic v Liverpool CityCouncil. North Liverpool Road. Land & Environment Court Proceedings No 0155 of 2000. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland
- Australand v Liverpool City Council. Land & Environment Court Proceedings No 10374, 10375, 10376, 10377 of 2003. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland and Sydney Coastal River-flat Forest
- Development Approval Managers v Liverpool City Council. Land & Environment Court Proceedings No. 10453 (Stage 3), No. 10455 (Stage 4) and No. 10454 (Stage 5) of 2003. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland and Sydney Coastal River-flat Forest
- BGP Properties v Lake Macquarie City Council - Lots 1 & 4 Cowlishaw Street, Redhead. Land & Environment Court Proceedings No 10042 of 2003. Engaged as a consultant by Lake Macquarie City Council. Issues relating to Sydney Freshwater Wetlands and Tetratheca juncea.
- Bentley v Hugh Gordon, Bentley v BGP Properties, Bentley v Whet Investments - Lots 1 & 4 Cowlishaw Street, Redhead. Land & Environment Court Proceedings No 50069-80 of 2003. Engaged as a consultant by NSW National Parks & Wildlife Service. Issues relating to Sydney Freshwater Wetlands and Tetratheca juncea.
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- Providence Projects Pty Ltd v Gosford City Council – Lot 17 Meacham Way, Woy Woy. Land and Environment Court Proceedings No. 11626 of 2004 & 10101 of 2005. Court appointed expert. Review of issues relating to the identification of Umina Coastal Sandplain Woodland.
- Liverpool City Council ats Muslim League of NSW – 264 Wilson Road, Green Valley. . Land & Environment Court Proceedings No 10394 of 2005. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland.
- Liverpool City Council ats AV Jennings – Stage 24 Dalmeny Drive, Prestons. Land & Environment Court Proceedings No 10395 of 2006. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland.
- Director General, Department of Environment & Conservation v Serenity Cove Business Park Pty Ltd – 238-258 Captain Cook Drive, Kurnell. Land & Environment Court Proceedings No 50003-5005 of 2006. Engaged as a consultant by the Department of Environment &

Conservation. Issues relating to Swamp Sclerophyll Forest on Coastal Floodplains (formerly Sydney Coastal Esutary Swamp Forest), Sydney Freshwater Wetlands & Kurnell Dune Forest.
- Sutherland Shire Council ats Rocla Pty Ltd. Land & Environment Court Proceedings No 10447 of 2005. Engaged by Sutherland Shire Council. Issues relating to Swamp Sclerophyll Forest on Coastal Floodplains and Sydney Freshwater Wetlands.
- Wollongong City Council ats Albert David Moulds. Land & Environment Court Proceedings No 10488 & 10563 of 2006. Engaged as Court Appointed Expert. Issues relating to Illawarra Subtropical Rainforest and *Cynanchum elegans.*
- Gerroa Environment Protection Society v Department of Planning and Cleary Bros. Pty Ltd. Land & Environment Court Proceedings No 10801 of 2007. Issues relating to Swamp Sclerophyll Forest, Bangalay Sand Forest and Littoral Rainforest.
- Ecological advice to Ku-ring-gai Council and Land & Environment Court in relation to proposed development at 1-9 Buckingham Road, Killara. Issues relating to Blue Gum High Forest.
- Kaligem Pty Ltd v Ku-ring-gai Council. Proceeding No: 10823 of 2008 Ecological advice to Ku-ring-gai Council and Land & Environment Court in relation to proposed development at 5-7, Lonsdale Avenue, Pymble. Issues relating to Sydney Turpentine Ironbark Forest.
- Proceedings No: 10496 of 2009 Ecological advice to Warringah Council and Land & Environment Court in relation to proposed development at Beacon Hill. Issues relating to threatened species & general environmental impact. Proceedings No 10973 & 10794 of 2009.
- Ecological advice to Ku-ring-gai Council and Land & Environment Court in relation to proposed development at 35 Billyard Avenue, Wahroonga. Issues relating to Blue Gum High Forest. Proceedings 10908 of 2009 (NSWLEC 1222).
- Expert advice to the Environmental Defenders Office and Land & Environment Court in relation to proposed development at Jordan Springs, St. Marys. Proceedings 40873 of 2011.
- Expert advice to the Office of Environment and Heritage and Land & Environment Court in relation to alleged clearing of endangered ecological communities (Cumberland Plain Woodland and Shale Sandstone Transition Forest) at Gilead, western Sydney. Proceedings 50604 of 2011.
- Expert advice to Ku-ring-gai Council and Land & Environment Court in relation to proposed development at Knox Grammar School, Warrawee. Issues relating to Blue Gum High Forest. Proceedings 10762 of 2011.
- Expert advice to The Hills Shire and NSW Land & Environment Court re proposed subdivision at 186-186A Cattai Ridge Rd Maraylya (Case No. 11216 of 2015).
- Expert advice to Cumberland Council and Land & Environment Court in relation to deemed refusal of DA (Fife Capital Pty Ltd) - Land and Environment Court Proceedings No. 2016/00310627
- Expert advice to Northern Beaches Council and Land & Environment Court in relation to deemed refusal of DA - Land and Environment Court Proceedings No. 53907 of 2017. Issues **- i**mpacts on *Swamp Sclerophyll Forest on Coastal Floodplains*, Warriewood.

Strategic Assessment for Cumberland Plain Conservation Plan

Greater Penrith to Eastern Creek and Western Sydney Aerotropolis Growth Areas

Expert Report for *Pimelea spicata* Spiked Rice-flower

Prepared for NSW Department of Planning & Environment

Teresa James April 2019

Contents

*GIS mapping prepared for report by Anthea Whitlam

Executive summary

Pimelea spicata is known to be present within the Greater Penrith to Eastern Creek Growth Area (9 records) and is likely to be present within the Western Sydney Aerotropolis Growth Area with one unsubstantiated record, >500 ha of potential habitat and a large population recently discovered just to the east. The study area is considered important habitat for the species at the western limit of its known extent on the Cumberland Plain.

Potential habitat is based on the:

- Presence of local records;
- Presence of suitable habitat;
- Ability of the species to persist as rootstock and seed for long periods; and
- Ability of the species to easily regenerate when environmental conditions are suitable.

Extensive areas of suitable habitat are identified across the study area. A total area of 2714 ha is identified within four vegetation communities, all threatened ecological communities (TEC's), across the two growth areas (2168 ha in the GPECGA & 564 ha in the WSAGA). The condition of habitat is not a reliable indicator of species presence and all condition states were considered in determining potential (suitable) habitat.

Survey effort within potential habitat across the study area is very low particularly for favoured Cumberland Plain Woodland habitat (only 5% and 7% for PCT 849 within the GPEC and WSA growth areas). More rural areas in western zones of the growth areas (particularly in the south) have been poorly surveyed largely reflecting private ownership and access restrictions. Where targeted survey has been undertaken, the reliability of detecting the species is considered low due to unsuitable conditions for growth and flowering with the best climatic conditions (particularly successive good rain events) occurring post-survey in late 2018 and much of the habitat being grazed and/or slashed. In view of the low reliability of surveys it is considered appropriate to assume a greater presence within the growth areas and reserve suitable habitat across its known range to protect the species long-term.

Within the Greater Penrith to Eastern Creek growth area 133 ha or 6% of potential (i.e. suitable) habitat is found within the certified zone, 178 ha (8%) is zoned for conservation and 1857 ha (86%) occurs in the non-certified zoning. The latter includes larger areas within Wianamatta Regional Park and the Orchard Hills Defence Establishment that has long been recognised for its conservation values. Small council reserves in the far north-west associated with a north to south ridge-line above the Hawkesbury-Nepean River floodplain are particularly important for known and potential *Pimelea spicata* habitat, only two of which currently have conservation zoning. With records of *Pimelea spicata* just outside of the GPECGA at Mulgoa the protection of suitable habitat adjacent and to the south of Mulgoa Nature Reserve is desirable.

In the Western Sydney Aerotropolis growth area just over 53% occurs within the certified or development zone with 43% zoned for conservation predominantly associated with the South Creek corridor (around Kemps Creek) and the upper catchment of Duncan's Creek in the vicinity of Willowdene Avenue, south of Luddenham. The latter area is close to the recently discovered population west of the Northern Road and includes similar habitat.

1. Introduction

1.1 Purpose of the expert report

An expert report may be prepared under section 6.5 of the Biodiversity Assessment Method (OEH 2017) in place of undertaking a threatened species survey. Use of an expert report may be beneficial where it is highly unlikely that a species may occur within the study area, survey effort is inadequate and/or the reliability of detecting the species through survey is low. In respect of *Pimelea spicata*, low survey effort and unreliability of survey are the primary reasons for preparing an expert report.

The purpose of this report is to provide scientific assessment of the current status and conservation needs of *Pimelea spicata* within the Western Sydney Aerotropolis and Greater Penrith to Eastern Creek growth areas of western Sydney. Specifically, the report is to determine whether:

- The species is unlikely to be present and in this case no further assessment is required, or
- The species is likely to be present and in this case the expert report must provide estimates of habitat area both within the growth and biocertified or development footprint areas.

1.2 Project context

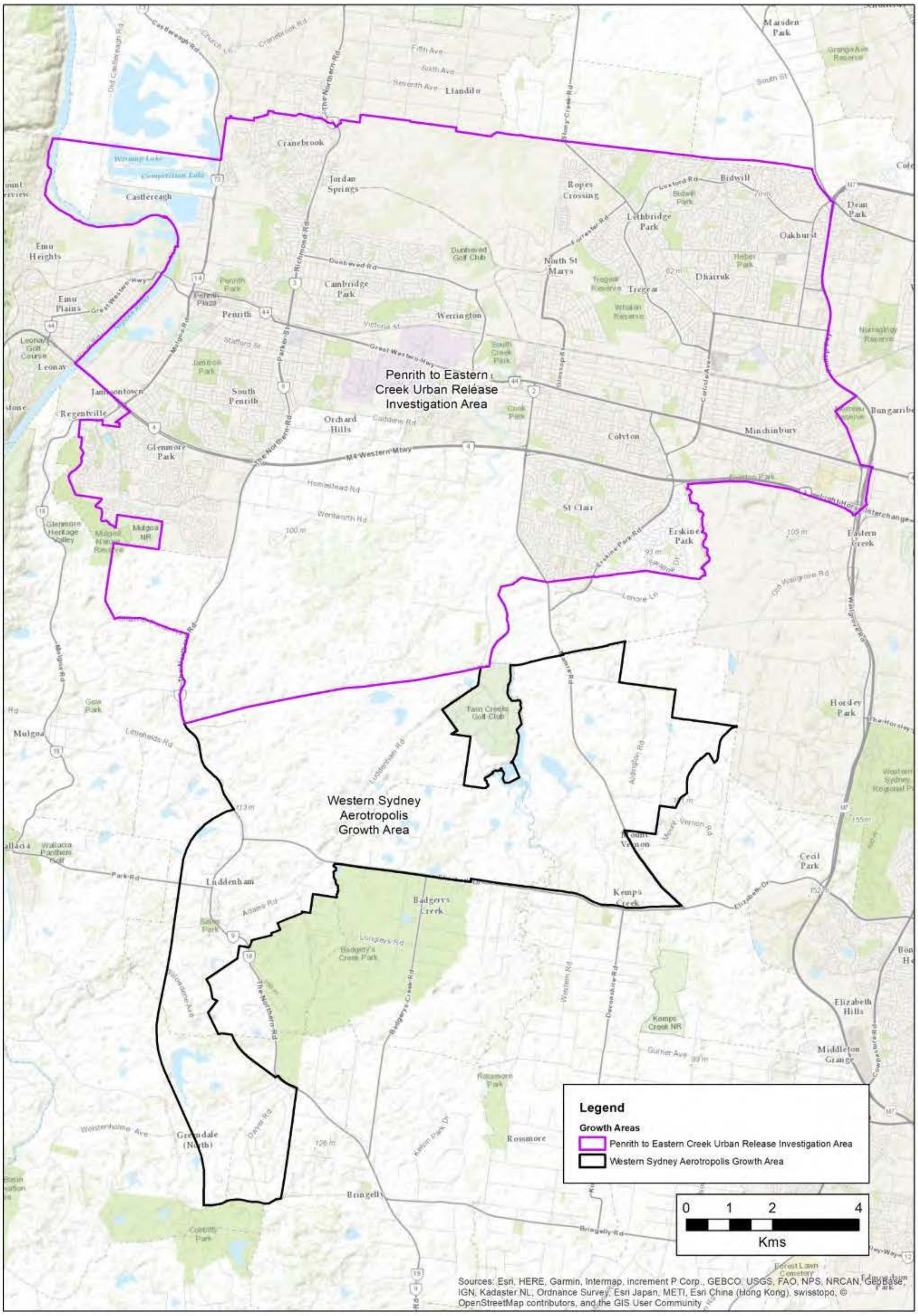
The NSW Government is identifying areas for future urban development and associated infrastructure in western Sydney. There are four priority growth areas: Wilton, Greater Macarthur (Campbelltown and Appin), Western Sydney Airport, and Greater Penrith to Eastern Creek. These new growth areas are all located within the Cumberland Interim Biogeographic Regionalisation for Australia (IBRA) sub-region.

As part of the planning for the priority growth areas, the Department of Planning and Environment (DPE) will prepare the Cumberland Plain Conservation Plan to identify development and conservation outcomes for the growth areas. A strategic assessment of this plan is underway and this expert report will assist the biodiversity assessment to assess the conservation benefits and development impacts of the Plan in respect of *Pimelea spicata*. This report is consistent with the Scope of Works for expert reports provided by DPE and dated November 2018.

1.3 The study area

The study area for this report comprises the growth areas of Western Sydney Aerotropolis and Greater Penrith to Eastern Creek (see Figure 1) and includes parts of the Penrith, Blacktown and Liverpool LGA's in far western to south-western parts of the Cumberland Plain, western Sydney. It adjoins the Western Sydney Airport in the south. The study area is located within the Cumberland subregion on Triassic Wianamatta Group sediments. The study area is within the Hawkesbury-Nepean River catchment and is dissected north to south by South Creek (and its tributaries). It is associated with low-lying to gently undulating land (<100 m a.s.l.) with clay soils (Blacktown and Luddenham soil landscapes) and recent alluvium on floodplains with soils of the Richmond, Freeman's Reach and South Creek soil landscapes.

Figure 1. Western Sydney Aerotropolis and Greater Penrith to Eastern Creek Priority Growth Areas



1.4 Reasons for use of an expert report

An expert report for *Pimelea spicata* is required as part of the threatened species assessment for the Cumberland Plain Conservation Plan for the following reasons:

1. The survey effort for this species did not meet the recommendations in the OEH threatened species guidelines (OEH 2016) for targeted surveys largely due to limitations imposed by land access. Around 3.7 % of total potential habitat for *Pimelea spicata* has been accessed for survey within the Greater Penrith to Eastern Creek Growth Area and 6% in the Western Sydney Aerotropolis Growth Area.
2. Poor survey timing. *Pimelea spicata* is difficult to detect particularly when not in flower. Flowering is unpredictable and considered dependant on good rains (Environmental Impact Assessment Guidelines NPWS 2004, and personal knowledge). During dry periods the species is often invisible above ground but may persist in the soil as rootstock and seed. Dry, hot spring/summers have been a particular feature of the western Sydney environment in the last few years and survey has not been timed to coincide with suitable conditions following good rain events.
3. The cryptic nature of the species and extent of disturbance across the growth areas significantly reduces the likelihood of detecting the species. Many populations have only been recorded once the disturbance factor e.g. mowing, grazing or weed infestation has been removed. Many of the sites surveyed are heavily grazed or mown/slashed.

Survey for *Pimelea spicata* has been insufficient to reliably determine the presence and extent of the species within the growth centres. An expert report is necessary to provide a more comprehensive and reliable level of scientific assessment appropriate for an endangered species.

1.5 Credentials of expert

I am a botanist/ecologist with over forty years of experience in vegetation survey, plant identification, conservation assessment and threatened species, particularly in western Sydney. I have worked within the NSW government (National Herbarium of NSW, NSW National Parks & Wildlife Service) and for the last twenty years as a consultant (sole trader). A summary of my credentials as required under the Biodiversity Assessment Methodology (2014, 2016) is provided in Table 1. Under 6.5.2.4 of the BAM I am recognized as a biodiversity expert for *Pimelea spicata*.

Table 1. Credentials of Teresa James

BAM section	BAM requirement	Details
BAM s 6.5.2.8 (g)	Name of expert	Teresa James
BAM s 6.5.2.4	Biodiversity expert	*Pimelea spicata*
BAM s 6.5.2.3 (a)	The expert's qualifications	Bachelor of Science (Honours), University of Exeter 1978 Accredited BioBanking Assessor (awarded 2008, renewed 2013)
BAM s 6.5.2.3 (b)	History of experience in ecological research and survey method, for the relevant species	Field surveys and other relevant studies: • Populations of *Pimelea spicata* across western Sydney e.g. Denham Court Road, Campbelltown (1999, 2012), Alpha Road Park, & Grey Box Reserve, Holroyd (2011), Cobham Road Reserve & Power Street Reserve, Fairfield (2016-17), Greendale (near Wallacia), private property (2016-7), Cranebrook Reserve, Penrith (2017). • Threatened community and threatened species (including *Pimelea spicata*) roadside surveys through Campbelltown

		LGA for Campbelltown City Council (2013) • Targeted survey for *Pimelea spicata* along Denham Court Road, near Camden Valley Way for SMEC (2012) • Expert report to DECCW: Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland at a property on Appin Road, Gilead (2011). • Targeted survey for *Pimelea spicata* at Menangle Park Offset Strategy for GHD (2009, 2010) • Biobanking Pilot Project at Wilton (2007). • Survey & monitoring of Cumberland Plain Woodland and *Pimelea spicata* at Faulkland Crescent Reserve, Blacktown (2004, 2007) for Blacktown City Council.
BAM s 6.5.2.3 (c)	A resume detailing projects pertaining to the survey of the relevant species	Resume attached at Appendix 1. Relevant field surveys listed above.
BAM s 6.5.2.3 (d)	Their employer's name and period of employment (where relevant)	Self-employed ecological consultant Teresa James Flora Consultant 1998 to present
BAM s 6.5.2.3 (f)	Evidence that the person is a well-known authority on the relevant species to which the survey relates	1. Author of several botanical guides to the flora of Western Sydney: • James, T.A., McDougall, L & Benson, D. (1999). Revised edition. *Rare Bushland Plants of Western Sydney.* Royal Botanic Gardens, Sydney. • James, Teresa (2013) Flora of Cumberland Plain Woodland – an identification guide. • James, Teresa (2015) Threatened Flora of the Fairfield LGA. • James, Teresa (2016) Native Flora of Shale Soils of the Cumberland Plain Woodland – An Identification Guide. 2. Author of flora component of Urban Bushland Biodiversity Survey of Western Sydney (1997). Included compilation of information on *Pimelea spicata* and its habitat across western Sydney local government areas. 3. Contributed information to the *Pimelea spicata* Approved Recovery Plan (2006). 4. Has acted as Expert witness in NSW Land and Environment Court in relation to threatened communities in western Sydney including: • Expert advice to OEH and Land & Environment Court in relation to alleged clearing of endangered ecological communities (Cumberland Plain Woodland and Shale Sandstone Transition Forest) at Gilead, western Sydney. Proceedings 50604 of 2011. • Expert advice to Liverpool City Council ats Muslim League of NSW – 264 Wilson Road, Green Valley. Land & Environment Court Proceedings No 10394 of 2005. Issues relating to Cumberland Plain Woodland. • Expert advice to Liverpool City Council ats AV Jennings – Stage 24 Dalmeny Drive, Prestons. Land & Environment Court Proceedings No 10395 of 2006. Issues relating to Cumberland Plain Woodland.

		5. PAS2 Expert Interviews for several NSW threatened species with OEH (February-August 2012) including a range of Cumberland Plain species 6. Member of SOS Project Panel (2018) – Cumberland Plain Woodland, Western Sydney Dry Rainforest, Moist Shale Woodland, River-flat Eucalypt Forest, Agnes Banks Woodland and Castlereagh Ironbark Forest 7. Member of NPWS Cumberland Plain Recovery Team (1998) 8. Author of expert report for *Pimelea spicata* in Greater Macarthur and Wilton growth areas (2018)

Through this experience I have developed a good knowledge and understanding of the life history and habitat requirements of *Pimelea spicata* and associated habitats within the growth areas.

2. Species Information

2.1 Species description

A small, slender to spreading shrub or sub-shrub to c. 50 cm high; stems 1-several, glabrous. Older stems are often seen intertwining with grasses and herbs. *Pimelea spicata* has an underground carrot-like tap root recorded up to 18 cm in length that gives plants the ability to re-sprout after defoliation and periods of drought stress (NSW NPWS 1997). The leaves are mostly opposite, narrow-elliptic to elliptic in shape, to 20 mm long and 8 mm wide, spreading, soft and often bluish-green. Inflorescence is a raceme, dense when young, elongated and interrupted at maturity, bracts absent. Flowers tubular, white to pink tinged, 7-10 mm long with four spreading lobes. Fruit is a narrow-ovoid nut, c. 3 mm long, 1-seeded, mostly green.

Pimelea spicata leaves (left); flowers & fruit (above)

2.2 Life cycle

Pimelea spicata is incapable of effective vegetative spread (Benson and McDougall 2001) although more recent observations suggest that mature individuals can spread over short distances through underground rhizomes (OEH 2017) giving rise to "clumps" of plants. Seed production, however, is the primary means of recruitment. Flowering is sporadic throughout the year and is likely in response to climatic conditions, particularly rainfall (DEC 2006). Flowering and fruiting has been observed in plants 1.5-2 years old (NPWS 1997); flowers continue to be produced as fruits mature. Native bees are known pollinators and moths may also contribute to pollination (DEC 2006). The species may also be capable of spontaneous self-pollination (DEC 2006). Fruiting is highly variable depending on environmental conditions. Seed viability has been recorded as relatively high ranging from 83% - 86% (Nash & Matthes 1995, Willis et al. 2003 cited in DEC 2006). Seed dispersal is highly localised with the majority of seedlings observed within 30 cm of adult plants following fire (Hogbin pers. obs. cited in DEC 2006). *Pimelea spicata* maintains a long-lived soil-stored seed bank resulting in potential for considerable recruitment following disturbance. The soil seed bank can survive under infestations of invasive weeds (Willis et al. cited in DEC 2006).

Seed germination can be triggered by disturbance including fire, slashing/mowing, grazing and soil disturbance (NPWS 1997, Willis et al. 2003 cited in DEC 2006). Monitoring of seedlings following fire revealed 80% survival in the first year (NPWS 1997 cited in DEC 2006). Ex-situ trials found that smoke application increased seed germination (Tozer & Robertson 1998), however, Willis et al. (2003) cited in DEC (2006) found only a 20-30% germination rate for seed in any trial.

Re-sprouting from the taproot occurs following defoliation caused by fire, drought or physical damage (NPWS 1997). The species can survive periods of drought stress or weed infestation by dying back to the tap root and re-sprouting when favourable conditions return. It is unknown at what age the tap root has to be of a sufficient size to facilitate re-sprouting.

2.3 Distribution and abundance

Pimelea spicata occurs in two disjunct regions of the Sydney Basin IBRA bioregion, the Cumberland subregion in western Sydney and the coastal region of the Illawarra, south of Sydney.

<u>Cumberland subregion</u>
In the Cumberland subregion *Pimelea spicata* is found on clay soils derived from Wianamatta Group Shales. The current known distribution extends from Freeman's Reach in the north to Douglas Park in the south and west from Penrith to Georges Hall in the east. *Pimelea spicata* has been recorded in the following vegetation communities:

PCT 849 – Grey Box – Forest Red Gum grassy woodlands on flats of the Cumberland Plain
PCT 850 - Grey Box – Forest Red Gum grassy woodlands on shale of the southern Cumberland Plain
PCT 830 – Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain
PCT 835 – Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain (most commonly when intergrading with CPW)

These communities are equivalent to the Cumberland Plain Woodland, Moist Shale Woodland and River-flat Eucalypt Forest threatened ecological communities and include derived grasslands.

The recovery plan for *Pimelea spicata* (DEC 2006) identified 25 populations on the Cumberland Plain. Currently there are approx. 70 sites (Bionet Atlas records, June 2018). The main concentration of sites is found in the Blacktown, Prospect, Bankstown and Narrellan districts. More recent records (post 2014) are from near Wallacia, Horsley Park - Cecil Park and Greendale. Populations in the Penrith LGA are at the western limit of the specie's geographical range.

<u>Coastal Illawarra</u>
In the Illawarra *Pimelea spicata* is associated with coastal headlands and hill tops from Mount Warrigal south to just north of Kiama. The recovery plan for *Pimelea spicata* (DEC 2006) identified 5 populations in the Illawarra.

In 2006, the total population of *Pimelea spicata* across 30 known populations was estimated to be around 4300. Populations varied from a few individuals to >500 plants although larger populations were rare with over half with <50 individuals and small habitat areas of less than 0.5 ha (DEC 2006, Dept. Environment & Heritage 2016*)*. Since 2006 several populations are likely to have been lost to development or habitat modification. At several sites survey has failed to re-locate plants including at Menangle and along Denham Court Road, Camden Valley Way and Jamisontown (James 2009, 2010, 2012, 2019). Prolonged periods of drought, increased weed invasion, heavy grazing/slashing or soil disturbance are likely to be the main causes. Counterbalancing losses are several new records within Fairfield, Liverpool, Penrith and Liverpool LGAs (mostly <50 individuals). A new site south-west of Luddenham within the Western Sydney Airport impact zone is by far the largest known population with >4000 plants recorded in 2017, however, is likely to be cleared. Increased population sizes are noted at Narellan and Prospect although numbers at any site at any one time will depend on the timing of rainfall and other environmental factors. Ongoing monitoring of the new population near Luddenham noted a decline from more than 4000 above-ground plants (after good summer and autumn rains in early 2017 together with exclusion of grazing and slashing) to around 400 by December 2017 (GHD 2018). Area of known habitat is likely to be a more accurate measure of population size than number of above-ground plants.

2.4 Habitat requirements

Pimelea spicata is found in grassy woodlands or at grassland sites on the Cumberland Plain and in the Illawarra.

<u>Cumberland subegion</u>
In the Cumberland subregion *Pimelea spicata* occurs in Cumberland Plain Woodland (CPW), intergrading zones between CPW and River-flat Eucalypt Forest, Moist Shale Woodland and associated derived grasslands. Associated canopy trees are Grey Box *Eucalyptus moluccana*, Forest Red Gum *E. tereticornis,* Narrow-leaved Ironbark *E. crebra* and Spotted Gum *Corymbia maculata*. The mid-storey typically contains *Acacia parramattensis, A. decurrens, Bursaria spinosa*, *Acacia implexa, A. falcata, Dillwynia sieberi* and *Indigofera australis*. Common groundcover grasses and herbs associated with most occurrences include Kangaroo Grass *Themeda triandra,* Weeping Grass *Microlaena stipoides,* Kidney Weed *Dichondra repens*, Woodruff *Asperula conferta* and Blue Trumpet Flower *Brunoniella australis*.

Pimelea spicata prefers moist soil and typically occurs on gentle lower slopes where groundwater seepage maintains higher soil moisture levels for longer (*T. James pers. obs.*). The more resilient sites appear to be those in protected gullies close to drainage lines e.g. Mountain View Reserve, Cranebrook. A relatively open grassy groundcover maintained by occasional disturbance e.g. fire or infrequent/low intensity grazing/slashing provides favourable habitat. Although the species can survive (and flower) among taller grasses and perennial weeds (e.g. at Cobham Street Road, Horsley Park) it is likely to disappear above ground under extended weed infestations. A population along Denham Court Road (around 2003), for example, was estimated to be hundreds yet in 2011 no plants were found (*T. James pers. obs.)*. The road reserve had become increasingly degraded with weed infestation in both the mid-storey layer (African Olive, Box Thorn and Lantana) and the ground-layer (Bridal Creeper, Prickly Pear, Blackberry & Mother-of Millions). The species was likely still present, however, in the soil seed-bank.

Frequent or intensive grazing, slashing or mowing will restrict the growth of plants with re-sprouting controlled by the frequency of disturbance and environmental conditions. Frequent cutting creates open, dry and hot conditions at the soil surface resulting in die-back of plants above ground. The species can persist for many years under such a regime as a tap root and seed in the soil. There are many examples of regeneration following cessation of mowing and slashing in council reserves e.g. Faulkland Crescent Reserve and Melrose Park in Blacktown and Power Street Reserve in Fairfield.


Habitat of *Pimelea spicata* along unformed road reserve (Cobham Road, Horsley Park)

Illawarra
In coastal habitat of the Illawarra *Pimelea spicata* occurs in a wider range of geologies and soils derived from the Permian Shoalhaven Group sediments (sandier than the clay soils of western Sydney). The favoured sites are on grassy headlands and hilltops with Kangaroo Grass *Themeda triandra*, Mat-grass *Lomandra longifolia* and Blady Grass *Imperata cylindrica*, often with Coast Banksia *Banksia integrifolia*. Woodland is also often dominated by Forest Red Gum *Eucalyptus tereticornis* and Thin-leaved Stringybark *E. eugenioides* above Kangaroo Grass, species also occurring in *Pimelea* habitat in western Sydney. Habitat in the Illawarra includes the endangered ecological community *Themeda Grasslands on Seacliffs and Coastal Headlands* (PCT 898).

3. Description of the study area

3.1 Land use history

Greater Penrith to Eastern Creek Growth Area (GPECGA)
An area of approx. 18, 619 ha extending east from the Nepean River to Wallgrove Road and from the former ADI site in the north to the Warragamba to Prospect Water Pipe-line in the south. The area is highly urbanised in northern and central parts and includes the city of Penrith and suburbs of St. Mary's Mt. Druitt, St. Clair, Glenmore Park and Jordan Springs. The Great Western Highway, the western railway line and the M4 Motorway all dissect the area east to west and act as a stimulus to further residential and industrial development. In contrast, a rural landscape predominates south of the Western Motorway although close proximity to the new airport has recently increased development activity.

Western Sydney Aerotropolis Growth Area (WSAGA)
The Western Sydney Aerotropolis Growth Area comprises a smaller area of approx. 6232 ha immediately to the north and east of the Western Sydney Airport site within the Penrith and Liverpool LGA's. It extends south from the Warragamba to Prospect Water Pipe-line to Greendale and includes the Northern Gateway, North Luddenham and Luddenham to Greendale zones. The western boundary is along the Northern Road. It has a predominantly rural landscape and has been extensively cleared in the past for farming. Close proximity to the new airport has significantly stimulated new development activity for infrastructure, housing and industry.

3.2 Landscape context

Greater Penrith to Eastern Creek Growth Area (GPECGA)
Reference to the 1:100,000 Geological Series Sheet for Penrith, indicates that most of the growth area is underlain by Triassic rocks (Bringelly Shale) and unconsolidated Quaternary sediments (alluvial gravel, sand, silt and clay). Small areas of older Tertiary alluvium occur particularly in the north-east associated with Ropes Creek. The Soil Landscape Series Sheet 9030 (Bannerman & Hazelton 1990) maps six soil landscape groups in the study area:

- Luddenham and Blacktown on shale
- Richmond, Freeman's Reach and South Creek on recent alluvium

- Berkshire Park on older (Tertiary) alluvium

The topography is low-lying to gently undulating land (<100 m a.s.l.). It is dissected north to south by the South Creek floodplain and includes the tributaries of Ropes Creek and Blaxland Creek. A small ridge-line up to 50 -60 m above sea level runs north to south extending up from the Nepean floodplain in the north-west of the GA (just north of the Penrith CBD) at Mount Pleasant and Kingswood Park on the hillier Luddenham soil landscape.

Native vegetation has been extensively cleared in the north for urban development and farming in the south. Open space corridors (including bushland) are centred along the creeks, particularly South Creek and Ropes Creek. Larger bushland remnants occur within Wianamatta Regional Park (237 ha) (formerly the ADI site) in the north and the Orchards Hills Defence Establishment (c. 260 ha) in the south. Higher concentrations of smaller remnants occur in the north-west (suburbs of Cranebrook to Kingswood Park) and the east (suburbs of Mt. Druitt, Plumpton).

Western Sydney Aerotropolis Growth Area (WSAGA)
Reference to the 1:100,000 Geological Series Sheet for Penrith, indicates that most of the growth area is underlain by Triassic rocks (Bringelly Shale) and unconsolidated Quaternary sediments (alluvial gravel, sand, silt and clay). The Soil Landscape Series Sheet 9030 (Bannerman & Hazelton 1990) maps three soil landscape groups in the study area, Luddenham, Blacktown and South Creek. The northern part of the area is low-lying and dissected by four creek-lines Badgerys Creek, South Creek, Cosgrove's Creek and Kemps Creek. A hilly ridge system up to 100-120 m above sea level is found in south-western parts extending south from Orchard Hills through Luddenham associated with the Luddenham Dyke comprising olivine basalt intruded into the Bringelly shale.

Native vegetation is patchy and occurs predominantly along Cosgrove's Creek (with a larger remnant west of Twin Creeks Golf Course), in the east between Erskine Creek and Kemps Creek and in the south-west south of Luddenham.

3.3 Native Vegetation

Greater Penrith to Eastern Creek Growth Area (GPECGA)
The predominant ecological communities are Cumberland Plain Woodland (CPW) and River-flat Eucalypt Forest (RFEF), both threatened ecological communities. Cumberland Plain Woodland is listed as critically endangered at both state (*Biodiversity Conservation Act, 2016*) and national (*EPBC Act, 1999*) levels. A summary of plant community types based on mapping provided by NSW Planning & Environment is found in Table 2.

Table 2. Plant community types (PCT's) within the Greater Penrith to Eastern Creek growth area

PCT No	PCT Name	TEC / Non-TEC	Area (ha)	Distribution & notes
724	Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin.	Shale Gravel Transition Forest	138.3	Main occurrence within Wianamatta Regional Park in far north. Small patches identified at Minchinbury, Claremont Meadows, St. Clair.
725	Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Cooks River Castlereagh Ironbark Forest	127.5	Main occurrence within Wianamatta Regional Park in far north. Small patches identified at Mount Druitt, Claremont Meadows.

PCT No	PCT Name	TEC / Non-TEC	Area (ha)	Distribution & notes
781	Coastal freshwater lagoons of the Sydney Basin Bioregion	Freshwater Wetlands on coastal floodplains	65.4	On Nepean floodplain in north-west. Small dams in southern area.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Moist Shale Woodland (MSW)	2.8	Small area identified at edge of Mulgoa Regional Park.
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	River-flat Eucalypt Forest (RFEF)	826.3	Along all creeks with largest patches within Wianamatta Regional Park and along South Creek corridor.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CPW)	1794	Larger remnants within Wianamatta Regional Park & Orchard Hills; medium size patches at north Luddenham, Plumpton; small patches through GA.
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Cumberland Plain Woodland (CPW)	80.8	More common within western parts e.g. Mulgoa NR on more hilly terrain.
806	Derived grasslands on shale hills of the Cumberland Plain	Cumberland Plain Woodland (CPW)	6.99	Only small areas mapped not representative of actual extent. Other areas included within 849 & 850 or unmapped.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland Castlereagh Swamp Woodland	6.5	Small linear remnants associated with watercourses in Wianamatta Regional Park, along Rope's Creek, Glenmore Park. More likely to be Castlereagh Swamp Woodland.
1395	Narrow-leaved Ironbark - Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain	Shale Sandstone Transition Forest (SSTF)	2	Small patch near Mulgoa, not ground-truthed.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain	River-flat Eucalypt Forest	118.4	Small patches with creek corridors mostly along South Creek, Rope's Creek & Cosgrove's Creek.

Western Sydney Aerotropolis Growth Area (WSAGA)
The predominant ecological vegetation communities within the WSAGA are Cumberland Plain Woodland (CPW) and River-flat Eucalypt Forest (RFEF), both threatened ecological communities. Cumberland Plain Woodland is listed as critically endangered at both state (*Biodiversity Conservation Act, 2016*) and national (*EPBC Act, 1999*) levels. A summary of mapped plant community types based on maps provided by NSW Planning & Environment and Cumberland Ecology (2018) is found in Table 3.

Table 3. Plant community types (PCT's) within the Western Sydney Aerotropolis growth area

PCT No	PCT Name	TEC / Non-TEC	Area (ha)	Distribution & notes
724	Broad-leaved Ironbark – Grey Box – Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain, Sydney Basin.	Shale Gravel Transition Forest	52.9	Localised at Kemps Creek north of Elizabeth Drive between creek-lines.
725	Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain, Sydney Basin Bioregion	Cooks River Castlereagh Ironbark Forest	39.9	Localised at Kemps Creek north of Elizabeth Drive between creek-lines.
781	Coastal freshwater lagoons of the Sydney Basin Bioregion	Freshwater Wetlands on coastal floodplains	3.5	Very small areas associated with Badgery's & South Creek but probably more common.
830	Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain	Moist Shale Woodland (MSW)		None mapped but potential to occur in far south-west associated with the Luddenham dyke.
835	Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain	River-flat Eucalypt Forest (RFEF)	162.9	Along all creek lines in association with 1800. Largest patch within South Creek corridor north of Elizabeth Drive.
849	Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain	Cumberland Plain Woodland (CPW)	550.1	Across the GA with largest remnant south of Erskine Park and south from Luddenham on rural properties (patchy less intact remnants).
850	Grey Box – Forest Red Gum grassy woodland on shale of the Southern Cumberland Plain	Cumberland Plain Woodland (CPW)	7.7	Small area mapped but more extensive in south western parts in vicinity of The Northern Road.
806	Derived grasslands on shale hills of the Cumberland Plain	Cumberland Plain Woodland (CPW)	53.35	Other areas included within 849 & 850 or unmapped.
883	Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain	Castlereagh Scribbly Gum Woodland Castlereagh Swamp Woodland	6.5	Very small area associated with Castlereagh Woodlands at Kemps Creek.
1800	Swamp Oak open forest on river-flats of the Cumberland Plain	River-flat Eucalypt Forest	110.1	Riparian forest along creek-lines in association with 835.

4. Assessment of species presence and habitat

4.1 Existing records and surveys

Existing records used in this report have been sourced primarily from the NSW Bionet Atlas. Two records were not in the Atlas but were identified in Appendix 2 of the *Pimelea spicata* Recovery Plan (DEC 2004). Penrith City Council and Local Land Services were also contacted for any additional records. In total there are ten records relating to eight sites for the Greater Penrith to

Eastern Creek Growth Area (GPEC) and just one for the Western Sydney Aerotropolis Growth Area (WSA) that is unsubstantiated (see tables 4 & 5).

The western ADI sites are located within the Jordan Springs development area but the northern ones are within Wianamatta Regional Park. The sites are typically associated with lower slopes and drainage lines. Population size is small with <10 plants recorded at most sites. Two of the sites (PS5 & PS6) have been confirmed by the author for this study (and Penrith City Council 2018) and are in council-managed reserves although PS6 (Grey Gums Reserve) is currently zoned uncertified rather than conservation. One of the records (PS9) at Badgerys Creek may be within or very close to certified land.

Table 4: *Pimelea spicata* records from Greater Penrith to Eastern Creek Growth Area

Record Id	Location	Date of record	No. of individuals	Map unit	Notes
PS1	ADI Site, St. Mary's	30/07/2004	4	835/849	Northern bank of drainage channel. Not observed in Biosis survey 2017.
PS2	ADI Site, St. Mary's	30/07/2004	5 - 20	835/849	Weedy area. In small gully with south western facing slope. Not observed in Biosis survey 2017.
PS3 & 4	Western part of ADI Site, St. Mary's	04/09/2003	3 (2 close sites)	849	Area now or soon to be developed, Jordan Springs
PS5	South of Nepean Street, Cranebrook (Mountain View Reserve)	02/08/07	c.80	849	Bottom of south-western facing slope; habitat area of 700 sq. m adjacent to drainage line. Monitored 2017-19 (TJ).
PS6	Grey Gums Reserve, Cranebrook (2 locations)	22/10/2010	30	849	Threatened by weeds and edge effects. Development & roads nearby. Confirmed in 2018 (PCC) & 2019 (James)
PS7	Kanangra Reserve, Glebe Place, Kingswood	2003 Appendix 2 of Recovery Plan 11/10/18	7 plants 1 plant	849	Council managed CPW adjacent to water reservoir. South-facing slope. Only 1 plant in poor health located in 2018 (PCC), no plants observed in Feb 19.
PS8	St. John Jamison Catholic Cemetery, Lilac Place, Jamisontown	2003 Appendix 2 of Recovery Plan	2 plants	849	Mostly mown/slashed grassland with some remnant trees. Native species persist around trees, over abandoned burial sites. Not seen 2019.
PS9	Badgerys Creek Lot 1 DP 111726	31/05/1999	1 small group of plants	835/849	Western side of bank, just before joins South Creek. Base of steep slope with SE aspect in small patch of thinned *Eucalyptus tereticornis*, mostly cleared around.
PS10	Kingswood Park Hickeys Lane (2 locations)	13/07/2018	10+	849	Two locations close to southern edge of reserve, one within APZ
	Mulgoa Nature Reserve		Few	LLS	On lee of dam

	Outside but close to Growth Area			**Source**	
	Just west of Chain O' Ponds Road Mulgoa	01/06/2005	30-60	Atlas of Australian Plants.	In grounds of 2 private properties. Similar habitat occurs just to the north within the GA. Current status unknown
	Gow Park, Mulgoa	03/10/18	5	PCC	West of car park in council reserve
	Blacktown and Liverpool LGA's	Various	Medium to larger populations	849, 850 & derived grassland	

*PCC = Penrith City Council LLS = Local Land Services

Records close to the growth areas

To the east of the growth areas there is a comparatively high density of sites in the Prospect, Quakers Hill and Western Sydney Regional Park districts (see Figure 2). Population size in these areas is typically moderate to large e.g. 150+ plants at Faukland Road Reserve (Kings Langley), several hundred's/thousands within Prospect Nature Reserve and 400 at Cobham Road Reserve (Horsley Park). This more central Cumberland Plain location is considered to comprise core habitat for the species.

Table 5 : *Pimelea spicata* records from the WSAGA or within 5 km

Record Id	**Location**	**Date of record**	**No. of individuals**	**Notes**
PS11	Just west of Aldington Road, east of Mamre Road, Kemps Creek	?	?	Sourced from (Biosis_FloraSightingPts, 2018) but not substantiated by Biosis or EcoPlanning for this report
	Outside of Growth Area			
	Private property along Greendale Road. Steep slope above tributary of Duncan's Creek.	April 2017	25-50	Recorded by the author (TJ). In regenerating CPW/MSW on steep, southeast-facing slope (after removal of African Olive).
	West of the Northern Road, south of Luddenham.	Mar-April 2017	4000+	In remnant modified CPW on rural grazing property. Habitat area of 2.94 ha. Likely to be cleared for construction of WSA.
	Twin Creeks Resort, Luddenham Road, Orchard Hills	Extant in 2003	?	Referenced in recovery plan but needed to be confirmed. Private tenure, likely now developed.

There are three records just to the west at Greendale and Mulgoa (details in Tables 4 & 5). The closest known records in the south of the Western Sydney Aerotropolis growth area do not appear in the Bionet data but are documented in biodiversity assessments for a transmission line realignment (GHD 2017) and the Western Sydney Airport Offset Strategy (DPIRDC 2018). Some 4000+ plants were recorded in 2017 from an area of 2.94 ha just west of the Northern Road (south-west of Luddenham) and c. 1 km east of the growth area.

Several of these populations are likely to be developed in the near future e.g. Cobham Road Reserve (road upgrade within Horsley Park Urban Plan) and south-west of Luddenham for the Western Sydney Airport.

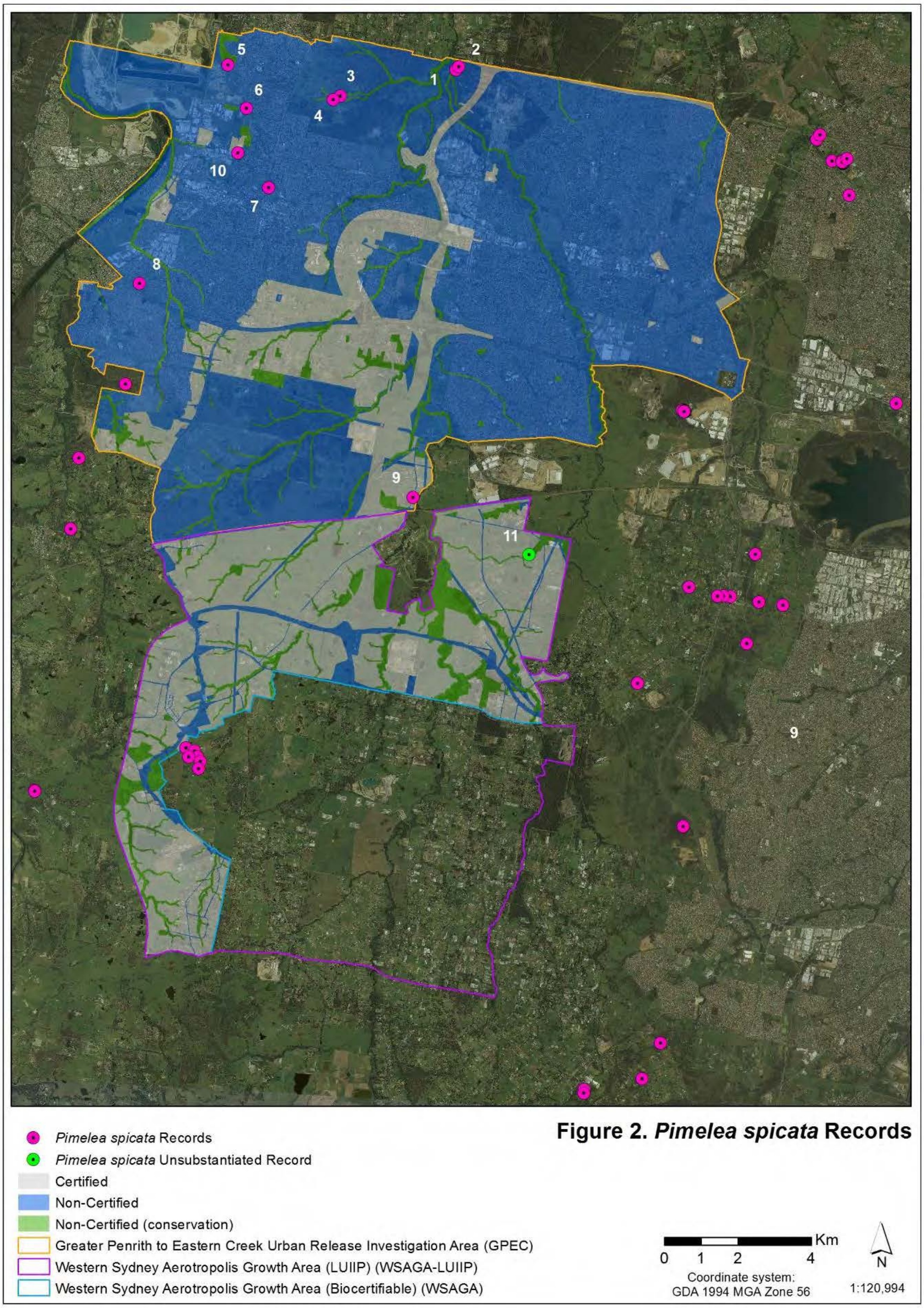


Figure 2. *Pimelea spicata* Records

4.2 Surveys completed for the biocertification

To assess the impacts of development within the growth areas new biometric data has been considered together with general and targeted survey. Field sampling and community/habitat verification has been undertaken by EcoPlanning and Biosis with assessment based on vegetation zones within Plant Community Types (PCT's) consistent with the Biodiversity Assessment Methodology (BAM 2017). No data from previous investigations within the growth areas was used. It is noted that the urban zone is being revised as the studies progress and accordingly the comparison of survey effort in relation to this zone is indicative only (DPE background information). The urban zone includes land zoned for future urban development plus transport corridors *within* the growth areas but not outside.

Survey and assessment was based on the following vegetation zones: Intact, Grasslands, Scattered Trees and Thinned. Survey effort has included the following:

- Field verification of vegetation type and condition mapping
- BAM plot sampling (all new)
- Flora and fauna habitat survey
- Targeted survey for threatened species using transects and random meanders

The location of survey areas, tracks and plots are shown in Figures 3 & 4. Quantitative plot data was collected to sample variability within each vegetation zone (EcoPlanning, Biosis 2017-18). The exact position of each plot within the vegetation patch was randomly located. Within the GPECGA a total of 10 BAM plots were sampled and within the WSAGA 56 plots.

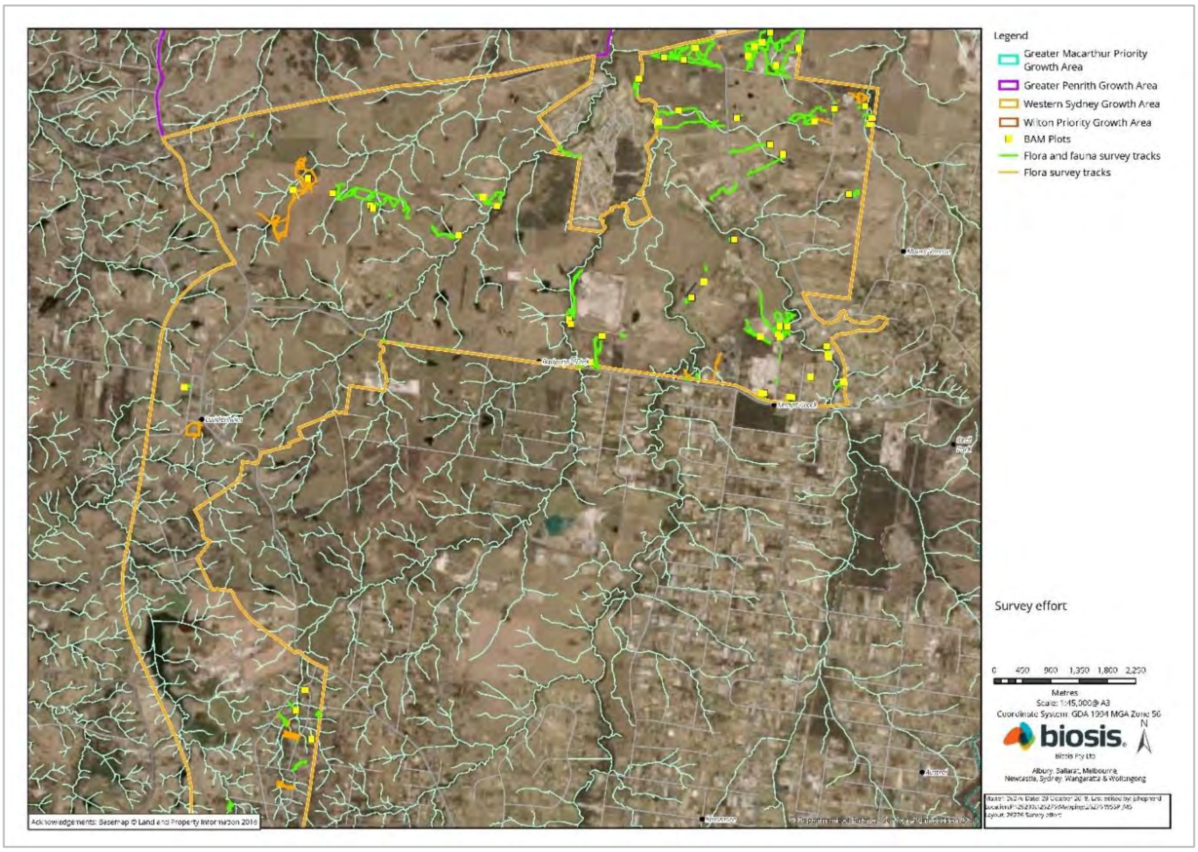
Targeted survey for threatened species, including *Pimelea spicata*, was conducted on accessible lands proposed for certification (and immediately adjacent) with particular attention to areas of lower disturbance and known topographic/habitat preferences. Survey comprised targeted random meanders (Figures 3 & 4) by Ecoplanning (orange tracks) and Biosis (green tracks). Biosis also surveyed for "fauna habitat" at the same time.

Land access
Within the GPECGA letters sent in 2017 and 2018 have led to 177 landholders providing access and an additional three landowners provided permission via door knocking with a 12% response rate. In addition access to 64 lots owned by Council was provided. Only properties with vegetation of particular interest were accessed.

A total of 432 letters were sent to landholders across the WSAGA between Nov 2017 and August 2018 with 84 granting access and a further seven properties accessed after doorknocking giving a response rate of 21%.

Survey timing
Surveys for *Pimelea spicata* should be undertaken when flowering due to its cryptic nature. Flowering is sporadic throughout the year and is likely to be in response to climatic conditions, particularly rainfall (DEC 2006). At other times plants are difficult to see or may only be present as rootstock or seed. Surveys have been undertaken mostly during 2017 and 2018 and no confirmed sighting of this species recorded within the growth areas. Periods of hot and/or dry conditions were experienced through this period although reasonable rain events occurred in February, November and December of 2018 (www.bom.gov.au/climate). Timing of surveys subsequent to such rain events is likely to be crucial in detecting the species.

Figures 3 & 4: Survey effort within GPEC (top) and WSA (bottom) growth areas



Survey effort
Threatened species survey effort within the GPEC (3.7%) and WSA (6%) growth areas is significantly lower than that completed for the Greater Macarthur and Wilton growth areas. Sites surveyed within or close to the certified zone include part of Hickeys Lane, Cranebrook (where *Pimelea spicata* was subsequently recorded by PCC), Claremont Meadows, South Creek in vicinity of Samuel Marsden Reserve, Kemps Creek (e.g. Aldington Road, South Creek), North Orchard Hills, Luddenham and Greendale North.

Most importantly survey effort for *Pimelea spicata* within preferred habitat across the growth areas is very low. For PCT 849 just 5% has been surveyed in the GPECGA and 7% in the WSAGA (see Table 6). There were no recorded sightings of *Pimelea spicata* during the surveys.

Table 6. Survey effort (20 m buffer from survey tracks) for threatened plant species (including *Pimelea spicata*) for relevant PCT's and growth area (data provided by DPE)

Growth Area	Vegetation Type (PCT)	Total area (ha) in GA	Survey area (ha)	% surveyed Within GA
Greater Penrith-Eastern Creek	849	1794	89	5
	850	81	0	0
	830	3	0	0
	835	826	13	2
Western Sydney Aerotropolis	849	550	37	7
	850	164	4	2
	835	163	12	7

A summary of plots sampled within the PCT's with potential habitat for *Pimelea spicata* is provided in the table below.

Table 7: Number of BAM plots undertaken by Growth Area, PCT & Vegetation Zone

	PCT 608	PCT 609	PCT 830	PCT 835	PCT 849	PCT 850	PCT 1395
GPEC							
Intact				2			
Grassland				2	1		
Scattered trees				1			
Thinned				4			
Total	0	0	0	9	1	0	0
WSA							
Intact				1	3	10	
Grassland				2	7	8	
Scattered trees				4	4	5	
Thinned				3	6	3	
Total	0	0	0	10	20	26	0

The level of plot sampling undertaken within potential *Pimelea spicata* habitat is very low for the GPECGA with no plots sampled within intact Cumberland Plain Woodland (PCT's 849 & 850) and just one plot sampled in modified CPW that being non-offsetable grassland (i.e. very low condition). Nine plots were sampled within River-flat Eucalypt Forest (PCT 835), however, this is not preferred habitat. No plots were sampled in Moist Shale Woodland (PCT 830) although only 2.8 ha of this community is currently mapped.

The level of survey undertaken within potential *Pimelea spicata* habitat within the WSAGA is higher with 20 plots surveyed across all vegetation zones for PCT 849 (Cumberland Plain Woodland) and 26 in PCT 850 which becomes more common on hilly terrain in the south-west. There is good coverage for River-flat Eucalypt Forest (PCT 835), however, this is not preferred habitat.

The more intensive and focused survey methodology of plot sampling is likely more reliable in detecting the species than meandering transects that often target more than one species.

4.3 Surveys completed for this assessment

Limited survey was undertaken in January and February 2019 by Teresa James and Anthea Whitlam. Survey was considered timely based on good rain events in late 2018 (www.bom.gov.au/climate) and regular storms in January and February 2019. By the mid-February, however, high temperatures and drier conditions resulted in rapid drying of soils with groundcovers, including plants of *Pimelea spicata*, showing marked signs of heat stress. Survey during December – January would have been more conducive to detection.

Confirmation of existing records
A known population at Mountain View Reserve, Cranebrook was checked in the field (January 2019) to confirm suitability of timing for survey. Other records were subsequently checked to determine presence and population status.

<u>Greater Penrith to Eastern Creek Growth Area</u>

Mountain View Reserve, Cranebrook
Moderate size population (80+), locally frequent adjacent to a small watercourse (habitat area c. 20 m x 5 m) at southern end of reserve, steep slope above to ridge-line. In Cumberland Plain Woodland dominated by Grey Box, *Eucalyptus moluccana*. Flowering and fruiting well in January 2019. By end of February flowering had ceased and leaves were shrivelling. This was used as a reference site.

Grey Gums Reserve, Cranebrook
A 2010 record was confirmed in the southern bushland area of the reserve close to the intersection of Andrews Road and Laycock Road. It is located on the lower slope below a footpath and above a drainage channel and road in Cumberland Plain Woodland dominated by Grey Box, *Eucalyptus moluccana*. Population size apparently smaller than previously with 5 clumps within an area of c. 5 m x 5 m but flowering and fruiting well. Weed invasion is reducing available habitat. A few plants were also recorded in late 2018 by PCC just above the footpath.

Kanangra Reserve, Glebe Place, Kingswood
A Council managed reserve containing Cumberland Plain Woodland adjacent to water reservoir. Seven (7) plants were recorded in 2003 (Appendix 2 of Recovery Plan), however, no details were provided relating to exact location and habitat. Search was undertaken on 28th February, 2019 for one hour and fifteen minutes focussing on intact habitat to the south and west of the reservoir. Conditions were warm and dry with native groundcovers showing signs of heat stress. The site is managed (weeding evident). Good potential habitat was observed to the south on a protected south-facing slope with a native grassy groundcover. No plants of *Pimelea spicata* were observed. Several small plants (re-sprouting from underground roots) of *Marsdenia viridiflora* subsp. *viridiflora*, however, were observed. To the west of the reservoir the groundcover is less intact in parts where scouring is evident on slopes from overwater flows and weed invasion more significant along ephemeral water courses.

Hickeys Lane Reserve, Kingswood Park (lower most disturbed part within certified area)
This reserve is south of the confirmed Cranebrook sites (see 4.3.1) on the same north-south running ridge-line. Similar habitat in Cumberland Plain Woodland exists on lower and mid parts of the slope

with high soil moisture associated with ephemeral watercourses, depressions and a wetland at the northern end. Lower slopes are dominated by Forest Red Gum *Eucalytus tereticornis* and higher slopes by Grey Box, *Eucalyptus moluccana*. Lower parts, in particular, are very weedy with dense exotic perennial grasses including Rhodes Grass, Paspalum and African Lovegrass. Condition of the vegetation improves upslope with active restoration occurring.

Survey was undertaken in January and February 2019 totalling 3 hours. Suitable habitat was observed, similar to known habitat within Grey Gums Reserve (plants at latter site were visible and flowering, although heat-stressed on the day of this survey) on slopes above the wetland in the north of the reserve. Good potential habitat also occurs on south and south-eastern slopes in the south of the reserve although unstable slopes and weeds are likely to restrict suitable sites/visibility. Subsequent to this inspection confirmation from Penrith City Council was received re a small population at two locations seen in late 2018. The lower part of this site (apparently adjacent to Hickeys Lane) was also surveyed by Biosis and EcoPlanning in mid-2018.

St. John Jamison Catholic Cemetery, Lilac Place, Jamisontown
At the time of inspection the grass had been recently mown, however, it was evident that native species persist on slopes and towards the back of the property away from the main central burial area. A range of native species were observed through the grassland, around the base of remnant trees and over old burial sites. No plants of *Pimelea spicata* were observed, however, some suitable habitat persists at the site.

<u>Western Sydney Aerotropolis Growth Area</u>

In vicinity of Aldington Road, Kemps Creek
An obscure record (included in a Biosis 2018 flora sightings file) from 99-111 Aldington Road with no date, habitat or population details. A patch of regenerating Cumberland Plain Woodland associated with a small gully off a ridge-top was searched on 06/02/19. The remainder of the property had been largely cleared except at the western end. The woodland was in moderate condition with past clearing and weed invasion (e.g. Blackberry and perennial exotic grasses). There was suitable habitat identified on protected south to south-west facing slopes of the gully but no plants were found. The far western section of the property was not accessed. Conditions were suitable for flowering with several other moisture sensitive species observed growing well and flowering.

This site and close vicinity was surveyed by Biosis/EcoPlanning in mid-2017.

Survey in potential habitat

<u>Greater Penrith to Eastern Creek Growth Area</u>

Peppermint Reserve, Kingswood
A council reserve with Cumberland Plain Woodland on gentle south-eastern and eastern facing slopes. Marginal habitat was observed (February 2019) with suitability constrained by lack of water availability in dry periods and weeds.

Werrington Creek, Kingswood
Good potential habitat was observed upslope from Werrington Creek within and south of the Western Sydney University Campus (February 2019), latter area in early stages of regeneration.

Glenmore Park (South) *Surveyor's Creek*
Drainage reserve east of Mulgoa Nature Reserve is mapped as Cumberland Plain Woodland, however, field inspection indicates it is River-flat Eucalypt Forest enhanced by plantings and landscaping and is not considered to provide potential habitat for *Pimelea spicata*. The mapping has been altered accordingly for this report.

Western Sydney Aerotropolis

Samuel Marsden Reserve, South Creek, Orchard Hills (within certified area)
Some existing records for *Pimelea spicata* are located close to creek lines in intergrading Cumberland Plain Woodland and River-flat Forest e.g. within the northern section of the former ADI site and at Badgerys Creek close to the confluence with South Creek. Similar habitat was searched on 6/02/19 along the creek at Samuel Marsden Reserve. Some flora survey was previously undertaken in spring 2018 at and in the vicinity of this site by Biosis/EcoPlanning but focussed on the eastern side of the creek and not after good rains.

The vegetation was regenerating and dominated by Forest Red Gum *Eucalytus tereticornis* (river-flat dominance) with an open, grassy groundcover. No plants of *Pimelea spicata* were observed although suitable habitat noted although limited.

West of Aldington Road, Kemps Creek
Good condition, mostly intact/regenerating Cumberland Plain Woodland on slopes above an ephemeral watercourse (mostly south-east facing) was searched on a property (53 Aldington Road) adjacent to the Aldington Road site described above in early February 2018. Despite good suitable habitat on protected lower slopes with Grey Box and Forest Red Gum no plants of *Pimelea spicata* were observed.

Greendale North/Bringelly
Small rural residential properties with modified Cumberland Plain Woodland and River-flat Forest associated with Badgerys Creek. At the time of inspection the understorey was highly modified through slashing, mowing and horse grazing. Although potential habitat for *Pimelea spicata* persists in this area, the vegetation condition and dryness at time of survey (and previous surveys) significantly limited the likelihood of plants being visible and no properties were accessed.

4.4 Assessment of species presence [BAM 6.5.2.8c]

Likelihood of species presence
Based on existing records (see Tables 4 & 5) and the extensive distribution of potential habitat (particularly Cumberland Plain Woodland including derived grasslands) it is confirmed that *Pimelea spicata* is present within the GPECGA and is likely to occur at other sites potentially within the proposed urban footprint (certified areas). There are no substantiated records for *Pimelea spicata* within the WSAGA, however, there are recent records within 1-5 km and extensive suitable or potential habitat.

Greater Penrith to Eastern Creek Growth Area (GPECGA)
Populations confirmed in this study or likely to still be present (based on habitat persistence) are summarised in Table 8. Two of the atlas records (PS 3 & 4) are no longer relevant for this report being within the Jordan Springs development footprint.

All sites, except PS7, are located in a regional park or council reserves and are assumed to have at least a moderate level of protection although it is noted that Grey Gums Reserve (PS6) is not currently zoned for conservation within the context of this report and known *Pimelea* habitat is mostly disturbed and weedy. The Badgerys Creek site appears to be in the vicinity of land zoned for conservation although the level of past and current protection and management, if any, is unknown. It is an older record (1999) with few plants recorded and the likelihood of the species persisting at the site is considered low.

There are no existing records located within the certified area although PS7 appears to be very close.

Table 8: Populations of *Pimelea spicata* confirmed or likely to persist in the GPECGA

Record Id	Location	Zoning	Protection level	Status
PS1	ADI Site, St. Mary's	Within regional park	Moderate – assumed active management	Presumed extant although not recorded in recent EcoPlanning survey
PS2	ADI Site, St. Mary's	Within regional park	Moderate – assumed active management	As above
PS5	North of Nepean Street, Cranebrook (now Mountain View Reserve)	Within council managed reserve, zoned conservation	Good – assumed active management	Confirmed 2018 (PCC), 2019 (James)
PS6	Grey Gums Reserve, Cranebrook (2 locations)	Within council reserve, zoned not certified	Low without management as in wetter more disturbed zone	Confirmed 2018 (PCC), 2019 (James)
PS9	Badgery's Creek	Probably just above riparian zone	Probably low	Unlikely but possible
PS10	Kingswood Park Hickeys Lane (2 locations)	Within council reserve	Low-moderate. In disturbed lower parts, one in APZ but council has ceased mowing at present	2018 (PCC)

Western Sydney Aerotropolis Growth Area

There are no confirmed or substantiated records for *Pimelea spicata* within the WSAGA. There is one vague record for *Pimelea spicata* west of Adlington Road, Kemps Creek (sourced from (*Biosis_FloraSightingPts*, 2018) located within the certified area, however, this record remains unsubstantiated. The site was inspected in early February 2019 but no plants were seen, however, suitable habitat was noted on this property and the adjoining one (53 Adlington Road). A very large population has been recently recorded within the adjoining airport zone less than a 1 km from the growth area boundary (see Figure 2). The plants were located on a rural grazing property in modified Cumberland Plain Woodland including derived grasslands. A summary of information on *Pimelea spicata* habitat at the airport site is provided below sourced from GHD (2017):

- Majority of plants were found in derived native grassland formerly supporting PCT 849.
- Grassland was in good condition with moderate species richness, high native grass and herb cover and low exotic plant cover.
- Clumps of plants were separated by tracks, building pads, dumped fill and dense African Olive infestations.

In view of this record, presence of similar habitat within the WSA and certified area and records to the west at Mulgoa and Greendale, there is a good likelihood of the species being present at additional sites within the growth area. A significant proportion of the potential habitat comprises derived grasslands dominated by native species or a mix of native and exotic.

Justification for determining presence

The association between known sites of *Pimelea spicata* both within and outside of the growth areas with Cumberland Plain Woodland and Moist Shale Woodland, and to a lesser extent River-flat Eucalypt Forest and Shale Sandstone Transition Forest is well documented in sections 4.3 and 4.5 of this report. Preferred habitats within these communities are described below.

<u>Physical environment</u>
Pimelea spicata is most often found on slopes in undulating low hilly terrain on Wianamatta Group shales including both Ashfield and Bringelly shales. Within the Greater Penrith and Sydney Airport growth areas Bringelly shales are the most widespread. *Pimelea spicata* prefers moist soils (clay helps to retain the moisture) and is often found on protected south or east facing slopes close to drainage lines or seepage points. Growth and flowering appears to be largely dependent on such moist soils with plants often not visible in dry periods and dying back to rootstock or persisting as seed in the soil seed bank. Such conditions occur extensively through the growth areas.

<u>Habitat condition</u>
Optimal habitat for *Pimelea spicata* is intact woodland with an open, grassy understorey, however, it can survive in disturbed and degraded landscapes e.g. recently discovered airport population south of Luddenham. Areas affected by localised woody weed infestations e.g. African Olive can also contain potential habitat. *Pimelea spicata* has been recorded after removal of African Olive at sites at Greendale (Penrith LGA) and Mt. Annan.
Many of the known records are associated with regenerating native vegetation e.g. after a disturbance such as mowing or grazing has ceased. Records from several council reserves have been made in recent years as "no mow" zones have been established. Examples include:

- Faulkland Reserve, Kings Langley (Blacktown LGA)
- Melrose Park, Quakers Hill (Blacktown LGA)
- Power Street Reserve (Fairfield LGA)

Woody weed infestations (e.g. African Olive) occur within the growth area, particularly in southern parts. These areas can still contain potential habitat (see Section 2.4) and are included.

The condition of habitat is not considered to be a reliable indicator of species presence and accordingly **all condition states** are considered in determining suitable habitat i.e. intact, thinned, scattered, derived shrubland and grasslands.

4.5 Assessment of suitable habitat [6.5.2.5]

Suitable habitat within the growth areas

Pimelea spicata is known to occur in the following vegetation communities:

PCT 849 – *Grey Box – Forest Red Gum grassy woodlands on flats of the Cumberland Plain*
PCT 850 - *Grey Box – Forest Red Gum grassy woodlands on shale of the southern Cumberland Plain*
PCT 806 & 807 – *Derived grasslands on shale hills and shale plains of the Cumberland Plain*
PCT 830 – *Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain*
PCT 835 - *Forest Red Gum – Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain* (particularly intergrading zone with PCT 849) where floodplain is not well defined
PCT 1395 - *Narrow-leaved Ironbark – Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain.* Low sandstone forms (at the shale end of the transition) of Shale Sandstone Transition Forest, which is structurally and floristically very similar to Cumberland Plain Woodland at the shale end of the transition.

The communities identified above are equivalent to the Cumberland Plain Woodland, Moist Shale Woodland, River-flat Eucalypt Forest and Shale Sandstone Transition Forest threatened ecological communities (see Tables 9 & 10). Degraded and disturbed examples of these communities (i.e.

reduced canopy and/or mid-layer cover or weedy areas) including road reserves can provide habitat for the species due to its long-term persistence as woody rootstock (tap root) and in the soil seed bank. Cumberland Plain Woodland and Moist Shale Woodland, including derived grasslands, are the most favoured habitat for *Pimelea spicata* occurring on mid to lower slopes or close to watercourses where soil moisture is retained for longer periods. Populations in such habitat appear to be more resilient to drought and other disturbances.

Within the growth areas there is extensive potential habitat for *Pimelea spicata* based on existing known sites, flora studies, scientific and personal knowledge. Important habitat attributes used to identify suitable habitat are discussed in section 4.3.

Greater Penrith to Eastern Creek Growth Area
Cumberland Plain Woodland comprises >57% of remnant vegetation in the *Greater Penrith to Eastern Creek Growth Area* with just 2.8 ha of Moist Shale Woodland. Only small patches of derived grasslands are mapped e.g. within the Orchard Hills RAAF site due to lack of targeted survey and are likely to be reasonably extensive. The 826 ha of land mapped as PCT 835 (part of River-flat Eucalypt Forest) is likely to include intergrading zones with Cumberland Plain Woodland that can provide suitable habitat for *Pimelea spicata.*

Table 9. Suitable habitat in the Greater Penrith to Eastern Creek Growth Area

Vegetation community	Distribution	Habitat value
Cumberland Plain Woodland (all conditions including mowed or slashed as long as meet final determination)	Across the GA with largest remnants within Wianamatta Regional Park & Orchard Hills RAAF base	High (primary habitat) but typically on mid to lower slopes or close to watercourses where soil moisture retained for longer periods.
Moist Shale Woodland	Restricted to small area at edge of Mulgoa Regional Park.	High: moist conditions and hilly terrain favour the species
Derived Native Grasslands (including mowed, slashed or grazed)	Throughout comprising grazing lands, roadsides & council reserves	Moderate to high: several records from over-cleared CPW or derived native grasslands
Cumberland Plain Woodland intergrading with Alluvial Woodland (RFEF) or more rarely Shale Gravel Transition Forest	Along creek corridors	Moderate to marginal depending on floodplain characteristics, again probably associated with higher moisture levels
Shale Sandstone Transition Forest	Only a small area (not confirmed in field) is mapped east of Mulgoa Nature Reserve	Moderate to high as expect very low sandstone influence & population known within the reserve (but in CPW).

The larger known populations in the north-west of the growth area are associated with a low ridge-line above the Nepean floodplain that is dissected by several ephemeral watercourses (PS 5 & 6). A relatively large patch of regenerating CPW associated with this ridge-line (south of PS 5 & 6) in Hickeys Lane Reserve provides good potential habitat and is currently not certified or zoned for conservation.

Sydney Aerotropolis Growth Area
The Sydney Aerotropolis Growth Area comprises predominantly a rural landscape with major creek corridors. Although it has been extensively cleared, patches of native vegetation, remnant trees and derived grasslands occur across the area. The dominant vegetation communities are Cumberland Plain Woodland (including derived grasslands) and River-flat Eucalypt Forest with extensive potential habitat for *Pimelea spicata*.

Table 10. Suitable habitat in the *Sydney Airport Aerotropolis* Growth Area

Vegetation community	**Distribution**	**Habitat value**
Cumberland Plain Woodland (all condition states)	Mostly in northern parts.	High, most records from CPW both Shale Plains and Shale Hills
Derived Native Grasslands (including mown, slashed or grazed)	Mostly northern areas comprising grazing lands, roadsides & council reserves	Moderate to high. Several records from over-cleared CPW or derived grasslands with varying levels of native species
Cumberland Plain Woodland intergrading with alluvial woodland part of River-flat Eucalypt Forest	Along creek corridor throughout growth area	Moderate to high, again probably driven by higher moisture levels

The large population recently discovered within the adjoining Airport zone less than a 1 km from the growth area boundary (GHD 2017) on a highly modified rural grazing property (including derived grasslands) suggests that similar habitat within the certified North Greendale district contains suitable habitat. Populations to the west of the growth area at Greendale and Mulgoa in similar habitat also supports this position.

Identification of habitat polygons

Extensive areas of potential habitat occur across the two growth areas. Potential habitat is identified based on the attributes described in Sections 4.3 of this report, existing populations, landscape context and personal knowledge. Although *Pimelea spicata* is known to occur in degraded sites, very small patches within over-cleared landscapes where the soil is likely to have been modified are excluded. Figures 5 & 6 show species polygons for the GPEC and WSA growth areas respectively.

<u>Estimate of area of habitat</u>

Ninety three (93) polygons containing a total of 2068 ha of suitable habitat within Cumberland Plain Woodland (PCT's 849 & 850) for *Pimelea spicata* are identified within the GPECGA. Small additional areas within Shale Gravel Transition Forest (PCT 724) and River-flat Eucalypt Forest (PCT 835) comprise marginal habitat. Seventy (70) polygons with 546 ha of suitable habitat are identified within the WSAGA mostly within Cumberland Plain Woodland (inclusive of derived grasslands). Small areas within Shale Gravel Transition Forest (PCT 724) and River-flat Eucalypt Forest (PCT 835) comprise marginal potential habitat in view of sandier soils and potentially denser tree canopy. The relative areas of vegetation communities are provided in Table 11..

Table 11. Areas (ha) of threatened communities identified as potential habitat for *Pimelea spicata*

Threatened Community	**PCT**	**Habitat value**	**Area (ha) in GPEC including WRP**	**Area (ha) in GPEC excluding WRP**	**Area (ha) in WSAGA**
Cumberland Plain Woodland (including derived grasslands)	850	High	59	59	3
Cumberland Plain Woodland (including derived grasslands)	849	High	2009	1511	483
River-flat Eucalypt Forest	835	Marginal	77	62	60
Shale Gravel Transition Forest	724	Marginal	18	9	0
Shale Sandstone Transition Forest (low sandstone)	1395	Marginal	2		

WRP = Wianamatta Regional Park

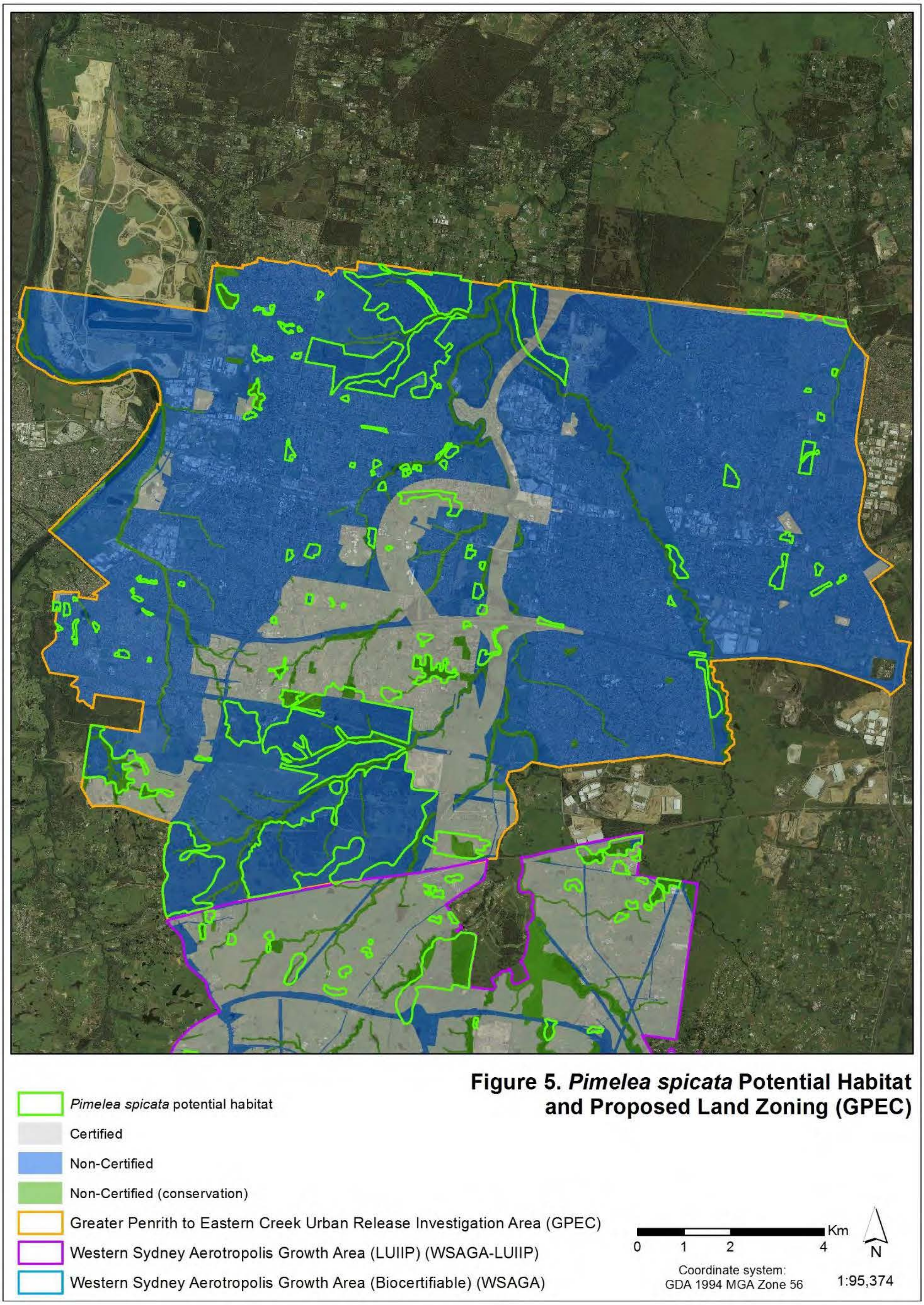


Figure 5. *Pimelea spicata* Potential Habitat and Proposed Land Zoning (GPEC)

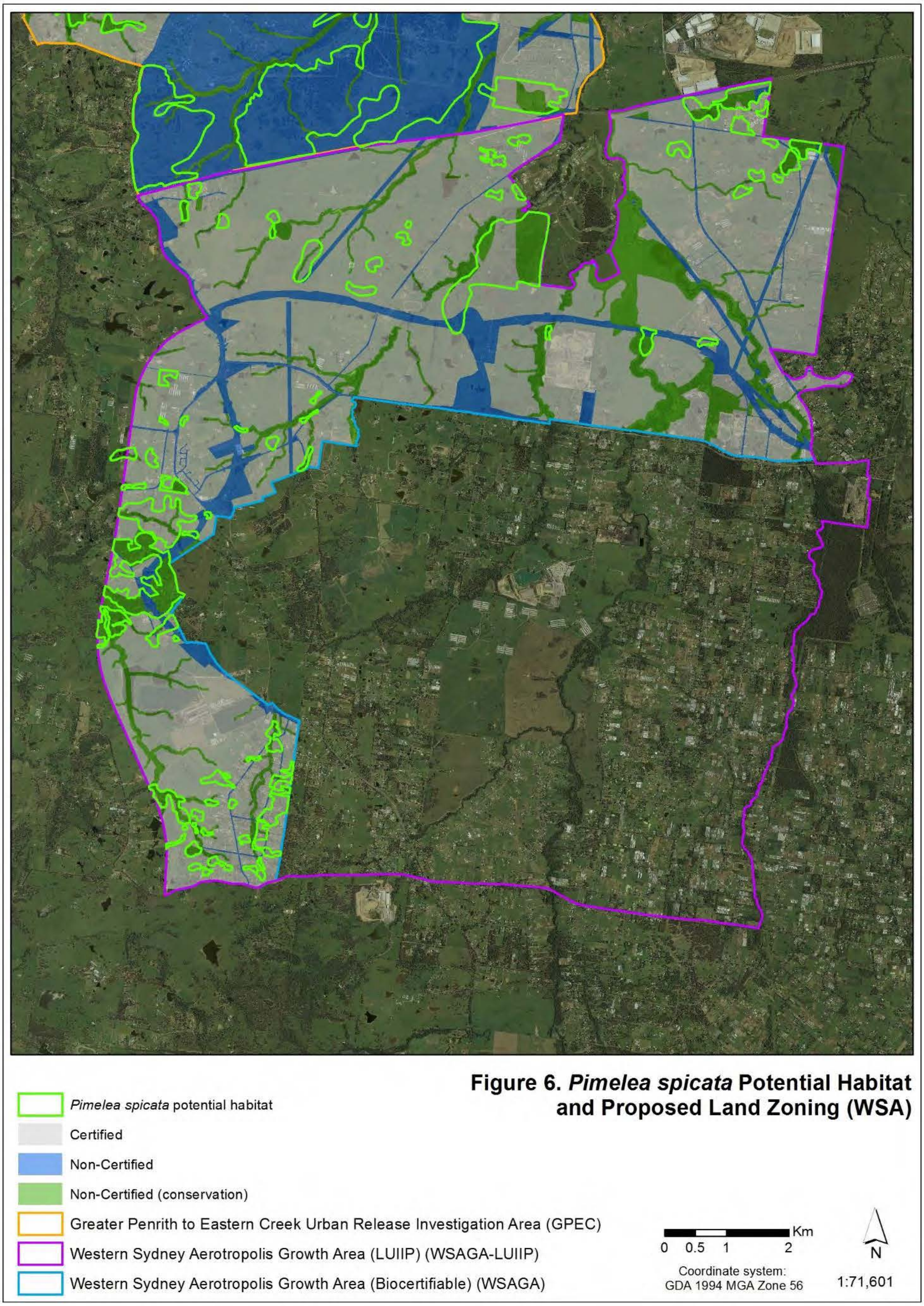


Figure 6. *Pimelea spicata* Potential Habitat and Proposed Land Zoning (WSA)

A significant proportion of the Cumberland Plain Woodland identified as potential habitat comprises native/mixed grasslands with scattered remnant trees and localised shrub regrowth. Such habitat is best represented at Orchard Hills (GPECGA) and between Luddenham and North Greendale in the WSAGA.

<u>Estimate of potential habitat relative to zoning (see Table 12)</u>

Within the Greater Penrith to Eastern Creek growth area 133 ha or 6% of potential habitat is found within the certified zone, 178 ha (8%) is zoned for conservation and 1857 ha (86%) occurs in the non-certified zoning. The latter includes larger areas within Wianamatta Regional Park [presumably with reasonable conservation prospects] and the Orchard Hills Defence Establishment that has long been recognised for its conservation values) and has been considered as an offset site for the Sydney Airport development (Dept. of Infrastructure, Regional Development & Cities, 2018).

Small council reserves in the far north-west associated with a north to south ridge-line above the Hawkesbury-Nepean River floodplain are particularly important for known and potential *Pimelea spicata* habitat, only two of which currently have conservation zoning. With records of *Pimelea spicata* (1) within and to the south of Mulgoa Nature Reserve, protection of potential habitat identified adjacent to the reserve also represents a good conservation opportunity for the species.

In the Western Sydney Aerotropolis growth area just over 53% occurs within the certified or development zone although 43% is zoned conservation predominantly associated with the South Creek corridor (around Kemps Creek) and the upper catchment of Duncan's Creek in the vicinity of Willowdene Avenue, south of Luddenham. The latter area is close to the recently discovered population west of the Northern Road and includes similar habitat. Potential habitat to the south around Greendale North is less intact and currently suppressed by a high level of grazing, however, may provide some conservation opportunities.

Table 12: Potential habitat relative to zoning

Growth Area	Greater Penrith-Eastern Creek (GPEC)	Western Sydney Aerotropolis (WSA)
Certified	133 ha	290 ha
Non-Certified	1857 ha	30 ha
Conservation	178 ha	237 ha

5. Information used in the assessment

5.1 NSW Planning & Environment and OEH resources

- Bionet sightings & other threatened species data from Atlas of Living Australia, *Pimelea spicata* Recovery Plan, Penrith City Council & LLS
- Greater Penrith to Eastern Creek and Western Sydney Airport Growth Areas Vegetation Mapping (see Table 13)
- Survey data, effort and land access details (see Table 13)

Unlike for the Wilton and Greater Macarthur growth areas all plots sampled were new i.e. surveyed for this project. Much of this information was available via the project's spatial viewer.

Table 13. Sources for existing vegetation survey data used in the biodiversity assessment

Data collector	Approx. no. plots	Survey year	Growth Area
Biosis & EcoPlanning	26	2017- 2018	Greater Penrith to Eastern Creek
Biosis & EcoPlanning	53	2017 - 2018	Western Sydney Airport

6. References

Benson & McDougall (2001) Ecology of Sydney Plants *Cunninghamiana* 7(2)

DEC (2006) Approved Recovery Plan for *Pimelea spicata*

Dept. of Environment & Heritage online Spiked Rice-flower *Pimelea spicata* SPRAT profile www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=20834

Dept. of Environment & Heritage (2016) Conservation Advice *Pimelea spicata* Spiked Rice-flower

Dept. of Infrastructure, Regional Development & Cities (2018) Western Sydney Airport Biodiversity Offset Delivery Plan

GHD (2018) TransGrid Re-location Appendix E Environmental assessment

Harden, G.J. (ed) (1990). *Flora of New South Wales. Volume One*. Kensington, NSW: University of NSW Press

NSW Bionet (OEH) online www.bionet.nsw.gov.au/ including Atlas records

NSW NPWS (1997) Urban Bushland Biodiversity Survey Stage 1 - Western Sydney

NSW NPWS (2004) Environmental Impact Assessment Guidelines

OEH (2016) NSW Guide to Surveying Threatened Plants

OEH (2017) Biodiversity Assessment Method http://www.environment.nsw.gov.au/resources/bcact/biodiversity-assessment-method-170206.pdf

OEH (2017) Spiked Rice-flower Profile http://www.environment.nsw.gov.au/ThreatenedSpeciesApp/profile.aspx?id=10632

Willis *et al.* (2003) Comparative seed ecology of the endangered shrub *Pimelea spicata* and a threatening weed Bridal Creeper. Ecological Management and Restoration Vol 4 Issue 1

Appendix 1. Curriculum Vitae for Teresa James

Home & work address: 1 Sharland Avenue, Chatswood NSW 2067

Mailing address: As above

Telephone: Mobile: 04 282 18502.

Email: t.james@optusnet.com.au

Key positions:

- Botanist/ecological consultant specialising in vegetation survey, plant identification, conservation assessment and threatened species.
- Until October 1998 held position of Identifications Botanist, Plant Sciences, National Herbarium of New South Wales, Royal Botanic Gardens, Sydney.

Qualifications:

Bachelor of Science (Combined Honours in Biology and Geography) - University of Exeter, England. 1978.

Accreditation:

Accreditation awarded (2008) as a BioBanking Assessor under the Threatened Species Conservation Act 1995 (NSW); accreditation renewed 2013. Accreditation number 0017.

Current employment (1998-present):

Self- employed flora/ecological consultant (sole trader working as Teresa James Flora Consultant).

- Flora surveys, site/conservation assessments and monitoring projects.
- Preparation of environmental impact assessment reports (e.g. 7-part test, species impact statement & review of environmental factors).
- Biobanking and Biodiversity Offset assessments.
- Preparation of threatened species management plans.
- Expert witness in the Land & Environment Court.
- Botanical training for local councils and community groups.

Previous employment

1978 (3 months)	Technical Assistant, Biological and Chemical Research Institute, Rydalmere (Department of Agriculture).
1978-1998	Employed at the Royal Botanic Gardens, Sydney.
1978-1979	Temporary Herbarium Assistant
1980-1982	Technical Officer, Botanical Information Section
1982-1986	Acting Identifications Botanist, Botanical Information Section
1987-1991	Technical Officer, Botanical Information Section
1991-1994	Acting Identifications Botanist, Botanical Information Section
1994	Secondment 4 days/week to World Heritage Assessment of the Blue Mountains (consultancy for NSW National Parks & Wildlife Service).
1994	Permanent appointment as Identifications Botanist.
1994-	Appointed Botanical Information Section Co-ordinator.
1996-1997	Secondment to NSW National Parks & Wildlife Service as Flora Officer for Urban Bushland Biodiversity Survey. Stage 1: Western Sydney.
1994-1998	Identifications Botanist & Botanical Information Section Co-ordinator.

<u>Selected longer-term projects:</u>

1998-1999	Vegetation sampling for NSW National Parks & Wildlife Service - Western Sydney Vegetation Mapping Project.

1999	Flora consultant to Eastern Gas Pipeline (Duke Australia Operations).
2000	Preparation of Fire Ecology Manual for Rural Fire Service and UWS.
October 2000-2003	Flora consultant to Biosis Research for Penrith City Council – proposed developments & TSC Act issues at Erskine Park.
2001	Field sampling and truthing for vegetation community mapping project - Baulkham Hills LGA. Baulkham Hills Shire Council.
2001-2003	Qualitative and quantitative vegetation surveys (including rare plant species and ecological communities, weeds and other threats, environmental assessment) of Wingecarribee Swamp with Sainty & Associates for the Sydney Catchment Authority.
February 2002-May 2002	Review of wetland boundaries and general vegetation mapping and condition assessment within Baulkham Hills local government area (for Baulkham Hills Shire Council).
2003	Vegetation survey in the Hunter, Nattai & Bargo districts as part of the National Parks & Wildlife Service Vegetation Survey Program.
2002-2007	Flora survey/monitoring at Dr Charles McKay Reserve, Mt. Druitt for Blacktown City Council.
September 2005 –2006	Field validation for Foreshore Vegetation Mapping Project on Sydney Harbour for Botanic Gardens Trust and NSW Maritime Services.
September 2000-2008	Flora consultant to Liverpool City Council – provide review & advice relating to development applications, plans of management & special projects.
February -May 2007	Field survey for Sydney Metropolitan Catchment Management Authority/DECC vegetation mapping. Plot data recorded for 100 sites within SMCMA.
May 2008-2010	Vegetation mapping and assessment of Blue Gum High Forest and Turpentine Ironbark Forest in Ku-ring-gai local government area
August 2008-present	Flora advice to Ku-ring-gai Council - review of development applications, plans of management and mapping/biodiversity projects.
February-August 2012	PAS2 Expert Interviews for NSW threatened species with Office of Environment & Heritage.

*See consultant reports for complete list of projects/surveys.

Special projects:

Assessment of the World Heritage Values of the Blue Mountains and surrounding plateaus

An assessment of the natural and cultural values of the sandstone plateaus of the Blue Mountains and surrounding areas was funded by the Federal and State Governments to determine the potential for world heritage nomination. A team of people worked on the project from the Royal Botanic Gardens, Australian Museum (cultural values) and experts from local universities. I was project co-ordinator for the assessment, wrote much of the text for the natural values sections and was editor of the final report. This report was used as a basis for the successful Blue Mountains World Heritage nomination (June 1998).

NPWS Urban Bushland Biodiversity Survey. Stage 1: Western Sydney

Documentation of biodiversity and conservation values in Western Sydney was the first priority project undertaken within the State Biodiversity Survey Program. The survey gave emphasis to threatened species, communities and habitats. The region was documented on a local government area basis. I co-ordinated the flora surveys and was principal author for the flora reports.

Particular expertise:

Plant Identification:

- New South Wales plants, native and naturalised (18 years of experience in the Botanical Information Section of the Royal Botanic Gardens, Sydney). Specimens received from all over state. Also cultivated plants.
- Specialist in Sydney flora.
- Prepared taxonomic treatments for various plant families in the publication Flora of New South Wales, volumes 1-4, produced by the Royal Botanic Gardens, Sydney.
- Conduct plant identification workshops both through the RBG and the University of Western Sydney.

Documentation and conservation/ impact assessment: plant communities and species

- Extensive range of sites surveyed with species lists compiled over the last twenty-five years, particularly in Western Sydney, the Blue Mountains and Southern Highlands. Plant specimens collected and incorporated into the National Herbarium of N.S.W. Information used in numerous reports and books e.g. World Heritage Assessment of the Blue Mountains, the NPWS Urban Bushland Biodiversity Survey, Rare Bushland Plants of Western Sydney and various papers.
- Prepare Tests of Significance and Species Impact Statements as required under current legislation (TSC Act, EPBC Act).
- Prepare Statements of Evidence & Affidavits for the Land & Environment Court.
- Provide advice to the community, developers, government agencies and councils concerning the identification of communities and species, impacts of proposed developments, the ecological effects of urbanisation, flood mitigation and management practices such as mowing, burning etc.

Peer review

Assessor services provided to government (all levels), consultancies and NGO's. Including the following:

- DA applications and associated reports e.g. REF's, SIS's, Tests of Significance
- BioBanking/Offset reports
- NSW Land & Environment Court reports

Education & training

- Involvement on committees or in groups providing technical advice and training eg. Greystanes Creek Management Committee, Upper Parramatta River Catchment Trust steering committees, Hawkesbury Rainforest Network.
- Presentations/talks e.g. National Parks Association, Society of Australian Plants, University of NSW, Landcare groups, local councils.
- Conduct plant community and species identification workshops/courses/tours through the Royal Botanic Gardens, the University of Western Sydney and privately.
- Prepared Fire Ecology Manual for Rural Fire Service (2000).
- Training for local government in threatened species, endangered ecological communities and biodiversity conservation.
- Publications e.g. primary author of revised edition of Rare Bushland Plants of Western Sydney (Royal Botanic Gardens 1999*),* contributor to Flora of New South Wales *(*Royal Botanic Gardens).

Courses/workshops & tours provided to local government/catchment management trusts/consultancies:

- Sept. 2004 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers & council staff
- October 2004 – Significant Plant Communities-of Baulkham Hills Shire Council – tour for council staff
- February 2005 – Community workshop in Cumberland Plain Woodland for Holroyd City Council
- July-August 2005 - Biodiversity training for Liverpool City Council – 3 workshops for council officers
- September 2005 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers

- August 2007 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2007 – Identification of plants in Cumberland Plain Woodland – for Hawkesbury Nepean CMA.
- April 2008 – Basic grass identification course for Baulkham Hills Shire Council (for bushcare volunteers).
- August 2008- Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- November 2008 to April 2009 – Weedy Grass Identification Workshop x 3 for Sydney Metro CMA.
- August 2009- Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2009 – EEC identification field day for Hawkesbury-Nepean CMA
- August 2010 - Threatened Species Tour for Baulkham Hills Shire Council bush care workers
- October 2010 – Cumberland Plain Woodland identification training for SMEC Australia
- April 2011- – Cumberland Plain Woodland identification training for SMEC Australia
- April 2011 – Field training in identification of communities & plants on the Cumberland Plain for Hawkesbury Nepean CMA.
- June 2011 – Presentation to council staff on threatened flora & fauna and biodiversity conservation within the Hills Shire.
- August 2011- Threatened Species Tour for Hills Shire Council bush care workers
- June 2012 – Eucalypt Identification workshop for Hills Shire Council.
- September 2014 - Threatened Species Tour for Hills Shire Council bush care workers
- September – November 2014 – Series of two-day workshops on threatened ecological communities in western Sydney.
- October 2014 – Plant identification training day held at Dr Charles Mckay Reserve, Mt. Druitt for Blue Tongue Ecosystems.
- March 2015 – Derived Grasslands Workshop (western Sydney) for government and community.
- May 2015 - Threatened Ecological Communities Workshop (western Sydney) for government and community.
- August 2015 – Shale Sandstone Transition Forest Workshop (western Sydney) for government and community.
- September 2015 – Northern Sydney Threatened Communities Workshop for government and community.
- April 2016 - Shale Sandstone Transition Forest Identification Workshop
- April 2016 – Introduction to Identifying Western Sydney Plants
- April 2016 – Grass Identification Workshop
- April 2016 – Cumberland Plain Woodland Workshop for Liverpool Council bushcarers
- August 2016 - Threatened Species Tour for Fairfield City Council.
- August 2016 - Threatened Species Tour for Hills Shire Council.
- April 2017 – Bushcare Training for Penrith Council
- Aug-Sept -Oct 2017 - Community bushland guided walks for Liverpool Council
- August 2017 - Threatened Species Tour for Fairfield City Council.
- August 2017 - Threatened Species Tour for Hills Shire Council.
- September 2017 – Flora workshops at Scheyville and Agnes Banks

Committee & community participation

- Member of NPWS Cumberland Plain Woodland Recovery Team (1998).
- Member of NPWS Acacia pubescens Recovery Team (1998 to 2002).
- Member, Green Corridors Strategy Steering Committee.Upper Parramatta River Catchment Trust. (1997-2000).
- Member, Water Quality Strategy Steering Committee. Upper Parramatta River Catchment Trust (1995-7).
- Member, State of the Environment Report Steering Committee for Holroyd City Council (1995-2002).
- Botanical Advisor for Management Committee, Greystanes Creek Restoration Project (1993-2000).
- Blue Gum High Forest Workshop / Advisory Committee – Ku-ring-gai Council. (2007).

Publications/booklets:

- Stepnell, K. & James, T. A. (1986). *Australia's Native Flowers*. Child & Henry Publishing Pty. Ltd.
- James, T.A. (1988). *Bertya ingramii* (Euphorbiaceae) a new species from New South Wales. *Telopea* 3(2): 285.
- Bedford, D. & James, T. (ed.) (1992). *Collection, Preparation & Preservation of Plant Specimens.* Royal Botanic Gardens, Sydney.
- Powell, J.M. & James, T.A. (1993) *Epacris sparsa* (Epacridaceae) reinstated. *Telopea* 5(2):375-380.
- James, T.A. (1990-1993) in *Flora of New South Wales*. Royal Botanic Gardens, Sydney
- Volume 1: Euphorbiaceae (part), Violaceae.
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- James, T.A. (1994). Observations on the effects of mowing on native species in remnant bushland, Western Sydney. *Cunninghamia* 3(3).
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- Contributor to Bowen Mountain Bushwalks (1994). Bowen Mountain Association.
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- James, T.A. (1996). New combination in *Viola* (Violaceae). *Muelleria* Vol. 9 pp.35-36.
- James, T.A. NSW NPWS. (1997). Urban Bushland Biodiversity Survey. Stage 1: Native flora in Western Sydney.
- Hosking, R. J & James, T.A. (1998). An analysis of the native and exotic flora of the North Western Slopes upstream of the junction of the Peel and Namoi Rivers, New South Wales.
- James, T.A., McDougall, L & Benson, D. (1999). Revised edition. *Rare Bushland Plants of Western Sydney.* Royal Botanic Gardens, Sydney.
- James, T.A. (2009) Threatened plant species of Baulkham Hills Shire – unpublished booklet for Baulkham Hills Shire Council.
- James, T.A. (2009) Vegetation communities of Baulkham Hills Shire – unpublished booklet for Baulkham Hills Shire Council.
- James, Teresa (2013) Flora of Cumberland Plain Woodland – an identification guide.
- James, Teresa (2015) Threatened Flora of the Fairfield LGA.
- James, Teresa (2016) Native Flora of Shale Soils of the Cumberland Plain Woodland – An Identification Guide.

Reports

List of unpublished species lists and reports over the last 15 years.

- Kodela, P.G., James, T.A., Coveny, R.G. and Hind, P.D. (1992). Reconaissance survey of the vegetation at Long Swamp, near Penrose, Central Tablelands, N.S.W. Royal Botanic Gardens, Sydney. Unpublished report.
- James, T.A. & Kodela, P.G. (1992). Species list for Little Cattai Creek and tributary creeks. Royal Botanic Gardens, Sydney. Unpublished species list.
- James, T.A. & Kodela, P.G. (1993). Plant species recorded from Butlers Swamp, Central Tablelands, N.S.W. Royal Botanic Gardens, Sydney. Unpublished species list.
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- James, T.A. (November 2006). Flora survey and assessment for proposed footbridge construction over Cabramatta Creek. Report to Liverpool City Council.
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- May 2008-June 2009. Assistance to Ku-ring-gai Council to map and assess Blue Gum High Forest and Turpentine Ironbark Forest.
- James, T.A. (August 2008). Flora review of Species Impact Statement prepared for proposed industrial development at 37 Beaumont Road, Mt. Ku-ring-gai. Report to Hornsby Shire Council.
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- James, T.A (2010). Field survey and ecological assessment for proposed park at Water Street, Wahroonga. Report to A. Parr.
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- March-April 2010. Advice on threatened species for Growth Centres Strategic Assessment under EPBC Act to EcoLogical Australia.
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- Joint project with Australian Museum (October 2010 - December 2011) – City of Sydney Biodiversity Survey & Strategy.
- James, T.A. (2011). Investigation into land clearing of Shale Sandstone Transition Forest and Cumberland Plain Woodland - 561 Appin Road, Gilead. Expert report to DECCW.

- James, T.A. (2011) Flora survey for three reserves in Holroyd LGA to document regeneration following the cessation of mowing. Report to Holroyd City Council.
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- Douglas, S & James, T (2011) Review of listing advice and conservation advice for Shale Sandstone Transition Forest EEC under the EPBC Act – in progress.
- James, T.A. (2011) External Review of White Box – Yellow Box – Blakeley's Red Gum grassy woodlands and derived native grassland ecological community for the Mt. Pleasant Project (EPBC 2011/5795). Report to Dept. of Sustainability, Environment, Water, Population and Communities.
- Ecological advice to SMEC Australia (July-August, 2011). Impact assessment for *Pimelea spicata* – upgrade of Camden Valley Way, western Sydney.
- Ecological advice to SMEC Australia (August-September, 2011). Survey and assessment for Eastern Flame Pea – Trans Grid Dapto substation upgrade.
- Field assistance to SMEC Australia (February 2012) - Targeted survey for *Pimelea spicata* and general survey for RTA Camden Valley Way upgrade.
- PAS2 Expert Interviews for NSW threatened species with Office of Environment & Heritage (February-August 2012).
- Plot survey and ground verification of vegetation mapping within Hills Shire Council (June 2012).
- Threatened species management plans for several species prepared for Hills Shire Council (June 2012) – multi-species plan for Paulls Road (South Maroota), individual plans for *Persoonia hirsuta* and *Epacris purpurascens* at Fred Caterson reserve.
- Joint project with Australian Museum - Narrabeen Lagoon multi-trail (stage 2) Species Impact Statement (June 2012)
- Field assistance to SMEC Australia - Western Sydney Parklands vegetation monitoring project for WSP Trust (July – August 2012).
- Biodiversity/conservation assessment for 12-14 Cabernet Circuit Orchard Hills. Unpublished report to Wayne Olling of CCA (October 2012)
- PAS Reviews for selected NSW threatened species with Office of Environment & Heritage (November 2012).
- Vegetation Peer Review for the Northern Beaches Health Service Project. Report to Health Infrastructure (January 2013).
- Flora survey and assessment on private properties within the Balmoral Release Area, Kellyville (15, 16-20, 24, 26 & 28) for the Hills Shire Council (May-June 2013).
- Preparation of a Threatened Species Plan of Management for *Dillwynia tenuifolia* endangered population along Maquires Road, Maraylya for the Hills Shire Council (May-June 2013).
- Biobanking Assessment Report for the Northern Beaches Hospital Precinct development (a State Significant Development). July 2013. Report to SMEC Australia and Health Infrastructure.
- Threatened species roadside survey and verification of threatened ecological communities for Campbelltown City Council (September-October 2013).
- Peer Review of Species Impact Statement for 34-36 Britton Street, Smithfield for Holroyd City Council (November 2013).
- Flora survey and condition assessment for Pacific Highway Upgrade Woolgoolga to Ballina (Feb - April 2014). Assistance to Ecosure for Roads and Maritime Services.
- Matching of threatened entities occurring in the Greater Sydney Region area to newly mapped vegetation/community types in the Sydney Metro CMA and other parts of the Greater Sydney Region (May-June 2014) for Office of Environment and Heritage (Sydney).
- Parramatta Park baseline flora survey and report for Parramatta Park & Western Sydney Parklands Trust (September 2014).
- Assistance to SMEC with survey and biodiversity report for commonwealth-owned land at Badgerys Creek (Sept-Oct 2014). Report to Department of Infrastructure and Regional Development.
- Identification of Shale Sandstone Transition Forest in the Hills Shire – report to Hills Shire Council (July 2015).
- Assistance with field survey to SMEC Australia at the Holsworthy Training Area for Department of Defence (September 2015).
- Assistance with field survey (base line monitoring) to SMEC Australia at the Kapooka Biodiversity Offset Site near Wagga Wagga for Roads and Maritime Services (Sept-Oct 2015).

- Assistance to SMEC Australia in preparation of a Species Impact Statement for the Mona Vale Road upgrade for RMS (Nov 15-Jan16).
- Assistance to Ecosure in field survey/assessment for Mosman Flora and Fauna Bushland Audit (Jan-Feb 2016).
- Ecological Survey of Sackville Cemetery – report to The Hills Shire Council (May 2016)
- Field survey with 20 m x 20 m plot sampling for OEH Western Cumberland Plain and Bargo Gap Project (targeting transitional areas) – June 2016
- Field survey with 20 m x 20 m plot sampling for OEH Wingecarribee Shire Project – February 2017
- Field survey for vegetation management advice at Greendale property, western Sydney (April 2017)
- Vegetation Benchmark Values Project for the Hills Shire Council (June 2017)
- Attendance on OEH Saving Our Species expert panel (2017-2018) for several threatened ecological communities
- Provide Roadside Vegetation Management RAM workshop training for Hawkesbury River County Council (Feb 2018)
- Field survey and assessment for Persoonia nutans at TestSafe Site, Londonderry for OEH (June 2018)
- Flora and fauna assessment for expansion of Sackville Cemetery for the Hills Shire Council (June 2018)
- Strategic assessment for Cumberland Plain Conservation Plan – expert report for *Pimelea spicata* – report to Department of Planning & Environment (May-August 2018)
- Rapid Assessment/monitoring workshop for Fairfield City Council (Sept 2018)
- Review of master list for selection of plant species for landscaping and restoration appropriate to range of habitats found within the Western Sydney Parklands. Report to Western Sydney Parklands
- Independent Peer Review of SIS for Lot 11 Progress Circuit, Prestons. Report to Liverpool City Council
- Preliminary advice re impacts on GDE's at Menangle Park and additional vegetation assessment. Report to Campbelltown City Council

NSW Land & Environment Court cases:

- Grand United Friendly Society v Minister for the Environment - 87A Hammers Road, Toongabbie**.** Land & Environment Court.Proceedings No. 40292 of 1997. Engaged as a consultant by NPWS. Issues relating to <u>Cumberland Plain Woodland</u> and <u>Shale Sandstone Transition Forest.</u>
- Australand v Penrith City Council, Erskine Park (Dec 1999-April 2000). Land & Environment Court Proceedings. Engaged as a consultant by Penrith City Council. <u>Cumberland Plain Woodland and Sydney Coastal River-flat Forest.</u>
- Penrith City Council v Norman Mathie & Others – 392-476 Luddenham Road, Luddenham. Land & Environment Court Proceedings No. 50080-82 of 1999. Engaged as a consultant by Penrith City Council. Issues relating to <u>Cumberland Plain Woodland and Sydney Coastal River-flat Forest.</u>
- Blacktown City Council v Megarry Excavations and Roadworks Pty Ltd. Land & Environment Court Proceedings No 40141 of 2000. Engaged as a consultant by Blacktown Council. Issues relating to <u>Cumberland Plain Woodland and Shale Gravel Transition Forest.</u>
- Mark Topic v Liverpool CityCouncil. North Liverpool Road. Land & Environment Court Proceedings No 0155 of 2000. Engaged as a consultant by Liverpool City Council. Issues relating to <u>Cumberland Plain Woodland</u>

- Australand v Liverpool City Council. Land & Environment Court Proceedings No 10374, 10375, 10376, 10377 of 2003. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland and Sydney Coastal River-flat Forest
- Development Approval Managers v Liverpool City Council. Land & Environment Court Proceedings No. 10453 (Stage 3), No. 10455 (Stage 4) and No. 10454 (Stage 5) of 2003. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland and Sydney Coastal River-flat Forest
- BGP Properties v Lake Macquarie City Council - Lots 1 & 4 Cowlishaw Street, Redhead. Land & Environment Court Proceedings No 10042 of 2003. Engaged as a consultant by Lake Macquarie City Council. Issues relating to Sydney Freshwater Wetlands and Tetratheca juncea.
- Bentley v Hugh Gordon, Bentley v BGP Properties, Bentley v Whet Investments - Lots 1 & 4 Cowlishaw Street, Redhead. Land & Environment Court Proceedings No 50069-80 of 2003. Engaged as a consultant by NSW National Parks & Wildlife Service. Issues relating to Sydney Freshwater Wetlands and Tetratheca juncea.
- Blue Mountains City Council ats Blaxland Park Pty Ltd. - 60 Winnicoopa Road, Blaxland. Land and Environment Court Proceedings No. 10033 of 2004. Court appointed expert. Survey, identification & assessment of *Eucalyptus sclerophylla* Bench Woodland and *Lomandra brevis* in Repsonse to Agreed Questions.
- Providence Projects Pty Ltd v Gosford City Council – Lot 17 Meacham Way, Woy Woy. Land and Environment Court Proceedings No. 11626 of 2004 & 10101 of 2005. Court appointed expert. Review of issues relating to the identification of Umina Coastal Sandplain Woodland.
- Liverpool City Council ats Muslim League of NSW – 264 Wilson Road, Green Valley. . Land & Environment Court Proceedings No 10394 of 2005. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland.
- Liverpool City Council ats AV Jennings – Stage 24 Dalmeny Drive, Prestons. Land & Environment Court Proceedings No 10395 of 2006. Engaged as a consultant by Liverpool City Council. Issues relating to Cumberland Plain Woodland.
- Director General, Department of Environment & Conservation v Serenity Cove Business Park Pty Ltd – 238-258 Captain Cook Drive, Kurnell. Land & Environment Court Proceedings No 50003-5005 of 2006. Engaged as a consultant by the Department of Environment & Conservation. Issues relating to Swamp Sclerophyll Forest on Coastal Floodplains (formerly Sydney Coastal Esutary Swamp Forest), Sydney Freshwater Wetlands & Kurnell Dune Forest.
- Sutherland Shire Council ats Rocla Pty Ltd. Land & Environment Court Proceedings No 10447 of 2005. Engaged by Sutherland Shire Council. Issues relating to Swamp Sclerophyll Forest on Coastal Floodplains and Sydney Freshwater Wetlands.
- Wollongong City Council ats Albert David Moulds. Land & Environment Court Proceedings No 10488 & 10563 of 2006. Engaged as Court Appointed Expert. Issues relating to Illawarra Subtropical Rainforest and *Cynanchum elegans.*
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Expert report – *Pterostylis saxicola*

Expert report on *Pterostylis saxicola*, the Sydney Plains Greenhood, in the Greater Macarthur and Wilton Growth Areas, Peter H. Weston, June 2018

Expert report on the Sydney Plains Greenhood, *Pterostylis saxicola* in the Western Sydney Aerotropolis Growth Area and Greater Penrith to Eastern Creek Urban Release Investigation Area, Peter H. Weston, September 2018

Strategic assessment for Cumberland Plain Conservation Plan

Expert report on *Pterostylis saxicola*, the Sydney Plains Greenhood, in the Greater Macarthur and Wilton Growth Areas

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Pterostylis saxicola (photo Wayne Cherry)

1. Introduction

1.1 PURPOSE

I was engaged by the Department of Planning and Environment in early June 2018, to produce an expert report on the distribution and abundance of *Pterostylis saxicola* (Orchidaceae) within the proposed Greater Macarthur and Wilton Growth Areas (collectively termed "the study area"). The aim of this exercise was to assess whether *P. saxicola* (the "focal species") is native to either of the Growth Areas and, if so, to assess where suitable habitat is located and to estimate the area of habitat of *P. saxicola* in the study area.

According to Section 6.5.2 of the Biodiversity Assessment Method, an expert report must:

- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- estimate the number of individuals or area of habitat (the latter being the unit of measurement that applies to *Pterostylis saxicola*) for the biodiversity certification assessment area, including a description of how the estimate was made
- demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report, and
- identify the expert and provide evidence of their expert credentials.

1.2 PROJECT CONTEXT

The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney, including the two growth areas that define the geographic scope of this report: the Greater Macarthur Growth Area and the Wilton Growth Area. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

1.3 STUDY AREA

The Greater Macarthur and Wilton Growth Areas are located in the south western part of the Sydney Metropolitan Area, between latitudes 33°57'29"S and 34°16'44"S and longitudes 150°37'12"E and 150°54'47"E (the area outlined in blue in figures 13 to 15).

1.4 CREDENTIALS OF EXPERT

I prepared this report as an independent botanical consultant but I am also currently an Honorary Research Associate at the at the New South Wales state herbarium (the National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust). In 2016, I retired from my role as a Senior Principal Research Scientist at the state herbarium, having worked there since

1982 as a Systematic Botanist and as curator of the herbarium's collections of specimens of Orchidaceae (including *Pterostylis saxicola*) (see my *Curriculum Vitae*, attached). I now work, part-time, at the National Herbarium of New South Wales as an Honorary Research Associate. I have published, either as sole author or as a co-author, 16 papers on the systematics and ecology of the Orchidaceae in the peer-reviewed scientific literature, including the most comprehensive phylogenetic analysis of the predominantly Australian subtribe Diurideae yet published (Weston *et al.* 2014). As curator of Orchidaceae at the state herbarium, I examined all specimens of *P. saxicola* incorporated into the collection between 1986 and 2016. I was invited to contribute to floristic treatments of the Orchidaceae for *Flora of New South Wales*, (see my *Curriculum Vitae*, attached). I was also asked to be lead author of the essay on the ecology of the Orchidaceae that accompanied the "Ecology of Sydney Plants" (Weston *et al.* 2005). Throughout my career I have participated in numerous collecting trips in the field, collecting specimens in all Australian states for the state herbarium. In documenting these specimens I had to describe the habitat at each collecting site, including associated plant species, substrate, aspect, degree and kind of disturbance. I have also cultivated numerous species of *Pterostylis* as an orchid enthusiast and advised horticulturalists at the Royal Botanic Gardens on appropriate techniques for cultivating species of *Pterostylis* and other orchids.

1.5 JUSTIFICATION FOR USE OF EXPERT REPORT

Pterostylis saxicola has been collected once, questionably, within the study area, at Minto. However, two specimens of *P. saxicola* held by the state herbarium (NSW884619, NSW521907), and several observations recorded in the Bionet Wildlife Atlas, have been collected only 0.5-1.5 km east and 1.0 km south of the boundaries the Greater Macarthur Growth Area, raising the strong possibility that suitable habitat for *P. saxicola* might exist in the study area.

Moreover, the OEH Threatened Species Data Collection indicates that *Pterostylis saxicola* has the potential to occur in the following plant communities within the Wilton and Greater Macarthur Growth Areas:

- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain

If this were so, *Pterostylis saxicola* might once have lived there, or still exist in the study area as unrecorded populations.

Pterostylis saxicola is a perennial, deciduous herb that can only be identified with confidence when flowering in Spring (late September to early November). At other times of year, the plants are either not visible at all when dormant from December to March, or are visible only as leaf rosettes, which resemble the leaves of other, closely related, co-occurring species of *Pterostylis* so closely that they cannot be distinguished with confidence. Conventional surveying during October would therefore be the most appropriate way to test for its presence, if unlimited access to the study area were allowed. Although surveys were undertaken on all areas of land where landowners granted access, the timing of these was inappropriate for this species, as they were conducted between November 2017 and May 2018.

These limitations and the possibility that *Pterostylis saxicola* might be native to the Greater Macarthur and Wilton Growth Areas triggered the need for an expert report.

1.6 SPECIES SURVEYS

An initial 726 letters were sent to landholders within the Growth Areas in late 2017. A second letter was sent in March 2018, and targeted door knocking occurred in May 2018. From this, just under 20% of landholders have responded. Surveys were undertaken on all areas of land where landowners granted access. Of the 14,984 hectares within the Wilton and Macarthur Growth Areas, of which 5,385 ha is potential native vegetation that could be impacted by development, DPE has completed surveys across 3,360 hectares (62% of the total survey area). Floristic surveys were undertaken from November 2017 to May 2018, which, unsurprisingly, resulted in no sightings of *Pterostylis saxicola*, which was dormant or recently re-shooting from subterranean tubers for most of that time.

2. Species information

2.1 SPECIES DESCRIPTION

The following morphological description of *Pterostylis saxicola* is a modified version of that published by Jones and Clements (1997), updated with data gathered from more recently collected specimens held by the National Herbarium of N.S.W.

Tuberous, terrestrial herb. Tubers oblate, c. 15-20 mm wide. Leaves oblong-elliptical to ovate-elliptical or obovate, 10-45 mm long, 5-15 mm wide, 5-10 in a radical rosette, green, the margins entire, shortly petiolate, apex subacute to apiculate, often withered at anthesis. Inflorescence 10.5-35 cm tall, slender, with 3-6 ensheathing, lanceolate sterile bracts. Floral bracts lanceolate, 6-19 mm long, 3-4 mm wide, acuminate, closely sheathing. Pedicels 3-26 mm long, slender, straight or slightly curved. Ovary narrowly obovoid, 3-5 mm long, 1-2 mm wide, reddish brown. Flowers 1-10, porrect to semi-erect, 12-12 mm long, transparent with dark red-brown markings and suffusions in the galea, the lateral sepals wholly red-brown, shiny; galea gibbous at the base, curved medially, decurved suddenly to the apex; petal flanges poorly developed, not touching and not closing off the base of the galea. Dorsal sepal 11-13 mm long, cucullate, obliquely erect, Abruptly decurved in distal quarter, apical point c. 3 mm long, filamentous, acuminate. Lateral sepals deflexed, ovate in outline when flattened, fused part 7-10 mm long, 9-11 mm wide, shallowly concave, the margins strongly incurved, glabrous; sinus narrow; free points filamentous, c. 5 mm long, curved forwards, divergent, 8-10 mm apart at the tips. Petals ovate-lanceolate, 11-14 mm long, 3.5-5 mm wide, nearly straight, transparent, with brown basal markings and two or three brown lines, dorsal margin brown, ciliate, proximal flange poorly developed. Labellum highly irritable, attached by a ligulate basal claw c. 2 mm long, c. 2 mm wide; lamina broadly obovate, 4.5-6 mm long, 2.5-3.5 mm wide, dark red-brown, constricted in the proximal quarter, adaxial surface shallowly concave to broadly grooved, apex obtuse; marginal trichomes 3-5 pairs, white, the longest pair c. 3.5 mm long, arising near the proximal constriction, basal lobe large, with 1-3 pairs of trichomes c. 0-.7 mm long, abaxial surface with a narrow central channel extending from the basal lobe to the apex. Column porrect from the end of the ovary, 10-12 mm long, c. 2.5 mm wide; column wings c. 3.3 mm long, c. 2.5 mm wide, more or less rectangular, anterior margins ciliate. Stigma elliptical to broadly scutiform, c. 5 mm long, c. 2.5 mm wide, the upper margins irregular. Anther c. 1.2 mm long, obtuse. Pollinia linear-oblong to clavate, c. 2 mm long, yellow, mealy. Fruiting capsules obovoid, 7-8 mm long, c. 4-5 mm wide, brownish, erect.

2.2 LIFE CYCLE

Pterostylis saxicola is a perennial, deciduous, tuberous herb that germinates from a minute, dust-like seed. Like all other orchids, germination is reliant on invasion of the seed by the hyphae of a specific fungal associate, which, in the case of *P. saxicola*, is an unnamed species of *Ceratobasidium* (Basidiomycota: Cantharellales) (Sommerville *et al.* 2008). The first morphological change that an orchid seed undergoes during germination is swelling to form a protocorm, a rootless, shootless 'blob'. The orchid fungus forms an intracellular relationship with its host, usually in the roots and/or tubers and is thus classed as an endomycorrhiza. It forms hyphal coils, called pelotons, in the cells of its host, which are beneficial to the orchid in that they provide the host plant with nutrients such as soluble sugars (Rasmussen 1995, Warcup 1990). The duration of the association varies according to the life history of the particular orchid species, with some species of orchids being completely dependent on their mycorrhizal fungi for life while other species are capable of living without their fungi from shortly after germination. The ease of cultivation of *Pterostylis* species and the green colour of almost all plant parts strongly suggest that adult plants are not obligately dependent on their mycorrhizal associates.

Plants of *Pterostylis saxicola*, like those of most other species in Orchidaceae subfamily Orchidoideae, are deciduous, with the whole shoot system growing anew every year from a dormant tuber. The new shoot usually starts growing from an apical meristem on the tuber in late summer, with new shoots usually breaking the soil surface by March. The shoot develops into a "rosette" of crowded leaves just above ground level and in late winter a terminal raceme starts growing from the centre of the rosette, reaching anthesis in Spring. While the shoot is growing above ground, a new replacement tuber is growing below ground, from the base of the shoot. Some species of *Pterostylis* multiply and spread vegetatively by producing additional new tubers on the ends of long roots but the subgenus to which *P. saxicola* belongs, *Oligochaetochilus*, does not share this attribute (Jones 2006).

Almost all species of *Pterostylis* are deceptively pollinated by male flies that attempt to copulate with the labellum of the flower. The labellum mimics a female fly of a particular species (or species group) in size, appearance and texture and by exuding an allomone that is identical to the pheromone released by the female flies (Phillips *et al.* 2013, Kuiter & Findlater-Smith 2017). In species of *Pterostylis* for which the pollination process has been studied and described, the labellum is highly motile ("irritable"), like that of *Pterostylis saxicola*, and a male fly that lands on it is tossed inside the hood (galea) formed by the dorsal sepal and lateral petals, and trapped there. The only escape route provided by the flower is a tunnel through which the male fly must squeeze in order to escape. In the process of negotiating its exit, the fly is forced to rub past the stigma of the flower, depositing on it any pollinaria that it was already carrying. The fly is then forced to contact the anther, sticking a pollinarium on its thorax, before it can finally escape. The pollinator of *Pterostylis saxicola* is still unknown, but the pollinators of other species of *Pterostylis* subgenus

Oligochaetochilus, where known, are males of unnamed species of *Orfelia* (Mycetophilidae) (Kuiter & Findlater-Smith 2017). Sexually deceptive pollination has evolved multiple times in the Australian terrestrial orchid flora, involving hundreds of species (Weston *et al.* 2014). Most of those for which pollinators have been identified are pollinated by the males of only one species of insect and *P. saxicola* is most likely pollinated by a single species of fly too.

Fruiting capsules of *Pterostylis saxicola* mature quickly, with the most proximal capsules sometimes dehiscing before the most distal flowers have withered. They split down six sutures to release thousands of minute, wind-dispersed seeds in November to early December.

2.3 DISTRIBUTION AND ABUNDANCE

Records for *Pterostylis saxicola* are widely distributed across the Cumberland Plain and lower Blue Mountains in an area bounded by Scheyville, Freemans Reach, Glenbrook, Douglas Park, Picnic Point, Ryde (an unvouchered record) and Cattai, with an outlying record from the Gingra Range in Kanangra Boyd National Park (Bionet Atlas, National Herbarium of New South Wales specimen database, all accessed 26/7/2018). It has been recorded at altitudes ranging from 30 to 400 metres. It is very sporadically distributed, partly because much of this land has been cleared for agriculture and suburban development but the outlying record suggests that any habitat model is unlikely to be a powerful predictor of the presence of populations at particular locations.

Plants are usually gregarious, with most collectors and observers noting multiple plants co-occurring together. At two sites for which I had highly precise grid references, and which I characterised in detail, I found pre-flowering leaf rosettes in clusters: 10 plants in a 10x10 cm patch (figure 1, site PS1, Appendix 1), two plants 5 cm apart, and 57 in a patch smaller than one square metre. As *P. saxicola* does not usually multiply vegetatively (Jones 2006), these clusters must be the result of seeds germinating close to their parents.

2.4 HABITAT REQUIREMENTS

The habitat model published in the endangered species profile for *Pterostylis saxicola* (NSW Office of Environment and Heritage 2018, hereafter “NOEH 2018”) states that it is “most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where *P. saxicola* occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils”. This description applies accurately to the habitat associated with some records in the southern half of the species’ distribution but not to those found elsewhere. The distributional range and habitat requirements of *P. saxicola* can be subdivided into two main sub-populations and one outlying population.

The northern sub-population is in an area bounded by Scheyville, Freemans Reach, “The Ironbarks” near Glenbrook, Toongabbie, Ryde, Glenhaven and Cattai. The substrate underlying the sites at Scheyville, Freemans Reach and Ryde is deep Ashfield Shale (Wianamatta Group), but the Cattai, Toongabbie and Glenbrook records came from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition zones. All of these sites are in gently rolling country, not on rugged sandstone outcrops.

I visited and characterised one of these sites at Scheyville National Park (site PS1, Appendix 1), the location of which was recorded with very high precision. I found pre-flowering *Pterostylis* rosettes

Figure 1. Pre-flowering rosettes of *Pterostylis saxicola* growing on Ashfield Shale in Scheyville National Park (site PS1, Appendix 1).

Figure 2. Site Ps1 with *Pterostylis saxicola* growing on the side of the track, next to the backpack, in Cumberland Plain Woodland on Ashfield Shale in Scheyville National Park (site PS1, Appendix 1).

there that were consistent with *Pterostylis saxicola* (figure 1, site PS1, Appendix 1). The population there was growing on the side of a track just below the crest of a ridge, the land sloping at about 5° to the south east, on Ashfield Shale, in Cumberland Plain Woodland (*sensu* Keith 2004) dominated by *Eucalyptus moluccana* and *E. crebra*, a plant community that I identified using the community identification tools in Bionet as 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain. This site was inconsistent with the species profile for *P. saxicola* (NOEH 2018) in both substrate (Ashfield Shale) and landform (gentle slope near ridge top). The closest sandstone outcrop to the site was at least 3.6 km to the east, the shale cap at the site being about 20-30 m thick according to the geological map covering this area (NSW Department of Minerals and Energy 1991).

The plant communities associated with recorded sites for *Pterostylis saxicola* in its northern sub-population, as determined from collectors' and observers' notes and from identification of precisely specified sites on vegetation maps (Tozer *et al.* 2010), are map unit GW p29 Cumberland Shale Plains Woodland, and map unit GW p2 Cumberland Shale Sandstone Transition Forest.

Most records from the southern sub-population, in an area bounded by Macquarie Fields, Minto, Douglas Park, Woronora River and Picnic Point differ strikingly in habitat from the northern records. In cases where they have highly precise locality data and/or detailed habitat descriptions, collections and observations from this area have been made on Hawkesbury Sandstone, on the rims and sides of the gorges of the Nepean, Georges and Woronora Rivers. Observers' notes repeatedly describe the soils as very shallow sands overlying sandstone rock shelves, as stated in the published habitat model (NOEH 2018). However, contrary to that model, only some of them were recorded above cliff lines. The only evidence of shale influence on the environment seems to be associated plant community types, with some precisely georeferenced sites being mapped by Tozer *et al.* (2010) to Cumberland Shale Sandstone Transition Forest (their map unit GW p2).

I visited and characterised four sites at which *Pterostylis saxicola* had previously been collected in the southern sub-population, at Simmos Beach Recreation Reserve Macquarie Fields (sites PS2, PS3), Boronia Road Reserve, Kentlyn (site PS4), and Amberdale Reserve, Picnic Point (site PS5, Appendix 1). At one of these I found pre-flowering rosettes identical to those of *P. saxicola* at the precise grid reference I had been provided by a previous collector, Karen Sommerville (figures 3-4, site PS3, Appendix 1). They were growing in a thin layer of dark brown humus-rich sand on a flat sandstone outcrop on a gently sloping ridge top. Other sites at which *P. saxicola* had previously been collected but where I did not find pre-flowering rosettes were similar, with sandstone rock shelves covered in a thin layer of sandy soil that was partly covered by mosses and lichens. Several plant species were associated with *P. saxicola* at all four of these southern sites: *Angophora bakeri*, *Banksia spinulosa*, *Hakea sericea*, *Leptospermum trinervium*, *Lomandra obliqua*, and *Persoonia levis*.

The plant community types that I identified at these locations, using the community identification tool in Bionet, were:

- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain;
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney.

Figure 3. Pre-flowering rosettes of *Pterostylis saxicola* growing at Simmos Beach Recreation Reserve, Macquarie Fields (site PS3, Appendix 1).

Figure 4. PCT 1081 Red Bloodwood - grey gum woodland on the edges of the Cumberland Plain, at site PS3 (Appendix 1)

- 1789 Smooth-barked Apple - Blackbutt - Red Bloodwood open forest in enriched sandstone gullies of the western Woronora plateau.

In addition to these plant community types, observational records of *Pterostylis saxicola* with highly precise grid references from outside the study area were assigned to map units using the maps and classification system of Tozer *et al.* (2010). However, in order to produce a unified, internally consistent habitat model, a standard plant community classification system needs to be adopted, and I have chosen the Bionet Vegetation Classification because that is the system that has been used for detailed mapping of the study area. Consequently, the relevant map units of Tozer *et al.* (2010) were converted to their equivalents in the Bionet classification, as indicated in the references cited with each plant community type in Bionet, reproduced in table 1 below.

Map unit of Tozer *et al.* (2010)	Equivalent PCT in the Bionet vegetation classification
GW p2 Cumberland Shale Sandstone Transition Forest	1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain
GW p29 Cumberland Shale Plains Woodland	849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain
DSF p37 Kowmung-Wollondilly Grassy Gorge Woodland	870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges
DSF p131 Coastal Sandstone Ridgetop Woodland	1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux
DSF p142 Hinterland Sandstone Gully Forest	1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney
DSF p146 Sydney Hinterland Transition Woodland	1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain

Table 1. Equivalence of some map units of Tozer *et al.* (2010) with plant community types in the Bionet Vegetation Classification.

Some of these plant community types are not represented in the study area according to the vegetation maps produced for this project. Nevertheless, they need to be incorporated into any new general habitat model for *P. saxicola*.

I am not equipped to produce a bioclimatic envelope for *Pterostylis saxicola* but univariate mean monthly rainfall and temperature statistics for the distributional range of the species can be interpreted as indicating areas of potentially suitable habitat. Climatic statistics for weather stations within its distributional range (http://www.bom.gov.au/climate/data, accessed 7/8/2018) indicate that *P. saxicola* occurs in an area where mean annual rainfall varies between 700 and 1200 mm, average minimum temperatures for the coldest month vary from 1.7° to 5.1°, winter frosts are rare to frequent and where average maximum temperatures for the warmest month vary from 27.1° to 30.3°.

Pterostylis saxicola has mostly been recorded growing in intact native vegetation but there is one notable exception: a plant described in a "Car Park growing through bitumen", adjacent to a large area of bushland from which other substantiated records had been made. Several others have come from small patches of remnant urban bushland, in some cases less than a hectare in area, surrounded by highly disturbed land, and from a long, narrow patch less than 50 m wide. However, no records mention heavily weed-infested habitats or evidence of heavy grazing introduced herbivores. Sites with significant edge effects are probably not sustainable reserves for conserving this species.

Given the significant discrepancies between the habitat model published in the threatened species profile for *Pterostylis saxicola* (NOEH 2018) and the characteristics of sites at which substantiated collections have been made, an improved habitat model is now required.

The following model incorporates habitat information associated with all of the records of *Pterostylis saxicola* from the Bionet Atlas, Atlas of Living Australia and specimen database of the National Herbarium of New South Wales (all accessed 26/7/2018).

Occurs on the Cumberland Plain along an ecological gradient from:

- Clay soils derived from Ashfield Shale (Wianamatta Group) on flat to gently hilly landscapes in PCT 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain;
- to: clay to sandy soils derived from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition substrates on gently hilly landscapes, in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain;
- to: thin accumulations of humus-rich sandy soil on Hawkesbury Sandstone sheets and rock shelves, on the rims and steep sides of river valleys, growing in PCT 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, or PCT 1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, or PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, or PCT 1789 Smooth-barked Apple - Blackbutt - Red Bloodwood open forest in enriched sandstone gullies of the western Woronora plateau.

Also occurs outside the Cumberland Plain on Devonian slate, in PCT 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges.

3. Description of the study area

3.1 LAND USE HISTORY

The following account is based largely on information gathered from Liston (1988), except where otherwise stated. The first human inhabitants of the study area were Aborigines who moved there many thousands of years ago. People of the Dharawal group were occupants of the study area when Europeans first started to settle in the Sydney Region in 1788. These hunter-gatherers would have managed the grassy woodlands that grew on Wianamatta Shales of the area using fire-stick farming methods (Benson & Howell 1990). In 1816 a large group of them were massacred by soldiers at Appin and by 1830 their community life in the Campbelltown area had disintegrated.

In 1788, six months after Sydney was founded, two bulls and four cows escaped from Sydney Cove. European exploration of the study area commenced in 1795, when 61 naturalised descendants of those bulls and cows were discovered near Menangle, in an area that became known as “the Cowpastures”. Those cattle had discovered a plentiful source of fodder on the alluvial flats of the Nepean River and adjacent grassy woodlands on Wianamatta Shales, which also proved to offer more fertile farming land than sandy soils derived from Hawkesbury Sandstone. By the end of 1809, 34 settlers had been granted land at Minto and Glenfield for farming. Further land was granted to settlers at Appin in 1811, Macquarie Fields and Airds in 1816 and at Campbelltown in 1820. From then to the 1950s, land use in both growth areas was dominated by agriculture, which necessitated extensive clearing of native vegetation from the more fertile alluvial and clayey soils. Agricultural activities conducted in the areas have included the cultivation of wheat (which was curtailed in 1864 when the whole crop was destroyed by an infestation of rust disease) and other cereal crops, grazing of sheep, cattle and horses, intensive production of pigs and poultry, and the cultivation of fruit and vegetables. Campbelltown grew slowly as an urban centre during the 19th century and first half of the 20th century, but population growth accelerated after 1950 due to the rezoning of agricultural land for housing development in the northern part of the Macarthur Growth Area, electrification of the railway line as far south as Macarthur in 1963, the release of the Three Cities Plan (Campbelltown-Camden-Appin) in 1972 and subsequent construction of a number of large-scale housing commission projects from 1973 (figure 5).

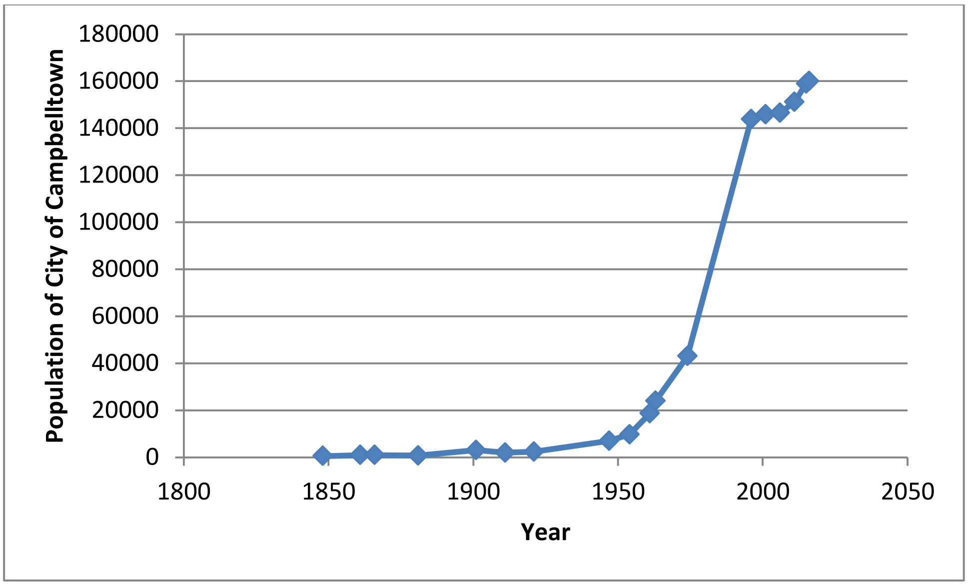

Figure 5. Population growth of Campbelltown, 1848-2016, assembled from data presented at https://www.campbelltown.nsw.gov.au/AboutCampbelltown/History/Campbelltowntimeline

Land use in the northern part of the Macarthur Growth Area is now dominated by residential housing, light industry and transport infrastructure, with only small pockets of pasture and urban bushland remaining intact, albeit weed-infested. In the southern half of the Macarthur Growth Area, south of the “waist” between Mt Annan and Glen Alpine, and in the Wilton Growth Area, land use is still largely rural, with the exception of limited residential and industrial development around Appin and Wilton. Agriculture has been largely restricted to soils derived from Wianamatta Shales and alluvium. Most areas of exposed Hawkesbury Sandstone either still support native vegetation or have been cleared for residential development.

3.2 HISTORY OF BOTANICAL EXPLORATION IN THE GROWTH AREAS

The first botanist to collect plant specimens in the same region as the growth areas was Joseph Banks’ employee, George Caley, who in 1802 made several expeditions from Prospect through the Cowpastures, reaching Mount Hunter, Menangle and Thirlmere Lakes (Webb 1995). Caley returned to the area in 1803, 1804 (during which he collected *Pterostylis saxicola* between Toongabbie and

South Creek), 1805 and 1807, once in the company of the great Scottish botanist Robert Brown. Caley mapped a section of Georges River near Ingleburn, following it to Appin, and explored the upper Nepean River system as far as Douglas Park and Appin Falls on the Cataract River (Webb 1995). On these trips, Caley and Brown made extensive botanical collections, from which Brown described numerous species that were new to science. The next botanical collector to visit the area was Franz Sieber, an Austrian who spent six months in the Sydney Region in 1823, during which time he collected specimens of 300 plant species (Ducker 1990), including many that are native to the study area. Botanical exploration of the area then became almost dormant until the late 19th century, when it intensified under the influence of J.H. Maiden, curator of the new Technological Museum, and later director of the Sydney Botanic Gardens. Botanists associated with Maiden, including R.T. Baker, J.L. Boorman, A.A. Hamilton, W.F. Blakely and E. Cheel made several thousand collections in the study area in the late 19th and early 20th centuries (National Herbarium of N.S.W. specimen database), long after much of the native vegetation on Wianamatta Shales and alluvia had been cleared for agriculture. Botanical exploration of the remnant vegetation of the study area has continued to the present day.

3.3 LANDSCAPE CONTEXT

The Greater Macarthur and Wilton Growth Areas are located on the southern to south eastern rim of the Cumberland Plain, the central part of the saucer-shaped sedimentary Sydney Basin. Here, the uppermost strata of the Sydney Basin, Cenozoic alluvia patchily overlie the Triassic Wianamatta Group rocks, mostly comprising Bringelly and Ashfield Shales, which, in turn overlie a thin layer of Mittagong Formation sandstone and shale and Triassic Hawkesbury Sandstone (Martyn 2018). Scattered small volcanic intrusions occasionally pierce the sedimentary strata, such as at Mt Annan, 0.7 km west of the “waist” in the middle of the Greater Macarthur Growth Area.

The most commonly exposed substrate in the northern part of the Greater Macarthur Growth Area is Ashfield Shale, over which patches of Bringelly Shale have been preserved on the western side, while Quaternary alluvia have accumulated in the valleys of Bow Bowing and Bunbury Curran Creeks (NSW Department of Minerals and Energy 1991, NSW Department of Mineral Resources 1985). Here, minor tributaries of the Georges River, such as Redfern, Smiths and McBarrons Creeks have exposed Hawkesbury Sandstone in narrow, shallow but steep-sided valleys.

In the southern half of the Greater Macarthur Growth Area, Bringelly Shale and Quaternary alluvium are restricted to the north west at Menangle Park. Further south, the Nepean and Georges Rivers and their tributaries have cut deep gorges through the Ashfield Shale, exposing large areas of Hawkesbury Sandstone on the steep valley sides and on the adjacent, flat to gently sloping valley borders. Large areas of transitional substrate exist here, where Ashfield Shale colluvium and soils derived from Mittagong Formation sandstones and shales thinly cover Hawkesbury Sandstone or mix with sandstone-derived soil. The landscape of the Wilton Growth Area resembles that of the southern half of the Greater Macarthur Growth Area but here the predominant substrate is Hawkesbury Sandstone over which an archipelago of thin islands of Ashfield Shale are preserved.

As the Greater Macarthur and Wilton Growth Areas are located on the southern to south eastern rim of the Cumberland Plain, they are gently tilted from south south west to north north east. However, topography also varies locally, with erosion having produced gently rolling landscapes over much of the area but steep-sided valleys contain the major water courses. The lowest point is in the far north east at Glenfield, where the banks of the Georges River are at 15 m altitude, but the land nearby rises to an altitude of 60 m at the junction of Campbelltown Road and Camden Valley Way. In the southern end of the Greater Macarthur Growth Area, just south east of Appin, the altitude reaches 260 m but drops to 230 m on the banks of the Georges River. The Wilton Growth Area varies in altitude from 105 m in the bottom of the Nepean Gorge to 310-320 m near its southern tip on the Picton Road.

Topographic variation as well as distance from the sea influences climate. The area just west of the Greater Macarthur Growth Area has the lowest average annual rainfall and the highest average January maximum temperature in the Sydney Region (Benson & Howell 1990). Both growth areas are subject to winter frosts.

3.4 NATIVE VEGETATION

In terms of the plant community types (PCTs) recognised in the Bionet Vegetation Classification and the vegetation maps that were prepared for this project, the remnant native vegetation of the growth areas consists of:

- 830 Forest Red Gum – Grey Box shrubby woodland on shale of the southern Cumberland Plain;
- 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain;
- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain;
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain;
- 883 Hard-leaved Scribbly Gum – Parramatta Red Gum heathy woodland of the Cumberland Plain;
- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain;
- 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney;
- 1292 Water Gum – Coachwood riparian scrub along sandstone streams;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain.

Plant community types 830, 849 and 850 occur on Wianamatta Shales, PCT 835 on quaternary alluvium, PCTs 883, 1081 and 1395 on Hawkesbury Sandstone under a thin layer of Ashfield Shale or shale colluvium and PCTs 1181 and 1292 on Hawkesbury Sandstone.

In the course of this project, I visited 19 sites in the field, 18 of which were either in, or adjacent to, the Growth Areas, 16 of which I characterised in detail (Appendix 1).

In the northern half of the Greater Macarthur Growth Area, native vegetation is restricted to small, mostly long, narrow patches of urban bushland, most of which line water courses. A few of these are conserved as council reserves. I visited four bushland remnants either in, or close to the northern part of the Greater Macarthur Growth Area (sites N1, N7, N13, N14, Appendix 1), two of which I characterised in detail (N1, N7). I found all of these to include substantial weed infestation, especially close to water courses. Two species of privet, *Ligustrum sinense* and *L. lucidum*, were the most common woody weeds growing on sandstone, while African Olive (*Olea europea* subsp. *cuspidata*) was common on Wianamatta Shales. Common herbaceous weeds included naturalised grasses, Bridal Creeper (*Asparagus asparagoides*) and, near watercourses, Wandering Jew (*Tradescantia fluminensis*). Dumped household and garden rubbish was common near road access points in most patches of remnant bushland.

In the southern half of the Greater Macarthur Growth Area, and in the Wilton Growth Area, patches of remnant native vegetation become progressively more plentiful, on larger blocks of land, as one moves south but they are still mostly associated with water courses. According to the vegetation maps that were prepared for this project, by far the most abundant plant community type here is PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain. This community type occurs on flat to gently sloping land, close to the interface between Ashfield Shale and Hawkesbury Sandstone, often adjacent to steep-sided sandstone gorges. Exposed sandstone surfaces are plentiful, with clayey to loamy soils derived from Ashfield Shale or shale colluvia occurring between rock outcrops and thin layers of humus rich sandy soil accumulating on flat sandstone surfaces, often colonised by mosses and lichens(e.g. site N9, figure 6).

Figure 6. Plant community type 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, on Ashfield shale colluvium over Hawkesbury Sandstone at Shingle Hill, Wilton (site N9, Appendix 1).

At one such site I found pre-flowering *Pterostylis* rosettes that closely resembled those of *P. saxicola* growing in a thin layer of dark brown sand on a sandstone shelf (figures 6 and 7).

Figure 7. Pre-flowering *Pterostylis* rosettes growing in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain at Shingle Hill, Wilton (site N3, Appendix 1).

Although almost all of PCT 1395 is coded as “intact” in the vegetation maps, I found the condition of these remnants variable, depending on the extent of grazing by stock to which they had been subjected. At one of my sites (site N3, Appendix 1), a shrub stratum was completely absent and all herbaceous plants had been grazed close to the ground (figure 8).

The sides of the gorges of the Nepean and Georges Rivers and their major tributaries are typically covered by PCT 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (e.g. site N11, figure 9). In some places this forms a mosaic with PCT 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain.

3.5 POTENTIAL HABITAT

The new, improved habitat model that I have developed for *Pterostylis saxicola* includes the following habitats that have been mapped in the study area:

- Clay soils derived from Ashfield Shale (Wianamatta Group) on flat to gently hilly landscapes in PCT 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain.

- Clay to sandy soils derived from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition substrates on gently hilly landscapes, in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain.
- Thin accumulations of humus-rich sandy soil on Hawkesbury Sandstone sheets and rock shelves, on the rims and steep sides of river valleys, growing in PCT 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, PCT 1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, and PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney.

Figure 8. Heavily grazed understory vegetation in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain at Allen Creek, Wilton (site N3, Appendix 1).

4. Assessment of species presence and suitable habitat

4.1 SPECIES RECORDS AND HABITAT ASSESSMENTS

Pterostylis saxicola has only been recorded once in the study area, at Minto, in 1947. The precision of this record is questionable because collectors at that time usually specified their collecting locations no more precisely than as the nearest named place. “Minto” could have meant “East Minto”, which, after 1973 became known as Minto Heights, most of which is outside the study area.

Figure 9. PCT 1181 Smooth-barked Apple – Red Bloodwood – Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, east of Appin (site N12, Appendix 1).

However, *Pterostylis saxicola* has been collected or observed at several sites within 1 km of the eastern side of the Greater Macarthur Growth Area and at one site between the growth areas, within 1 km of the north eastern corner of the Wilton Growth Area and within 2 km of the south western corner of the Greater Macarthur Growth Area. No formal habitat assessment has ever been conducted in the study area.

4.2 PRIOR SPECIES SURVEYS

No formal, targeted surveys had been conducted for *Pterostylis saxicola* specifically in the study area prior to the start of this project, although Teresa James surveyed known sites of occurrence in 2007. Floristic surveys were undertaken in the study area from November 2017 to May 2018, starting at the tail end of the flowering period of *P. saxicola,* proceeding through its dormancy period, during which it persists as a subterranean tuber, to the time when plants would probably have been visible as newly emerged, pre-flowering rosettes. Only in the first two to four weeks of the survey period would plants of *P. saxicola* have been morphologically identifiable, so survey effort for this species in this project has been negligible.

4.3 ASSESSMENT OF SPECIES PRESENCE

Pterostylis saxicola is highly likely to be growing, unrecorded, in both the Greater Macarthur Growth Area and the Wilton Growth Area.

4.4 JUSTIFICATION FOR DETERMINATION

Evidence and arguments against the hypothesis that *Pterostylis saxicola* is, or once was native to the study area

Pterostylis saxicola has been recorded only once, dubiously, in the study area despite a 210 year history of botanical exploration there. This species, like most orchids, is highly reliant on associated, highly specialised symbionts for germination and pollination, so even if all other habitat variables were suitable for its growth and reproduction in the study area, it could not reproduce sustainably there if either of those symbionts were absent. Perhaps *P. saxicola* has only been recorded once in the study area because one or both of its obligate symbionts is absent there.

Evidence and arguments for the hypothesis that *Pterostylis saxicola* is native to the study area

Pterostylis saxicola has been recorded outside the study area in four plant community types (PCTs 849, 1081, 1181 and 1395) that occur in the study area, some abundantly. At each of those recorded sites the substrates mapped there by geologists (Ashfield Shale, Mittagong Formation shales and sandstones, Hawkesbury Sandstone and transitions between them) are substrates that occur in the study area. Indeed, Ashfield Shale and Hawkesbury Sandstone are the two most abundant substrates there. The whole of the study area also seems to be climatically suitable for *P. saxicola*. Its highest point, less than 320 metres in altitude, at the southern tip of the Wilton Growth Area, is comfortably within the species' altitudinal range of 30-400 metres. One has to conclude that extensive suitable habitat for *P. saxicola* occurs in the study area.

It is reasonable, however, to ask why the species has not been collected more often there. To address this question, a histogram of records over time is instructive (see figure 10, below).

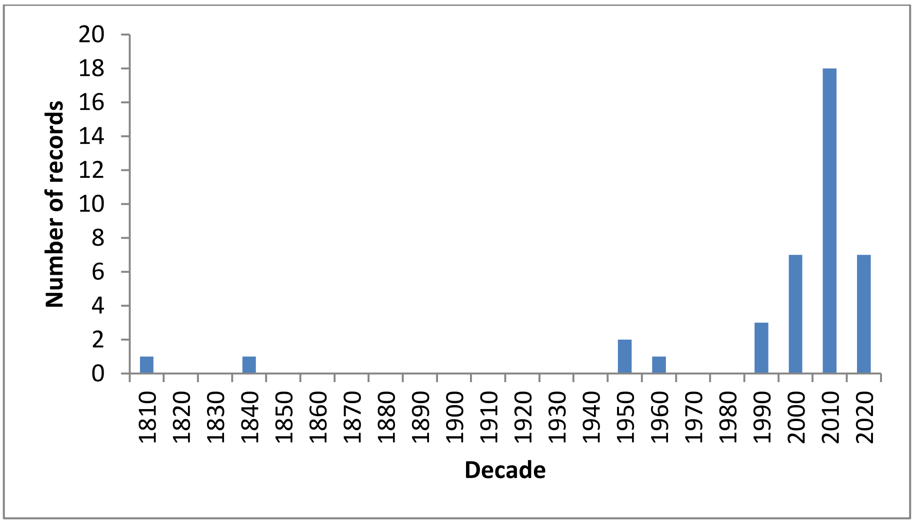

Figure 10. Histogram of the number of observational records and collections of *Pterostylis saxicola* per decade since 1800.

From 1804 to 1989, *Pterostylis saxicola* was recorded only six times. In 1997 it was recognised as specifically distinct, named and described. Botanists, conservation biologists, ecologists and orchid enthusiasts suddenly became interested in it. The collection of specimens and observations accelerated, encouraged by funding for rare plant surveys and an *ex-situ* conservation project. Most of this activity was concentrated on publicly accessible land, which accounted for 19 of the 26 records made since 1997, 18 of which were additional records from previously recorded sites. Most exploratory effort expended on *P. saxicola* was being put into detailed surveys of known populations. New populations were still being discovered as incidental benefits of other botanical work, not as the result of targeted searches in previously unexplored areas. The dearth of new records from the southern part of the study area was probably due to a lack of searches there. Absence of evidence is not necessarily evidence of absence.

Targeted exploration of new territory for previously unknown populations of *Pterostylis saxicola* would, in any case be a potentially frustrating task. This orchid is sporadically distributed, not continuously spread through its habitat. It is also difficult to find, even at locations at which it is relatively common: the plants are small, cryptically coloured, and only recognisable for a period of six weeks or less while flowering. Moreover, most of the potential habitat in the study area is on private land, much of which is inaccessible because the landowners have not given permission for biodiversity surveyors to work on their land.

4.5 LIKELIHOOD OF SPECIES PRESENCE

Figures 10 and 11 show frequency histograms of populations of *Pterostylis saxicola* from the Bionet Wildlife Atlas and state herbarium's specimen database, categorised in latitudinal and longitudinal samples 0.05 degrees wide. Populations are here defined as records, or clusters of records separated by at least 1 km. These diagrams display two perspectives of the spatial relationship between the study area and distribution and abundance of known populations of *P. saxicola*. The bimodal clustering of populations into northern and southern sub-populations is clear in the latitudinal

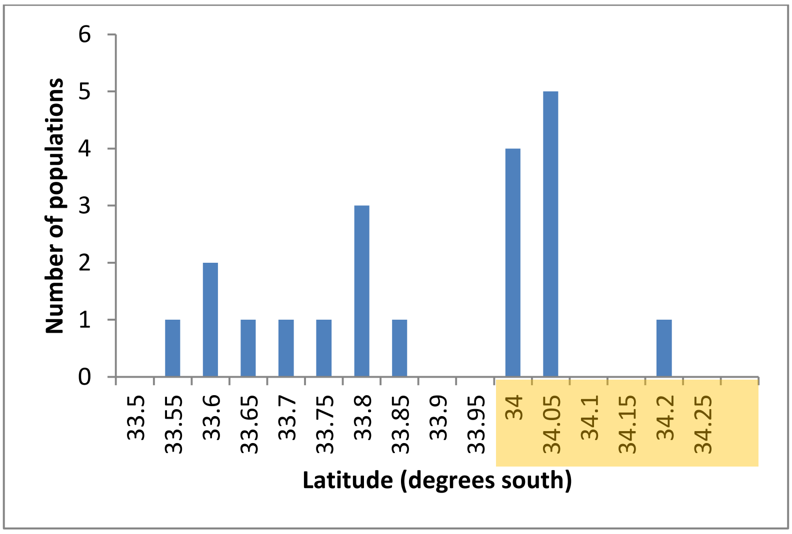

Figure 11. Frequency histogram of populations of *Pterostylis saxicola* from the Bionet Wildlife Atlas and state herbarium specimen database, classified according to latitude. The orange rectangle indicates the latitudinal extent of the study area.

distribution. The longitudinal distribution of records more closely approximates the typical Gaussian curve of many species distributions (Brown 1984). The study area is nested within the longitudinal distribution of the species and extensively overlaps the latitudinal one, despite the existence of only one dubious record from there.

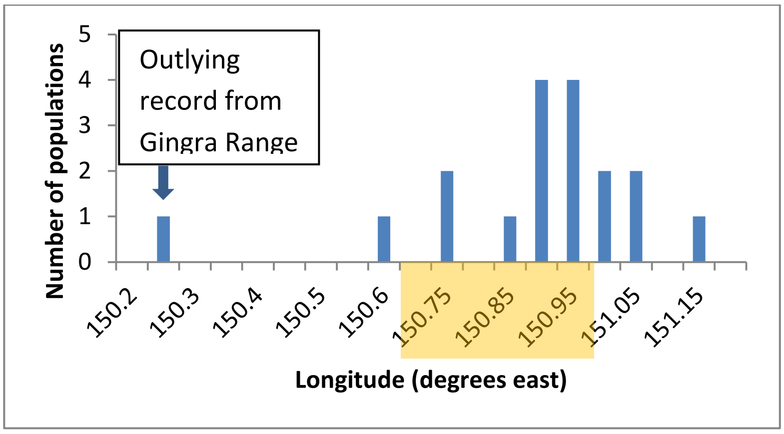

Figure 12. Frequency histogram of populations of *Pterostylis saxicola* from the Bionet Wildlife Atlas and state herbarium specimen database, classified according to longitude. The orange rectangle indicates the longitudinal extent of the study area.

If we accept the simplifying assumption that population frequencies are unbiased, then these frequency distributions can be interpreted as probability distributions, suggesting that *Pterostylis saxicola* is highly likely to be native to the study area.

4.6 ASSESSMENT OF SUITABLE HABITAT

Pterostylis saxicola has been recorded from outside the study area in four plant community types (PCTs 849, 1081, 1181 and 1395) that also occur in the study area (see sections 2.4, 3.3, 3.4, 4.4 above). These communities in the study area occur on suitable substrates (Hawkesbury Sandstone, Mittagong Formation, Ashfield Shale – see sections 3.3, 3.4), so the full extent of these plant community types should be regarded as potential ly suitable habitat for *P. saxicola* there.

Four classes of vegetation condition, were mapped for this project: “intact”, “thinned”, “scattered trees”, and “native grassland”. Having seen sites in the study area representing all of these categories I would describe them as follows:

- Intact: native vegetation structure, composition and regenerative capacity remain intact, sometimes with disturbance or thinning of the understorey and usually with weed incursion in the northern part of Greater Macarthur Growth Area;
- Thinned: the structure of native vegetation has been altered, with the canopy reduced in density and the understorey dominated by herbaceous plants;
- Scattered trees: Most canopy trees and most or all shrubs have been removed so that the structure, composition and regenerative capacity of the native vegetation have been significantly altered by land use;

- Native grassland: native vegetation has been altered so profoundly that only native grasses remain, usually intermixed with exotic species.

Although some of the patches of bushland in which *P. saxicola* has been recorded are smaller than one hectare, all but one record were reported in intact vegetation. The one exception is an extraordinary, unvouchered record of this species at the "Car Park growing through bitumen Simmos Beach Reserve, Macquarie Fields". A bitumen carpark is not a sustainable habitat for any native ground orchid but in this case a flat bitumen surface covered in a thin layer of soil might have functionally approximated a sandstone surface covered in a thin layer of humic sand for long enough for a seed to germinate, reach reproductive maturity and flower. Some species of terrestrial orchids, most notably some species of *Microtis*, can reasonably be described as weedy, readily colonising some anthropogenic habitats, but I would not include any species of *Pterostylis* in that category. I have seen some of the vegetatively multiplying species, such as *P. curta* and *P. nutans*, persisting at the margins of mown lawns but I have never seen any species of *Pterostylis* subgenus *Oligochaetochilus* growing in highly disturbed environments. *P. saxicola* has not been recorded from pastures that are largely or totally devoid of trees and shrubs, so vegetation classed as "scattered trees" and "native grassland" can be rejected as suitable habitat.

The modified eucalypt-dominated communities classed as "thinned" are the only disturbed environments that could arguably be classed as marginally suitable habitats for *Pterostylis saxicola*. An argument justifying the inclusion of thinned vegetation in an estimate of potentially suitable habitat is that such modified vegetation is capable of regenerating to the equivalent of intact condition, if the processes that caused its degradation cease to operate. Those processes include the selective culling of native plants. If thinned vegetation is managed so that regrowth of native plants is not suppressed and introduced weeds are actively removed, then suitable habitat for *P. saxicola* could be re-created from thinned vegetation. A good example of an area that has such a history and now provides suitable habitat for *P. saxicola* is Scheyville National Park, which was used for grazing and farming from the early 19th century to 1940, after which it was used as a military training base and later for a large migrants' hostel (NSW National Parks and Wildlife Service 2000). After 1972 the vegetation there was fortuitously allowed to regenerate spontaneously and much of it now has the character of residual, intact native vegetation and hosts arguably the most significant population of *P. saxicola* in the northern Cumberland Plain. If patches of thinned land that had previously supported PCTs 849, 1081, 1181 and 1395) in the study area were appropriately managed, then a similar outcome is likely to prevail there too.

However, eucalypt forests and woodlands have often been thinned in the study area to facilitate grazing by non-native herbivores: cattle, sheep and horses (see section 3.1). Grazing by stock is one of the threats listed in the threatened species profile of *P. saxicola* (NOEH 2018), because most terrestrial orchids, including *Pterostylis* are highly palatable. Duncan *et al.* (2005), in discussing threats to threatened terrestrial orchid species in Victoria, considered grazing of terrestrial orchids by introduced mammal species to be potentially “devastating”. Clearly, intact vegetation usually provides a much more suitable habitat for *P. saxicola* than similar but thinned vegetation. At issue is whether thinned, continually grazed vegetation provides any suitable habitat for the sustained existence of *P. saxicola* at all. Given that *P. saxicola* has not been reported from thinned vegetation (as distinct from highly fragmented remnants of intact vegetation), and that regeneration of thinned vegetation to intact condition would require active management if the land were embedded within a suburban context, I conclude that thinned vegetation does not presently constitute suitable habitat for the sustained existence of *P. saxicola*. It could, however, be regenerated to provide suitable habitat under sustained appropriate land management. Consequently, I have treated only intact patches of PCTs 849, 1081, 1181 and 1395 as suitable habitat for *P. saxicola*.

4.7 SPECIES POLYGONS

My species polygons for *Pterostylis saxicola* (figures 13 and 14) include all intact patches of PCTs 849, 1081, 1181 and 1395 in the Greater Macarthur and Wilton Growth Areas. They were prepared with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by Biosis Pty Ltd. A shape file for these polygons is held by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment.

My arguments justifying these polygons have been set out in sections 2.3, 2.4, 4.4, 4.5 and 4.6.

4.8 ESTIMATE OF AREA OF HABITAT

The areas estimated to represent suitable habitat for *Pterostylis saxicola* in figures 13 to 15 are as follows:

- Greater Macarthur Growth Area
    - Habitat mapped – 1,784.36 ha
    - Habitat impacted by development footprint – 46.51 ha
- Wilton Growth Area
    - Habitat mapped – 962.15 ha
    - Habitat impacted by development footprint – 38.92 ha

These estimates were calculated with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by Biosis Pty Ltd. My arguments justifying the polygons from which these estimates were calculated have been set out in sections 2.3, 2.4, 4.4, 4.5 and 4.6.

5. Information used in the assessment

My assessment was based on information obtained from a diversity of sources:

- Databases of observational and vouchered specimen records of *Pterostylis saxicola*:
    - National Herbarium of New South Wales specimen database;
    - Bionet Wildlfie Atlas;

- Interviews with collectors, observers, propagators and scientists of *P. saxicola* (see section 6, acknowledgements);
- Fieldwork at 19 sites (see Appendix 1):
    - Five sites at which *P. saxicola* had previously been collected;
    - 14 sites in or near the study area that had potentially suitable habitat;
- The scientific and scholarly literature (see section 7, references);
- Vegetation maps for the study area prepared by Biosis Pty Ltd, provided by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment;
- My personal knowledge and experience, gained from 47 years as a native orchid enthusiast and 40 years as a professional botanist.

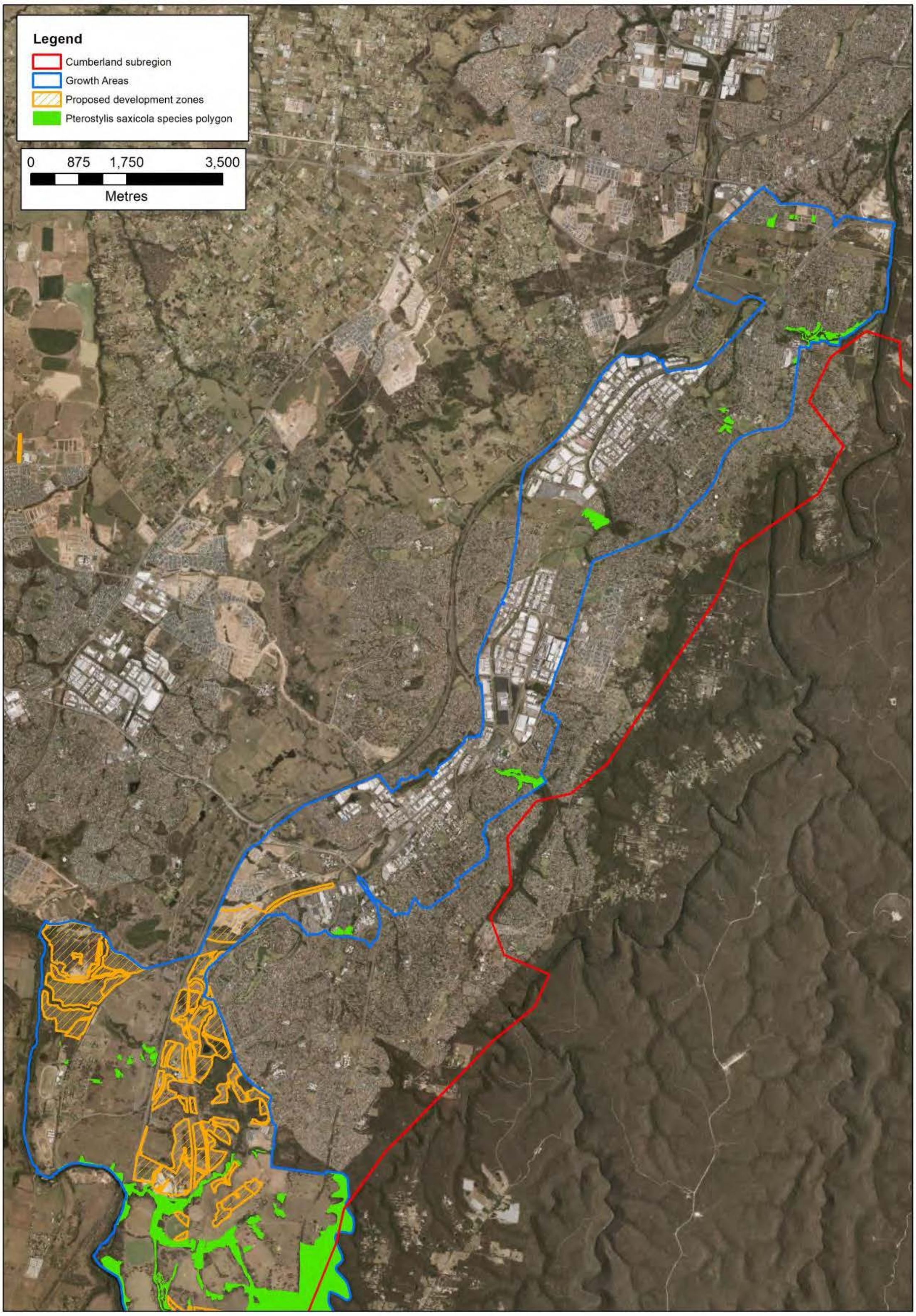

Figure 13. Species polygons for *Pterostylis saxicola* (green colouring) in the northern part of the Greater Macarthur Growth Area (outline in blue). The urban development footprint is marked with yellow cross-hatching.

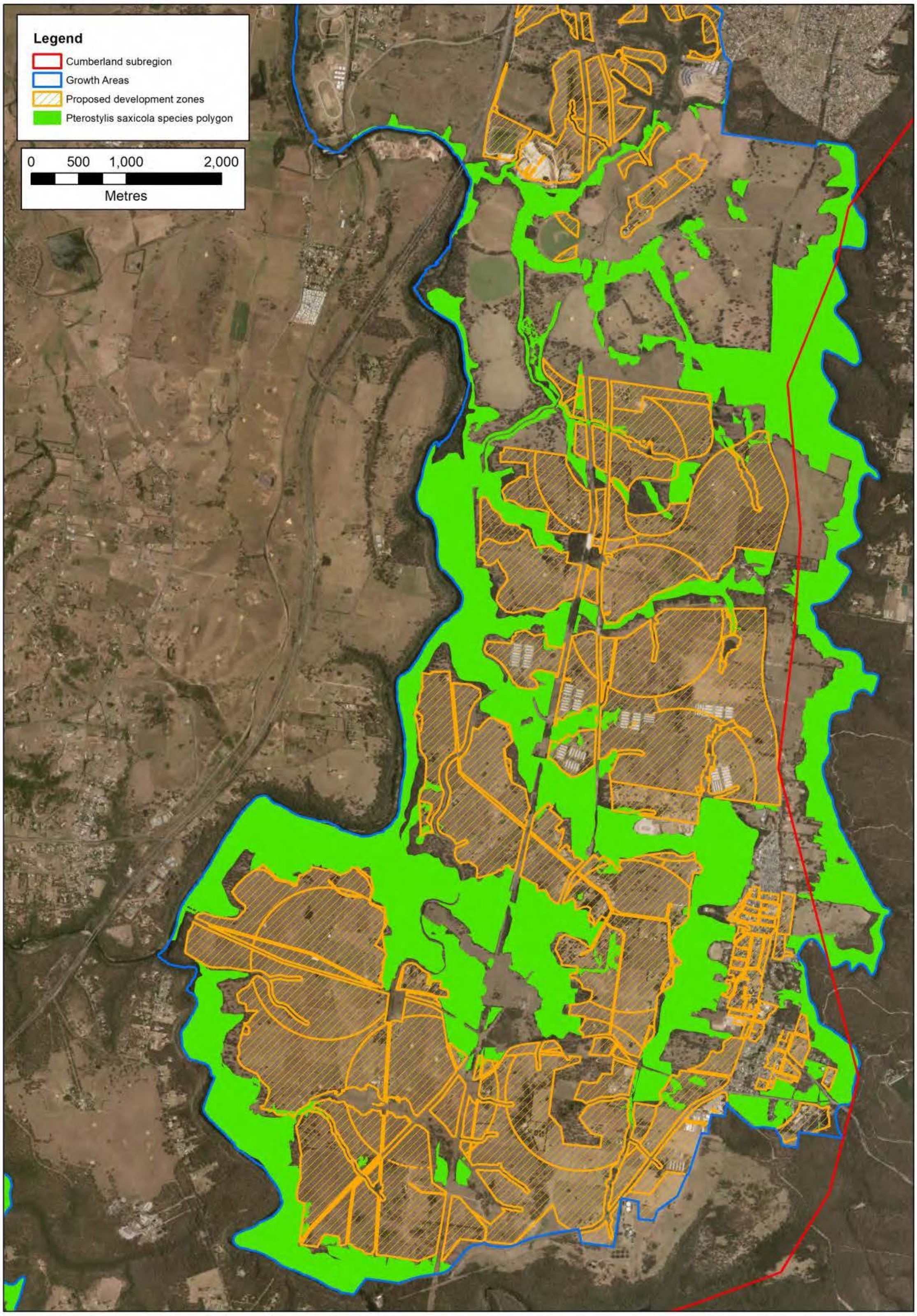

Figure 14. Species polygons for *Pterostylis saxicola* (green colouring) in the southern part of the Greater Macarthur Growth Area (outline in blue). The urban development footprint is marked with yellow cross-hatching.

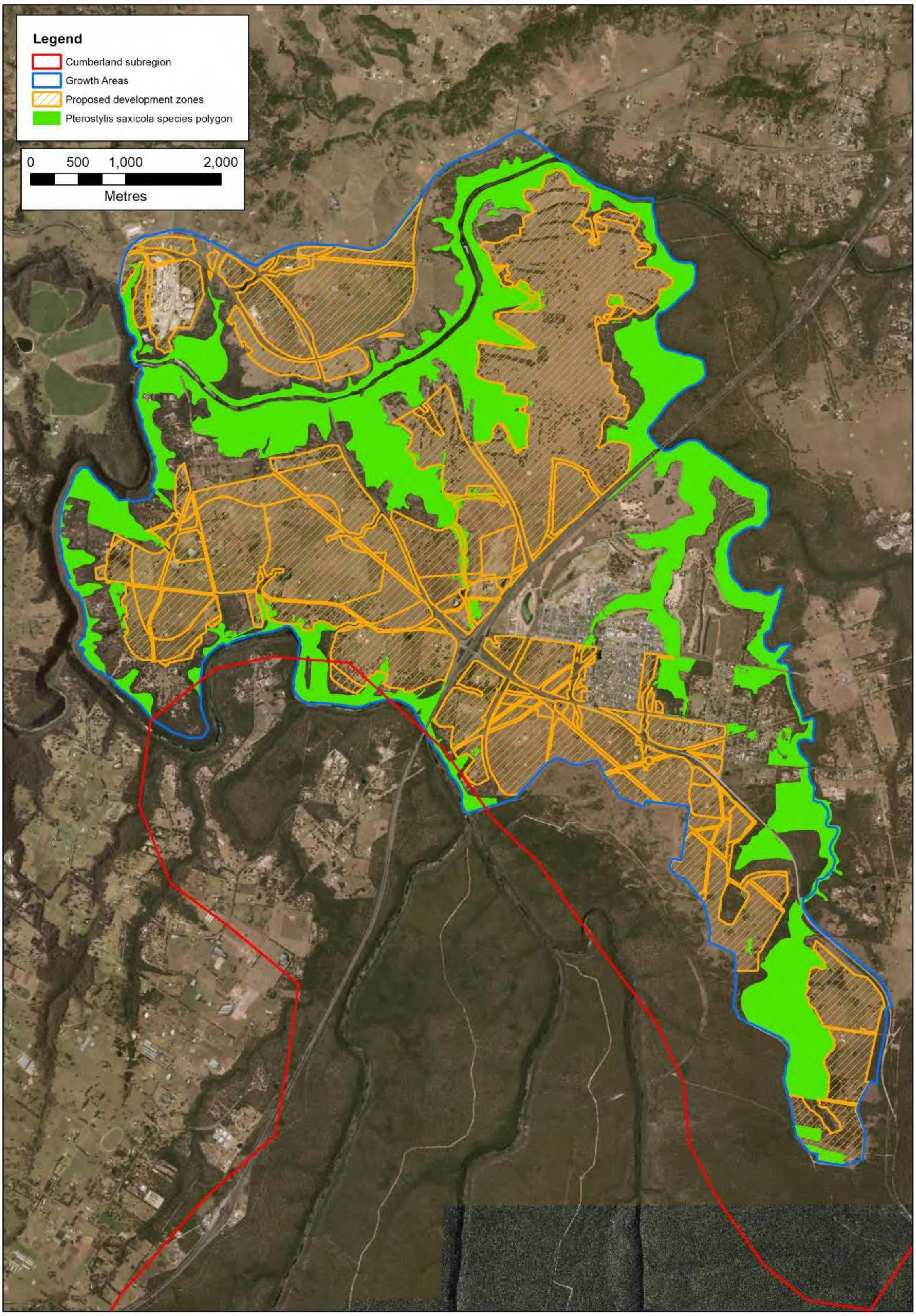

Figure 15. Species polygons for *Pterostylis saxicola* (green colouring) in the Wilton Growth Area (outline in blue). The urban development footprint is marked with yellow cross-hatching.

6. Acknowledgements

I am grateful to Andrew Orme, Teresa James, Karen Sommerville, Greg Steenbeeke, Wayne Cherry and David Keith, for happily being interviewed, and for generously sharing their knowledge about populations of *Pterostylis saxicola*. Wayne Cherry gave me permission to use his photograph of a flower of *Pterostylis saxicola* on the title page of this report. Darren James (DAJ Environmental), kindly assisted me in producing species polygons and area estimates using the ArcMap software package.

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8. Appendices

APPENDIX 1: Characterisation of habitat at selected sites

The tables on following pages record data that I collected at sites both within and outside the study area. Two of these sites (N13, N14) received "over the fence" assessments and were not characterised in detail. Each site that was characterised in detail was centred either on an arbitrarily selected plant of *Pterostylis saxicola* (sites numbered PS1, PS3) or at places where the focal species had previously been reported (sites PS2, PS4, PS5) or at an arbitrarily point in the case of sites examined as potential habitat in or near the growth areas (sites N1–N14). At each site the precise latitude and longitude, altitude, substrate, soil description, slope and aspect were also recorded. Also, at each site all woody plant species and a few species of herbaceous plants that could be reliably identified from vegetative characters were recorded within a radius of 30 metres. Attributes of sites at which *P. saxicola* had been found (sites PS1–PS5) were compared with comparable attributes of sites in or near the growth areas to assess whether any sites in the growth areas closely matched *P. saxicola* sites. Locations at which *Pterostylis saxicola* has been recorded by me and/or others have had their latitudes and longitudes transformed to the nearest 10 minutes.

Site	Location	Latitude	Longitude	Altitude	substrate
PS1	Old Schofield Trail, Scheyville National Park	33°40'S	150°50'E	70 m	Ashfield Shale
PS2	Simmos Beach Recreation Reserve, Macquarie Fields	34°00'S	150°50'E	45 m	Hawkesbury Sandstone
PS3	Simmos Beach Recreation Reserve, Macquarie Fields	34°00'S	150°50'E	43 m	Hawkesbury Sandstone
PS4	Boronia Rd Reserve, Peter Meadows Creek, Kentlyn	34°00'S	150°50'E	98 m	Hawkesbury Sandstone
PS5	Amberdale Reserve, Picnic Point	34°00'S	151°00'E	36 m	Hawkesbury Sandstone
N1	Smiths Creek, Leumeah	34°03'22.6"S	150°50'24.3"E	87 m	Hawkesbury Sandstone
N2	Douglas Park bridge, Nepean River	34°11'32.5"S	150°42'48.6"E	110 m	Hawkesbury Sandstone
N3	Allens Creek, Wilton site 1	34°12'36.7"S	150°41'15.4"E	157 m	Hawkesbury Sandstone
N4	Allens Creek, Wilton site 2	34°12'25.7"S	150°41'17.9"E	201 m	Hawkesbury Sandstone
N5	Allens Creek, Wilton site 3	34°12'25.2"S	150°41'23.5"E	140 m	Hawkesbury Sandstone
N6	Ouesdale Creek, Appin	34°11'30.1"S	150°46'53.5"E	215 m	Hawkesbury Sandstone
N7	Noorumba Reserve, Rosemeadow	34°06'49.3"S	150°47'27.2"E	139 m	Ashfield Shale
N8	Shingle Hill, site 1	34°12'26.8"S	150°38'50.5"E	145 m	Hawkesbury Sandstone
N9	Shingle Hill, site 2	34°12'26.8"S	150°38'50.5"E	144 m	Hawkesbury Sandstone
N10	Shingle Hill, site 3	34°12'35.3"S	150°38'54.1"E	160 m	Mittagong Formation
N11	Georges River, Appin site 1	34°12'27.4"S	150°47'50.9"E	268 m	Hawkesbury Sandstone
N12	Georges River, Appin site 2	34°12'18.4"S	150°47'50.5"E	260 m	Hawkesbury Sandstone
N13	Bicentennary Reserve, Minto	34°00'49.7"S	150°51'11.5"E	30 m	Ashfield Shale
N14	Bunbury Curran Reserve, Macquarie Fields	33°59'00.2"S	150°53'51.7"E	20 m	Hawkesbury Sandstone

Appendix 1a: Environmental data for sites visited as part of this study (continued on next page)

Site	soil description	slope	Aspect	Vegetation structure (canopy)	Vegetation structure (understory)
PS1	brown clay-loam	5°	S	Dry sclerophyll forest	moderately dense shrubby understory
PS2	brown sand	0°		Dry sclerophyll woodland	moderately dense shrubby understory
PS3	dark brown humus-rich sand	0-5°	N	Dry sclerophyll woodland	moderately dense shrubby understory
PS4	dark brown humus-rich sand	0-5°	N	Dry sclerophyll woodland	moderately dense shrubby understory, dense subcanopy
PS5	dark brown humus-rich sand	<5°	E	Dry sclerophyll woodland	moderately dense shrubby understory, dense subcanopy
N1	black sand	0°		Disturbed dry sclerophyll forest	moderately dense shrubby understory
N2	black sand	0-20°	SW	Dry sclerophyll forest	sparse shrubby understory
N3	brown sandy loam	0°		Heavily grazed dry sclerophyll forest	no shrub layer
N4	brown sandy loam	0°		Heavily grazed dry sclerophyll forest	mosaic of shrubby thickets and clear ground
N5	pale grey-brown sand	5-30°	SE	Dry sclerophyll forest	moderately dense shrubby understory
N6	brown sandy loam	5-15°	SSW	Dry sclerophyll forest	mosaic of dense to moderately dense shrubby thickets
N7	red-brown clay	0°		Dry sclerophyll forest	moderately dense shrubby understory
N8	dark brown humus-rich sand	<5°	N	Dry sclerophyll woodland	sparse to dense shrubby understory
N9	dark brown humus-rich sand	<5°	W	Dry sclerophyll woodland	sparse to moderately dense shrubby understory
N10	brown loam	<5°	N	Dry sclerophyll forest	dense shrubby understory
N11	dark brown humus-rich sand	0°		Dry sclerophyll forest	sparse to moderately dense shrubby understory
N12	dark brown humus-rich sand	0°		Dry sclerophyll forest	sparse to moderately dense shrubby understory
N13					
N14					

Appendix 1a (continued): Environmental data for sites visited as part of this study

Sites >

Associated species	PS1	PS2	PS3	PS4	PS5	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Acacia binervata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Acacia binervia	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Acacia implexa	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia linifolia	0	1	1	0	1	0	0	0	0	0	0	0	1	1	0	1	1
Acacia mearnsii	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Acacia suaveolens	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Acacia terminalis	0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1
Acacia ulicifolia	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0
Acrotriche divaricata	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0
Actinotus helianthi	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	0	0	0	1	1	0	1	0	1	1	1	0	1	1	1	1	1
Allocasuarina torulosa	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Angophora bakeri	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Angophora costata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Astroloma pinifolium	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Astrotricha latifolia	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0
Backhousia myrtifolia	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Banksia serrata	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Banksia spinulosa	0	1	1	1	1	0	1	0	1	0	0	0	1	1	0	1	1
Beyeria viscosa	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Billardiera scandens	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Bossiaea obcordata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Brachyloma daphnoides	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b: Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	PS1	PS2	PS3	PS4	PS5	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Breynia oblongifolia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bursaria spinosa	1	0	0	0	0	1	1	0	0	1	0	1	0	1	1	0	0
Ceratopetalum gummiferum	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1
Correa reflexa	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0
Corymbia gummifera	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1
Crowea exalata	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Cryptandra spinescens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Dampiera stricta	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Dampiera purpurea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Daviesia corymbosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Daviesia ulicifolia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dillwynia acicularis	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Dillwynia sieberi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea triquetra	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Elaeocarpus reticulatus	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Eremophila debilis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriostemon australasius	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Eucalyptus crebra	1	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0
Eucalyptus fibrosa	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Eucalyptus globoidea	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Eucalyptus moluccana	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Eucalyptus paniculata	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Eucalyptus pilularis	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
Eucalyptus piperita	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	PS1	PS2	PS3	PS4	PS5	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Eucalyptus punctata	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1
Eucalyptus sclerophylla	0	1	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1
Eucalyptus sieberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Eucalyptus sparsifolia	0	1	0	0	0	0	1	1	1	1	0	0	0	1	1	0	1
Exocarpos cupressiformis	1	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0
Exocarpos strictus	0	0	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1
Gompholobium grandiflorum	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goodenia hederacea	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Grevillea arenaria	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Grevillea diffusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Grevillea mucronulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Grevillea sericea	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Grevillea sphacelata	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea laevipes	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Hakea sericea	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Hardenbergia violacea	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hibbertia aspera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hovea linearis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hovea purpurea	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Isopogon anemonifolius	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Jacksonia scoparia	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Kunzea ambigua	0	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	0
Lambertia formosa	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Lasiopetalum ferrugineum subsp. *cordatum*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	PS1	PS2	PS3	PS4	PS5	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Lasiopetalum ferrugineum subsp. *ferrugineum*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Leptospermum parvifolium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptospermum polygalifolium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Leptospermum trinervium	0	1	1	1	1	0	1	0	0	1	0	0	1	1	1	1	1
Leucopogon ericoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Leucopogon juniperinus	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Leucopogon virgatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Lissanthe strigosa	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Lomandra longifolia	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	1	0
Lomandra obliqua	0	1	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Lomatia silaifolia	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Macrozamia spiralis	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca decora	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Melaleuca linearifolia	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0
Melaleuca nodosa	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Monotoca scoparia	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Myrsine variabilis	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Notelaea longifolia	0	0	0	0	1	1	1	0	1	1	0	0	1	1	1	0	0
Olearia viscidula	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ozothamnus diosmifolius	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Patersonia glabrata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Persoonia lanceolata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Persoonia levis	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Persoonia linearis	0	0	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	PS1	PS2	PS3	PS4	PS5	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Persoonia pinifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Petrophile sessilis	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Pimelea linifolia	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pittosporum revolutum	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pittosporum undulatum	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
Platysace linearifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Podolobium ilicifolium	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	0
Polyscias sambucifolia	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Pteridium esculentum	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Ricinocarpos pinifolius	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Stenocarpus salignus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Stylidium laricifolium	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Stypandra glauca	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Styphelia laeta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Syncarpia glomulifera	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Westringia longifolia	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Xanthorrhoea concava	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea media	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1
Xanthosia pilosa	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Xylomelum pyriforme	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Zieria compacta	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Zieria cytisoides	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study

APPENDIX 2: PETER WESTON'S CURRICULUM VITAE

Personal details

Name: Peter Henry Weston.

Address: 18 Lyle Avenue, Lindfield, New South Wales 2070, Australia.

Date and place of birth: 22 October 1956, Lower Hutt, New Zealand.

Nationality: Australian.

Academic Qualifications

i) **B.Sc.** (first class honours; equal first in order of merit) School of Biological Sciences, University of Sydney; 1975-78, conferred 7 April 1979.
Thesis title: "The evolution and classification of *Boronia* Sm."

ii) **Ph.D.**, School of Biological Sciences, University of Sydney, 1979-83; conferred 18 May 1985.
Thesis title: "Systematics and biogeography of the Persooniinae (Proteaceae)".

Awards, Fellowships and Scholarships

2014	Nancy Burbidge Medal (awarded by the Australasian Systematic Botany Society to a person who has made a longstanding and significant contribution to Australasian systematic botany. It is the foremost award that can be conferred by ASBS).
2014	Australian Biological Resources Study-sponsored Winston Churchill Fellowship for an established career researcher in taxonomy.
2009	Grady L. Webster Structural Botany Publication Award for 2008 and 2009 from the Botanical Society of America. The BSA component of the award (it is awarded in alternate years by the BSA and the American Society of Plant Taxonomists) recognizes the most outstanding paper published in the *American Journal of Botany* in the field of structural and developmental botany (i.e., anatomy and morphology) over a two-year period. It was awarded to Gregory J. Jordan, Peter H. Weston, Raymond J. Carpenter, Rebecca A. Dillon and Timothy J. Brodribb for: "The evolutionary relations of sunken, covered, and encrypted stomata to dry habitats in Proteaceae," American Journal of Botany, Volume 95, Issue 5; May 2008.
2006	Carrick Award for Australian University Teaching from the Australian Learning and Teaching Council (one of five members of a teaching team from the University of New England cited for Outstanding Contributions to Student Learning).
1992-93	Posting to Royal Botanic Gardens, Kew, as Australian Botanical Liaison Officer.

1982	Charles Gilbert Heydon Travelling Fellowship for the biological sciences (not taken up).
1980-82	University of Sydney Postgraduate Scholarship.
1979-82	Commonwealth Postgraduate Award.
1977	G.S. Caird Scholarship for Third Year Botany, University of Sydney.
1976	Slade Prize for Practical Plant Biology, University of Sydney.

Employment

Present Position: Honorary Research Associate, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney and independent botanical consultant.

Previous positions held:
2008-2016 Senior Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

2000-2008 Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1994-2000 Senior Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1989-1994 Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1982-1989 Scientific Officer, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1979-82 Part-time demonstrator, School of Biological Sciences, University of Sydney.

Adjunct and visiting university appointments

2013-	Adjunct Associate Professor, La Trobe University.
2011-	Adjunct Associate Professor, University of New South Wales.
2006	Visiting Lecturer, Rhodes University, Grahamstown, South Africa.
2004-2009	Adjunct Associate Professor, University of New England.
2000-2004	Adjunct Senior Lecturer, University of New England.

Administrative/management experience

2009	Acting Manager Plant Diversity
2002-2003	Member, Plant Diversity Research Program Leaders Committee
1998-99	Systematics Liaison Officer
1997-98	Member RBGS Market testing working party

1997 Member, RBGS advisory committee for restructuring senior management

1990-91 Systematics Co-ordinator

1996-98 Member, RBGS Joint Consultative Committee

Membership of Learned Societies

1996- Society of Australian Systematic Biologists

1984- Willi Hennig Society (Elected Fellow, 1992-, Council member, 1998-2000)

1979- Society of Systematic Biologists (member, Editorial Board 1993-95)

1978- Australasian Systematic Botany Society (formerly Australian Systematic Botany Society: President, 2009-2012, Vice President, 2008-2009, Chairman, Hansjörg Eichler Research Fund Committee, 1998-2002, Council member, 1996-2002)

Membership of External Committees

2015- Financial Grants Standing Committee (formerly the Grants Policy Standing Committee) of the Australasian Systematic Botany Society

2012-2013 Conference Organising Committee of *Systematics Without Borders*, a joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, University of Sydney (Chairman)

2011- Editorial Board, *Phytotaxa*

2008-2009 Corresponding Member, Editorial Advisory Committee, *Australian Systematic Botany*

2006-2014 Ira Butler Memorial Trophy Committee (a joint committee of the Australasian Native Orchid Society and the Orchid Society of New South Wales) (Chairman)

2004- Editorial Advisory Board, *Kew Bulletin*

2001-2006 Panel of Judges, Eureka Prize for Biodiversity Research

2000-2012 Bushland Management Advisory Committee, Lane Cove Council (Chairman, 2008-2010)

1999-2004 Editorial Advisory Committee, *Australian Systematic Botany*

Spoken presentations at conferences (not including presentations delivered by others)

2015 Building Our Botanical Capital, annual conference of the Australasian Systematic Botany Society: “A database of variation in floral characters in the Proteaceae, and implications for key questions in floral evolution”.

2014 Next Generation Systematics, annual conference of the Australasian Systematic Botany Society: Nancy Burbidge Memorial Lecture: “Problems and progress in plant systematics since Nancy Burbidge”

2013 Genetics Society of Australasia conference, Sydney *Genetics in the Harbour City*: “Molecular phylogeny of the subtribe

Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2013 Joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, Sydney, *Systematics Without Borders*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2012 Australasian Systematic Botany Society conference, Perth, *Local knowledge, global delivery*: “Contested, Uncontested and Potentially Controversial Taxonomic Changes in the Proteaceae: How Do They Differ?”

2011 37th annual conference of the South African Association of Botanists, *Plants in a Changing World* and 9th conference of the South African Society of Systematic Biologists, *Biodiversity Matters*; plenary address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

2011 XVIII International Botanical Congress, Melbourne: “Floral evolution in animal-pollinated Australian angiosperm clades: patterns and potential explanations”.

2010 VI Southern Connection Congress, Bariloche: “Cladistic biogeography, molecular dating, fossils and the Proteaceae”

2010 VI Southern Connection Congress, Bariloche: “Diversification of the Proteaceae in Mediterranean hotspots of the Southern Hemisphere and in tropical rainforests”

2010 Australian Systematic Botany Society conference *Systematic Botany Across the Ditch: Links Between Australia and New Zealand*; Keynote address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

1999 XVI International Botanical Congress, Saint Louis: “Historical biogeography of Proteaceae”.

1997 II Southern Connection Congress, Valdivia: “Cladistic biogeography of a key woody group: Proteaceae”.

1997 First Biennial International Conference of the Systematic Association, Oxford: “Rolf Sattler’s Plant Morphology and Cladistic Analysis”.

1996 *An International Symposium on the Biology of Proteaceae*, Melbourne: “ITS squence variation in the Proteaceae and what it tells us about phylogeny”.

1993 Joint conference of The Systematics Associations and The Linnean Society on *Models in Phylogeny Reconstruction*, London: “Direct methods for polarising character transformation series”.

1990 IXth meeting of the Willi Hennig Society, Canberra: “Transoceanic cladistic patterns in the Proteaceae”.

2003 The Third International Conference on *the Comparative Biology of the Monocotyledons*, Ontario: “Co-evolution of *Chiloglottis* (Orchidaceae) and its Thynnine wasp pollinators”.

2005 XVII International Botanical Congress, Vienna: “Food is good but sex is better: the evolution of deceptive pollination in the tribe Diurideae (Orchidaceae)”.
2006 Australian Systematic Botany Society conference, Cairns, *Plant Diversity in the Tropics*: “A new suprageneric classification of the Proteaceae”.
2007 5th Southern Connection Congress, Adelaide: “‘I’m not dead yet’ – Gondwana (the Proteaceae are at least partially congruent with Gondwanic fragmentation)”.
1989 Australian Systematic Botany Society symposium, on *Gondwanan Elements in the Australian Flora*, Sydney: “Transpacific cladistic patterns in the Proteaceae and Elaeocarpaceae”.
1988 Symposium on *Panbiogeography of New Zealand*, Wellington: “Problems with the statistical testing of panbiogeographic hypotheses”.
1985 Australian Flora Foundation Symposium on *Waratahs*, Canberra: “Drifting waratahs or continents?”
1984 Australian Systematic Botany Society symposium on *Cladistics, Systematics and Phylogeny*, Canberra: “A reappraisal of Nelson's direct method of character analysis”.

Refereeing manuscripts, grant applications, reports and examining postgraduate theses (last five years)

2016: *Australian Systematic Botany*; *Botanical Journal of the Linnean Society*, *National Research Foundation* (South Africa).
2015: *American Journal of Botany*; Australian Research Council (4); *Australian Systematic Botany*; *Muelleria*; *Nuytsia*; *Phytotaxa*; *PLOS One*; *Telopea* (6).
2014: Australian Research Council (3); *Australian Systematic Botany* (2); *Cunninghamia*; *Journal of Biogeography* (2); *Muelleria*; National Research Foundation (South Africa); *Orchadian*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Plant Systematics and Evolution*; *Telopea* (3).
2013: Australian Research Council; *Australian Systematic Botany*; *Biology Letters*; *Cladistics*; *Diversity and Distributions*; *Evolution*; *Journal of Biogeography*; *New Zealand Journal of Botany*; *Taxon*; *Telopea*.
2012: Australian Research Council (3); *Australian Systematic Botany*; “Darwin, Then and Now” (chapter of book published by University of Chicago Press); *Diversity and Distributions*; *Journal of Biogeography*; National Research Foundation (South Africa); *Phytokeys*.

Research

My research has been in the theoretical and practical aspects of systematic botany, with emphasis on the theory and practice of phylogenetic analysis, and the broader uses to which phylogenetic knowledge may be applied. I have phylogenetically analysed groups in the plant families Proteaceae, Fabaceae, Orchidaceae, Rutaceae, Winteraceae and Lauraceae, contributed to more general analyses of angiosperm phylogeny, and used the results of these analyses to improve biological classification and to test theories of historical biogeography, trait evolution, co-evolution and adaptation. I have earned an international reputation for my contributions to both theoretical and empirical developments in this field.

Herbarium curation and collections

My curatorial responsibilities at the National Herbarium of New South Wales have included the families Rutaceae (1982-1998), Proteaceae (1982-2016), Orchidaceae (1986-2016) and Fabaceae subfamily Faboideae (1986-2016). I have collected plant specimens (mostly angiosperms) in Australia, England, New Zealand, New Caledonia, Chile, South Africa, and Argentina, mostly for the herbarium and living collections of the Royal Botanic Gardens and Domain Trust, Sydney. Duplicates of my collections have been distributed to over 20 herbaria in 8 different countries.

Teaching

I have been actively involved in the preparation and teaching of four third year undergraduate courses in biosystematics:
Western Sydney University (2015-2017): “Principles of Evolution” (unit 300980), “Botany” (unit 300836).
University of New South Wales (2010-2016): “Assembling the Tree of Life” (BIOS3221)
University of New England (2000-2010): Biosystematics (Biosyst 301, Biosyst 302, Evol 301/501).
Botany Department, Rhodes University, Grahamstown, South Africa (February-March 2006): “Plant Biodiversity” course in collaboration with Associate Professor Nigel Barker.

I am currently co-supervising one postgraduate student:
Nanette Thomas (Ph.D., University of New England): Systematics of *Tasmannia* informs Biogeography of Winteraceae.

Postgraduate and honours students I have previously co-supervised include:
Margaret Stimpson (Ph.D., University of New England): Systematics, evolution and ecology of the *Banksia spinulosa* complex (graduated 2017).
Melita Milner (Ph.D., Australian National University): Phylogeography of *Lomatia and Telopea* (Proteaceae) in south eastern Australia (graduated 2015).
Samanta Oon (B.Sc. Honours, University of New South Wales): *Lomatia* likes it both ways: rampant bidirectional introgression of chloroplast genomes between two morphologically distinct species of Lomatia (Proteaceae) (graduated 2015).
Zoe Reynolds (B.Sc. Honours, Australian National University): Phylogenetic, taxonomic and functional turnover in Proteaceae assemblages (graduated 2013).
Emma McIntosh (B.Sc. Honours, University of Sydney): Hybridization and introgression between *Lomatia myricoides* and *L. silaifolia* (Proteaceae) (graduated 2011).
Margaret Stimpson (M.Sc.Stud., University of New England): Review of the *Banksia spinulosa* species complex (Proteaceae) (graduated 2011).

James Indsto (M.Sc., University of Wollongong): Pollination Ecology and Molecular Systematics of *Diuris* (Orchidaceae) of the Sydney Region (graduated 2010).
Nanette Thomas (Grad.Dip.Sci., University of New England): Phylogenetic analysis of Winteraceae (graduated 2009).
David McKenna (Ph.D., University of Wollongong: Demographic and ecological indicators for rarity in obligate-seeding *Persoonia* (Proteaceae) shrubs of the Sydney region, graduated 2007).
Paul Rymer (Ph.D., University of Wollongong: Plant rarity: species distributional patterns, population genetics, pollination biology and seed dispersal in *Persoonia* (Proteaceae), graduated, 2006).
Georgina Lloyd (B.Sc. Honours, University of Sydney: Pseudocopulation in two species of *Cryptostylis*: Implications for maintaining species integrity, graduated 2004)
Andrew Perkins (Ph.D., University of Sydney: Phylogenetic Systematics of the Genus *Calochilus* (Orchidaceae), graduated 2002).
Jim Mant (Ph.D., Australian National University: Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae), graduated 2002).
Siegfried Krauss (Ph.D., University of Wollongong: Systematic pattern and evolutionary process in the complex species *Persoonia mollis* (Proteaceae), graduated 1995).

I have examined 14 honours and postgraduate theses:
Australian National University (Ph.D., 2003, 2007, 2008)
University of Melbourne (Ph.D., 1995, 2011)
University of Newcastle (M.Phil., 2003)
University of Queensland (Ph.D., 2003)
University of Sydney (Ph.D., 1991, 1994, 1997, 2009)
University of Wollongong (B.Sc. Hons., 2001, 2003)
Victoria University (Ph.D., 2007)

Competitive Research and Infrastructure Grants

Peakall, R., Pichersky, E., Linde, C., Weston, P.H. (2015-2019) The biosynthesis and evolution of novel semiochemicals in orchids. $644,800, Australian Research Council Discovery Grant DP150102762.

Hoebee, S.E., Weston, P.H., & Edwards, T.J. (2015-18) Evolution in action or the demise of iconic Australian flora? $217,700, Australian Research Council Discovery Grant DP150100508.

He, T., Lamont, B., Weston, P.H., & Cowling, R. (2012-2014) Origin and evolution of plant functional traits in relation to fire. $310,000, Australian Research Council Discovery Grant DP120103389.

Rossetto, M., Crayn, D.M. & Weston, P.H. (2008-2010) Integrating molecular and morphological data for generic delimitation and species identification in Lauraceae. $73,333, Australian Biological Resources Study.

Cantrill, D., Murphy, D. & Weston, P.H. (2008-10) Understanding the origins of the Australian flora by integrating molecular phylogenies and fossil data in the Proteaceae. $88,900, Hermon Slade Foundation.

Rossetto, M. & Weston, P.H. (2007-2009) Speciation in the Australian flora: testing explanatory hypotheses in waratahs and their allies. $78,000, Hermon Slade Foundation.

Considine, J.A., Krauss, S.L. & Weston, P.H. (2002-2004) A biological basis for the efficient breeding of native plants for export markets: a case study with the Australian Goodeniaceae. $168,126, ARC – Linkage (Krauss and Weston representing industry partners)

Whelan, R.J., Ayre, D.J., England, P., Auld, T.D., & Weston, P.H. (2000-2002) Ecology and genetics of fire-sensitive *Persoonia* species: threatened species recovery and management. $126,480, Australian Research Council (ARC– SPIRT, Auld and Weston representing industry partners).

Trent, R. *et al.* (2000) Enhancement of DNA sequencing equipment for the Sydney University and Prince Alfred Molecular Analysis Centre. $600,000, Australian Research Council (ARC-REIF).

Weston, P.H. (1999-2001) Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae). $75,000, Hermon Slade Foundation.

Weston, P.H. (1997-2000) Taxonomic revision of *Dillwynia* (Fabaceae: Faboideae: Mirbelieae). $62,836, Australian Biological Resources Study.

Weston, P.H. & Thomson, J.A. (1993) A molecular approach to the evolution and biogeography of the Queensland tree waratahs. $4000, Queensland Wet Tropics Management Authority

Weston, P.H. & Thomson, J.A. (1991-92) A molecular approach to the evolution and biogeography of the waratahs. $80,100, Australian Research Council (large grants scheme).

Weston, P.H. (1984) Establishment of a data bank for eucalypt specimens held by NSW. $20,000, Australian Biological Resources Study.

Scientific Publications

[the numbers in square brackets following a reference indicates: 1. the journal's 2016-17 impact factor according to ISI Web of Knowledge, then the number of literature citations for the paper found by Google Scholar, as of 23 May 2018]

H-index = 32, total number of citations = 3831 as of 24 May 2018

1. Craw, R.C. & **Weston, P.H.** (1984) Panbiogeography: a progressive research program? *Systematic Zoology* 33: 1-13. [8.917, 90]

2. **Weston, P.H.**, Carolin, R.C., & Armstrong, J.A. (1984) A cladistic analysis of *Boronia* Sm. and *Boronella* Baill. (Rutaceae). *Australian Journal of Botany* 32: 187-203. [0.793, 48]

3. Morrison, D.A. & **Weston, P.H.** (1985) Analysis of morphological variation in a field sample of *Caladenia catenata* (Smith) Druce (Orchidaceae). *Australian Journal of Botany* 33: 185-195. [0.793, 11]

4. Crisp, M.D. & **Weston, P.H.** (1987a) Waratahs - how many species? Pp. 3-15, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 13]

5. Crisp, M.D. & **Weston, P.H.** (1987b) Cladistics and legume systematics, with an analysis of the Bossiaeeae, Brongniartieae and Mirbelieae. Pp. 65-130, in C.H. Stirton (ed.) *Advances in Legume Systematics Part 3* (Royal Botanic Gardens: Kew). [-, 126]

6. **Weston, P.H.** (1987) *Persoonia* (Proteaceae). Pp. 348-350, in N.G. Marchant *et al*. (eds.) *Flora of the Perth Region* (Western Australian Herbarium: Perth). [-, 0]

7. **Weston, P.H.** & Crisp, M.D. (1987) Evolution and biogeography of the Waratahs. Pp. 17-34, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 14]

8. **Weston, P.H.**, Wilson, P.G., & Hill, K.D. (1987) Identification of *Cannabis*. *Department of Agriculture New South Wales Miscellaneous Bulletin* 25: 148-150. [-, 0]

9. **Weston, P.H.** (1988a) A revision of *Hicksbeachia* (Proteaceae). *Telopea* 3: 231-239. [0.6, 3]

10. **Weston, P.H.** (1988b) Indirect and direct methods in systematics. Pp. 27-56, in C.J. Humphries (ed.) *Ontogeny and Systematics* (Columbia Univ. Press: New York). [-, 75]

11. **Weston, P.H.** (1989) Problems with the statistical testing of panbiogeographic hypotheses. *New Zealand Journal of Zoology* 16: 511. [0.811, 6]

12. **Weston, P.H.** (1990) Notes on *Boronia* (Rutaceae) in New South Wales, including descriptions of three new species. *Telopea* 4: 121-128. [0.6, 6]

13. **Weston, P.H.** & Johnson, L.A.S. (1991) Taxonomic changes in *Persoonia* (Proteaceae) in New South Wales. *Telopea* 4: 269-306. [0.6, 9]

14. Crisp, M.D. & **Weston, P.H.** (1991) *Almaleea*, a new genus of Fabaceae from south-eastern Australia. *Telopea* 4: 307-311. [0.6, 10]

15. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae), a new genus from New Guinea and eastern Australia. *Telopea* 4: 497-507. [0.6, 12]

16. **Weston, P.H.** (1991) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium*, *Pultenaea* and *Dillwynia* (Fabaceae). Pp. 2-19, 452-455, 456-461, 481-497, 499-504, in G. Harden (ed.) *Flora of New South Wales* vol. 2 (New South Wales Univ. Press: Sydney). [-, 0]

17. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae) and *Almaleea* (Fabaceae). Pp. 29-30, 497-498, in G. Harden (ed.) *op. cit.* [-, 0]

18. **Weston, P.H.** & Porteners, M.F. (1991) *Boronia*, *Eriostemon* and *Phebalium* (Rutaceae). Pp. 227-236, 250-254, 255-263, in G. Harden (ed.) *op. cit.* [-, 0]

19. Porteners, M.F. & **Weston, P.H.** (1991) *Correa* and *Crowea* (Rutaceae). Pp. 247-249, 254-255, in G. Harden (ed.) *op. cit.* [-, 0]

20. Crisp, M.D. & **Weston, P.H.** (1991) *Telopea*. Pp. 30-31, in G. Harden (ed.) *op. cit.* [0.6, 0]

21. Gross, C.L. & **Weston, P.H.** (1992) *Macadamia jansenii* (Proteaceae), a new species from central Queensland. *Australian Systematic Botany* 5: 725-28. [0.75, 7]

22. Crisp, M.D. & **Weston, P.H.** (1993) Geographic and ontogenetic variation in morphology of Australian waratahs (*Telopea*: Proteaceae). *Systematic Biology* 42: 49-76. [14.387, 74]

23. Gilmore, S., **Weston, P.H.**, & Thomson, J.A. (1993) A simple, rapid, inexpensive and widely applicable technique for purifying plant DNA. *Australian Systematic Botany* 6: 139-148. [0.75, 38]

24. **Weston, P.H.** (1993) Key to genera, *Cyrtostylis*, *Cryptostylis*, *Zeuxine*, *Cheirostylis*, *Pseudovanilla*, *Erythrorchis*, *Epipogium*, *Gastrodia*, *Oberonia*, *Liparis*, *Dendrobium*, *Calanthe*, *Phaius*, *Geodorum*, *Dipodium*, *Cymbidium*, *Sarcochilus*, *Rhinerrhiza*, *Peristeranthus*, *Papillilabium*, *Schistotylus*, *Plectorrhiza*, *Taeniophyllum* (Orchidaceae). Pp. 134-138, 218-219, 219-221, 221-233, 236-247, in G. Harden (ed.) *Flora of New South Wales* vol. 4 (New South Wales Univ. Press: Sydney). [-, 0]

25. **Weston, P.H.** & Hill, K.D. (1993) *Bulbophyllum* (Orchidaceae). Pp. 233-236, in G. Harden (ed.) *op. cit.* [-, 0]

26. **Weston, P.H.** & Crisp, M.D. (1994) Cladistic biogeography of Waratahs and their allies (Embothrieae: Proteaceae) across the Pacific. *Australian Systematic Botany* 7: 225-249. [0.75, 72]

27. **Weston, P.H.** (1994) The Western Australian species of subtribe Persooniinae (Proteaceae: Persoonioideae: Persoonieae). *Telopea* 6: 51-165. [0.6, 17]

28. **Weston, P.H.** & Johnson, L.A.S. (1994) Three new species of *Persoonia* (Proteaceae) from Queensland. *Telopea* 6: 31-37. [0.6, 1]

29. **Weston, P.H.** (1994) Methods for rooting cladistic trees. Pp. 125-155, in D.J. Siebert, R.W. Scotland and D.M. Williams (eds.) *Models in Phylogeny Reconstruction* (Oxford Univ. Press: Oxford). [-, 36]

30. Crisp, M.D. & **Weston, P.H.** (1995) Mirbelieae. Pp. 245-282, in J.J. Doyle and M.D. Crisp (eds.) *Advances in Legume Systematics Part 7: Phylogeny* (Royal Botanic Gardens: Kew). [-, 36]

31. Crisp, M.D. & **Weston, P.H.** (1995) Subtribe Embothriinae (Proteaceae). *Flora of Australia* 16: 382-390. [-, 0]

32. Crisp, M.D., Linder, H.P. & **Weston, P.H.** (1995) Cladistic biogeography of plants in Australia and New Guinea: congruent pattern reveals two endemic tropical tracks. *Systematic Biology* 44: 457-473. [8.917, 119]

33. Thomson, J.A., **Weston, P.H.** & Tan, M.K. (1995) A molecular approach to tracing the major lineages in *Pteridium*. Pp. 21-28, in R.T. Smith and J.A. Taylor (eds.) *Bracken: an Environmental Issue* (University of Leeds: Leeds). [-, 13]

34. **Weston, P.H.** (1995) Key to the genera of Proteaceae in Australia, Subfamily Persoonioideae, Subfamily Bellendenoideae, Subtribe Gevuininae, Subtribe Hicksbeachiinae. *Flora of Australia* 16: 41-46, 47-125, 125-127, 409-410. [-, 0]

35. Bernhardt, P. & **Weston, P.H.** (1996) The pollination ecology of *Persoonia* (Proteaceae) in eastern Australia. *Telopea* 6: 775-804. [0.6, 46]

36. **Weston, P.H.** & Crisp, M.D. (1996) Trans-Pacific biogeographic patterns in the Proteaceae. Pp. 215-232, in A. Keast & S.E. Miller (eds.) *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processes* (SPB Academic Publishing: Amsterdam). [-, 34]

37. **Weston, P.H.** & Johnson, L.A.S. (1997) *Persoonia hindii* (Proteaceae), a new species from the Newnes Plateau, New South Wales. *Telopea* 7: 199-203. [0.6, 5]

38. Jobson, P.C. & **Weston, P.H.** (1998) *Dillwynia glaucula* (Fabaceae: Mirbelieae), a new species from the Southern Tablelands, New South Wales. *Telopea* 8: 1-5. [0.6, 1]

39. **Weston, P.H.** (1999) *Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8: 159-164. [0.6, 4]

40. Crisp, M.D., Gilmore, S.R. & **Weston, P.H.** (1999) The phylogenetic relationships of two anomalous species of *Pultenaea* (Fabaceae: Mirbelieae) from molecular and morphological data, and description of a new genus. *Taxon* 48: 701-714. [2.447, 19]

41. Jobson, P.C. & **Weston, P.H.** (1999) Two new species of *Dillwynia* (Fabaceae: Mirbelieae), from the Southern Tablelands of New South Wales. *Telopea* 8: 363-369. [0.6, 0]

42. Thomson, J.A., **Weston, P.H.** and Tan, M.K. (1999) A molecular approach to tracing major lineages in *Pteridium*: update and amendment. Pp. 35-36 in J.A. Taylor & R.T. Smith (eds.) *Bracken Fern: Toxicity, Biology and Control* (International Bracken Group: Aberystwyth). [-, 1]

43. **Weston, P.H.** (2000) Process morphology from a cladistic perspective. Pp. 124-144 in R. Scotland & T. Pennington (eds.) *Homology and Systematics: Coding Characters for Phylogenetic Analysis* (Taylor & Francis: Basingstoke). [-, 25]

44. Indsto, J. & **Weston, P.H.** (2000) Near-ultraviolet reflectance in *Dendrobium* (Orchidaceae). Pp. 326-334 in K.L. Wilson and D.A. Morrison (eds.) *Monocots: Systematics and Evolution*. (CSIRO: Melbourne). [-, 5]

45. Kores, P.J., **Weston, P.H.**, Molvray, M., & Chase, M.W. (2000) Phylogenetic relationships within the Diurideae (Orchidaceae); inferences from plastid *mat*K DNA sequences. Pp. 449-456 in K.L. Wilson and D.A. Morrison (eds.) *Monocots: Systematics and Evolution*. (CSIRO: Melbourne). [-, 60]

46. Savolainen, V., Fay, M.F., Albach, D.C., Backlund, A., van der Bank, M., Cameron, K.M., Johnson, S.A., Lledo, M.D., Pintaud, J.-C., Powell, M., Sheahan, M.C., Soltis, D.E., Soltis, P.S., **Weston, P.H.**, Whitten, W.M., Wurdack, K.J., & Chase, M.W., (2000) Phylogeny of the eudicots: a nearly complete familial analysis based on *rbc*L gene sequences. *Kew Bulletin* 55: 257-309. [0.577, 451]

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Papers in Preparation

1. Stimpson, M.L., Wright, B.R., **Weston, P.H.**, Whalley, R.D.B., & Bruhl, J.J. (in prep.) Seedling morphology helps unravel the taxonomic intricacies in the *Banksia spinulosa* complex (Proteaceae). *Botanical Journal of the Linnean Society* [2.523, -]

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Conference Abstracts

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Strategic assessment for Cumberland Plain Conservation Plan Expert report on the Sydney Plains Greenhood, *Pterostylis saxicola* in the Western Sydney Aerotropolis Growth Area, and Greater Penrith to Eastern Creek Urban Release Investigation Area

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1. Introduction

1.1 Purpose of the expert report

I was engaged by the Department of Planning and Envionment in September 2018, to produce an expert report on the distribution and abundance of *Pterostylis saxicola* (Orchidaceae) within the proposed Western Sydney Aerotropolis, and Greater Penrith to Eastern Creek Growth Areas (collectively termed "the study area"). This immediately followed my submission of a similar report on the same species for the Greater Macarthur and Wilton Growth Areas (Weston unpublished). The aim of this exercise was to assess whether *P. saxicola* is native to either of the Growth Areas and, if so, to assess where suitable habitat is located and to estimate the area occupied by *P. saxicola* in the study area and within the development footprint.

According to Section 6.5.2 of the Biodiversity Assessment Method, an expert report must:
- identify the relevant species or population
- justify the use of an expert report
- indicate and justify the likelihood of presence of the species or population
- estimate the number of individuals or area of habitat (whichever unit of measurement applies to the species/individual) for the biodiversity certification assessment area, including a description of how the estimate was made
- demonstrate what information was considered, rejected and discounted in relation to the determination made in the expert report, and
- identify the expert and provide evidence of their expert credentials.

1.2 Project context

The Department of Planning and Environment is leading a strategic biocertification of several identified growth areas within Western Sydney, including the two growth areas that define the geographic scope of this report: the Western Sydney Aerotropolis Growth Area and the Greater Penrith to Eastern Creek Urban Release Investigation Area. The strategic biodiversity assessment is an integral part of the Cumberland Plain Conservation Plan that will determine the impact of urban development on threatened species and ecological communities within these growth areas. The Plan will also provide conservation measures to mitigate any impact, as specified by NSW and Commonwealth environmental legislation.

1.3 Study area

The stu8dy area is located in the western to south western part of the Sydney Metropolitan Area, between latitudes 33.712°S and 33.941°S and longitudes 150.654°E and 150.857°E (figure 1).

1.4 Reasons for use of expert report

Pterostylis saxicola has never been collected within the study area. However, sites at which the species has been collected or observed, according to the Bionet Wildlife Atlas, are known beyond all sides of the study area, suggesting that it is part of the distributional range of *P. saxicola*. Moreover, according to Tozer *et al.* (2010), at least one of the plant community types in which known populations of *P. saxicola* occur, PCT 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, is scattered throughout the study area, raising the strong possibility that suitable habitat for *P. saxicola* might exist there. If this were so, *P. saxicola* might once have lived there, or still exist in the study area as unrecorded populations.

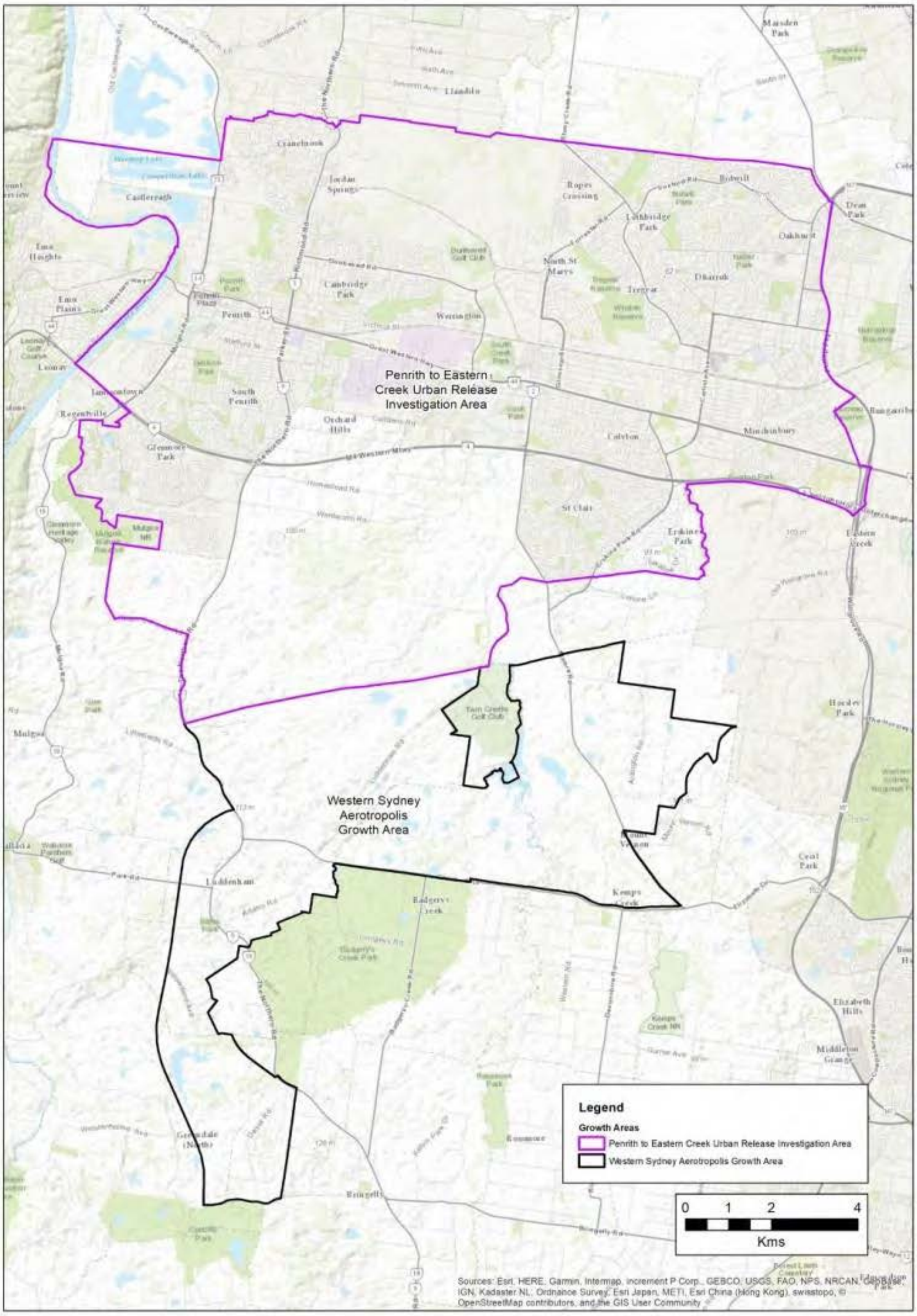

Figure 1. The Greater Penrith to Eastern Creek Urban Release Investigation Area (outlined in purple) and the Western Sydney Aerotropolis Growth Area (outlined in black). © OpenStreetMap contributors.

Pterostylis saxicola is a perennial, deciduous herb that can only be identified with confidence when flowering in Spring (late September to early November). Fortunately, the timing of the field work that I conducted for this project, 7 October to 22 November 2018, largely overlapped with this flowering period. However, the cryptic coloration and small size of this plant render it a challenging subject for conventional surveying: “drive by” surveys are not feasible and even experienced orchid spotters need to be standing within a few metres of a flowering plant to notice it. Moreover, plants may not flower if climatic conditions during the growing season from March to December (see section 2.2 below) are poor, as they have been in 2018 due to drought. Another limitation to conventional surveying was lack of access to a substantial proportion of the remnant native vegetation in the study area. Although sizeable blocks of the remnant bushland are found in public reserves, most of the native vegetation occurs on private land or land managed by the Australian Department of Defence and only 13.5% of landowners granted permission for surveys to be conducted on their land. The Australian Department of Defence land was not surveyed. These limitations and the possibility that *P. saxicola* might be native to the study area triggered the need for an expert report.

An alternative approach involves the construction of a general habitat model for *Pterostylis saxicola*, which can then be used, in conjunction with environmental maps, to identify suitable habitat on all land tenures across the study area.

1.5 Credentials of expert

I prepared this report as an independent botanical consultant but I am also currently an Honorary Research Associate at the New South Wales state herbarium (the National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust). In 2016, I retired from my role as a Senior Principal Research Scientist at the state herbarium, having worked there since 1982 as a Systematic Botanist and as curator of the herbarium’s collections of specimens of Orchidaceae (including *Pterostylis saxicola*) (see my Curriculum Vitae, attached). I now work, part-time, at the National Herbarium of New South Wales as an Honorary Research Associate. I have published, either as sole author or as a co-author, 16 papers on the systematics and ecology of the Orchidaceae in the peer-reviewed scientific literature, including the most comprehensive phylogenetic analysis of the predominantly Australian subtribe Diurideae yet published (Weston et al. 2014). As curator of Orchidaceae at the state herbarium, I examined all specimens of P. saxicola incorporated into the collection between 1986 and 2016. I was invited to contribute to floristic treatments of the Orchidaceae for Flora of New South Wales, (see my Curriculum Vitae, attached). I was also asked to be lead author of the essay on the ecology of the Orchidaceae that accompanied the “Ecology of Sydney Plants” (Weston et al. 2005). Throughout my career I have participated in numerous collecting trips in the field, collecting specimens in all Australian states for the state herbarium. In documenting these specimens I had to describe the habitat at each collecting site, including associated plant species, substrate, aspect, degree and kind of disturbance. I have also cultivated numerous species of Pterostylis as an orchid enthusiast and advised horticulturalists at the Royal Botanic Gardens on appropriate techniques for cultivating species of Pterostylis and other orchids.

In June 2018 I was appointed to prepare an expert report on *Pterostylis saxicola* in the Greater Macarthur and Wilton Growth Areas (Weston unpublished), during the preparation of which I characterised in detail the associated plant species and other ecological attributes of five plots, each of 30 metre radius, centred on highly precise grid references of sites at which *P. saxicola* had previously been collected, at two of which I found pre-flowering leaf rosettes that were indistinguishable from those of the orchid. I am personally familiar with this taxon and the habitats in which it lives.

In November 2018 I was approved by the Office of Environment and Heritage as a species expert for *Pterostylis saxicola* under section 6.5.2 of the Biodiversity Assessment Method. This approval is current for a period of six years.

1.6 Species surveys conducted on behalf of the Department of Planning and Environment

Letters were sent by the Department of Planning and Environment (DPE) to all landholders within the development footprint to request access. A total of 432 letters were sent to landholders across the Western Sydney Aerotropolis Growth Area between November 2017 and August 2018 with 84 landholders responding positively to provide access. A further seven properties were accessed after doorknocking, resulting in a response rate of 21%.

A small number of targeted letters were sent to landholders in the Greater Penrith to Eastern Creek Urban Release Investigation Area from November 2017. However, most letters (more than 1500) were sent in August 2018, which included many urban and small acreage landholders. From this, 177 landholders provided access to their properties and an additional three landholders provided permission via doorknocking (12% response rate). Not all of these properties were surveyed as some did not support vegetation patches of interest. In addition, the Open Spaces Team at Penrith Council facilitated access to 64 lots owned by Council. Surveys were undertaken by DPE's contract ecologists on all areas of land where landowners granted access. Access to the Defence Establishment Orchard Hills, which includes large patches of native vegetation, was not provided.

A targeted survey for threatened species was conducted on lands where access was granted. Vegetation transects and random meanders for threatened flora were conducted by the Ecoplanning Pty Ltd and Biosis Pty Ltd in accessible areas proposed for certification, with particular attention to areas of likely habitat. The survey included effort through each plant community type and vegetation zone, and extended into suitable habitat adjacent to the edge of the future urban area where potential indirect impacts to high quality habitat may occur (up to ~50m). Likely habitat for most flora species comprised areas of lower disturbance. This included areas with a predominantly native understorey (with or without a canopy), the base of scattered trees in paddocks, paddocks with an apparent low grazing pressure, and known topographic/habitat preferences for certain flora. *Pterostylis saxicola* was not found in the study area during this survey.

The percentages of remnant native vegetation in the growth areas that were sampled in the threatened species survey were 1.0% in Greater Penrith to Eastern Creek Urban Release Investigation Area and 7.1% in the Western Sydney Aerotropolis Growth Area. The percentages of sampled remnant native vegetation that were covered by the urban development footprint were 7.9% in Greater Penrith to Eastern Creek and 18.4% in the Western Sydney Aerotropolis. These data include a 20 m buffer from survey tracks.

2. Species information

2.1 Species description

The following morphological description of *Pterostylis saxicola* is a modified version of that published by Jones and Clements (1997), updated with data gathered from more recently collected specimens held by the National Herbarium of N.S.W.

Tuberous, terrestrial herb (see figure 2). Tubers oblate, c. 15-20 mm wide. Leaves oblong-elliptical to ovate-elliptical or obovate, 10-45 mm long, 5-15 mm wide, 5-10 in a radical rosette, green, the margins entire, shortly petiolate, apex subacute to apiculate, often withered at anthesis. Inflorescence 10.5-35 cm tall, slender, with 3-6 ensheathing, lanceolate sterile bracts. Floral bracts lanceolate, 6-19 mm long, 3-4 mm wide, acuminate, closely sheathing. Pedicels 3-26 mm long, slender, straight or slightly curved. Ovary narrowly obovoid, 3-5 mm long, 1-2 mm wide, reddish brown. Flowers 1-10, porrect to semi-erect, 12-12 mm long, transparent with dark red-brown markings and suffusions in the galea, the lateral sepals wholly red-brown, shiny; galea gibbous at the base, curved medially, decurved suddenly to the apex; petal flanges poorly developed, not touching and not closing off the base of the galea. Dorsal sepal 11-13 mm long, cucullate, obliquely erect, Abruptly decurved in distal quarter, apical point c. 3 mm long, filamentous, acuminate. Lateral sepals deflexed, ovate in outline when flattened, fused part 7-10 mm long, 9-11 mm wide, shallowly concave, the margins strongly incurved, glabrous; sinus narrow; free points filamentous, c. 5 mm long, curved forwards, divergent, 8-10 mm apart at the tips. Petals ovate-lanceolate, 11-14 mm long, 3.5-5 mm wide, nearly straight, transparent, with brown basal markings and two or three brown lines, dorsal margin brown, ciliate, proximal flange poorly developed. Labellum highly irritable, attached by a ligulate basal claw c. 2 mm long, c. 2 mm wide; lamina broadly obovate, 4.5-6 mm long, 2.5-3.5 mm wide, dark red-brown, constricted in the proximal quarter, adaxial surface shallowly concave to broadly grooved, apex obtuse; marginal trichomes 3-5 pairs, white, the longest pair c. 3.5 mm long, arising near the proximal constriction, basal lobe large, with 1-3 pairs of trichomes c. 0-.7 mm long, abaxial surface with a narrow central channel extending from the basal lobe to the apex. Column porrect from the end of the ovary, 10-12 mm long, c. 2.5 mm wide; column wings c. 3.3 mm long, c. 2.5 mm wide, more or less rectangular, anterior margins ciliate. Stigma elliptical to broadly scutiform, c. 5 mm long, c. 2.5 mm wide, the upper margins irregular. Anther c. 1.2 mm long, obtuse. Pollinia linear-oblong to clavate, c. 2 mm long, yellow, mealy. Fruiting capsules obovoid, 7-8 mm long, c. 4-5 mm wide, brownish, erect.

2.2 Life cycle

Pterostylis saxicola is a perennial, deciduous, tuberous herb that germinates from a minute, dust-like seed. Like all other orchids, germination is reliant on invasion of the seed by the hyphae of a specific fungal associate, which, in the case of *P. saxicola*, is an unnamed species of *Ceratobasidium* (Basidiomycota: Cantharellales) (Sommerville et al. 2008). The first morphological change that an orchid seed undergoes during germination is swelling to form a protocorm, a rootless, shootless ‘blob’. The orchid fungus forms an intracellular relationship with its host, usually in the roots and/or tubers and is thus classed as an endomycorrhiza. It forms hyphal coils, called pelotons, in the cells of its host, which are beneficial to the orchid in that they provide the host plant with nutrients such as soluble sugars (Rasmussen 1995, Warcup 1990). The duration of the association varies according to the life history of the particular orchid species, with some species of orchids being completely dependent on their mycorrhizal fungi for life while other species are capable of living without their fungi from shortly after germination. The ease of cultivation of *Pterostylis* species and the green colour of almost all plant parts strongly suggest that adult plants are not obligately dependent on their mycorrhizal associates as adult plants.

Plants of *Pterostylis saxicola*, like those of most other species in Orchidaceae subfamily Orchidoideae, are deciduous, with the whole shoot system growing anew every year from a dormant tuber. The new shoot usually starts growing from an apical meristem on the tuber in late summer, with new shoots usually breaking the soil surface by March. The shoot develops into a “rosette” of crowded leaves just above ground level and in late winter a terminal raceme starts growing from the centre of the rosette, reaching anthesis in Spring. While the shoot is growing above ground, a new replacement tuber is growing below ground, from the base of the shoot. Some species of *Pterostylis* multiply and spread vegetatively by producing additional new tubers on the ends of long roots but the subgenus to which *P. saxicola* belongs, *Oligochaetochilus*, does not share this attribute (Jones 2006).

Figure 2. Flowering plant of *Pterostylis saxicola*, at Scheyville National Park, showing the basal rosette of crowded leaves lying flat on the ground and a terminal, erect inflorescence, bearing one open flower from the side and an unopened flower bud.

Figure 3. Flower of *Pterostylis saxicola*, at Scheyville National Park, frontal view, showing galea, labellum and paired lateral sepals.

Almost all species of *Pterostylis* are deceptively pollinated by male flies that attempt to copulate with the labellum of the flower. The labellum mimics a female fly of a particular species (or species group) in size, appearance and texture and by exuding an allomone that is identical to the pheromone released by the female flies (Phillips et al. 2013, Kuiter & Findlater-Smith 2017). In species of *Pterostylis* for which the pollination process has been studied and described, the labellum is highly motile ("irritable"), like that of *Pterostylis* saxicola, and a male fly that lands on it is tossed inside the hood (galea) formed by the dorsal sepal and lateral petals, and trapped there. The only escape route provided by the flower is a tunnel through which the male fly must squeeze in order to escape. In the process of negotiating its exit, the fly is forced to rub past the stigma of the flower, depositing on it any pollinaria that it was already carrying. The fly is then forced to contact the anther, sticking a pollinarium on its thorax, before it can finally escape. The pollinator of *P. saxicola* is still unknown, but the pollinators of other species of *Pterostylis* subgenus *Oligochaetochilus*, where known, are males of unnamed species of *Orfelia* (Mycetophilidae) (Kuiter & Findlater-Smith 2017). Sexually deceptive pollination has evolved multiple times in the Australian terrestrial orchid flora, involving hundreds of species (Weston et al. 2014). Most of those for which pollinators have been identified are pollinated by the males of only one species of insect and *P. saxicola* is most likely pollinated by a single species of fly too.

Fruiting capsules of *Pterostylis saxicola* mature quickly, with the most proximal capsules sometimes dehiscing before the most distal flowers have withered. They split down six sutures to release thousands of minute, wind-dispersed seeds in November to early December.

2.3 Distribution and abundance

Records for *Pterostylis saxicola* are widely distributed across the Cumberland Plain and lower Blue Mountains in an area bounded by Scheyville, Freemans Reach, Glenbrook, Douglas Park, Picnic Point, Ryde (an unvouchered record) and Cattai, with an outlying record from the Gingra Range in Kanangra Boyd National Park (Bionet Atlas, National Herbarium of New South Wales specimen database, all accessed 26/7/2018). It has been recorded at altitudes ranging from 30 to 400 metres. It is very sporadically distributed, partly because much of this land has been cleared for agriculture and suburban development but the outlying record suggests that any habitat model is unlikely to be a powerful predictor of the presence of populations at particular locations.

Plants are usually gregarious, with most collectors and observers noting multiple plants co-occurring together. At two sites for which I had highly precise grid references, and which I characterised in detail, I found plants in clusters: 10 plants in a 10x10 cm patch, two plants 5 cm apart, and 57 in a patch smaller than one square metre. As *P. saxicola* does not usually multiply vegetatively (Jones 2006), these clusters must be the result of seeds germinating close to their parents.

2.4 Habitat requirements

The habitat model published in the endangered species profile for *Pterostylis saxicola* (NSW Office of Environment and Heritage 2018a) states that it is "most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where *P. saxicola* occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils". This description applies accurately to the habitat associated with some records in the southern half of the species' distribution but not to those found elsewhere. The distributional range and habitat requirements of *P. saxicola* can be subdivided into two main sub-populations and one outlying population.

The northern sub-population is in an area bounded by Scheyville, Freemans Reach, "The Ironbarks" near Glenbrook, Toongabbie, Ryde, Glenhaven and Cattai. The substrate underlying the sites at

Scheyville, Freemans Reach and Ryde is deep Ashfield Shale (Wianamatta Group), but the Cattai, Toongabbie and Glenbrook records came from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition zones. All of these sites are in gently rolling country, not on rugged sandstone outcrops.

The plant communities associated with recorded sites for *Pterostylis saxicola* in its northern sub-population, as determined from collectors' and observers' notes and from identification of precisely specified sites on the vegetation maps of Tozer *et al.* (2010), are their map units GW p29 and GW p2. According to the references cited in the Bionet Vegetation Classification, these are equivalent to:

- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (see figure 4);
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain (see figure 5).

Most records from the southern sub-population, in an area bounded by Macquarie Fields, Minto, Douglas Park, Woronora River and Picnic Point differ in habitat from the northern records. In cases where they have highly precise locality data and/or detailed habitat descriptions, collections and observations from this area have been made on Hawkesbury Sandstone, on the rims and sides of the gorges of the Nepean, Georges and Woronora Rivers. Observers' notes repeatedly describe the soils as very shallow sands overlying sandstone rock shelves, as stated in the published habitat model (NSW Office of Environment and Heritage 2018a). However, contrary to that model, only some of them were recorded above cliff lines. All of these sites occur close to outcrops of Ashfield Shale, mostly downhill from them, but for some of these sites, the only evidence of shale influence on the environment seems to be associated plant community types. Precisely georeferenced sites are mapped by Tozer *et al.* (2010) to their map units DSF p146, Sydney hinterland transition forest and their map unit GW p2, Cumberland Shale Sandstone Transition Forest. According to the references cited in the Bionet Vegetation Classification, these are equivalent to:

- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain).

In addition to the two main sub-populations, there is also an outlying, precisely georeferenced, herbarium record from the Gingra Range in Kanangra Boyd National Park. This site is on Devonian metasediments, and was mapped by Tozer *et al.* (2010) to their map unit DSF p37 Kowmung-Wollondilly Grassy Gorge Woodland.

According to the references cited in the Bionet Vegetation Classification, this is equivalent to:

- 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges.

Pterostylis saxicola has mostly been recorded growing in intact native vegetation but there is one notable exception: a plant described in a "Car Park growing through bitumen", adjacent to a large area of bushland from which other substantiated records had been made. Several others have come from small patches of remnant urban bushland, in some cases less than a hectare in area, surrounded by highly disturbed land, and from a long, narrow patch less than 50 m wide. However, no records mention heavily weed-infested habitats or evidence of heavy grazing by introduced herbivores. Sites with significant edge effects are probably not sustainable reserves for conserving this species.

Figure 4. PCT 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain, on Ashfield Shale at Scheyville National Park (my site PS1).

Figure 5. PCT 1395 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain, on Mittagong Formation at Cattai (my site PS7).

3. Description of the study area

3.1 Land use history

This section is based primarily on information from penrithhistory.com, a website maintained by Penrith Library (Penrith Library 2018), except where other sources are explicitly cited. The first human inhabitants of the study area were Aborigines who moved there many thousands of years ago. People of the Darug language group were occupants of the study area when the British first started to settle in the Sydney Region in 1788 (Logan 2011). These hunter-gatherers would have managed the grassy woodlands that grew on Bringelly Shale and Cenozoic alluvia of the area using fire-stick farming methods (Benson & Howell 1990). They used the natural landscape seasonally, taking advantage of different food sources depending on availability, establishing temporary open camps of simple gunyahs on higher ground near water courses. The Nepean River and its tributaries were significant sources of fish, shellfish and useful plants while the wooded plains and gentle hills were sources of game, edible tubers, seeds, fruits and materials for making clothing, tools and shelters (Logan 2011).

In 1789, 18 months after the founding of Sydney, Captain Watkin Tench led a group from Rose Hill to the Nepean River, followed soon by further expeditions from there to Razorback in the south and downstream to the Hawkesbury River in the north (Fitzhardinge 1967). The alluvial flats of the Nepean River and adjacent grassy woodlands on Wianamatta Shales, offered more fertile farming land than sandy soils derived from Hawkesbury Sandstone surrounding the Cumberland Plain. However, violent clashes between the British and the Darug people led by Pemulwuy delayed settlement west of Prospect until 1802, when Governor King built a headquarters for his government stock reserve at what is now Rooty Hill (NSW Office of Environment and Heritage 2018b). King went on to issue land grants at what are now Penrith and Cranebrook in 1804, and Orchard Hills, St Marys and Badgerys Creek in 1806. Further land grants were made in what are now Mulgoa and Greendale in 1810, and Luddenham in 1813. In 1815 the Great Western Road was completed between Parramatta and Bathurst, placing the northern part of the study area on what soon became a major transport artery. Completion of the western railway line from Sydney to Penrith in 1867 and its extension to Bathurst in 1876 significantly enhanced accessibility of the northern part of the study area. From first settlement in the early 19th century to the 1950s, land use in the study area was dominated by timber production, agriculture and quarrying, all of which necessitated extensive clearing of native vegetation, especially from the more fertile alluvial and clayey soils. Agricultural activities conducted in the areas have included the cultivation of wheat (which was curtailed in 1861 when the whole crop was destroyed by an infestation of rust disease) and other cereal crops, grazing of sheep, cattle and horses, intensive production of pigs and poultry, and the cultivation of fruit, vegetables, turf and cut-flowers (Wilkinson 2011). Industrial facilities that processed saw logs and agricultural produce, such as timber mills, flour mills, milk processing plants, cattle sale yards, tanneries, canneries and wineries began to be built early in the 19th century and mostly continued operating well into the 20th century. A few manufacturing plants, producing textiles, munitions and bricks were also developed in the 19th and early 20th centuries.

Penrith grew slowly as an urban centre during the 19th century and first half of the 20th century, but population growth accelerated after 1960 due to the establishment of several social housing projects by the N.S.W. Housing Commission. This was followed from the 1970s by the gradual rezoning of much of the agricultural land in the northern part of the Greater Penrith to Eastern Creek Urban Release Investigation Area for urban development. Land use in this growth area is now dominated by residential housing, retail precincts, light industry and transport infrastructure, but Orchard Hills in the south is still largely rural. Most protected patches of remnant native vegetation are less than 20 Ha in area but the two largest reserves containing intact bushland, Wianamatta

Regional Park in the north and The Defence Establishment Orchard Hills in the south, cover approximately 900 Ha and 1370 Ha respectively.

The Western Sydney Aerotropolis Growth Area is still largely rural but includes a staggeringly small area of remnant bushland in public reserves. The largest patch consists of about 3.5 hectares of weed-infested Grey Box – Forest Red Gum grassy woodland in Sales Park, Luddenham. Soon it will be a small green oasis, surrounded by urban development.

3.2 Landscape context

The Sydney Basin is a geological entity, composed of sedimentary rocks, which is shaped a bit like a tilted, triangular, art deco saucer. In the middle of this structure is the Cumberland Plain, in the northern half of which is located the study area. Here, the uppermost strata of the Sydney Basin, Cenozoic alluvia, patchily overlie the Triassic Wianamatta Group, comprising Bringelly Shale, Minchinbury Sandstone and Ashfield Shale, which, in turn overlie Triassic Hawkesbury Sandstone, the Triassic Narrabeen Group and the Permian Shoalhaven Group (Martyn 2018). Scattered small Jurassic basalt diatremes occasionally pierce the sedimentary strata, such as at Lethbridge Park and Bidwill.

The most commonly exposed substrate in the study area is Bringelly Shale. Over this, the second most commonly exposed substrate, Quaternary alluvial clay, which has mostly been eroded from Bringelly Shale, has accumulated in a branching pattern across the study area on the floodplains of South Creek and its tributaries, including Kemps, Badgerys, Cosgrove, Blaxland, Claremont, Werrington and Ropes Creeks (NSW Department of Minerals and Energy 1991).

Other substrates are also exposed over a much smaller area on the northern and western margins of the Greater Penrith to Eastern Creek Urban Release Investigation Area. Two patches of Londonderry Clay, a Paleogene-Neogene alluvium, covering an area of about six square kilometres, have been preserved on the northern edge between St Marys and Shanes Park. On the western margin, between Mulgoa and the north-western corner, gravelly, sandy, silty and clayey Quaternary alluvia of the Cranebrook formation line the eastern bank of the Nepean River and its eastern tributaries, forming an extensive deposit up to four kilometres wide north of Regentville. On the western margin, several square kilometres of Ashfield Shale and a smaller area of Rickabys Creek Gravel, a Paleogene-Neogene alluvium, are exposed from Jamisontown to Glenmore Park.

The whole study area is gently tilted from south to north and all watercourses flow in that general direction. Topography varies subtly in the Greater Penrith to Eastern Creek Urban Release Investigation Area with low, rounded ridges alternating with flat-bottomed flood plains. The lowest point is in the north west corner at Upper Castlereagh, where the bank of the Nepean River is below 10 m altitude, and along the northern margin the altitude is less than 70 metres. The highest point in the Greater Penrith to Eastern Creek Urban Release Investigation Area is 93 metres in altitude at Sovereign, in the south west corner. Along the boundary between the two growth areas, altitude varies from 40 metres in the east to 90 metres in the west.

Topographic relief is still quite gentle, but more noticeable, with steeper slopes, in the Western Sydney Aerotropolis Growth Area. The altitude varies from 40 metres in the north eastern corner to 106 metres just south east of Luddenham village.

Topographic variation, as well as distance from the sea influence climate. The Cumberland Plain is the driest part of the Sydney Region and also experiences the most extreme temperatures in the region. Key climate statistics for the three weather stations in the study area, for which data are freely available, are shown in table 1. The whole study area is subject to winter frosts.

Weather station	Mean annual rainfall (mm)	Mean maximum temperature (°C)	Mean minimum temperature (°C)
Penrith Lakes AWS (1995-)	718.6	31.0	5.3
Orchard Hills Treatment Works (1970-)	832.7	28.5	5.3
Badgerys Creek McMasters F (1995-)	794.3	28.6	3.8

Table 1. Key climatic statistics for weather stations in the growth areas.

3.3 Native vegetation communities

In terms of the plant community types recognised in the Bionet Vegetation Classification and the vegetation maps that were prepared for this project, the remnant native vegetation of the study area consists of:

- 724 Broad-leaved Ironbark - Grey Box - Melaleuca decora grassy open forest on clay/gravel soils of the Cumberland Plain (191.3 ha);
- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain (167.4 ha);
- 781 Freshwater wetland (68.9 ha);
- 830 Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (2.8 ha);
- 835 Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats of the Cumberland Plain (989.2 ha);
- 849 Grey Box – Forest Red Gum grassy woodland on flats of the Cumberland Plain (2334.1 ha);
- 850 Grey Box – Forest Red Gum grassy woodland on shale of the southern Cumberland Plain (88.5 ha);
- 883 Hard-leaved Scribbly Gum - Parramatta Red Gum heathy woodland of the Cumberland Plain (6.5 ha);
- 1105 River Oak open forest of major streams, Sydney Basin Bioregion and South East Corner Bioregion (94.2 ha);
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest of the edges of the Cumberland Plain (2.0 ha).
- 1800 Swamp Oak open forest on river flats of the Cumberland Plain and Hunter valley (228.5 ha).

In the study area, according to the vegetation mapping that was conducted for this project, the following substrates support the following plant community types:

- Quaternary alluvium: 781, 835, 849, 850, 1105, 1800;
- Londonderry Clay: 724, 725, 835, 849;
- Bringelly Shale: 724, 725, 835, 849, 883;
- Ashfield Shale: 835, 849, 1395;
- Rickabys Creek Gravel: 849.

PCT 849 is the most abundant plant community type throughout both growth areas, growing on most of the uncleared land above the zone of floodwater inundation, most commonly on Bringelly Shale. Over 50% of the two largest patches of remnant bushland, Wianamatta Regional Park and the Defence Establishment Orchard Hills is covered in PCT 849 and it covers most of the smaller reserves too. PCT 835 covers the second largest area and also occurs throughout the study area, vegetating the uncleared flood plains of South Creek and its tributaries on Quaternary alluvium, as well as the lowest part of the adjacent slopes. The banks of those creeks as well as some other blocks of low-lying land on Quaternary alluvium, are dominated by PCT 1800. PCTs 724 and 725 are dominant on

Londonderry Clay in the northern part of the study area but also occur patchily elsewhere on Bringelly Shale, most notably in the Kemps Creek area and on a rectangular block of regenerating vegetation 0.6-0.8 km west of Luddenham Road, 0.2-0.6 km north of the Warragamba-Prospect water pipeline. PCT 1105 dominates remnant vegetation on the banks of the Nepean River north of Penrith, on Cranebrook Formation alluvium. The remaining plant community types occur only rarely as tiny fragments in the study area. About 6.5 ha of PCT 883 occurs in two patches at the eastern end of Wianamatta Regional Park and about 15 ha remains in a block 0.6 km north of Elizabeth Drive, Kemps Creek. PCT 1395 is represented by a sliver of two hectares on Ashfield Shale at Glenmore Park. PCT 830 is restricted to a fringe of under three hectares in area on the eastern the border of Mulgoa Nature Reserve.

Weed infestation is a problem throughout the study area. This is well illustrated by two sites at Claremont Meadows. The vegetation at a site beyond the eastern end of Caddens Road, on the flood plain of South Creek, which I visited but did not include in my sampling, consisted of a closed forest of *Ligustrum sinense*, *Ligustrum lucidum* (both natives of China, the latter extending to Japan) and *Olea europaea* subsp. *cuspidata* (native of Africa), with scattered emergent trees of *Eucalyptus tereticornis* and *E. amplifoli*a. This would have been a forest of PCT 835 before weed infestation converted it into a novel, derived plant community. Only 0.6 km to the west north west of that site is a superficially pristine block of PCT 724. Even here, however, *Ligustrum sinense* and *Ligustrum lucidum* already dominate the vegetation near South Creek, *Eragrostis curvifolia* is a common component of the ground stratum and seedlings of *Olea europaea* subsp. *cuspidata* are starting to establish throughout the reserve.

4. Assessment of species presence and habitat

4.1 Existing records and surveys

A search for records of *Pterostylis saxicola* in the Bionet Atlas, conducted on 3 December 2018, returned 30 observational records. Several targeted surveys of this species seem to have been conducted since 2000. Teresa James surveyed for this species across the species' distribution in Spring 2007, for the NSW Department of Environment Climate Change and Water, submitting an unpublished report, observational records at five sites and a herbarium specimen (Teresa James personal communication). From November 2010 to January 2011, Total Earth Care Pty Ltd conducted a survey of threatened plant species in the Simmos Beach Recreation Reserve, Macquarie Fields for Campbelltown City Council, submitting an unpublished report and observational records at eight sites (Lachlan Laurie personal communication). In Spring 2011, *P. saxicola* was again targeted at Simmos Beach Recreation Reserve by a research group from The Royal Botanic Gardens and Domain Trust that investigated the mycorrhizal associates of the orchid, with the aim of identifying and culturing the relevant fungus or fungi, adding seeds of this species to the seed collection at the Australian Plantbank, and germinating seeds of the orchid in septic culture. Two scientific papers were published, and three herbarium specimens collected as part of this project. All of those surveys and searches were conducted outside the study area.

Highly precise grid references associated with a number of the Bionet records enabled me to identify the plant community types (as mapped by Tozer *et al.* (2010) and substrates (as mapped by NSW Department of Minerals and Energy 1991) at sites at which these records of *Pterostylis saxicola* occurred. They were:

- 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain, on Ashfield Shale;

- 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges, on Devonian metasediments;
- 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, on Hawkesbury Sandstone;
- 1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, on Hawkesbury Sandstone;
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney, on Hawkesbury Sandstone;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain, on Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone transitional landscapes.

4.2 Surveys completed for the biocertification

Apart from the surveys conducted for this expert report, no targeted surveys for *Pterostylis saxicola* were conducted for biocertification of the study area.

4.3 Surveys completed for this assessment

4.3.1 Survey Methods

In the course of preparing my expert reports on *Grevillea juniperina* subsp. *juniperina* and *Pterostylis saxicola* in the Greater Macarthur and Wilton Growth Areas (Weston unpublished a,b), I characterised 20 plots of native vegetation in detail, each plot being a circle of radius 30 m (an of area 2827 m^2), centred either on a plant of *Grevillea juniperina* subsp. *juniperina* or *P. saxicola* or on an arbitrarily chosen point (at sites where both the *Grevillea* and the *Pterostylis* were absent). I have included data from five of those plots as samples from outside the study area in my analyses for this report.

I have also used the same methods to search for *Pterostylis saxicola* and characterise 34 plots in and around the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area. I chose the locations with the aim of sampling patches of accessible, remnant bushland representing as broad an ecological range and geographic extent across the two Growth Areas as time would allow, sampling more plots in areas where *Grevillea juniperina* subsp. *juniperina* had previously been recorded. Some habitats, such as freshwater wetlands, and substrates on which neither *Grevillea juniperina* subsp. *juniperina* nor *P. saxicola* had ever been recorded, such as Cranebrook Formation alluvia, were avoided. At each plot I listed all vascular plant species that could feasibly be identified, taking photographs and sometimes specimens of plants for later reference in cases where the plant's identity was in question. The latitude and longitude of the centre of each plot was determined using a GPS instrument. The altitude of each site was determined later from 1:25,000 topographic maps. The soil and topography at each site was described and the substrate identified using the Penrith 1:100,000 geological map (NSW Department of Minerals and Energy 1991) and 1:25,000 topographic maps.

I identified the plant community type in each plot using the PCT identification tool in Bionet, and my list of plant species found in each plot.

I developed an improved habitat model for *Pterostylis saxicola*, using data from the published literature, 38 observers' and collectors' records of *P. saxicola* in the Bionet Wildlife Atlas, vegetation mapping conducted for the Cumberland Plain Conservation Plan (Biosis unpublished), the geological map of the area (NSW Department of Minerals and Energy 1991) and my own botanical surveys of 7 plots where I was confident that plants of *P. saxicola* were present.

4.3.2 Results and Conclusions from my Surveys Completed for this Assessment

Site and ecological data for my plots are shown in Appendix 2. I sampled most plant community types and most substrates known in the study area in these plots, as well as one plant community type, PCT 849, in which *Pterostylis saxicola* has been recorded. However, I did not find *P. saxicola* in any plots within the study area.

According to my identifications of plant community types, *Pterostylis saxicola* was present in the following PCTs in seven of my plots outside the study area:

- 849 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain (2 plots);
- 1081 Red Bloodwood - grey gum woodland on the edges of the Cumberland Plain (3 plots);
- 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney (1 plot);
- 1395 Narrow-leaved Ironbark - Broad-leaved Ironbark - Grey Gum open forest of the edges of the Cumberland Plain (1 plot).

According to the vegetation mapping conducted for this study, two of these plant community types were found within the study area, PCT 849, which is common and widespread there, covering 2344 hectares, and PCT 1395, which is represented by a remnant of just two hectares at Glenmore Park.

Plant community types that I sampled in the study area, in which *Pterostylis saxicola* has never been recorded, were the following.

- 725 Broad-leaved Ironbark - Melaleuca decora shrubby open forest on clay soils of the Cumberland Plain (nine plots sampled);
- 835 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain;
- 1800 Swamp Oak open forest on riverflats of the Cumberland Plain and Hunter valley (3 plots).

Substrates on which *Pterostylis saxicola* was present in my plots outside the study area were:

- Hawkesbury Sandstone (four plots);
- Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition zone (one plot);
- Ashfield Shale (two plots).

Hawkesbury Sandstone is not exposed anywhere in the study area. An area of 14.3 hectares of Ashfield Shale supports intact remnant vegetation of PCTs 849 and 1395 in the study area, in several small reserves at Glenmore Park and on private land north of Mulgoa. I inspected two of the reserves for plants of *Pterostylis saxicola* on 22 November 2018 (including my plot PEC29), when plants that had recently flowered outside the study area were still clearly visible but I could find no evidence of *P. saxicola* in either reserve. Nevertheless, *P. saxicola* might occur in small areas of suitable habitat within the study area but have been overlooked. Even mature plants do not flower every year, especially if climatic conditions have been poor (see section 2.4), as they have over the past 12 months of drought.

Pterostylis saxicola has never been recorded on the following substrates that are exposed in the study area:

- Bringelly Shale;

- Cenozoic Alluvium.

Previously, (Weston unpublished) I argued that the habitat model that was published as part of OEH's threatened species profile of *Pterostylis saxicola* (NSW Office of Environment and Heritage 2018a) needed updating. The new habitat model that I proposed there was as follows:

Occurs on the Cumberland Plain along an ecological gradient from:

- Clay soils derived from Ashfield Shale (Wianamatta Group) on flat to gently hilly landscapes in PCT 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain;
- to: clay to sandy soils derived from Hawkesbury Sandstone – Mittagong Formation – Ashfield Shale transition substrates on gently hilly landscapes, in PCT 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain;
- to: thin accumulations of humus-rich sandy soil on Hawkesbury Sandstone sheets and rock shelves, on the rims and steep sides of river valleys, growing in PCT 1081 Red Bloodwood – Grey Gum woodland on the edges of the Cumberland Plain, or PCT 1083 Red Bloodwood - scribbly gum heathy woodland on sandstone plateaux, or PCT 1181 Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest on slopes of dry sandstone gullies of western and southern Sydney.

Also occurs outside the Cumberland Plain on Devonian slate, in PCT 870 Grey Gum - Thin-leaved Stringybark grassy woodland of the southern Blue Mountains gorges.

4.4 Assessment of species presence

4.4.1 Likelihood of species presence

The total area of suitable habitat in the study area (see 4.5 below) is only 14.3 ha, all of which occurs in the Greater Penrith to Eastern Creek Urban Release Investigation Area. Given the rarity and sporadic distribution of this species, the likelihood of any populations remaining undetected in those remnants is low. However, it is not zero. No suitable habitat exists in the Western Sydney Aerotropolis Growth Area and it is most unlikely to occur there.

4.4.2 Justification for determining presence

Pterostylis saxicola has never been recorded in either the Greater Penrith to Eastern Creek or Western Sydney Aerotropolis Growth Area and I failed to find any plants of it in the 30 plots that I surveyed in detail. Nevertheless, a small area of suitable habitat remains near the western margin of the Greater Penrith to Eastern Creek Urban Release Investigation Area so its presence there cannot be ruled out. A precautionary approach would treat all of the remaining suitable habitat as part of the area of occupancy of this species.

4.5 Assessment of suitable habitat

4.5.1 Suitable habitat within the study area

Assessing the suitable habitat of *Pterostylis saxicola*, given the present state of knowledge of the biology of this species, has to be a descriptive exercise. The causal processes that constrain its distribution and abundance are largely unknown but probably include physiological limits to tolerance of temperature and humidity, the availability of mineral nutrients and water, factors limiting the distribution and abundance of its obligate symbionts – its pollinators and mycorrhizal associates, and the distribution and abundance of native herbivores, pathogens and parasites. Suitable habitat has to be estimated on the basis of associations between its distribution and environmental proxies such as substrate types and plant community types, and interactions between them. Multidimensional bioclimatic modelling would extend this approach to climatic variables but such analysis is beyond the scope of this report.

Records of *Pterostylis saxicola* have been mapped to six plant community types recognised in the Bionet Vegetation Classification, two of which are known to occur in the study area:

- 849 Grey Box – Forest Red Gum grassy woodland on Flats of the Cumberland Plain, on Ashfield Shale;
- 1395 Narrow-leaved Ironbark – Broad-leaved Ironbark – Grey Gum open forest on the edges of the Cumberland Plain, on Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone transitional landscapes.

Pterostylis saxicola has almost always been reported from intact native vegetation (see section 2.4), which is unsurprising, given its dependence on at least two other symbiotic associates and the vulnerability of ground orchids to grazing by introduced herbivores (Duncan *et al.* 2005). It is reasonable to conclude that only intact remnants of the two plant community types listed above comprise suitable habitat for this species.

Pterostylis saxicola is known to occur naturally on four substrate types recognised by the Geological Survey of New South Wales, only one of which is known to be exposed in the study area:

- Triassic Ashfield Shale (Wianamatta Group).

The intersection of either of the above plant community types with Ashfield Shale indicates suitable habitat for *Pterostylis saxicola*.

4.5.2 Species polygons

My species polygons for *Pterostylis saxicola* (figure 6) include all patches of PCTs 849 and 1395 growing on Ashfield Shale in the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area. They were prepared with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by Biosis Pty Ltd. A shape file for these polygons is held by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment.

My arguments justifying these polygons have been set out in sections 2.3, 2.4, 4.1, 4.3, 4.4 and 4.5.1.

4.5.3 Estimate of area of habitat

The areas estimated to represent suitable habitat for *Pterostylis saxicola* in figure 7 are as follows:

- Greater Penrith to Eastern Creek Area Urban Release Investigation Area
    - Habitat mapped – 14.3 ha
    - Habitat impacted by development footprint – 0.8 ha
- Western Sydney Aerotropolis Growth Area
    - Habitat mapped – 0 ha
    - Habitat impacted by development footprint – 0 ha

These estimates were calculated with the assistance of Darren James (DAJ Environmental), using the ArcMap software package, from vegetation maps of the study area produced by

Biosis Pty Ltd. My arguments justifying the polygons from which these estimates were calculated have been set out in sections 2.3, 2.4, 4.1, 4.3, 4.4 and 4.5.1.

5. Information used in this assessment

My assessment was based on information obtained from a diversity of sources:

- Databases of observational and vouchered specimen records of *Pterostylis saxicola*:
    - National Herbarium of New South Wales specimen database;
    - Bionet Wildlfie Atlas;
- Interviews with collectors, observers, propagators and scientists of *P. saxicola* (see section 6, acknowledgements);
- Fieldwork at 42 sites (see Appendix 1):
    - Seven sites at which *P. saxicola* had previously been collected;
    - 14 sites in or near the study area that had potentially suitable habitat;
- The scientific and scholarly literature (see section 7, references);
- A GIS map of the study area with layers representing the boundaries, plant community types, development footprint, and the results of flora and fauna surveys, prepared by Biosis Pty Ltd, provided through the Biosis spatial viewer;
- Background information on the study area provided by the Biodiversity and Sustainability Branch of the NSW Department of Planning and Environment;
- My personal knowledge and experience, gained from 40 years as a professional botanist specialising in the systematics and ecology of the Orchidaceae.

6. Acknowledgements

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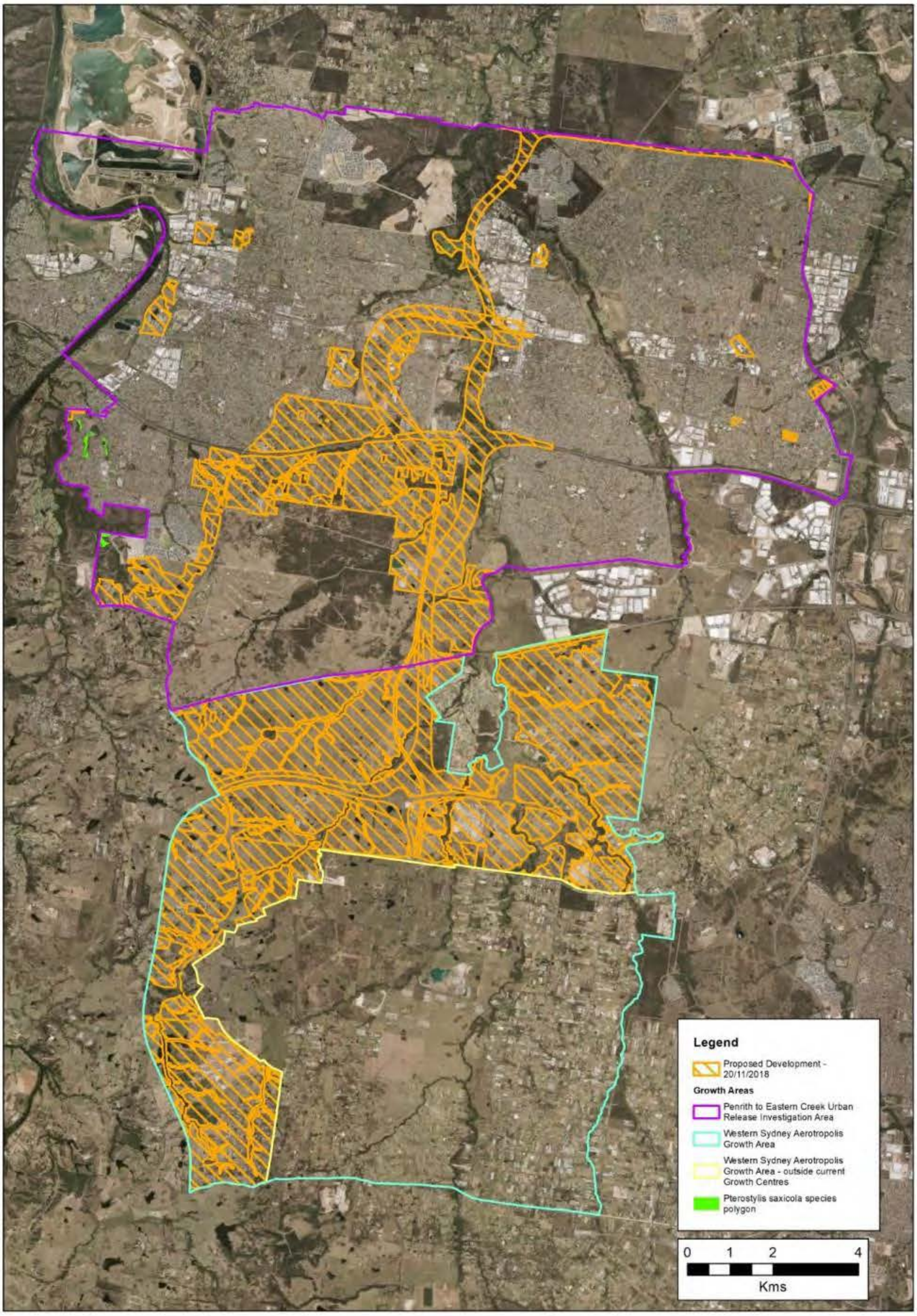

Figure 6. Polygons of suitable habitat for *Pterostylis saxicola* in the Greater Penrith to Eastern Creek Urban Release Investigation Area and Western Sydney Aerotropolis Growth Area.

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8. Appendices

8.1 Appendix 1: Characterisation of habitat at selected sites

The tables on following pages record data that I collected at sites both within and outside the study area. Each site was centred on an arbitrarily selected plant of *Grevillea juniperina* subsp. *juniperina* or *Pterostylis saxicola*, or at an arbitrarily chosen point where the focal taxon was absent from the site. At each site the precise latitude and longitude, altitude, substrate, and soil description, were recorded. Also, at each site all plant species that could be reliably identified were recorded within a radius of 30 metres. Locations at which *Pterostylis saxicola* has been recorded by me and/or others have had their latitudes and longitudes transformed to the nearest 10 minutes.

Site	Location	Latitude	Longitude	Altitude (m)	Substrate
PEC1	Wianamatta Regional Park, 50 m S of Palmyra Ave, Ropes Crossing	33°43'10.7"S	150°46'34.6"E	30	Londonderry Clay
PEC2	Wianamatta Regional Park, S boundary, Ropes Crossing	33°43'52.6"S	150°46'27.5"E	30	Londonderry Clay
PEC3	Tregear Reserve, Tregear	33°44'45.0"S	150°47'15.0"E	25	Quarternary alluvium
PEC4	Ropes Crossing Boulevard 60 m N of Ropes Creek, Ropes Crossing	33°44'22.3"S	150°46'43.2"E	20	Quarternary alluvium
PEC5	Ropes Crossing Boulevard 350 m N of Ropes Creek, Ropes Crossing	33°44'13.0"S	150°46'43.8"E	30	Londonderry Clay
PEC6	Links Road, St Marys	33°44'15.7"S	150°45'57.0"E	20	Londonderry Clay
PEC7	Embankment, east of entrance to Dunheved Golf Course, St Marys	33°44'44.1"S	150°45'52.5"E	25	Londonderry Clay
PEC8	Embankment, south of abandoned railway line, St Marys	33°44'46.8"S	150°46'03.1"E	25	Londonderry Clay
PEC9	Bushland between Christie St and abandoned railway line, St Marys	33°44'48.9"S	150°46'08.4"E	25	Londonderry Clay
PEC10	Abandoned railway land N of 73A Christie St, St Marys	33°44'46.3"S	150°45'59.4"E	25	Londonderry Clay
PEC11	Southern side of abandoned railway station, St Marys	33°44'48.4"S	150°46'14.2"E	30	Londonderry Clay
PEC12	Bush between Dunheved Rd and John Oxley Avenue, Werrington County	33°45'09.1"S	150°44'59.4"E	20	Quarternary alluvium
PEC13	Bush between Dunheved Rd and Dunheved Golf Course, Werrington County	33°44'49.2"S	150°45'08.4"E	30	Quarternary alluvium
PEC14	Sinclair Parade, Jordans Springs	33°42'53.3"S	150°43'44.6"E	50	Bringelly Shale
PEC15	Putland Street, Claremont Meadows	33°46'12.8"S	150°45'21.9"E	30	Bringelly Shale
PEC16	Corner of Caulfield Road and Equestrian Circuit, Claremont Meadows	33°46'42.3"S	150°45'16.8"E	40	Bringelly Shale
PEC17	Caddens Road east, Claremont Meadows	33°46'48.9"S	150°45'36.6"E	25	Quarternary alluvium
PEC18	Heaton Avenue, Claremont Meadows	33°46'49.0"S	150°44'28.7"E	35	Quarternary alluvium
PEC19	Pandorea Street, Claremont Meadows	33°46'55.1"S	150°44'35.4"E	40	Bringelly Shale
PEC20	Pandorea Street, Claremont Meadows	33°46'57.1"S	150°44'35.4"E	40	Bringelly Shale

Appendix 1a: Environmental data for sites visited as part of this study (continued on next page)

Site	Location	Latitude	Longitude	Altitude (m)	Substrate
PEC21	Flinders Lane, Orchard Hills	33°47'21.7"S	150°45'28.7"E	25	Quarternary alluvium
PEC22	Samuel Marsden Reserve, Orchard Hills	33°47'08.5"S	150°45'40.5"E	25	Quarternary alluvium
PEC23	34-64 Wentworth Rd, Orchard Hills (native vegetation on N side of fence)	33°47'56.9"S	150°44'17.1"E	50	Bringelly Shale
PEC24	Opposite 121 Wentworth Rd, Orchard Hills (through the fence plus road verges)	33°47'52.7"S	150°43'45.5"E	60	Bringelly Shale
PEC25	327 Luddenham Rd, Orchard Hills	33°49'43.2"S	150°45'30.7"E	40	Bringelly Shale
PEC26	Plumpton Park, Plumpton	33°45'10.3"S	150°50'05.9"E	50	Bringelly Shale
PEC27	Dr Charles Mackay Reserve, Mt Druitt	33°46'29.8"S	150°49'39.1"E	70	Bringelly Shale
PEC28	Kestrel Crescent Reserve, Erskine Park	33°47'34.6"S	150°48'34.5"E	45	Bringelly Shale
PEC29	Apple Gum Reserve, Glenmore Park	33°47'00.9"S	150°39'51.0"E	40	Ashfield Shale
PEC30	Forest Redgum Reserve, Glenmore Park	33°46'43.5"S	150°39'44.7.0"E	50	Rickabys Creek Gravel
WSA1	Sales Park, Luddenham	33°52'55.5"S	150°41'26.3"E	90	Bringelly Shale
WSA2	Between Cosgrove Creek and Halmstad Boulevard, Luddenham	33°50'58.9"S	150°44'52.6"E	55	Bringelly Shale
PS1	Old Schofield Trail, Scheyville National Park	33°40'S	150°50'E	70	Ashfield Shale
PS2	Simmos Beach Recreation Reserve Macquarie Fields	34°00'S	150°50'E	45	Hawkesbury Sandstone
PS3	Simmos Beach Recreation Reserve Macquarie Fields	34°00'S	150°50'E	43	Hawkesbury Sandstone
PS4	Boronia Rd Reserve, Peter Meadows Creek, Kentlyn	34°00'S	150°50'E	98	Hawkesbury Sandstone
PS5	Amberdale Reserve, Picnic Point	34°00'S	151°00'E	36	Hawkesbury Sandstone
PS6	Hawkesbury High School, Freemans Reach	33°30'S	150°50'E	40	Ashfield Shale
PS7	Mitchell Park Road, Cattai	33°30'S	150°50'E	25	Ashfield Shale-Mittagong Formation-Hawkesbury Sandstone

Appendix 1a (continued): Environmental data for sites visited as part of this study

Site	Soil description	Vegetation structure (canopy)	Vegetation structure (understorey)	PCT (my identification)
PEC1	brown , gravelly clay-loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC2	brown , gravelly clay-loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC3	brown clay loam	dry sclerophyll woodland	grassy understory with scattered shrubs	1800
PEC4	brown clay loam	dry sclerophyll forest	dense shrubby understorey	1800
PEC5	red-brown gravelly loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC6	red-brown gravelly clay	remnant dry sclerophyll woodland	grassy understorey with scattered shrubs	849
PEC7	red-brown gravelly clay	dry sclerophyll forest	grassy, moderately dense shrubby understorey	725
PEC8	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	725
PEC9	red-brown gravelly clay	dry sclerophyll woodland	grassy, shrubby understorey	849
PEC10	red-brown gravelly clay	dry sclerophyll woodland	grassy, shrubby understorey	725
PEC11	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	849
PEC12	ochre brown clay	dry sclerophyll forest	grassy, shrubby understorey	849
PEC13	ochre brown clay	dry sclerophyll forest	grassy, shrubby understorey	849
PEC14	red-brown gravelly clay	dry sclerophyll woodland	moderately dense shrubby understorey	725
PEC15	dark brown loam	dry sclerophyll forest	grassy, moderately dense shrubby understorey	849
PEC16	gravelly dark brown loam	dry sclerophyll forest	sparse shrubby understorey	725
PEC17	brown clay	dry sclerophyll forest	moderately dense shrubby understorey	835
PEC18	brown clay	dry sclerophyll forest	moderately dense shrubby understorey	835
PEC19	dark brown loam	dry sclerophyll forest	moderately dense shrubby understorey	849
PEC20	dark brown loam	dry sclerophyll woodland	dense shrubby understorey	849

Appendix 1a (continued): Environmental data for sites visited as part of this study

Site	Soil description	Vegetation structure (canopy)	Vegetation structure (understorey)	PCT (my identification)
PEC21	grey-brown loam	dry sclerophyll forest	dense shrubby understorey	835
PEC22	pale brown loam	dry sclerophyll forest	sparse shrubby understorey	835
PEC23	Red-brown clay with lateritic pebbles	dry sclerophyll forest	dense shrubby understorey	849
PEC24	mid-brown clay	dry sclerophyll forest	dense shrubby understorey	849
PEC25	mid-brown clay	dry sclerophyll forest	dense shrubby understorey	849
PEC26	grey-brown loam	dry sclerophyll woodland	grassy understory with scattered shrubs	849
PEC27	grey-brown loam	dry sclerophyll woodland to forest	grassy understorey with sparse to dense shrub stratum	849
PEC28	mid-brown loam	dry sclerophyll woodland	grassy understorey with sparse to dense shrub stratum	849
PEC29	mid-brown loam	dry sclerophyll forest	shrubby, grassy understorey	849
PEC30	ochre brown gravelly loam with abundant, large rounded stones	dry sclerophyll forest	Grassy, sparsely to densely shrubby understorey	849
WSA1	mid-brown loam	dry sclerophyll forest	grassy, shrubby understorey	849
WSA2	red-brown gravelly loam	dry sclerophyll woodland	shrubby grassland	725
PS1	brown clay-loam	Dry sclerophyll forest	sparse shrubby understorey	849
PS2	brown sand	Dry sclerophyll woodland	moderately dense shrubby understory	1081
PS3	dark brown humus-rich sand	dry sclerophyll forest	moderately dense shrubby understory	1081
PS4	dark brown humus-rich sand	Dry sclerophyll woodland	moderately dense shrubby understory under dense subcanopy	1081
PS5	dark brown humus-rich sand	Dry sclerophyll woodland	moderately dense shrubby understory	1181
PS6	red-brown clay with lateritic pebbles	dry sclerophyll forest	Grassy, sparsely to densely shrubby understorey	849
PS7	fine, mid-brown sand	dry sclerophyll forest	Grassy, moderately to densely shrubby understorey	1395

Appendix 1a (continued): Environmental data for sites visited as part of this study

Sites >													
Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Acacia binervia	1	0	0	0	0	0	0	1	1	0	1	0	0
Acacia brownii	1	0	0	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	1	0	0	0	0	0	0	0	0	0	0	0	0
Acacia elongata	0	0	0	0	0	0	0	0	0	1	0	0	0
Acacia falcata	1	1	0	0	0	0	1	0	1	0	1	0	0
Acacia fimbriata	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia floribunda	0	1	0	0	0	0	0	0	0	0	0	0	0
Acacia implexa	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia parramattensis	0	1	1	1	0	0	0	0	1	0	1	1	0
Acacia parvipinnula	0	0	0	0	0	0	0	0	1	0	0	0	0
Acacia suaveolens	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia terminalis	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acrotriche divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga australis	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocasuarina littoralis	1	1	0	0	0	0	0	1	1	1	1	0	0
Angophora bakeri	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora costata	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora floribunda	0	0	1	1	0	0	1	1	1	1	1	1	1
Angophora subvelutina	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b: Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >												
Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Aristida ramosa	?	?	?	?	?	?	?	?	?	?	?	?	?
Aristida vagans	?	?	?	?	?	?	?	?	?	?	?	?	?
Arthropodium milleflorum	0	0	0	0	0	0	0	0	0	0	0	0	0
Asperula conferta	0	0	0	0	0	0	0	0	0	0	0	0	0
Astroloma humifusum	0	0	0	0	1	0	0	0	0	0	0	0	0
Astroloma pinifolium	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrostipa verticillata	0	0	0	0	0	0	0	0	0	0	0	0	0
Banksia serrata	0	0	0	0	0	0	0	0	0	0	0	0	0
Banksia spinulosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Billardiera scandens	1	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	0	0	0	0	0	0	0	0	1	0
Brunoniella australis	0	1	0	0	1	0	0	0	1	0	1	1	0
Bursaria spinosa	1	1	1	0	1	1	1	1	1	1	0	1	1
Caesia vittata	0	0	0	0	0	0	0	0	0	0	0	0	0
Calandrinia pickeringii	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistemon salignus	0	0	0	0	0	0	0	0	0	0	0	1	0
Calotis cuneifolia	0	1	0	0	0	0	0	0	0	0	0	0	0
Carex inversa	?	?	?	?	?	?	?	?	?	?	?	?	?
Casuarina glauca	0	0	1	0	1	0	0	0	0	0	0	1	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites >

Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Cheilanthes sieberi	1	0	0	0	0	0	0	0	0	0	0	0	1
Chrysocephalum apiculatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis aristata	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis glycinoides	0	0	1	1	0	0	1	0	0	0	0	0	0
Commelina cyanea	0	0	0	0	0	0	0	0	0	0	0	0	0
Commelina ensifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Corymbia gummifera	0	0	0	0	0	0	0	0	0	0	0	0	0
Crassula sieberiana	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptandra amara	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptandra spinescens	0	0	0	0	1	0	0	0	0	0	0	0	0
Cymbidium suave	0	0	0	0	0	0	0	0	0	0	0	0	0
Daviesia ulicifolia	0	0	0	0	1	0	1	1	0	1	1	0	0
Desmodium brachypodium	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium varians	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella caerulea var. *producta*	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *longifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *stenophylla*	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella revoluta var. *revoluta*	0	0	0	0	0	0	0	0	0	0	0	0	0
Dichondra repens	0	0	0	0	0	0	0	0	1	0	1	1	0
Dichopogon fimbriatus	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >												
Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Dillwynia sieberi	0	1	0	0	1	0	0	1	0	1	1	0	0
Dillwynia tenuifolia	1	0	0	0	0	0	0	0	0	0	0	0	0
Dipodium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea triquetra	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinopogon caespitosus	?	?	?	?	?	?	?	?	?	?	?	?	?
Einadia hastata	0	0	0	0	0	0	0	0	0	0	0	0	0
Entolasia stricta	0	0	0	0	0	0	0	0	0	0	0	0	1
Eremophila debilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriostemon australasius	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypts amplifolia	0	0	0	1	0	0	0	0	0	0	0	0	0
Eucalyptus baueriana	0	0	1	0	0	0	0	0	0	0	0	0	0
Eucalyptus crebra	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus eugenioides	0	0	0	0	0	0	0	0	0	0	0	0	1
Eucalyptus fibrosa	1	1	0	0	1	0	0	0	1	0	1	0	0
Eucalyptus globoidea	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus moluccana	0	1	1	0	1	1	0	0	1	0	0	1	1
Eucalyptus piperita	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sclerophylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sparsifolia	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

Sites
>

Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Eucalyptus tereticornis	0	1	1	0	1	1	0	1	1	0	1	1	1
Exocarpos cupressiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	0	0	0	0	0	0	0	0	0	0	0
Geitonoplesium cymosum	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycine tabacina	0	0	0	0	0	0	0	0	0	0	0	0	0
Glycine clandestina	0	0	0	0	0	0	0	0	0	0	0	0	0
Gompholobium grandiflorum	0	0	0	0	0	0	0	0	0	0	0	0	0
Goodenia hederacea	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea juniperina	1	1	0	0	1	1	1	1	1	1	1	0	0
Grevillea mucronulata	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea sericea	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea sphacelata	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea laevipes	0	0	0	0	0	0	0	0	0	0	0	0	0
Hakea sericea	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardenbergia violacea	0	0	1	1	0	1	1	0	0	0	1	0	0
Hibbertia diffusa	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypoxis hygrometrica	0	0	0	0	0	0	0	0	0	0	0	0	0
Imperata cylindrica	0	0	0	0	0	0	0	0	0	0	0	0	0
Indigofera australis	0	0	0	1	0	0	0	0	0	0	1	0	0
Isopogon anemonifolius	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonia scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study (continued on next page)

	Sites >												
Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Kunzea ambigua	1	0	0	0	0	0	0	0	0	0	0	0	0
Lagenifera stipitata	1	0	0	0	0	0	0	0	0	0	0	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Laxmannia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidosperma laterale	1	1	0	0	1	1	0	0	0	0	0	0	0
Leptospermum parvifolium	0	0	1	0	0	0	0	0	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum marginale	0	0	0	0	0	0	0	0	0	0	0	0	0
Lissanthe strigosa	1	0	0	0	1	0	0	1	1	0	0	0	0
Lobelia purpurascens	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomandra filiformis	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomandra longifolia	0	0	1	0	0	0	0	0	0	0	0	0	0
Lomandra multiflora	0	0	0	0	0	0	0	1	0	0	0	0	0
Lomandra obliqua	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus australis	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrozamia spiralis	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca decora	1	1	1	0	0	1	0	1	0	0	0	1	0
Melaleuca linariifolia	0	0	0	1	0	0	0	0	0	0	0	0	0
Melaleuca nodosa	1	0	0	0	1	0	0	0	0	0	0	0	0
Melaleuca styphelioides	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Melia azedarach	0	0	0	0	0	0	0	0	0	0	0	0	0
Microlaena stipoides	?	?	?	?	?	?	?	?	?	?	?	?	?
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0
Murdannia graminea	0	0	0	0	0	0	0	0	0	0	0	0	0
Notelaea longifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia aspera	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia diphylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Oplismenus imbecilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis perennans	0	0	0	0	0	0	0	0	0	0	0	0	0
Ozothamnus diosmifolius	1	1	0	0	0	0	0	1	0	0	0	0	0
Parsonsia straminea	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia linearis	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrophile sessilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus virgatus	0	0	0	0	0	0	0	0	0	0	0	0	0
Pimelea glauca	1	0	0	0	0	0	0	0	0	0	0	0	0
Pittosporum undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago debilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago gaudichaudii	0	0	0	0	0	0	0	0	0	0	0	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC1	PEC2	PEC3	PEC4	PEC5	PEC6	PEC7	PEC8	PEC9	PEC10	PEC11	PEC12	PEC13
Pteridium esculentum	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterostylis saxicola	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea microphylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea parviflora	0	1	0	0	0	0	0	1	0	0	0	0	0
Ranunculus lappaceus	0	0	0	0	0	0	0	0	0	0	0	0	0
Ricinocarpos pinifolius	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylidium laricifolium	0	0	0	0	0	0	0	0	0	0	0	0	0
Themeda triandra	0	0	0	0	0	0	0	0	0	0	0	0	1
Tricoryne elatior	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola hederacea	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahlenbergia communis	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahlenbergia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea concava	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea media	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea minor	1	0	0	0	0	0	0	0	0	0	0	0	0
Xanthosia pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Acacia binervia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia brownii	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	1	1	1	0	1	1	0	0	0	0	1	1
Acacia elongata	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia falcata	0	0	0	0	0	1	1	0	0	0	0	0	0
Acacia fimbriata	0	0	0	0	0	0	0	0	0	0	0	0	1
Acacia floribunda	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia implexa	0	0	1	0	0	0	0	0	0	0	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia parramattensis	1	1	0	1	1	1	0	0	0	0	0	0	0
Acacia parvipinnula	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia suaveolens	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia terminalis	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acrotriche divaricata	0	0	0	0	0	0	0	0	0	0	0	0	0
Ajuga australis	0	0	0	0	0	0	0	0	0	0	1	0	0
Allocasuarina littoralis	0	0	0	0	0	0	0	1	0	0	0	0	0
Angophora bakeri	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora costata	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora floribunda	0	0	0	1	0	0	1	0	0	0	0	0	0
Angophora subvelutina	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Aristida ramosa	?	?	?	?	?	?	?	0	0	0	0	0	0
Aristida vagans	?	?	?	?	?	?	?	0	0	0	0	0	1
Arthropodium milleflorum	0	1	1	0	0	0	0	0	0	1	0	0	1
Asperula conferta	0	0	0	0	0	0	0	1	0	0	1	0	0
Astroloma humifusum	1	0	0	0	0	0	0	0	0	0	0	0	0
Astroloma pinifolium	0	0	0	0	0	0	0	0	0	0	0	0	0
Austrostipa verticillata	0	0	0	0	0	0	0	1	0	0	0	0	0
Banksia serrata	0	0	0	0	0	0	0	0	0	0	0	0	0
Banksia spinulosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Billardiera scandens	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	0	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	0	0	0
Breynia oblongifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Brunoniella australis	0	1	1	0	0	1	1	1	1	1	0	1	1
Bursaria spinosa	1	1	1	1	1	1	1	1	1	1	1	1	1
Caesia vittata	0	0	0	0	0	0	0	0	0	0	1	0	0
Calandrinia pickeringii	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistemon salignus	0	0	0	1	0	0	0	0	0	0	0	0	0
Calotis cuneifolia	0	1	1	0	0	0	0	0	0	0	0	0	1
Carex inversa	?	?	?	?	?	?	?	0	0	0	0	0	0
Casuarina glauca	0	0	0	1	0	1	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >													
Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Cheilanthes sieberi	0	1	1	0	0	1	1	1	1	1	0	1	0
Chrysocephalum apiculatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis aristata	0	0	0	0	0	0	0	0	0	0	0	0	0
Clematis glycinoides	0	0	0	0	0	0	0	0	0	0	0	0	0
Commelina cyanea	0	0	0	0	0	0	0	0	0	0	0	0	0
Commelina ensifolia	0	0	1	0	0	0	0	0	1	0	0	0	1
Corymbia gummifera	0	0	0	0	0	0	0	0	0	0	0	0	0
Crassula sieberiana	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptandra amara	0	0	0	0	0	1	0	0	0	0	0	0	0
Cryptandra spinescens	0	0	1	0	0	0	0	0	0	0	0	0	0
Cymbidium suave	0	0	0	0	0	0	0	0	0	0	0	0	0
Daviesia ulicifolia	0	1	1	0	0	0	0	0	0	0	0	1	0
Desmodium brachypodium	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium varians	0	0	0	0	0	0	0	0	0	1	0	0	0
Dianella caerulea var. *producta*	0	0	0	0	1	0	0	0	0	0	0	0	0
Dianella longifolia var. *longifolia*	0	0	0	0	0	0	0	0	0	0	0	0	0
Dianella longifolia var. *stenophylla*	0	0	0	0	0	0	0	0	0	1	0	0	1
Dianella revoluta var. *revoluta*	0	0	1	0	0	0	0	0	0	0	0	0	1
Dichondra repens	0	1	0	0	0	1	1	1	1	1	0	0	1
Dichopogon fimbriatus	0	0	0	0	0	0	0	1	1	0	0	0	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Dillwynia sieberi	1	0	0	0	0	0	0	0	0	0	0	1	1
Dillwynia tenuifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Dipodium punctatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea triquetra	0	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. cuneata	1	0	0	0	0	0	0	0	0	0	0	0	0
Echinopogon caespitosus	?	?	?	?	?	?	?	0	0	0	0	0	0
Einadia hastata	0	0	1	0	0	0	0	0	0	0	0	1	0
Entolasia stricta	0	0	1	0	0	0	0	0	0	0	0	0	0
Eremophila debilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriostemon australasius	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalypts amplifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus baueriana	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus crebra	0	0	0	0	0	1	0	0	0	0	0	0	0
Eucalyptus eugenioides	0	0	1	0	0	1	0	0	0	0	0	0	0
Eucalyptus fibrosa	1	1	1	0	0	0	0	0	0	0	0	0	1
Eucalyptus globoidea	0	0	0	1	0	0	0	0	0	0	0	0	0
Eucalyptus moluccana	1	1	1	0	1	1	1	1	0	1	1	0	1
Eucalyptus piperita	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sclerophylla	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus sparsifolia	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >													
Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Kunzea ambigua	0	0	0	0	0	0	0	0	0	0	0	0	0
Lagenifera stipitata	0	0	0	0	0	0	0	0	0	0	0	0	0
Lambertia formosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Laxmannia gracilis	0	0	1	0	0	0	0	0	0	0	0	0	0
Lepidosperma laterale	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptospermum parvifolium	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum marginale	0	0	0	0	0	0	0	0	0	1	0	0	0
Lissanthe strigosa	0	0	1	0	0	0	0	0	0	0	0	0	0
Lobelia purpurascens	0	1	0	0	0	1	0	1	0	0	0	0	0
Lomandra filiformis	0	0	0	0	0	0	0	1	0	0	0	1	0
Lomandra longifolia	0	0	1	1	0	0	0	0	0	0	0	0	0
Lomandra multiflora	0	0	0	0	1	1	0	0	0	0	0	0	0
Lomandra obliqua	0	0	0	0	0	0	0	0	0	0	0	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotus australis	0	0	0	0	0	0	0	0	0	0	1	0	0
Macrozamia spiralis	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca decora	0	1	0	0	0	1	0	0	0	0	0	1	0
Melaleuca linariifolia	0	0	0	1	0	0	0	0	0	0	0	0	0
Melaleuca nodosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca styphelioides	0	0	0	1	0	0	0	0	0	0	0	0	1

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Melia azedarach	0	0	0	0	0	0	0	0	0	0	1	0	0
Microlaena stipoides	?	?	?	?	?	?	?	0	0	0	0	0	1
Monotoca scoparia	0	0	0	0	0	0	0	0	0	0	0	0	0
Murdannia graminea	0	0	0	0	0	0	0	0	0	0	0	0	1
Notelaea longifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia aspera	0	0	0	0	0	0	0	0	0	0	0	0	0
Opercularia diphylla	0	0	0	0	0	0	0	0	0	0	0	0	1
Oplismenus imbecilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Oxalis perennans	0	0	0	0	1	1	0	0	0	0	0	0	0
Ozothamnus diosmifolius	1	1	1	1	0	0	0	0	1	0	0	0	0
Parsonsia straminea	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia levis	0	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia linearis	0	0	0	0	0	0	0	0	0	0	0	0	0
Petrophile sessilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus virgatus	0	0	0	0	0	0	0	0	0	0	0	0	1
Pimelea glauca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittosporum undulatum	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago debilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago gaudichaudii	0	0	0	0	0	0	0	0	0	1	0	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC14	PEC15	PEC16	PEC17	PEC18	PEC19	PEC20	PEC21	PEC22	PEC23	PEC24	PEC25	PEC26
Pteridium esculentum	0	0	0	0	0	0	0	0	0	0	0	0	0
Pterostylis saxicola	0	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea microphylla	0	0	0	0	0	0	0	0	0	0	0	0	1
Pultenaea parviflora	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus lappaceus	0	0	0	0	0	0	0	0	0	0	1	0	0
Ricinocarpos pinifolius	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum prinophyllum	0	0	0	1	0	0	0	0	1	0	0	0	0
Stylidium laricifolium	0	0	0	0	0	0	0	0	0	0	0	0	0
Themeda triandra	0	0	0	0	1	0	0	0	0	1	0	0	1
Tricoryne elatior	0	0	0	0	0	0	0	0	0	0	0	0	0
Viola hederacea	0	0	0	0	0	0	0	1	0	0	0	0	0
Wahlenbergia communis	0	0	0	0	0	0	0	0	0	0	1	0	0
Wahlenbergia gracilis	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea concava	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea media	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea minor	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthosia pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Acacia binervia	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia brownii	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia decurrens	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia elongata	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia falcata	1	0	1	1	0	0	0	0	0	0	0	0	0
Acacia fimbriata	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia floribunda	0	0	0	0	0	0	0	0	0	0	0	0	1
Acacia implexa	1	0	0	1	1	0	0	0	0	1	0	0	0
Acacia linifolia	0	0	0	0	0	0	0	1	1	0	1	0	0
Acacia parramattensis	0	0	1	1	0	0	0	0	0	0	0	0	0
Acacia parvipinnula	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia suaveolens	0	0	0	0	0	0	0	0	0	0	1	0	0
Acacia terminalis	0	0	0	0	0	0	0	1	1	0	1	0	0
Acacia ulicifolia	0	0	0	0	0	0	0	0	1	0	1	0	0
Acrotriche divaricata	0	0	0	0	0	0	0	0	0	1	0	0	0
Ajuga australis	0	0	0	0	0	0	?	0	?	0	0	0	0
Allocasuarina littoralis	0	0	1	1	0	1	0	0	0	1	1	0	1
Angophora bakeri	0	0	0	0	0	0	0	1	1	1	1	0	1
Angophora costata	0	0	0	0	0	0	0	0	0	0	1	0	0
Angophora floribunda	0	0	0	0	0	0	0	0	0	0	0	0	0
Angophora subvelutina	0	0	1	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Aristida ramosa	0	0	1	1	0	0	?	?	?	?	?	1	0
Aristida vagans	1	0	1	1	1	0	?	?	?	?	?	1	0
Arthropodium milleflorum	0	0	0	0	1	0	0	0	0	0	0	1	0
Asperula conferta	1	0	0	0	1	0	?	?	?	?	?	0	0
Astroloma humifusum	0	0	0	0	0	1	0	0	0	0	0	0	0
Astroloma pinifolium	0	0	0	0	0	0	0	0	0	0	1	0	0
Austrostipa verticillata	0	1	0	0	0	0	?	?	?	?	?	0	0
Banksia serrata	0	0	0	0	0	0	0	0	0	0	1	0	0
Banksia spinulosa	0	0	0	0	0	0	0	1	1	1	1	0	0
Billardiera scandens	0	0	0	0	0	0	0	0	0	0	0	0	0
Bossiaea prostrata	1	0	0	0	0	0	0	0	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	1	0	0	0	0
Breynia oblongifolia	0	0	0	1	0	0	1	0	0	0	0	1	0
Brunoniella australis	1	1	1	1	1	0	1	0	0	0	0	1`	0
Bursaria spinosa	1	1	1	1	1	1	1	0	0	0	0	1	1
Caesia vittata	0	0	1	0	1	0	?	?	?	?	?	0	0
Calandrinia pickeringii	0	0	0	0	0	0	?	?	?	?	?	0	1
Callistemon salignus	0	0	0	0	0	0	0	0	0	0	0	0	0
Calotis cuneifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Carex inversa	0	0	1	0	1	0	?	?	?	?	?	0	0
Casuarina glauca	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Cheilanthes sieberi	1	0	1	1	1	0	1	1	0	1	0	1	1
Chrysocephalum apiculatum	0	0	1	0	0	0	?	?	?	?	?	0	0
Clematis aristata	0	1	0	0	0	0	0	0	0	0	0	0	?
Clematis glycinoides	0	0	0	1	0	0	0	0	0	0	0	0	?
Commelina cyanea	0	0	0	0	0	0	?	?	?	?	?	0	1
Commelina ensifolia	0	1	1	1	0	0	?	?	?	?	?	1	0
Corymbia gummifera	0	0	0	0	0	0	0	0	0	1	1	0	0
Crassula sieberiana	0	0	0	0	0	0	?	?	?	?	?	0	1
Cryptandra amara	0	0	0	0	0	0	0	0	0	0	0	0	0
Cryptandra spinescens	0	0	0	0	0	0	0	0	0	0	0	0	0
Cymbidium suave	0	0	0	0	0	0	0	0	0	0	0	0	1
Daviesia ulicifolia	0	0	1	0	0	0	1	0	0	0	0	1	0
Desmodium brachypodium	1	0	0	0	0	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	0	0	0	0	0	0	0	0	0	0	1	0
Desmodium varians	0	0	0	0	0	0	?	?	?	?	?	0	0
Dianella caerulea var. *producta*	0	0	0	0	0	0	?	?	?	?	?	0	0
Dianella longifolia var. *longifolia*	0	0	0	0	1	0	?	?	?	?	?	0	0
Dianella longifolia var. *stenophylla*	1	0	1	1	0	0	?	?	?	?	?	0	1
Dianella revoluta var. *revoluta*	0	0	0	0	0	0	?	?	?	?	?	0	0
Dichondra repens	1	1	1	0	1	0	1	0	0	0	0	1	1
Dichopogon fimbriatus	0	0	0	0	0	0	?	?	?	?	?	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Dillwynia sieberi	1	0	0	0	0	0	1	0	0	0	0	0	0
Dillwynia tenuifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Dipodium punctatum	0	0	0	1	0	0	?	?	?	?	?	0	0
Dodonaea triquetra	0	0	0	0	0	0	0	0	0	0	1	0	0
Dodonaea viscosa subsp. cuneata	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinopogon caespitosus	0	0	0	1	0	0	?	?	?	?	?	0	0
Einadia hastata	0	1	1	0	0	0	?	?	?	?	?	1	1
Entolasia stricta	0	0	0	0	0	0	0	0	0	0	0	0	1
Eremophila debilis	1	0	0	0	0	0	1	0	0	0	0	0	0
Eriostemon australasius	0	0	0	0	0	0	0	0	0	1	0	0	0
Eucalypts amplifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus baueriana	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus crebra	1	0	0	1	1	0	1	0	0	0	0	1	0
Eucalyptus eugenioides	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus fibrosa	1	1	0	1	0	0	0	0	0	0	0	0	0
Eucalyptus globoidea	0	0	0	1	0	0	0	0	0	0	0	0	1
Eucalyptus moluccana	0	1	1	0	1	0	1	0	0	0	0	0	0
Eucalyptus piperita	0	0	0	0	0	0	0	0	0	0	1	0	0
Eucalyptus punctata	0	0	0	0	0	0	0	0	1	1	1	0	1
Eucalyptus sclerophylla	0	0	0	0	0	0	0	1	1	1	0	0	0
Eucalyptus sparsifolia	0	0	0	0	0	0	0	1	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites >

Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Eucalyptus tereticornis	1	1	1	1	1	0	0	0	0	0	0	1	1
Exocarpos cupressiformis	0	0	0	0	0	0	1	0	0	0	1	0	0
Exocarpos strictus	0	0	1	0	0	0	0	0	1	1	1	0	0
Geitonoplesium cymosum	0	0	0	0	1	0	0	0	0	0	0	0	0
Glycine tabacina	1	1	1	1	1	0	0	0	0	0	0	1	1
Glycine clandestina	1	0	1	1	0	0	0	0	0	0	0	0	1
Gompholobium grandiflorum	0	0	1	0	0	0	0	1	0	0	0	0	0
Goodenia hederacea	1	0	1	1	0	0	0	0	1	0	0	1	1
Grevillea juniperina	1	1	0	0	0	0	0	0	0	0	0	0	0
Grevillea mucronulata	0	0	0	0	0	0	0	0	0	0	0	0	0
Grevillea sericea	0	0	0	0	0	0	0	0	0	0	1	0	0
Grevillea sphacelata	0	0	0	0	0	0	0	1	1	0	0	0	0
Hakea laevipes	0	0	0	0	0	0	0	1	1	1	0	0	0
Hakea sericea	0	0	0	0	0	1	0	1	1	1	1	0	0
Hardenbergia violacea	1	0	1	0	0	0	1	0	0	0	0	1	0
Hibbertia diffusa	0	0	1	1	0	0	?	?	?	?	?	1	1
Hypoxis hygrometrica	1	0	0	0	0	0	?	?	?	?	?	0	0
Imperata cylindrica	0	0	0	0	0	0	0	0	0	0	0	0	1
Indigofera australis	0	0	0	0	1	0	0	0	0	0	0	0	0
Isopogon anemonifolius	0	0	0	0	0	0	0	1	1	1	0	0	0
Jacksonia scoparia	0	0	0	0	0	0	0	0	0	1	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

	Sites >												
Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Kunzea ambigua	0	0	0	0	0	1	0	1	1	1	1	0	1
Lagenifera stipitata	0	0	0	0	0	0	0	0	0	0	0	1	1
Lambertia formosa	0	0	0	0	0	0	0	1	1	0	1	0	0
Laxmannia gracilis	1	0	0	0	0	0	?	?	?	?	?	0	1
Lepidosperma laterale	0	0	0	0	0	0	0	0	0	0	0	0	1
Leptospermum parvifolium	0	0	0	0	0	0	0	1	0	0	0	0	0
Leptospermum trinervium	0	0	0	0	0	0	0	1	1	1	1	0	1
Linum marginale	0	0	0	0	0	0	?	?	?	?	?	0	0
Lissanthe strigosa	0	0	0	0	0	0	0	0	0	1	0	0	0
Lobelia purpurascens	0	1	0	1	1	0	?	?	?	?	?	1	1
Lomandra filiformis	1	0	0	0	0	0	?	?	?	?	?	0	0
Lomandra longifolia	0	0	1	0	0	0	0	0	0	0	1	0	1
Lomandra multiflora	1	0	0	0	0	0	0	0	0	0	0	0	1
Lomandra obliqua	0	0	0	0	0	0	0	1	1	1	1	0	0
Lomatia silaifolia	0	0	0	0	0	0	0	0	0	0	1	0	0
Lotus australis	0	0	0	0	0	0	?	?	?	?	?	0	0
Macrozamia spiralis	0	0	0	0	0	0	0	0	0	1	0	0	0
Melaleuca decora	0	1	0	0	0	1	0	0	0	0	0	0	0
Melaleuca linariifolia	0	0	0	0	0	0	0	0	0	0	0	0	0
Melaleuca nodosa	0	0	0	0	0	0	0	0	1	0	1	0	0
Melaleuca styphelioides	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites
>

Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Melia azedarach	0	0	1	1	0	0	0	0	0	0	0	0	0
Microlaena stipoides	0	0	1	1	0	0	?	?	?	?	?	1	1
Monotoca scoparia	0	0	0	0	0	0	0	0	1	1	1	0	0
Murdannia graminea	0	0	0	0	0	0	?	?	?	?	?	0	0
Notelaea longifolia	0	0	0	0	0	0	0	0	0	0	1	0	0
Opercularia aspera	0	0	0	0	1	0	?	?	?	?	?	0	0
Opercularia diphylla	1	0	1	1	0	0	?	?	?	?	?	1	1
Oplismenus imbecilis	0	0	0	0	0	0	?	?	?	?	0	0	1
Oxalis perennans	0	0	0	1	1	0	?	?	?	?	?	0	1
Ozothamnus diosmifolius	0	0	0	1	0	0	1	0	1	0	0	1	0
Parsonsia straminea	0	0	0	0	0	0	0	0	0	0	0	0	1
Persoonia levis	0	0	0	0	0	0	0	1	1	1	1	0	0
Persoonia linearis	0	0	0	0	0	0	0	0	1	1	1	0	0
Petrophile sessilis	0	0	0	0	0	0	0	1	0	1	1	0	0
Phyllanthus virgatus	0	0	0	0	0	0	?	?	?	?	?	0	0
Pimelea glauca	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittosporum undulatum	0	0	0	0	0	0	0	0	0	0	1	0	0
Plantago debilis	0	0	0	0	0	0	?	?	?	?	?	1	0
Plantago gaudichaudii	0	0	0	0	0	0	?	?	?	?	?	0	0
Plectranthus sp.	0	0	0	0	0	0	0	0	0	0	0	1	0
Polygala japonica	0	0	0	0	1	0	?	?	?	?	?	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

Sites
>

Associated species	PEC27	PEC28	PEC29	PEC30	WSA1	WSA2	PS1	PS2	PS3	PS4	PS5	PS6	PS7
Pteridium esculentum	0	0	0	0	0	0	0	0	0	0	1	0	0
Pterostylis saxicola	0	0	0	0	0	0	1	1	1	1	1	1	1
Pultenaea microphylla	1	0	0	0	0	0	0	0	0	0	0	0	0
Pultenaea parviflora	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus lappaceus	0	0	0	0	0	0	?	?	?	?	?	0	0
Ricinocarpos pinifolius	0	0	0	0	0	0	0	0	0	0	1	0	0
Solanum prinophyllum	0	1	0	0	1	0	1	0	0	0	0	1	1
Stylidium laricifolium	0	0	0	0	0	0	0	0	0	1	0	0	0
Themeda triandra	0	0	1	1	1	0	0	0	0	0	0	1	1
Tricoryne elatior	1	1	1	1	1	1	?	?	?	?	?	1	1
Viola hederacea	0	0	0	0	0	0	?	?	?	?	?	0	1
Wahlenbergia communis	1	0	0	0	0	0	?	?	?	?	?	0	0
Wahlenbergia gracilis	0	1	0	0	0	0	?	?	?	?	?	0	0
Xanthorrhoea concava	0	0	0	0	0	0	0	0	0	0	1	0	0
Xanthorrhoea media	0	0	0	0	0	0	0	1	1	0	1	0	0
Xanthorrhoea minor	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthosia pilosa	0	0	0	0	0	0	0	0	0	0	1	0	0

Appendix 1b (continued from previous page): Data on presence (1) or absence (0) of associated species for sites characterised as part of this study.

8.2 Appendix 2: Peter Weston's curriculum vitae

Personal details

Name: Peter Henry Weston.

Address: 18 Lyle Avenue, Lindfield, New South Wales 2070, Australia.

Date and place of birth: 22 October 1956, Lower Hutt, New Zealand.

Immediate family: wife (Susan) and three children (Timothy 34, Caitlin 32, Nicholas 29).

Nationality: Australian.

Interests: soccer, reading, guitar, orchid growing, cross-country skiing, bush walking.

Academic Qualifications

i) **B.Sc.** (first class honours; equal first in order of merit) School of Biological Sciences, University of Sydney; 1975-78, conferred 7 April 1979.
Thesis title: "The evolution and classification of *Boronia* Sm."

ii) **Ph.D.**, School of Biological Sciences, University of Sydney, 1979-83; conferred 18 May 1985.
Thesis title: "Systematics and biogeography of the Persooniinae (Proteaceae)".

Awards, Fellowships and Scholarships

2014	Nancy Burbidge Medal (awarded by the Australasian Systematic Botany Society to a person who has made a longstanding and significant contribution to Australasian systematic botany. It is the foremost award that can be conferred by ASBS).
2014	Australian Biological Resources Study-sponsored Winston Churchill Fellowship for an established career researcher in taxonomy.
2009	Grady L. Webster Structural Botany Publication Award for 2008 and 2009 from the Botanical Society of America. The BSA component of the award (it is awarded in alternate years by the BSA and the American Society of Plant Taxonomists) recognizes the most outstanding paper published in the *American Journal of Botany* in the field of structural and developmental botany (i.e., anatomy and morphology) over a two-year period. It was awarded to Gregory J. Jordan, Peter H. Weston, Raymond J. Carpenter, Rebecca A. Dillon and Timothy J. Brodribb for: "The evolutionary relations of sunken, covered, and encrypted stomata to dry habitats in Proteaceae," American Journal of Botany, Volume 95, Issue 5; May 2008.
2006	Carrick Award for Australian University Teaching from the Australian Learning and Teaching Council (one of five members of a teaching team from the University of New England cited for Outstanding Contributions to Student Learning).
1992-93	Posting to Royal Botanic Gardens, Kew, as Australian Botanical Liaison Officer.
1982	Charles Gilbert Heydon Travelling Fellowship for the biological sciences (not taken up).
1980-82	University of Sydney Postgraduate Scholarship.

1979-82	Commonwealth Postgraduate Award.
1977	G.S. Caird Scholarship for Third Year Botany, University of Sydney.
1976	Slade Prize for Practical Plant Biology, University of Sydney.

Employment

Present Position: Honorary Research Associate, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney and independent botanical consultant.

Previous positions held:
2008-2016 Senior Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

2000-2008 Principal Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1994-2000 Senior Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1989-1994 Research Scientist, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1982-1989 Scientific Officer, National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust, Sydney.

1979-82 Part-time demonstrator, School of Biological Sciences, University of Sydney.

Adjunct and visiting university appointments

2013-	Adjunct Associate Professor, La Trobe University.
2011-2016	Adjunct Associate Professor, University of New South Wales.
2006	Visiting Lecturer, Rhodes University, Grahamstown, South Africa.
2004-2009	Adjunct Associate Professor, University of New England.
2000-2004	Adjunct Senior Lecturer, University of New England.

Administrative/management experience

2009	Acting Manager Plant Diversity
2002-2003	Member, Plant Diversity Research Program Leaders Committee
1998-99	Systematics Liaison Officer
1997-98	Member RBGS Market testing working party
1997	Member, RBGS advisory committee for restructuring senior management
1990-91	Systematics Co-ordinator
1996-98	Member, RBGS Joint Consultative Committee

Membership of Learned Societies

1996-	Society of Australian Systematic Biologists
1984-	Willi Hennig Society (Elected Fellow, 1992-, Council member, 1998-2000)
1979-	Society of Systematic Biologists (member, Editorial Board 1993-95)

1978- Australasian Systematic Botany Society (formerly Australian Systematic Botany Society: President, 2009-2012, Vice President, 2008-2009, Chairman, Hansjörg Eichler Research Fund Committee, 1998-2002, Council member, 1996-2002)

Membership of External Committees

2015- Financial Grants Standing Committee (formerly the Grants Policy Standing Committee) of the Australasian Systematic Botany Society

2012-2013 Conference Organising Committee of *Systematics Without Borders*, a joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, University of Sydney (Chairman)

2011- Editorial Board, *Phytotaxa*

2008-2009 Corresponding Member, Editorial Advisory Committee, *Australian Systematic Botany*

2006-2014 Ira Butler Memorial Trophy Committee (a joint committee of the Australasian Native Orchid Society and the Orchid Society of New South Wales) (Chairman)

2004- Editorial Advisory Board, *Kew Bulletin*

2001-2006 Panel of Judges, Eureka Prize for Biodiversity Research

2000-2012 Bushland Management Advisory Committee, Lane Cove Council (Chairman, 2008-2010)

1999-2004 Editorial Advisory Committee, *Australian Systematic Botany*

Spoken presentations at conferences (not including presentations delivered by others)

2015 Building Our Botanical Capital, annual conference of the Australasian Systematic Botany Society: “A database of variation in floral characters in the Proteaceae, and implications for key questions in floral evolution”.

2014 Next Generation Systematics, annual conference of the Australasian Systematic Botany Society: Nancy Burbidge Memorial Lecture: “Problems and progress in plant systematics since Nancy Burbidge”

2013 Genetics Society of Australasia conference, Sydney *Genetics in the Harbour City*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2013 Joint conference of the Australasian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation, Sydney, *Systematics Without Borders*: “Molecular phylogeny of the subtribe Hakeinae (Green Plants: Proteaceae tribe Embothrieae) and its implications”.

2012 Australasian Systematic Botany Society conference, Perth, *Local knowledge, global delivery*: “Contested, Uncontested and Potentially Controversial Taxonomic Changes in the Proteaceae: How Do They Differ?”

2011 37th annual conference of the South African Association of Botanists, *Plants in a Changing World* and 9th conference of the South African Society of Systematic Biologists, *Biodiversity Matters*; plenary address: “Cenozoic environmental change and the systematics of southern hemisphere plants”

2011 XVIII International Botanical Congress, Melbourne: “Floral evolution in animal-pollinated Australian angiosperm clades: patterns and potential explanations”.

2010 VI Southern Connection Congress, Bariloche: “Cladistic biogeography, molecular dating, fossils and the Proteaceae”

2010 VI Southern Connection Congress, Bariloche: “Diversification of the Proteaceae in Mediterranean hotspots of the Southern Hemisphere and in tropical rainforests”

2010 Australian Systematic Botany Society conference *Systematic Botany Across the Ditch: Links Between Australia and New Zealand*; Keynote address: "Cenozoic environmental change and the systematics of southern hemisphere plants"
1999 XVI International Botanical Congress, Saint Louis: "Historical biogeography of Proteaceae".
1997 II Southern Connection Congress, Valdivia: "Cladistic biogeography of a key woody group: Proteaceae".
1997 First Biennial International Conference of the Systematic Association, Oxford: "Rolf Sattler's Plant Morphology and Cladistic Analysis".
1996 *An International Symposium on the Biology of Proteaceae*, Melbourne: "ITS squence variation in the Proteaceae and what it tells us about phylogeny".
1993 Joint conference of The Systematics Associations and The Linnean Society on *Models in Phylogeny Reconstruction*, London: "Direct methods for polarising character transformation series".
1990 IXth meeting of the Willi Hennig Society, Canberra: "Transoceanic cladistic patterns in the Proteaceae".
2003 The Third International Conference on *the Comparative Biology of the Monocotyledons*, Ontario: "Co-evolution of *Chiloglottis* (Orchidaceae) and its Thynnine wasp pollinators".
2005 XVII International Botanical Congress, Vienna: "Food is good but sex is better: the evolution of deceptive pollination in the tribe Diurideae (Orchidaceae)".
2006 Australian Systematic Botany Society conference, Cairns, *Plant Diversity in the Tropics*: "A new suprageneric classification of the Proteaceae".
2007 5th Southern Connection Congress, Adelaide: "'I'm not dead yet' – Gondwana (the Proteaceae are at least partially congruent with Gondwanic fragmentation)".
1989 Australian Systematic Botany Society symposium, on *Gondwanan Elements in the Australian Flora*, Sydney: "Transpacific cladistic patterns in the Proteaceae and Elaeocarpaceae".
1988 Symposium on *Panbiogeography of New Zealand*, Wellington: "Problems with the statistical testing of panbiogeographic hypotheses".
1985 Australian Flora Foundation Symposium on *Waratahs*, Canberra: "Drifting waratahs or continents?"
1984 Australian Systematic Botany Society symposium on *Cladistics, Systematics and Phylogeny*, Canberra: "A reappraisal of Nelson's direct method of character analysis".

Refereeing manuscripts, grant applications, reports and examining postgraduate theses (last five years)

2018: *Candollea*; *Flora of the Hunter Region*; *Journal of Biogeography.*
2017: *Australian Systematic Botany*; *Evolution*; *New Zealand Journal of Botany*; *Nuytsia*; *South African Journal of Botany.*
2016: *Australian Systematic Botany*; *Botanical Journal of the Linnean Society*, *National Research Foundation* (South Africa).
2015: *American Journal of Botany*; Australian Research Council (4); *Australian Systematic Botany*; *Muelleria*; *Nuytsia*; *Phytotaxa*; *PLOS One*; *Telopea* (6).
2014: Australian Research Council (3); *Australian Systematic Botany* (2); *Cunninghamia*; *Journal of Biogeography* (2); *Muelleria*; National Research Foundation (South Africa); *Orchadian*; *Perspectives in Plant Ecology, Evolution and Systematics*; *Plant Systematics and Evolution*; *Telopea* (3).

Research

My research has been in the theoretical and practical aspects of systematic botany, with emphasis on the theory and practice of phylogenetic analysis, and the broader uses to which phylogenetic knowledge may be applied. I have phylogenetically analysed groups in the plant families Proteaceae, Fabaceae, Orchidaceae, Rutaceae, Winteraceae and Lauraceae, contributed to more general analyses of angiosperm phylogeny, and used the results of these analyses to improve biological classification and to test theories of historical biogeography, trait evolution, co-evolution and adaptation. I have earned an international reputation for my contributions to both theoretical and empirical developments in this field.

Herbarium curation and collections

My curatorial responsibilities at the National Herbarium of New South Wales have included the families Rutaceae (1982-1998), Proteaceae (1982-2016), Orchidaceae (1986-2016) and Fabaceae subfamily Faboideae (1986-2016). I have collected plant specimens (mostly angiosperms) in Australia, England, New Zealand, New Caledonia, Chile, South Africa, and Argentina, mostly for the herbarium and living collections of the Royal Botanic Gardens and Domain Trust, Sydney. Duplicates of my collections have been distributed to over 20 herbaria in 8 different countries.

Teaching

I have been actively involved in the preparation and teaching of four third year undergraduate courses in biosystematics:
Western Sydney University (2015-2018): “Principles of Evolution” (unit 300980), “Botany” (unit 300836).
University of New South Wales (2010-2016): “Assembling the Tree of Life” (BIOS3221)
University of New England (2000-2010): Biosystematics (Biosyst 301, Biosyst 302, Evol 301/501).
Botany Department, Rhodes University, Grahamstown, South Africa (February-March 2006): “Plant Biodiversity” course in collaboration with Associate Professor Nigel Barker.

I am currently co-supervising one postgraduate student:
Nanette Thomas (Ph.D., University of New England): Systematics of *Tasmannia* informs Biogeography of Winteraceae.

Postgraduate and honours students I have previously co-supervised include:
Margaret Stimpson (Ph.D., University of New England): Systematics, evolution and ecology of the *Banksia spinulosa* complex (graduated 2017).
Melita Milner (Ph.D., Australian National University): Phylogeography of *Lomatia and Telopea* (Proteaceae) in south eastern Australia (graduated 2015).
Samanta Oon (B.Sc. Honours, University of New South Wales): *Lomatia* likes it both ways: rampant bidirectional introgression of chloroplast genomes between two morphologically distinct species of Lomatia (Proteaceae) (graduated 2015).
Zoe Reynolds (B.Sc. Honours, Australian National University): Phylogenetic, taxonomic and functional turnover in Proteaceae assemblages (graduated 2013).
Emma McIntosh (B.Sc. Honours, University of Sydney): Hybridization and introgression between *Lomatia myricoides* and *L. silaifolia* (Proteaceae) (graduated 2011).
Margaret Stimpson (M.Sc.Stud., University of New England): Review of the *Banksia spinulosa* species complex (Proteaceae) (graduated 2011).
James Indsto (M.Sc., University of Wollongong): Pollination Ecology and Molecular Systematics of *Diuris* (Orchidaceae) of the Sydney Region (graduated 2010).
Nanette Thomas (Grad.Dip.Sci., University of New England): Phylogenetic analysis of Winteraceae (graduated 2009).

David McKenna (Ph.D., University of Wollongong: Demographic and ecological indicators for rarity in obligate-seeding *Persoonia* (Proteaceae) shrubs of the Sydney region, graduated 2007).
Paul Rymer (Ph.D., University of Wollongong: Plant rarity: species distributional patterns, population genetics, pollination biology and seed dispersal in *Persoonia* (Proteaceae), graduated, 2006).
Georgina Lloyd (B.Sc. Honours, University of Sydney: Pseudocopulation in two species of *Cryptostylis*: Implications for maintaining species integrity, graduated 2004)
Andrew Perkins (Ph.D., University of Sydney: Phylogenetic Systematics of the Genus *Calochilus* (Orchidaceae), graduated 2002).
Jim Mant (Ph.D., Australian National University: Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae), graduated 2002).
Siegfried Krauss (Ph.D., University of Wollongong: Systematic pattern and evolutionary process in the complex species *Persoonia mollis* (Proteaceae), graduated 1995).

I have examined 14 honours and postgraduate theses:
Australian National University (Ph.D., 2003, 2007, 2008)
University of Melbourne (Ph.D., 1995, 2011)
University of Newcastle (M.Phil., 2003)
University of Queensland (Ph.D., 2003)
University of Sydney (Ph.D., 1991, 1994, 1997, 2009)
University of Wollongong (B.Sc. Hons., 2001, 2003)
Victoria University (Ph.D., 2007)

Competitive Research and Infrastructure Grants

Peakall, R., Pichersky, E., Linde, C., Weston, P.H. (2015-2019) The biosynthesis and evolution of novel semiochemicals in orchids. $644,800, Australian Research Council Discovery Grant DP150102762.

Hoebee, S.E., Weston, P.H., & Edwards, T.J. (2015-18) Evolution in action or the demise of iconic Australian flora? $217,700, Australian Research Council Discovery Grant DP150100508.

He, T., Lamont, B., Weston, P.H., & Cowling, R. (2012-2014) Origin and evolution of plant functional traits in relation to fire. $310,000, Australian Research Council Discovery Grant DP120103389.

Rossetto, M., Crayn, D.M. & Weston, P.H. (2008-2010) Integrating molecular and morphological data for generic delimitation and species identification in Lauraceae. $73,333, Australian Biological Resources Study.

Cantrill, D., Murphy, D. & Weston, P.H. (2008-10) Understanding the origins of the Australian flora by integrating molecular phylogenies and fossil data in the Proteaceae. $88,900, Hermon Slade Foundation.

Rossetto, M. & Weston, P.H. (2007-2009) Speciation in the Australian flora: testing explanatory hypotheses in waratahs and their allies. $78,000, Hermon Slade Foundation.

Considine, J.A., Krauss, S.L. & Weston, P.H. (2002-2004) A biological basis for the efficient breeding of native plants for export markets: a case study with the Australian Goodeniaceae. $168,126, ARC – Linkage (Krauss and Weston representing industry partners)

Whelan, R.J., Ayre, D.J., England, P., Auld, T.D., & Weston, P.H. (2000-2002) Ecology and genetics of fire-sensitive *Persoonia* species: threatened species recovery and management. $126,480, Australian Research Council (ARC– SPIRT, Auld and Weston representing industry partners).

Trent, R. *et al.* (2000) Enhancement of DNA sequencing equipment for the Sydney University and Prince Alfred Molecular Analysis Centre. $600,000, Australian Research Council (ARC-REIF).

Weston, P.H. (1999-2001) Comparative biology of *Chiloglottis* (Orchidaceae) and its thynnine wasp pollinators (Tiphiidae). $75,000, Hermon Slade Foundation.

Weston, P.H. (1997-2000) Taxonomic revision of *Dillwynia* (Fabaceae: Faboideae: Mirbelieae). $62,836, Australian Biological Resources Study.

Weston, P.H. & Thomson, J.A. (1993) A molecular approach to the evolution and biogeography of the Queensland tree waratahs. $4000, Queensland Wet Tropics Management Authority

Weston, P.H. & Thomson, J.A. (1991-92) A molecular approach to the evolution and biogeography of the waratahs. $80,100, Australian Research Council (large grants scheme).

Weston, P.H. (1984) Establishment of a data bank for eucalypt specimens held by NSW. $20,000, Australian Biological Resources Study.

Scientific Publications

[the numbers in square brackets following a reference indicates: 1. the journal's 2016-17 impact factor according to ISI Web of Knowledge, then the number of literature citations for the paper found by Google Scholar, as of 13 Feb 2019]

H-index = 34, total number of citations = 4081 as of 13 Feb 2019

1. Craw, R.C. & **Weston, P.H.** (1984) Panbiogeography: a progressive research program? *Systematic Zoology* 33: 1-13. [8.917, 90]

2. **Weston, P.H.**, Carolin, R.C., & Armstrong, J.A. (1984) A cladistic analysis of *Boronia* Sm. and *Boronella* Baill. (Rutaceae). *Australian Journal of Botany* 32: 187-203. [0.793, 49]

3. Morrison, D.A. & **Weston, P.H.** (1985) Analysis of morphological variation in a field sample of *Caladenia catenata* (Smith) Druce (Orchidaceae). *Australian Journal of Botany* 33: 185-195. [0.793, 11]

4. Crisp, M.D. & **Weston, P.H.** (1987a) Waratahs - how many species? Pp. 3-15, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 13]

5. Crisp, M.D. & **Weston, P.H.** (1987b) Cladistics and legume systematics, with an analysis of the Bossiaeeae, Brongniartieae and Mirbelieae. Pp. 65-130, in C.H. Stirton (ed.) *Advances in Legume Systematics Part 3* (Royal Botanic Gardens: Kew). [-, 131]

6. **Weston, P.H.** (1987) *Persoonia* (Proteaceae). Pp. 348-350, in N.G. Marchant *et al*. (eds.) *Flora of the Perth Region* (Western Australian Herbarium: Perth). [-, 0]

7. **Weston, P.H.** & Crisp, M.D. (1987) Evolution and biogeography of the Waratahs. Pp. 17-34, in J.A. Armstrong (ed.) *Waratahs, Their Biology, Cultivation and Conservation* (Australian National Botanic Gardens: Canberra). [-, 14]

8. **Weston, P.H.**, Wilson, P.G., & Hill, K.D. (1987) Identification of *Cannabis*. *Department of Agriculture New South Wales Miscellaneous Bulletin* 25: 148-150. [-, 0]

9. **Weston, P.H.** (1988a) A revision of *Hicksbeachia* (Proteaceae). *Telopea* 3: 231-239. [0.6, 3]

10. **Weston, P.H.** (1988b) Indirect and direct methods in systematics. Pp. 27-56, in C.J. Humphries (ed.) *Ontogeny and Systematics* (Columbia Univ. Press: New York). [-, 76]

11. **Weston, P.H.** (1989) Problems with the statistical testing of panbiogeographic hypotheses. *New Zealand Journal of Zoology* 16: 511. [0.811, 7]

12. **Weston, P.H.** (1990) Notes on *Boronia* (Rutaceae) in New South Wales, including descriptions of three new species. *Telopea* 4: 121-128. [0.6, 6]

13. **Weston, P.H.** & Johnson, L.A.S. (1991) Taxonomic changes in *Persoonia* (Proteaceae) in New South Wales. *Telopea* 4: 269-306. [0.6, 9]

14. Crisp, M.D. & **Weston, P.H.** (1991) *Almaleea*, a new genus of Fabaceae from south-eastern Australia. *Telopea* 4: 307-311. [0.6, 10]

15. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae), a new genus from New Guinea and eastern Australia. *Telopea* 4: 497-507. [0.6, 12]

16. **Weston, P.H.** (1991) Key to genera, *Persoonia* (Proteaceae), *Medicago*, *Trifolium*, *Pultenaea* and *Dillwynia* (Fabaceae). Pp. 2-19, 452-455, 456-461, 481-497, 499-504, in G. Harden (ed.) *Flora of New South Wales* vol. 2 (New South Wales Univ. Press: Sydney). [-, 0]

17. **Weston, P.H.** & Crisp, M.D. (1991) *Alloxylon* (Proteaceae) and *Almaleea* (Fabaceae). Pp. 29-30, 497-498, in G. Harden (ed.) *op. cit.* [-, 0]

18. **Weston, P.H.** & Porteners, M.F. (1991) *Boronia*, *Eriostemon* and *Phebalium* (Rutaceae). Pp. 227-236, 250-254, 255-263, in G. Harden (ed.) *op. cit.* [-, 0]

19. Porteners, M.F. & **Weston, P.H.** (1991) *Correa* and *Crowea* (Rutaceae). Pp. 247-249, 254-255, in G. Harden (ed.) *op. cit.* [-, 0]

20. Crisp, M.D. & **Weston, P.H.** (1991) *Telopea*. Pp. 30-31, in G. Harden (ed.) *op. cit.* [0.6, 0]

21. Gross, C.L. & **Weston, P.H.** (1992) *Macadamia jansenii* (Proteaceae), a new species from central Queensland. *Australian Systematic Botany* 5: 725-28. [0.75, 8]

22. Crisp, M.D. & **Weston, P.H.** (1993) Geographic and ontogenetic variation in morphology of Australian waratahs (*Telopea*: Proteaceae). *Systematic Biology* 42: 49-76. [14.387, 76]

23. Gilmore, S., **Weston, P.H.**, & Thomson, J.A. (1993) A simple, rapid, inexpensive and widely applicable technique for purifying plant DNA. *Australian Systematic Botany* 6: 139-148. [0.75, 41]

24. **Weston, P.H.** (1993) Key to genera, *Cyrtostylis*, *Cryptostylis*, *Zeuxine*, *Cheirostylis*, *Pseudovanilla*, *Erythrorchis*, *Epipogium*, *Gastrodia*, *Oberonia*, *Liparis*, *Dendrobium*, *Calanthe*, *Phaius*, *Geodorum*, *Dipodium*, *Cymbidium*, *Sarcochilus*, *Rhinerrhiza*, *Peristeranthus*, *Papillilabium*, *Schistotylus*, *Plectorrhiza*, *Taeniophyllum* (Orchidaceae). Pp. 134-138, 218-219, 219-221, 221-233, 236-247, in G. Harden (ed.) *Flora of New South Wales* vol. 4 (New South Wales Univ. Press: Sydney). [-, 0]

25. **Weston, P.H.** & Hill, K.D. (1993) *Bulbophyllum* (Orchidaceae). Pp. 233-236, in G. Harden (ed.) *op. cit.* [-, 0]

26. **Weston, P.H.** & Crisp, M.D. (1994) Cladistic biogeography of Waratahs and their allies (Embothrieae: Proteaceae) across the Pacific. *Australian Systematic Botany* 7: 225-249. [0.75, 73]

27. **Weston, P.H.** (1994) The Western Australian species of subtribe Persooniinae (Proteaceae: Persoonioideae: Persoonieae). *Telopea* 6: 51-165. [0.6, 19]

28. **Weston, P.H.** & Johnson, L.A.S. (1994) Three new species of *Persoonia* (Proteaceae) from Queensland. *Telopea* 6: 31-37. [0.6, 1]

29. **Weston, P.H.** (1994) Methods for rooting cladistic trees. Pp. 125-155, in D.J. Siebert, R.W. Scotland and D.M. Williams (eds.) *Models in Phylogeny Reconstruction* (Oxford Univ. Press: Oxford). [-, 38]

30. Crisp, M.D. & **Weston, P.H.** (1995) Mirbelieae. Pp. 245-282, in J.J. Doyle and M.D. Crisp (eds.) *Advances in Legume Systematics Part 7: Phylogeny* (Royal Botanic Gardens: Kew). [-, 37]

31. Crisp, M.D. & **Weston, P.H.** (1995) Subtribe Embothriinae (Proteaceae). *Flora of Australia* 16: 382-390. [-, 0]

32. Crisp, M.D., Linder, H.P. & **Weston, P.H.** (1995) Cladistic biogeography of plants in Australia and New Guinea: congruent pattern reveals two endemic tropical tracks. *Systematic Biology* 44: 457-473. [8.917, 121]

33. Thomson, J.A., **Weston, P.H.** & Tan, M.K. (1995) A molecular approach to tracing the major lineages in *Pteridium*. Pp. 21-28, in R.T. Smith and J.A. Taylor (eds.) *Bracken: an Environmental Issue* (University of Leeds: Leeds). [-, 13]

34. **Weston, P.H.** (1995) Key to the genera of Proteaceae in Australia, Subfamily Persoonioideae, Subfamily Bellendenoideae, Subtribe Gevuininae, Subtribe Hicksbeachiinae. *Flora of Australia* 16: 41-46, 47-125, 125-127, 409-410. [-, 0]

35. Bernhardt, P. & **Weston, P.H.** (1996) The pollination ecology of *Persoonia* (Proteaceae) in eastern Australia. *Telopea* 6: 775-804. [0.6, 48]

36. **Weston, P.H.** & Crisp, M.D. (1996) Trans-Pacific biogeographic patterns in the Proteaceae. Pp. 215-232, in A. Keast & S.E. Miller (eds.) *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and Processes* (SPB Academic Publishing: Amsterdam). [-, 34]

37. **Weston, P.H.** & Johnson, L.A.S. (1997) *Persoonia hindii* (Proteaceae), a new species from the Newnes Plateau, New South Wales. *Telopea* 7: 199-203. [0.6, 6]

38. Jobson, P.C. & **Weston, P.H.** (1998) *Dillwynia glaucula* (Fabaceae: Mirbelieae), a new species from the Southern Tablelands, New South Wales. *Telopea* 8: 1-5. [0.6, 1]

39. **Weston, P.H.** (1999) *Persoonia pauciflora* (Proteaceae), a new species from the Hunter Valley, New South Wales. *Telopea* 8: 159-164. [0.6, 5]

40. Crisp, M.D., Gilmore, S.R. & **Weston, P.H.** (1999) The phylogenetic relationships of two anomalous species of *Pultenaea* (Fabaceae: Mirbelieae) from molecular and morphological data, and description of a new genus. *Taxon* 48: 701-714. [2.447, 21]

41. Jobson, P.C. & **Weston, P.H.** (1999) Two new species of *Dillwynia* (Fabaceae: Mirbelieae), from the Southern Tablelands of New South Wales. *Telopea* 8: 363-369. [0.6, 0]

42. Thomson, J.A., **Weston, P.H.** and Tan, M.K. (1999) A molecular approach to tracing major lineages in *Pteridium*: update and amendment. Pp. 35-36 in J.A. Taylor & R.T. Smith (eds.) *Bracken Fern: Toxicity, Biology and Control* (International Bracken Group: Aberystwyth). [-, 1]

43. **Weston, P.H.** (2000) Process morphology from a cladistic perspective. Pp. 124-144 in R. Scotland & T. Pennington (eds.) *Homology and Systematics: Coding Characters for Phylogenetic Analysis* (Taylor & Francis: Basingstoke). [-, 24]

44. Indsto, J. & **Weston, P.H.** (2000) Near-ultraviolet reflectance in *Dendrobium* (Orchidaceae). Pp. 326-334 in K.L. Wilson and D.A. Morrison (eds.) *Monocots: Systematics and Evolution*. (CSIRO: Melbourne). [-, 5]

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Papers in Preparation

1. Stimpson, M.L., Wright, B.R., **Weston, P.H.**, Whalley, R.D.B., & Bruhl, J.J. (in review) Seedling morphology helps unravel the taxonomic intricacies in the *Banksia spinulosa* complex (Proteaceae). *Botanical Journal of the Linnean Society* [2.523, -]

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Conference Abstracts

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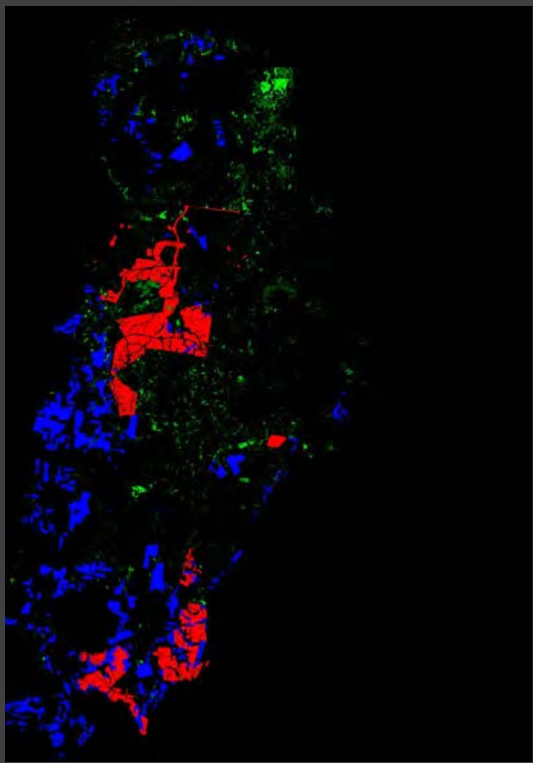
AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document D – Trend analysis

Cumberland Subregion Conservation Plan – Vegetation Trend Analysis



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RMIT University

PREPARED FOR THE NSW DEPARTMENT OF

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SUMMARY

The NSW Government has identified four urban Growth Areas, a new rail line and a series of road and rail Transport Corridors to support planned future growth in Western Sydney over the next 37 years.

As part of this process, the NSW Department of Planning, Industry and Environment (DPIE) is preparing the Cumberland Plain Conservation Plan (the Plan) to support two separate statutory approvals processes under State and Commonwealth laws to address the impacts of the proposed development on biodiversity values.

The Plan describes the proposed urban and transport development and a set of commitments and actions to achieve the Plan's objective and offset the impacts of the proposed development on biodiversity values.

This report presents the results of a trend analysis examining long-term changes in the extent and condition of a native vegetation community in the Cumberland subregion under various scenarios that approximate the development impacts of the Growth Areas and the conservation benefits of the offsets under the Plan.

The native vegetation community examined is Plant Community Type (PCT) 849 *Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion*. This is one of two PCTs that make up the threatened ecological community *Cumberland Plain Woodland in the Sydney Basin Bioregion* as defined under the Biodiversity Conservation Act (the other being PCT 850). PCT 849 is also part of the threatened ecological community *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* under the EPBC Act, although size and condition thresholds apply to the definition of the community under this Act.

PCT 849 is referred to in this report as 'CPW' hereafter.

The purpose of the trend analysis is to better understand, in relation to CPW extent and condition:

- Underlying trends in the subregion
- The significance of existing landscape scale threats relative to urban development
- Potential benefits of securing offsets early relative to late in program implementation
- The outcomes of different management regimes in offset areas in different existing condition states, including the potential benefits of restoring low condition sites through high intensity management

In this report, the condition of CPW is characterized using an approximation of the vegetation integrity score defined in the NSW Biodiversity Assessment Method (BAM).

The report consists of two major outputs: (i) a formal expert elicitation to gather quantitative knowledge regarding how the condition of CPW will change over time under high or low intensity management, and where subject to typical ongoing private land activities; and (ii) quantitative modelling to simulate the urban development within the Growth Areas, compensation via managing areas as offsets in a strategically defined offset region, and the ecological response of CPW.

The modelling includes 10 scenarios, with 8 of these exploring different options for implementing biodiversity offsets. These 8 scenarios vary the timing of when the offsets are implemented, the total area of offsets implemented, and the type of management implemented for the offsets (low or high intensity). The 10 scenarios examined were:

1. Do nothing — continuation of typical private land activities, with no development or offsetting.
2. Development only — development in Growth Areas, with no offsets. All subsequent scenarios use the same development model.
3. Development in Growth Areas with strategic offsets secured early, subject to low intensity management. Offsets are all implemented in the first time-step of the simulation.

4. Development in Growth Areas with strategic offsets secured incrementally, subject to low intensity management. Offsets are implemented at an approximately constant rate, such that all parcels are offset by the end of the 37 years of simulation.
5. Development in Growth Areas with strategic offsets secured early, subject to high intensity management. This is the same as Scenario 3, but with offsets subject to high intensity management.
6. Development in Growth Areas with strategic offsets secured incrementally, subject to high intensity management. This is the same as Scenario 4, but with offsets subject to high intensity management.

Four additional scenarios were also defined: scenarios 3A, 4A, 5A, and 6A. These are identical to scenarios 3-6, respectively, except that only half the parcels (randomly selected) in the strategic offset area are implemented as offsets.

The key findings of this trend analysis for CPW can be summarized as follows:

- Landscape-scale threats across the Cumberland subregion, such as weed invasion, grazing, rubbish dumping, and disturbance from recreational activities are causing significant declines.
- The negative impact of development in the Growth Areas is of a similar scale to ongoing declines from landscape scale threats across the whole Cumberland subregion over 37 years. Landscape scale threats are projected to result in a 5.8 % drop in summed vegetation integrity score over 37 years. The additional impact of development adds further losses of almost the same magnitude (another 5.78 %).
- The Plan is generally unlikely to reverse declines from landscape scale threats across the whole Cumberland subregion because the magnitude of these threats is large and the Plan only influences a proportion of the subregion. The only scenario where declines were always reversed at the landscape scale was scenario 5, where it was assumed that: (i) all parcels in the strategic offset area are implemented as offsets, (ii) all offsets were implemented immediately; and (iii) all offsets had high-intensity management. This comprises the outer bound of the best-case scenario, and may not be feasible to implement.
- In terms of whether the Plan addresses the impacts of development in the Growth Areas alone within the program area (ignoring declines from landscape scale threats), two of the four offset scenarios (scenarios 5 and 6) provided adequate compensation irrespective of whether 100% or 50% of the CPW was secured as offsets in the strategic offset area. When 100% of the CPW available in the strategic offset area is secured as an offset, three of the four offset scenarios compensate for development impacts (all except scenario 4). When 50% of the CPW available in the strategic offset area is secured as an offset, only two of the four offset scenarios provide adequate compensation.
- In terms of whether the Plan addresses the impacts of development in the Growth Areas as well as declines from landscape scale threats within the program area, three of the four offset scenarios (scenarios 3, 5, and 6) compensate for both these impact types when 100% of the CPW in the strategic offset area is secured. However, none of the offset scenarios can compensate for both these impact types in the program area if only 50% of the CPW in the strategic offset area is secured.
- The timing of offset implementation and the level of management intensity make a significant difference to the gains able to be achieved by offsets, with early implementation/high intensity management always performing best.
- The relative benefit of early implementation compared to high intensity management depends on the time period over which gains are evaluated. The results suggest that:
  - Early implementation with low or high intensity management delivers greater gains in the short term (1 to 2 decades).
  - Early implementation with high intensity management delivers the greatest gains in the long term.
- Results of expert elicitation indicate that high intensity management provides significant potential for providing restoration gains for CPW, even when starting from a low initial condition. However, low intensity management has limited capacity to improve the ecological condition of CPW, especially when starting from a low initial condition.

INTRODUCTION

BACKGROUND AND CONTEXT

The NSW Government has identified four Growth Areas, a new rail line – the Sydney Metro Stage 1 Western Sydney Airport Stage 1 (Sydney Metro Stage 1), and a series of road and rail Transport Corridors to support planned future growth in Western Sydney for the next 37 years (Figure 1). These initiatives are identified under two key planning strategies:

- *A Metropolis of Three Cities - The Greater Sydney Region Plan* (Greater Sydney Commission, 2017)
- *Future Transport 2056* (Transport NSW, 2017)

The Growth Areas program represents the strategic prioritisation and delivery of new development as part of the long-term growth of Greater Sydney provided under the Greater Sydney Region Plan. The Growth Areas are the key focus for development over the coming 37 years and will be the centres of economic activity in Western Sydney. The Growth Areas occur largely within the Cumberland subregion and are:

- Wilton
- Greater Macarthur (GMAC)
- Western Sydney Aerotropolis (WSAGA)
- Greater Penrith to Eastern Creek Urban Release Investigation Area (GPEC)

the NSW Department of Planning, Industry and Environment (DPIE) is progressing the planning and environmental approvals required for the proposed development. As part of the biodiversity approvals required, DPIE is preparing the Cumberland Plain Conservation Plan (the Plan) to provide long-term certainty for biodiversity and development in Western Sydney.

The Plan will support two separate statutory approvals processes under State and Commonwealth laws required to address the impacts of the proposed development on biodiversity values:

- Strategic biodiversity certification under Part 8 of NSW Biodiversity Conservation Act 2016 (BC Act)
- Strategic assessment under Part 10 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

The objective of the Plan is to:

> *Deliver biodiversity outcomes and support the ecological function of the Cumberland Plain, improving liveability and facilitating urban development in Western Sydney*

The Plan describes the proposed urban and transport development and a set of commitments and actions to achieve the Plan's objective and offset the impacts of the proposed development on biodiversity values. This includes identifying Conservation Investigation Areas within which offsets will be strategically secured through several mechanisms, including reservation of land and Biodiversity Stewardship Agreements. These Conservation Investigation Areas are referred to hereafter as the 'strategic offset area'.

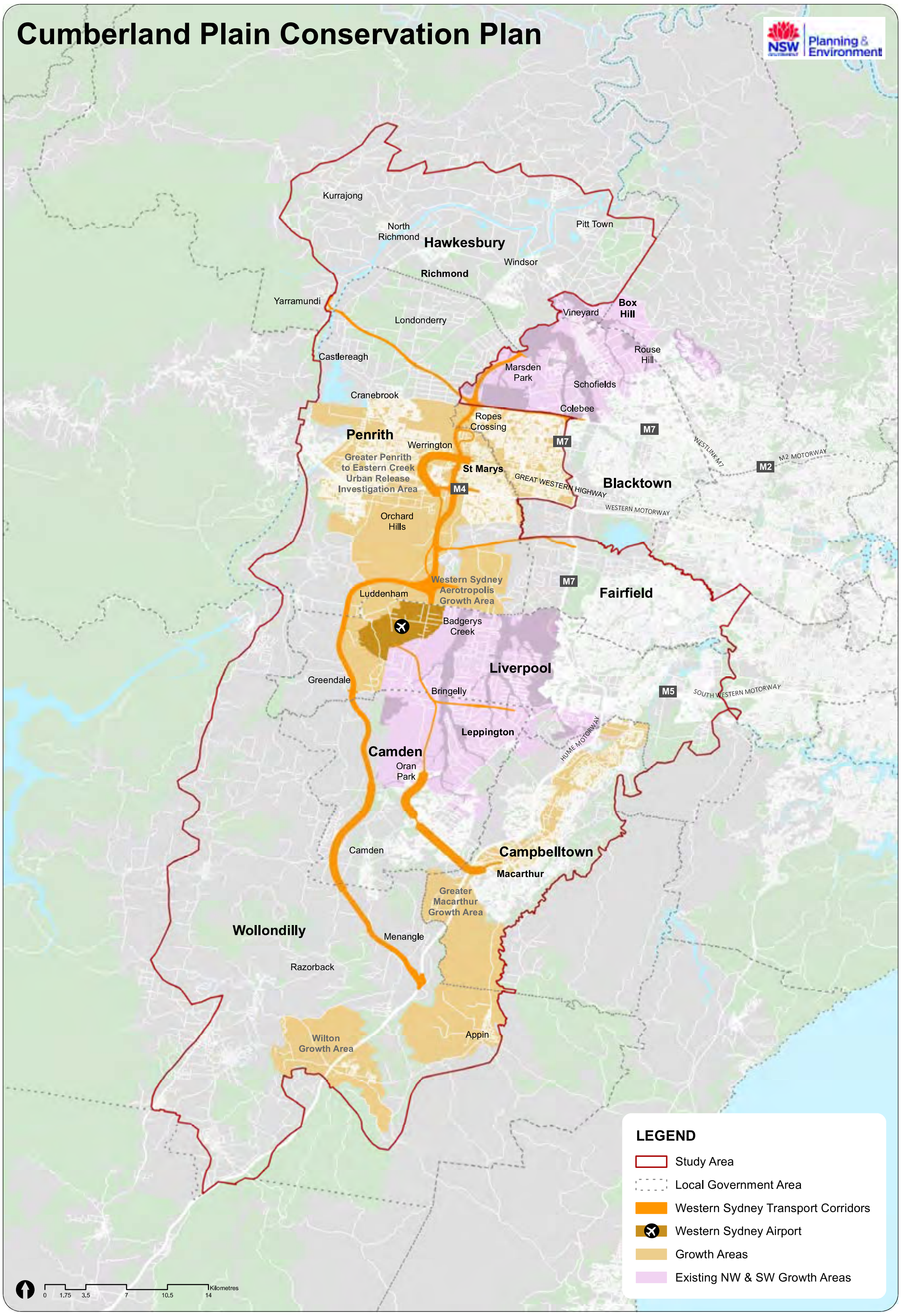

Figure 1. Map of depicting the Growth Areas and transport corridors in the Cumberland subregion.

AIMS OF THIS RESEARCH

This report presents the results of a trend analysis examining long-term changes in the extent and condition of a native vegetation community in the Cumberland subregion under various scenarios that approximate the development impacts of the Growth Areas and the conservation benefits of the offsets under the Plan.

The native vegetation community examined is PCT 849 *Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion*. This is one of two PCTs that make up the threatened ecological community *Cumberland Plain Woodland in the Sydney Basin Bioregion* as defined under the BC Act (the other being PCT 850). PCT 849 is also part of the threatened ecological community *Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* under the EPBC Act, although size and condition thresholds apply to the definition of the community under this Act.

This community is referred to in this report hereafter as CPW.

The purpose of the trend analysis is to better understand, in relation to CPW extent and condition:

- Underlying trends in the subregion
- The significance of existing landscape scale threats relative to urban development
- Potential benefits of securing offsets early relative to late in program implementation
- The outcomes of different management regimes in offset areas in different existing condition states, including the potential benefits of restoring low condition sites through high intensity management

This information can be used to support key decisions in developing the Plan, as well as inform the evaluation of the adequacy of the Plan in accordance with the requirements of the BC Act and EPBC Act.

The trend analysis builds on work already undertaken for other development projects that models the impact of development and mitigation in the form of biodiversity offsets on native vegetation (Gordon, 2015; Gordon et al., 2011a, Gordon et al., 2011b). This present work extends these existing approaches to model changes in the condition of CPW using more sophisticated metrics of ecological condition, that are an approximation of the metrics specified for vegetation integrity in the BAM (BAM; OEH, 2017).

The report consists of two major outputs: (i) a formal expert elicitation to gather quantitative knowledge regarding how the condition of CPW will change over time, under high or low intensity management, and under the case where CPW is exposed to typical ongoing private land activities; and (ii) quantitative modelling to simulate the urban development within the Growth Areas, compensation via managing areas as offsets in a strategically defined offset region, and the ecological response of CPW.

BACKGROUND THEORY

The aim of a biodiversity offset is to counterbalance a specified biodiversity loss (usually after appropriate avoidance measures have been considered (Bull et al., 2013)). When the gains attributed to the offset fully mitigate the losses attributed to the development, the offset is considered to have achieved 'No Net Loss' of biodiversity (Bull et al., 2014). However, it is important to note that there are multiple ways in which the gains and losses can be calculated and No Net Loss defined. This potentially has a large influence on whether No Net Loss can be said to have been achieved (Maron et al., 2018), or equivalently, it also has a large influence on the offset requirements needed to achieve No Net Loss.

It is important to note that the offset scheme under the NSW BC Act defines the term No Net Loss of biodiversity and establishes a process to determine whether this has been achieved, which involves the calculation of biodiversity credits under the BAM. In relation to biodiversity certification, the BC Act does not require that the value of offsets be calculated in terms of credits, or require the number of credits needed to achieve No Net Loss be secured (OEH, 2017). The objective of the Plan is to deliver biodiversity outcomes and support the ecological function of the Cumberland Plain rather than to specifically achieve 'No Net Loss' as defined under the BAM. However, here we start by introducing what is required to be able assess whether offsets have achieved No Net Loss and the relevant background theory for this.

To understand if No Net Loss is achieved, it is necessary to measure and compare the change attributable to the development actions with the change attributable to the offset actions associated with that development. Here we use terminology from impact evaluation and refer to this change as the *impact* (which can be either negative due to development or positive due to offsets).

To determine the impact, it is necessary to measure the difference between what happened on-ground subsequent to the development and offset interventions (the *outcome*) compared to what would have happened in the absence of the intervention (the *counterfactual*) (Baylis et al., 2016; Ferraro, 2009).

In traditional *ex-post* impact evaluation, the outcome is measured after the intervention, and the counterfactual is estimated (using a range of approaches depending on context) to provide the estimate of impact. In this case we undertake an *ex-ante* analysis to examine the impacts of different scenarios by estimating the outcome (via simulation) and comparing that to the estimated "do nothing" case where landscape scale threats and typical private land activities continue (the counterfactual).

The modelling presented in this report can be used to estimate the net impact of development and offsetting in the Cumberland subregion on CPW. The modelling incorporates three processes: (i) development which is assumed to remove all CPW on developed parcels; (ii) offsetting, for which offset parcels are assumed be managed in a way that improves the condition of CPW on the site; and (iii) the trajectory of the vegetation on parcels that are neither developed or offset, which is assumed to be a slow decline in condition due to landscape scale threats and typical private land activities such as grazing, and minimal weed and pest management, etc (excepting existing conservation areas—which are assumed to be managed). This is consistent with the expectations of Section 13.5 of the BAM (OEH, 2017). It is important to note that this modelling exercise involved an expert elicitation process to inform how CPW responds to management as an offset and to landscape scale threats in areas that are not developed or offset.

In this case the typical private land activities are assumed to be the counterfactual, i.e. what would have occurred without development or offsetting. This is schematically depicted in Figure 2, which shows the trajectory of the development parcel (in yellow, which goes to zero when development occurs), the offset parcel (in green, which gradually improves due to management), and the assumed counterfactual of slow ongoing decline without offsetting or development. The thick black dotted line shows the net outcome of the combined offset and development action. In this example, we use the definition of No Net Loss as relative to the counterfactual of ongoing decline (Maron et al., 2018). Under this definition, No Net Loss is achieved when the combined outcomes of the offset and development results in what would have happened without either offsetting or development (shown at t_2 in Figure 2). However, it is important to note that with this definition of No Net Loss, even when it has occurred, there has still been a loss of biodiversity relative to what was there before the development and impact occurred. We could also use a more stringent definition of No Let Loss which would require the offset to both compensated for loss due to development, and for the ongoing declines due to landscape scale threats. This would result in the net outcome being the same as what was present before the development and offset were implemented. In this case, the dashed line representing the net outcome would need to reach the level at which it started, shown at t_1.

In this report we use the former definition of No Net Loss, depicted in Figure 2, which involves the development and offset together achieving the same outcome as the ongoing background declines that would have occurred without them. Under this definition of No Net Loss, achieving the same outcome as what was present before the offset and development would be referred to as a Net Positive Impact (Maron et al., 2018).

The results of impacts and outcomes in this report are shown at two different scales: the ***program scale*** and the ***landscape scale***. Each scale is important and provides different information.

The ***program scale*** results are obtained by summing the vegetation integrity score multiplied by the area of CPW in ***all the developed and offset parcels only*** (this is equivalent to what is shown in Figure 2 with the loss and gain curves being assumed to come from multiple parcels). At this scale, the outcomes show the net ecological condition of all parcels developed and offset. This can be used to determine the extent to which the offsets have compensated for the development losses due to the program (but not ongoing declines that would have still occurred). If a net impact of zero is achieved, this means the development and offset(s) have together resulted in the same background decline that would have occurred with only typical private land activities occurring on the development and offset parcels. It can also be used to examine the extent to which it has averted the losses (or delivered additional gains) relative to what would have occurred without the development (in this case due to typical private land activities) on the program parcels. This only occurs if a net positive impact is generated so both development losses and the background declines can be compensated for. If the net result is the same or better than the biodiversity value before the interventions, then it is clear that both degrading processes (development and typical private land activities) have been compensated for.

The ***landscape scale*** results are obtained by summing the vegetation integrity score multiplied by the area of CPW in all parcels in the whole Cumberland subregion. This includes the parcels that are not part of the program and subject to ongoing declines due to typical private land activities. For the modelling results presented here, it also includes all the conservation areas outside the program that are assumed to be managed. Thus, if the net outcome at this scale achieves a value equal or greater than the starting value, the offset impacts have compensated not only for the development, but also for the ongoing declines of all the parcels that are not part of the program.

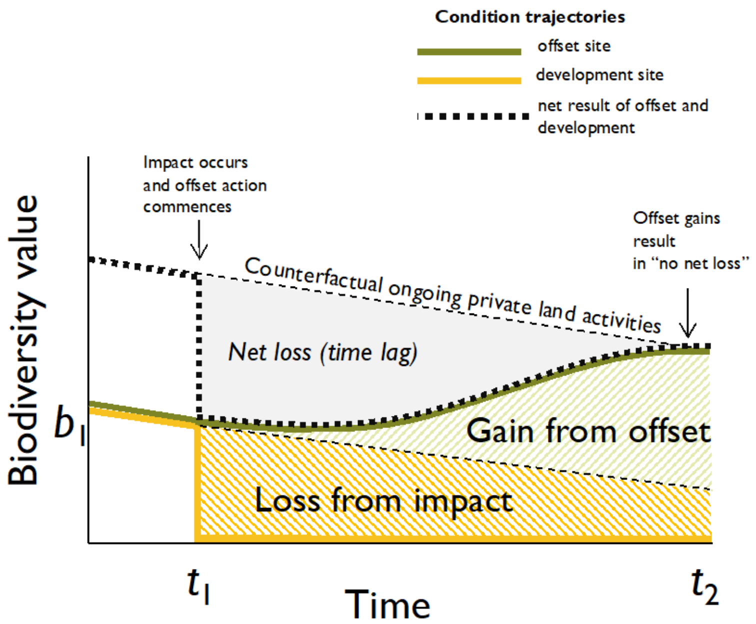

Figure 2. Schematic depiction of the biodiversity trajectory at the development site (yellow line), the offset site (green line) and net result of the offset and development (black dotted line). The counterfactual of ongoing decline is shown with the thin black dashed line. Where the net outcome is the same as the counterfactual (at t_2), no net loss can be said to occur. However, this still represents an absolute loss relative to the biodiversity value at t_1, and achieving the same outcome as what was present at t_2 would be referred to as a Net Positive Impact.

METHODS

OVERVIEW

For the modelling results presented in this report, we use the open source *R* package OffsetSim (see https://github.com/isaacpeterson/offset_simulator), developed by Isaac Peterson and Ascelin Gordon at RMIT University. This is used to simulate development, offsetting and the resulting ecological dynamics for CPW.

OffsetSim works using raster layers as one set of inputs and requires a land parcel layer, and layers showing which parcels can be developed and offset. It can also use one or more ecological features. The ecological value of a particular location is determined using a user-specified metric that can be defined over a set of one or more feature layers (e.g. using a multiple-component metric of vegetation community condition or an aggregated metric such as the BAM (OEH, 2017) or other individual features such as species-occupancy or species-abundance (Bull et al., 2016, 2013; Maron et al., 2012; Quétier and Lavorel, 2011)). Raster layers depicting the initial value of each ecological component are required, and then OffsetSim provides a model that needs to be parameterised to evolve each feature over time based on whether it is developed, managed as an offset, or not subject to any intervention. In this case, we used CPW as the ecological community of interest.

Below, we provide details of the expert elicitation used to develop the condition-change model which allows the condition (measured via an "ecological integrity score"—see below) of CPW to change over time, under each of two different management regimes, or under no management. This requires use of ecological feature layers for the richness and cover of different plant growth form groups, as specified within section 5.3.4.10 of the BAM (OEH, 2017; Oliver et al., 2019).

While OffsetSim has the capacity to select offsets for a given development such that the offsets are determined to deliver appropriate gains within some time horizon to compensate for the development losses, we do not use that feature here. Instead, the development and offset areas are pre-specified, and developments and offsets are implemented at a fixed rate throughout the simulation as described in detail below. We then use OffsetSim to evaluate the ecological impacts of these scenarios.

VEGETATION DATA

Data on the extent and condition of CPW in the Cumberland subregion was used from multiple sources. Within the Growth Areas this was based on detailed mapping of native vegetation that was informed by field surveys undertaken by Biosis in 2018 in accordance with the BAM. Within the Cumberland subregion but outside the Growth Areas, the mapping was based on existing native vegetation maps prepared by OEH, which are described in detail in Table 1.

The condition of CPW in the mapping was captured using the following categories: Intact, Thinned, Scattered Trees, Derived Native Grassland, and Urban native/Exotic. Below, these categories are explained with notes about how they were applied as part of the Biosis mapping of the Growth Areas.

- **Intact:** This condition type was assigned to areas of wooded vegetation, including regrowth, displaying a range of structural layers and likely to have fauna habitat features present (e.g. tree hollows, fallen timber, leaf litter). The canopy density is largely unmodified with a range of age classes and species present. This condition type was assigned during the desktop mapping to areas where Nearmap imagery indicated significant patches of continuous canopy and the Canopy Height Model (from LiDAR) indicated vegetation in both the upper and mid storeys.
- **Thinned:** This condition type was assigned to native vegetation in various states of modification and included: 1) wooded vegetation with a partly cleared canopy resulting in a more open structure than the

intact category of the same PCT; 2) areas of wooded vegetation that has been under-scrubbed; 3) areas of regrowth. This condition type was assigned during the desktop mapping to areas where the Nearmap imagery indicated patches of reduced density. This was typically where the Canopy Height Model indicated canopy and visible ground only, with no discernible shrub layer or structural complexity.

- **Scattered trees:** This condition type includes a single tree or small group of trees surrounded by native or exotic grassland or areas of cultivation. Typically, other structural components of the vegetation have been removed. This condition type was assigned during the desktop mapping to areas where the Nearmap imagery and LiDAR canopy polygons indicated one or a few likely native trees surrounded by cleared land.
- **Derived Native Grasslands** Areas of potential Derived Native Grassland (DNG) were identified from the Nearmap imagery and later verified in the field.
- **Urban native/exotic:** Urban native/exotic areas were areas within built up zones and residential areas that consisted of street trees, urban parks and other patches of planted vegetation that could provide habitat for native species.

There were no patches of vegetation categorized as grasslands or urban native/exotic for CPW.

Table 1. Existing native vegetation maps of the Cumberland Plain

Native vegetation dataset	Description (from VIS)
Remnant Vegetation of the Western Cumberland Subregion 2013 Update (OEH 2013)	A 2013 update to the western parts of the Remnant Vegetation of the Cumberland subregion GIS data layers (VIS_IDs 2221, 2222 and 3785) using 2011 and 2012 imagery. Update focused on removing large areas of clearing at 1:10,000-1:15,000 scale. Those areas within the Sydney Metro Catchment Management Authority boundary, which were covered by the Sydney Metro Veg V2 2013 vegetation map (VIS_ID 3817), were not updated. Provides data on native vegetation extent, type (PCTs) and condition Note: Previous update completed by the Scientific Committee and Simpson 2008 (VIS_ID 3785) was integrated into this update. Txu (<10% canopy cover of urban land) vegetation (VIS_ID 2223) is excluded from the update and this layer. Areas of significant regrowth were added.
The Native Vegetation of the Sydney Metropolitan Area Version 3.0 (OEH 2016)	Provides data on native vegetation extent, PCTs and condition for the eastern part of the Cumberland subregion. The purpose of the data is to provide a single detailed coverage of native vegetation communities in the Sydney metropolitan area using standardised vegetation classification. This classification is designed to relate to the objectives of the OEH vegetation information systems and to assist users with the assessment of threatened ecological communities listed under the NSW TSC Act and Commonwealth EPBC Act This update replaces version 2.0 (VIS_ID 3817) and creates a seamless alignment between the GIS layer and the Plant Community and Biometric Vegetation Types in the Biodiversity Assessment Method tool.

EXPERT ELICITATION

BACKGROUND

This section provides a summary of the expert elicitation process carried out to develop the ecological condition change model. This model allows the components that make up the vegetation integrity score that is defined in the BAM (OEH, 2017) to be modelled as changing through time for CPW, based on a given initial condition and a specified type of management. The expert elicitation was undertaken in two separate workshops in 2018, at the Biosis offices in Sydney.

Information was elicited from experts in a structured way such that best estimates and confidence intervals were obtained, with an opportunity for experts to refine their estimates through structured discussion. This involved using a modified Delphi procedure called "the IDEA protocol" (Investigate, Discuss, Estimate, and Aggregate) to elicit the expert judgments, in a way that has been shown to minimize contextual biases (Burgman et al., 2011; Hemming et al., 2017). This involves initially eliciting the information from the experts, and these judgments are then compiled and shown to the group anonymously, where they are discussed and visually summarised. In a second round of the elicitation, the experts then have the option to revise their estimates and update the comments on their estimates. They also have the option not to change their estimates.

The expert elicitation was led by Dr Ascelin Gordon, with Dr Isaac Peterson providing technical support. Tom Holden (Open Lines) and Rebecca Dwyer (Biosis) provided logistical support for the workshops.

SELECTION OF EXPERTS

Participants were invited to take part in the elicitation if they worked in an area that requires ecological expertise of the Cumberland subregion and had been identified as an expert by peers. Participants were sought mainly from local or state government agencies and universities.

Participants were identified by contacting an initial group of people identified by Ascelin Gordon, Tom Holden (Open Lines) and Rebecca Dwyer (Biosis). These experts were then asked to suggest additional suitably qualified experts. This process generated a list of 10 potential participants, 7 of which were available to participate in the initial workshop. The experts who participated in the first workshop were:

- David Keith (University of NSW)
- Charles Morris (University of Western Sydney)
- Peter Ridgeway (Local Land Services)
- David Kirkland (Western Sydney Parklands Trust)
- Jonathan Sanders (formerly NSW National Parks and Wildlife Service)
- Paul Price (Biosis)
- Greg Steenbeeke (on secondment to DPIE from OEH)

In a follow up workshop to finalize the elicitation, two experts were unable to attend (Peter Ridgeway and Paul Price). So, the full elicitation was only able to be completed with five experts.

In the run up to the workshop, information was compiled to brief the experts on the background of the project and provide them with details of what they would be asked to provide during the elicitation.

DETAILS OF ELICITATION

The elicitation focused on CPW, and specifically three growth form groups (*Trees*; *Grass & grass-like*; and *Forbs*) and two ecological attributes (*species richness*; and *cover* of the plant growth form type). The elicitation also used four initial conditions, and three management regimes (see below).

Information was elicited such that an approximation of the vegetation integrity score defined in the BAM (OEH, 2017; see below) could be derived, along with how it will change through time under different management regimes.

The experts were asked to provide estimates for how the ecological attributes Species Richness and a simplified value for Projected Cover changed over time for a 'vegetation zone' within CPW. The attributes are defined as follows:

- ***Plant species richness***: the mean species richness of the growth form group recorded (observed) from all the plots in the vegetation zone. This is used to calculate a 'composition condition score' in the BAM.
- ***Plant cover***: the mean cover for the growth form group recorded (observed) from all plots/transects in the vegetation zone. This is used to calculate the structure condition score of the BAM. Note that the elicitation used a simplified version of cover, being the percentage of the plot covered by the growth form group, compared to the BAM, which uses a more complex measure of cover (the sum of the individual cover values for each species in the growth form group, which can therefore be greater than 100%).

The BAM defines a *vegetation zone* as "an area of native vegetation on the subject land that is the same PCT and has a similar broad condition state" (OEH, 2017). Within a zone, the BAM specifies a plot area to be $400m^2$ (generally a standard 20m x 20m, but geometry can be varied though area remains the same), and the number of plots required for a survey varies from 1-8 depending on the overall area represented in all polygons of the vegetation zone.

The default benchmark values for each ecological component for the plant type (as drawn from the VIS-C database that informs the process) were provided as part of the elicitation. As a subset of the full canopy cover measure is being used compared to what is specified in the BAM, the experts were asked to provide estimates of what the benchmark value should be for the definition of cover we used.

The experts were asked to provide information for CPW that was in one of four initial conditions. The assumption regarding the initial conditions determined the initial value for richness or cover. After being giving an initial value for each measure, the experts were asked to provide estimates for the values of the richness and cover at 20, 40, and 60 years into the future under each of 3 different management regimes.

The initial condition states were:

- ***Low site quality:*** These are sites that were historically cleared and used for farming. They have a largely exotic ground cover and/or midstorey, and a sparse woody component. This type of site has mostly weedy grasses and a few opportunistic native forbs and grasses in the understorey. It has less than 5% cover of large old hollow-bearing trees with some canopy dieback and flowering in some years. It often includes the presence of African olives (Olea europaea subsp. cuspidata).

- ***Medium quality 1:*** This state is of similar history to *Low* but may have had less clearing of trees and less intensity of farming, and there is more resilience is clearly evident in the native groundcover clearly evident. It has a native/exotic ground layer with no dominant species, and the site has had grazing and limited fertiliser. There is some presence of perennial grass weeds (not at high density and not transformer species). There is approximately a 10% canopy cover of regrowth trees (large enough to flower but without hollows) with no presence of African Olives. It is assumed that no superphosphate or nitrogen fertilizers have been used on these sites.

- ***Medium quality 2:*** This state has been more intensively farmed and it has had the application of superphosphate. It has a greater amount of canopy regeneration and the understory has a greater presence of weeds. African olives or blackberries (*Rubus fruticosus* species complex) have a foothold and often dominate the understorey. Some native ground cover observed but limited due to the high presence of woody weeds (African olive and/or blackberry). Woody components are present and due to regrowth, often comprise a cover level greater than the benchmark for the plant community type but are not mature.

- ***High quality:*** Here the ground cover is mostly native; the site has been free of fertilizer and has had no grazing or grazing only at light to moderate intensity. The woody component is mostly native and there is little presence of African olives.

These categories were chosen as to be generally representative of current condition states that CPW would be found in within the Cumberland subregion, while being limited to no more than four condition states, due to constraints on the amount of information that could be elicited over the workshops. Figure 3 shows example photographs of CPW in each of the initial condition states.

The 3 management regimes were:

- ***Typical private land activities:*** Under this management regime, it is assumed that ongoing declines in CPW condition are expected due to a range of threatening processes. It is also assumed that there is a continuation of the typical practices as currently employed by most landholders. This includes grazing, often at high intensities; minimal weed management for agricultural weeds; and minimal pest management for agricultural pests.
- ***Low-intensity management:*** This primarily comprises threat management that focuses on control of aggressive weeds and exclusion or restriction of grazing, i.e. managing issues that change the structural and functional composition of the community. It is assumed that this management is consistent with the 'required management actions' for a biodiversity stewardship site under the BAM.
- ***High-intensity management:*** This involves the same threat management as low-intensity management, but also includes regenerative weed control, active planting of the site (via direct seeding or by using tubestock) and other techniques to increase diversity (e.g. fire, creating habitat, fauna reintroduction). It is assumed that this management is consistent with what is required for 'active restoration management' at a biodiversity stewardship site under the BAM, what are in addition to the actions required under low-intensity management.

The required management actions specified in the BAM for low-intensity management are given in Table 2 and in Table 3 for high-intensity management (OEH 2017).

Table 2. Required management actions and types of management activities for improving vegetation integrity and threatened species habitat at a biodiversity stewardship site. Source: OEH (2017).

Required management action	Types of management activities that may be undertaken as part of the required management action for ecosystem credits and species credits
Preparation of a management plan	Preparation of a management plan for the biodiversity stewardship agreement for the site
Fire management	Undertake ecological burning activities, including where identified, the prevention of fire
Grazing management	Fencing to exclude stock, or strategic grazing of stock
Native vegetation management	Restore/rehabilitate native vegetation Retain and manage regrowth Undertake nutrient control Threatened species habitat management activities related to native vegetation
Threatened species habitat management	Protection of breeding habitat features or sites Undertake any other required management action identified in the Threatened Biodiversity Data Collection to create species credits or ecosystem credits required for that threatened species
Integrated pest animal control	Undertake feral pest management including control of foxes, cats, pigs, goats, avian pests, horses and any other miscellaneous species as required
Integrated weed management and control of high threat weeds	Undertake weed management and activities to control high threat exotic and other exotic vegetation Fine-scale intensive removal of high threat exotic and other exotic vegetation
Management of human disturbance	Exclude development and clearing activities except those listed as permissible in the biodiversity stewardship agreement Identify sensitive locations and protect from disturbance Undertake rubbish removal Implement measures to restrict access to the site where necessary (vehicles, etc.)
Monitoring	Monitoring for evidence of disease Assessment of the management plan and activities against the performance measures Establishment of permanent plots to provide a baseline for assessing biodiversity outcomes Establishment of 360° photo points Review of the management plan and management activities

Table 3. Active restoration management actions that may be undertaken to improve or manage native vegetation or threatened species habitat at a biodiversity stewardship site. Source: OEH (2017).

Types of active restoration management actions	Types of management activities that may be undertaken as part of the active restoration management actions for ecosystem credits and species credits
Habitat enhancement	Inclusion of artificial nesting boxes and if the management plan specifies ongoing management, replacement and maintenance Relocation of fallen logs onto biodiversity stewardship site from appropriate sources Addition of rocks from appropriate sources Relocation and securing of dead hollow-bearing stag trees from appropriate sources
Native vegetation and habitat management and augmentation	Undertake targeted supplementary planting to: • increase native plant richness and cover above the level determined for management gain • restore or enhance the condition and species composition of recognisable PCTs • improve habitat suitability for specific threatened species • restoration of PCTs through changed hydrological flows
Integrated weed management and control of high threat exotic vegetation	Removal of high threat exotic vegetation through appropriate methods (e.g. scalping) and replacement with native vegetation Other approved methods to reduce cover of high threat exotic vegetation
Hydrology management	Create artificial frog ponds or wetlands Manage drainage Install sediment trap(s) Manage debris Undertake nutrient control
Monitoring	Assessment of performance measures of outcomes related to the active restoration components such as: • evidence of occupation of and condition of artificial hollows or relocated logs and stags • persistence and abundance of species targeted by supplementary plantings or sowings

To elicit the trends over time, each expert was asked to fill a spreadsheet (via a Google sheets link) containing information as to how each ecological attribute will change over time for each plant growth form group. Given all the combinations of the growth form groups; initial conditions; and management actions, experts were required to provide data to inform the shape of 50 curves, as detailed in Table 4.

For each curve, the experts were requested to provide their best estimate; upper; and lower bounds, for the component being elicited, at a notional time points 20, 40, and 60 years into the future.

An example of the spreadsheets used for the elicitation is available here: https://docs.google.com/spreadsheets/d/1rFkq80R3orUgCRv_rbFW6crgTZN1-1rc5Wi-J6AhU7Y/edit?usp=sharing. The spreadsheet asks the experts to provide upper and lower bounds first (in any order), and then to provide a best estimate, and additionally to provide an estimate of their confidence that the true value falls within the bounds they have provided. Curves were generated as participants enter the data to show how their bounds and best estimate change over time. The spreadsheet automatically extrapolated bounds to show the 90 percent confidence intervals based on the estimate of confidence given by the participant.

Ethics approval for undertaking this component of the research involving human participants was obtained from RMIT University (approval number CHEAN A 21472-04/18).

High quality (foreground only - olive in the gully behind is Medium quality 2)	***Medium quality 1*** **(foreground only - olive in the gully behind is medium 2)**
	
Medium quality 2	**Low quality**
	

Figure 3. Examples of CPW in each of the initial condition class categories (photograph credits: Greg Steenbeeke).

Table 4. The spreadsheets components to be filled in by each expert during the elicitation process — a total of 50 curves needed to be elicited.

Tab no.	Plant growth form group	Ecological attribute	Initial condition	Management actions	No. of curves
1	Tree	Richness	Low	all 3	3
2	Tree	Richness	Med 1	all 3	3
3	Tree	Richness	Med 2	all 3	3
4	Tree	Richness	High	Typical private land activities only	1
5	Grass & grass-like	Richness	Low	all 3	3
6	Grass & grass-like	Richness	Med 1	all 3	3
7	Grass & grass-like	Richness	Med 2	all 3	3
8	Grass & grass-like	Richness	High	Typical private land activities only	1
9	Forbs	Richness	Low	all 3	3
10	Forbs	Richness	Med 1	all 3	3
11	Forbs	Richness	Med 2	all 3	3
12	Forbs	Richness	High	Typical private land activities	1
13	Tree	Cover	Low	all 3	3
14	Tree	Cover	Med 1	all 3	3
15	Tree	Cover	Med 2	all 3	3
16	Tree	Cover	High	Typical private land activities	1
17	Grass & grass-like	Cover	Low	all 3	3
18	Grass & grass-like	Cover	Med 1	all 3	3
19	Grass & grass-like	Cover	Med 2	all 3	3
20	Grass & grass-like	Cover	High	Typical private land activities	1
				Total	**50**

CONVERTING MAPPED VEGETATION CONDITION TO EXPERT ELICITATION CONDITION CLASSES

As described above in the section on Vegetation Data, the condition information in the available spatial data on native vegetation does not match the initial conditions that were required by the experts to elicit the response of richness and cover for the relevant plant growth-form groups.

The following scheme was used to convert the condition categories used in the mapping, to the condition classes used in the expert-elicited condition change model. While the correspondence between each category is not perfect, they are approximating the same kinds of condition states for native woodlands.

- ***Scattered paddock trees*** was determined to equate to ***low site quality***, as it contains a single tree or small group of trees surrounded by low-condition native or exotic grassland, or areas of cultivation. One or more structural layers may be absent (e.g. shrubs and/or grasses/forbs).

- ***Derived Native Grasslands*** (DNG) was determined to equate to ***medium quality 1*** given it contains a grassland community where the cover of native species is 50% or more, and has some presence of perennial grass weeds but not at high density.

- ***Thinned*** was determined to equate to ***medium quality 2*** given it contains:
    - Woodlands that have a partly cleared canopy resulting in a more open structure than intact vegetation.
    - Vegetation that has been under-scrubbed (shrub layer removed).
    - Some areas of regrown woodland that would otherwise approach the intact condition.

- ***Intact*** was determined to equate to ***high quality*** native woodland or open forest that is in good condition, including good DNG within short distances (distance (typically under 30 metres) of intact canopy cover. Intact CPW displays a diversity of vegetation layers and habitat features (such as tree hollows, fallen timber, groundcover, leaf litter). Tree density is close to natural, and a range of ages is present including established mature trees. Regrowth may be included if it meets the above criteria.

CALCULATING THE VEGETATION INTEGRITY SCORE

Once all the richness and cover estimates were elicited, they were converted to the vegetation integrity score via the following approach, derived from BAM (OEH, 2017).

First the *unweighted richness condition score* is calculated via

$$URC_i = 100.68\,(1 - e^{-5\left(\frac{\bar{x}_i}{B_i}\right)^{2.5}}),$$

Where $\bar{x}_i$ is the mean of species richness of the i^{th} growth form group and B_i is the benchmark richness value for the i^{th} growth form group. Weights are then calculated as follows:

$$w_i = \frac{B_i}{\sum_{j=1}^{n} B_j}$$

where w_i is the weight for the i^{th} growth form group, B_i is the benchmark richness value of the attribute for the i^{th} growth form group, and n is the number of growth form groups.

The final *richness condition score* is then given by

$$RC = \sum_{i=1}^{n} URC_i \times w_i$$

An identical procedure was undertaken to calculate the final cover condition score (*CC*), replacing the richness terms (and benchmarks) in the above equations with the cover terms (and benchmarks). Given we do not include the function condition scores which are a component in the full BAM vegetation integrity score, we calculated the final vegetation integrity score as

$$VI = \sqrt{RC \times CC}$$

This is consistent with the vegetation integrity score using only richness and cover. This vegetation integrity score is then used as the metric to evaluate how the condition of CPW changes under management regimes, and to evaluate the different development and offsetting scenarios.

The additional components that make up the BAM vegetation integrity score were excluded due to the constraints the amount of information that could be elicited from the experts.

SIMULATING DEVELOPMENT, OFFSETTING AND CONDITION CHANGE OVER TIME

The OffsetSim model has three components:

1. A ***development model***, which in this case simulates development in the Growth Areas within development footprints (see below);
2. An ***offset model***, that implements offsets with either high or low intensity management in the strategically-defined offset areas (see below); and
3. A ***vegetation condition change model*** to simulate change in the condition of CPW over time under management types of different intensity, including no management.

The simulation works by running for a specified number of time steps. In each time step the following processes occur:

1. ***Develop parcels:*** Parcels are randomly selected from the development footprint area, with the number developed at each time step set so that all parcels in the development footprint area are developed within 37 years at an approximately even rate of development.
2. ***Offset parcels:*** Depending on the scenario (see below), offsetting is done in two ways. In one case parcels are randomly selected to be offsets in the strategic offset area, at a rate such that all or half of the parcels (depending on the scenario) are offset after 37 years, with offsetting occurring at an approximately constant rate. For other scenarios all or half (depending on the scenario) of the parcels in the strategic offset area are implemented as advanced offsets in the first time step.
3. ***Update ecological condition:*** The condition of CPW in each pixel is updated based on the relevant scenario occurring on the parcel where the CPW occurs: (i) for developed parcels, the condition of CPW is set to zero; (ii) for parcels managed as offsets, the condition of CPW improves based on the expert elicited curves depending on whether high or low intensity management is being used for the offsets; (iii) for parcels that are not offset or developed, the CPW will slowly decline in condition based on the expert elicited do nothing curves, which assumes typical private land activities continue.

These three processes are repeated every time step till the simulation is finished, and the condition of every pixel of CPW is retained for every time step. This allows the generation of the trends in condition over time, where condition scores are aggregated over either the whole Cumberland subregion, or the program area.

SPATIAL DATA INPUTS

All data was rasterized to a resolution of 20 m x 20 m, as the BAM specifies 20 m x 20 m survey plots are to be used to assess the composition and structure attributes (OEH, 2017). Thus, a vegetation integrity score consistent with the BAM can be modelled for each pixel in the vegetation raster layers without any additional transformation as each pixel is the size of standard BAM survey plot.

The required spatial inputs to the OffsetSim model comprise spatial raster layers depicting the development footprints and the set of locations where strategic offsets can occur, and the package allows these to be specified in any way, including having these areas overlapping.

The development footprints and strategic offset area are shown in Figure 4. It is important to note that these areas are based on preliminary boundaries as at November 2018, and are likely to change under the final Plan. It is also important to note that the strategic offset area at November 2018 contains approximately 1,605 ha of offsets for PCT 849 (CPW). However, the current draft target for PCT 849 under the Plan is 2,802 ha. Securing this larger amount of PCT 849 would change the results of the trend analysis.

OffsetSim also requires raster layers depicting the conservation features of interest, which in this case is the extent and condition of CPW. The extent of CPW is shown in Figure 5, overlaid on the development footprints and strategic offset area for reference. This layer includes the two existing vegetation data sets described above in the section on Vegetation Data, along with the data resulting from the Biosis field surveys in the Growth Areas. Figure 6 and Figure 7 show the condition classes of the CPW, with Figure 7 showing a close up that enables more of the vegetation patches and condition classes to be visible (see the Vegetation Data section above for a description of the condition classes in Figure 6 and Figure 7).

The land parcels for the Cumberland subregion are shown in Figure 8. These were sourced from the NSW Spatial Services Digital Cadastral Database (see http://spatialservices.finance.nsw.gov.au/mapping_and_imagery/cadastral_data), and rasterized to the same 20m pixel resolution as the other data. The parcels are the objects the simulation operates upon by selecting parcels to develop that are within the development region, and parcels to offset within the offset region. For this study, land parcels less than 1 ha were excluded from the analysis, as these are predominantly urban areas with very little CPW. Including these parcels creates significant challenges in running the simulation.

The simulation included existing conservation areas in the Cumberland subregion, including Biobank areas. This data is shown in Figure 9. Biobank sites are shown in pink to differentiate them from other conservation areas (shown in green). The spatial data for this information was provided by OEH in 2018. In the simulation it was assumed that Biobank sites were managed with *high intensity management,* while other conservation areas were managed with *low intensity management* (see Expert Elicitation section, above).

Table 5 shows the total area and the proportion of CPW that occurs in each of the spatial regions defined for the analysis. Of the 14,293.9 ha of CPW in the Cumberland subregion, 5.8% of it occurs in the development footprint area, 11.2% occurs within the strategic offset area, and 10.8 % occurs in existing Biobank and other conservation areas (Table 5).

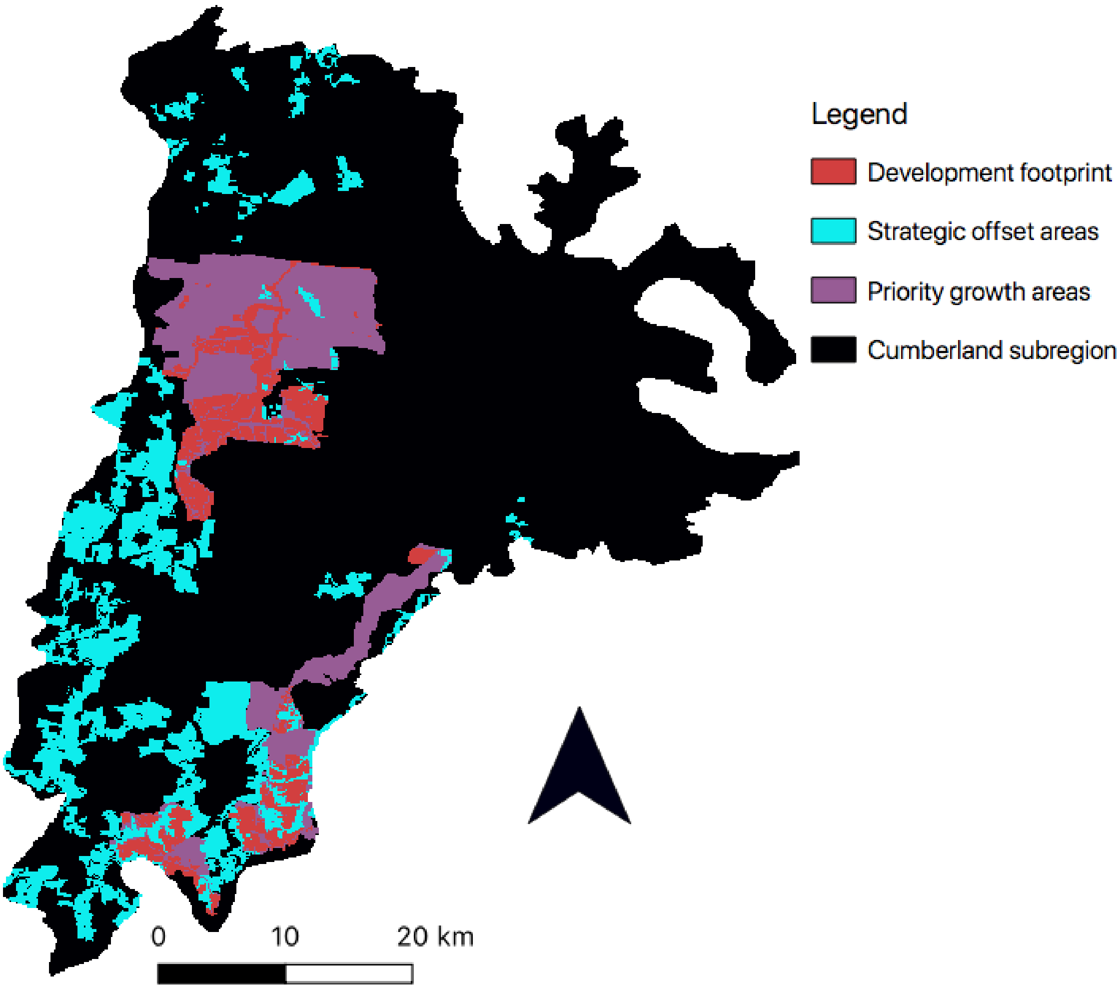

Figure 4. Map depicting the Growth Areas and the development footprint within them, and strategic offset locations within the Cumberland subregion.

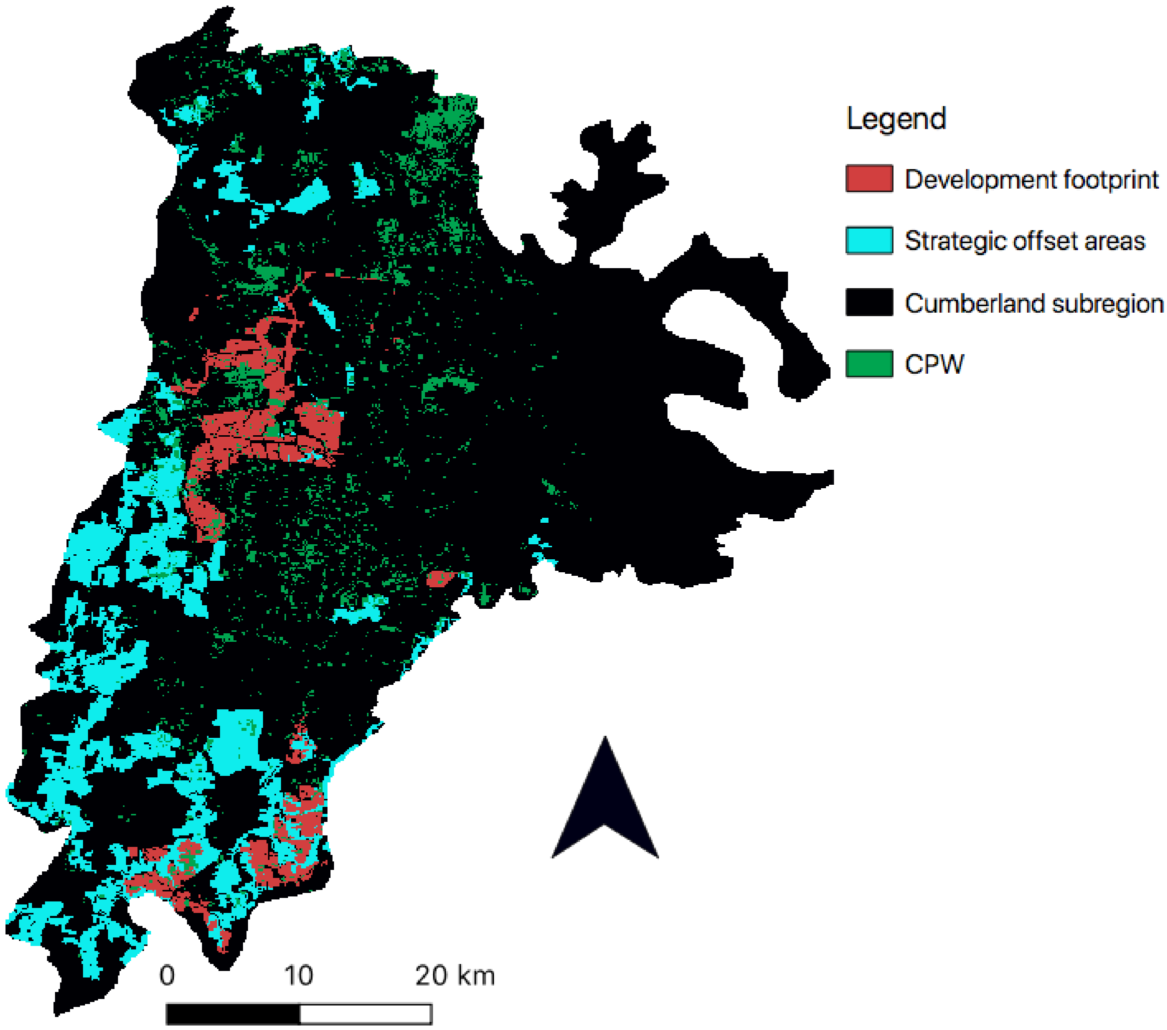

Figure 5. Map depicting the development footprint and strategic offset area, with distribution of CPW shown overlaid in green.

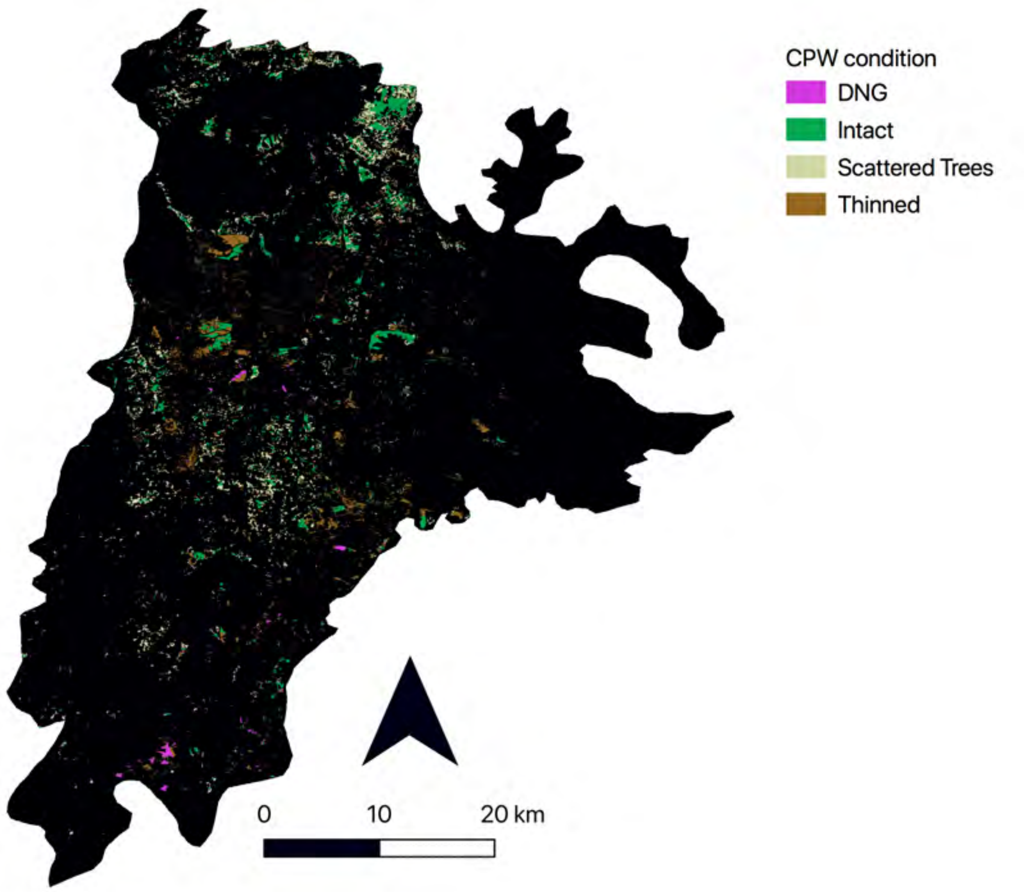

Figure 6. The distribution of CPW in the study area, showing the condition class of the vegetation.

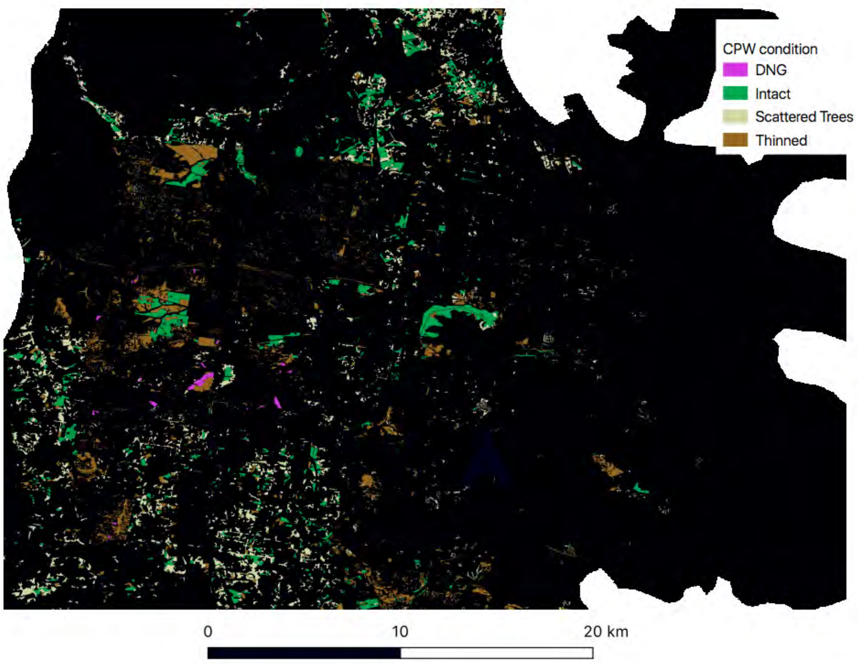

Figure 7. Close up of the layer showing the patches of CPW and their condition classes in the northern part of the Cumberland study area.

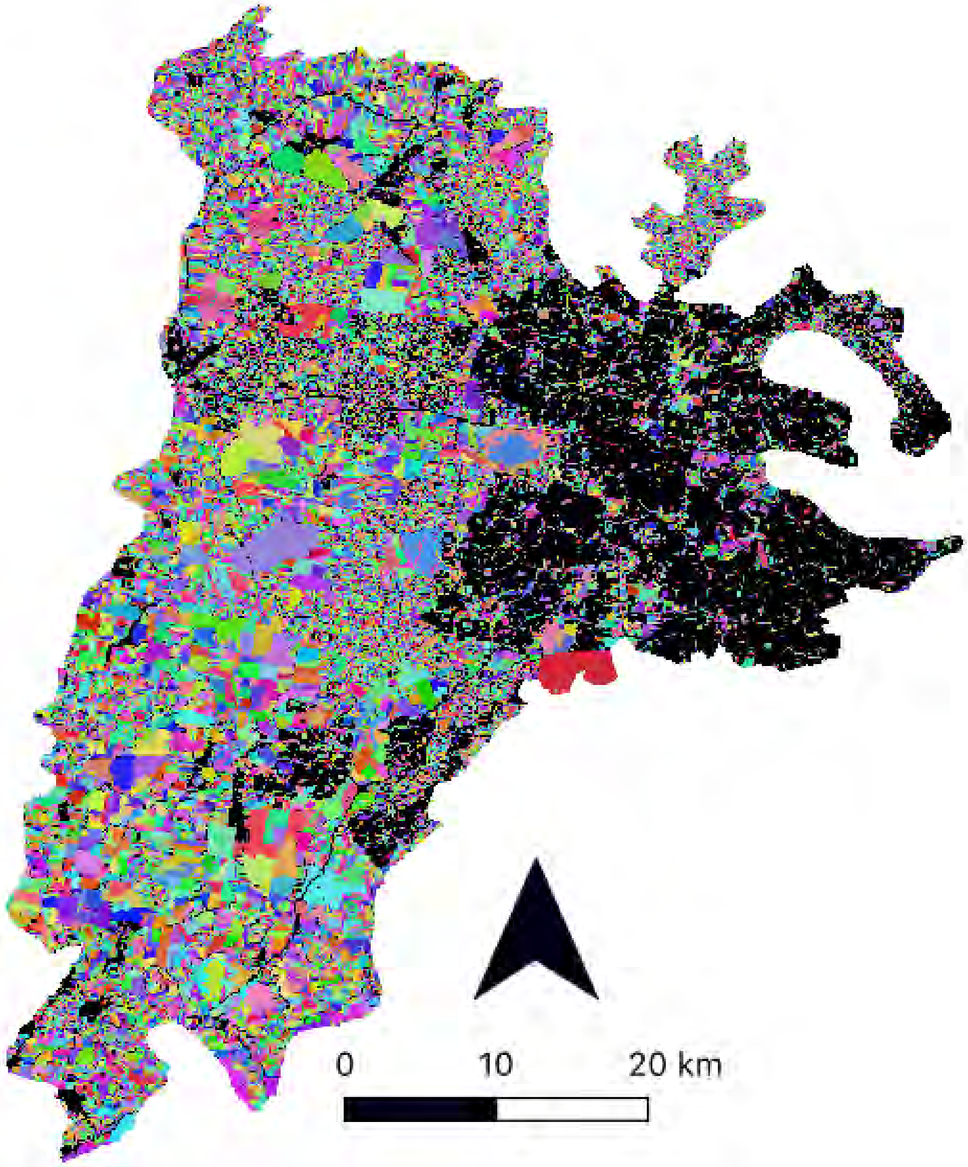

Figure 8. Map depicting the land parcels in the Cumberland subregion. Note that parcels less than 1 ha were excluded from the analysis, as these areas consisted primarily of urban areas, and contained very little CPW. Ares with excluded parcels are shown in black.

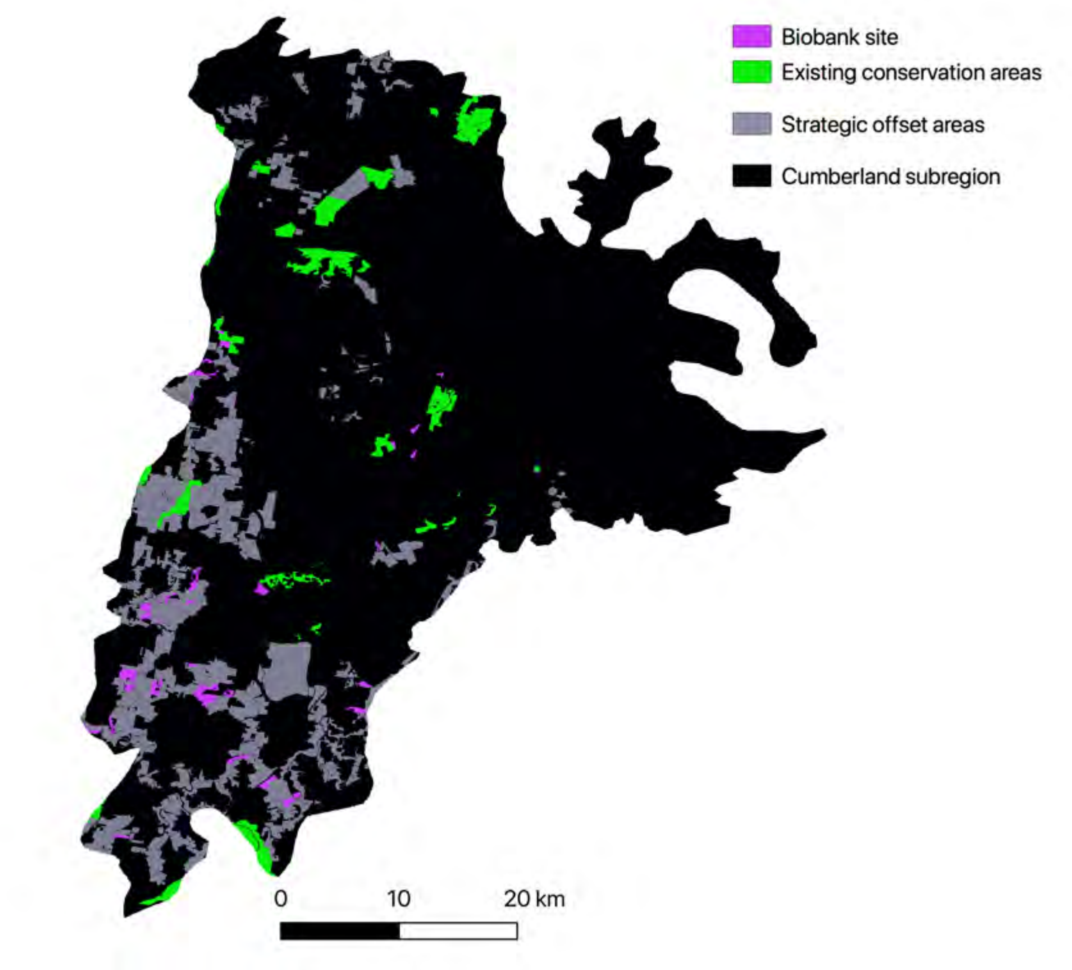

Figure 9. Existing conservation areas in the Cumberland subregion. Purple locations show existing Biobank sites, green areas show other existing conservation areas. For reference, the strategic offset areas are shown in grey.

Table 5. The total area and proportion of CPW in each of the regions used in the analysis.

Analysis feature	Area of CPW (ha)	Percentage of CPW in study area
Cumberland subregion	14,293.9	100 %
Growth Areas	3,083.7	21.6 %
Development footprint	827.0	5.8 %
Strategic offset area	1,605.3	11.2 %
Biobank sites	120.5	0.8 %
Other existing conservation areas	1,424.5	10.0 %
Phase zero areas (excluding offsets, overlaps with development region)	8,908.1	62.3 %

MODELLING CONDITION CHANGE OVER TIME

Modelling condition change involved three key steps:

- Setting the initial condition of each parcel of CPW – this was done differently depending on whether the parcel of CPW was within or outside the Growth Areas
- Applying the expert elicited curves to each parcel of CPW to predict how the initial condition changes under the scenarios (managed as an offset, developed, or subject to typical private land activities)
- Combining all the plant growth form richness and cover values into a vegetation integrity score

Firstly, the initial condition of every parcel of CPW was set to one of four condition classes used in the expert elicitation (*low*, *medium 1*, *medium 2*, or *high*, see above).

For CPW within the Growth Areas, this was done by directly converting the mapped condition classes determined during surveys undertaken by Biosis to the expert elicitation condition classes described above. Based on information from the experts during the elicitation, the mapped condition classes for CPW outside the Growth Areas is less accurate. Thus, the following approach was used to assign the initial condition classes outside the Growth Areas. First, the statistical distribution of the areas of CPW patches was determined for each of the condition classes in the Growth Areas. This characterises how likely a patch of CPW of a given size will be in a given condition class. These resulting distributions were used to undertake statistical sampling to assign an initial condition class to CPW patches outside the Growth Areas. While this means there is some randomness to the condition class assigned to these patches, it will result in the distribution of CPW patch sizes for each condition class being approximately the same for patches both within and outside the Growth Areas. The two fundamental assumptions underpinning this approach are: (i) patch area is the most important factor in determining the condition class of a patch of CPW, and (ii) that the relationship between patch area and condition is the same both inside the outside the Growth Areas. While neither of these assumptions will fully hold all the time, they are likely to provide a reasonable approximation.

Once the initial condition of each patch was determined, the initial values for richness and cover for the different plant growth form types were then determined (see the Expert Elicitation section, above). Next, the model updates the richness and cover values for each plant growth form type based on the curves provided by the experts (see Appendix A). In this analysis, the curves ***used were the means across all experts*** (see Figures A1-A5) and the particular curve applied to any given pixel of CPW depends on the scenario (i.e. managed as an offset; developed; or subject to typical private land activities).

The complexity of the condition change process comes in when a parcel moves from one state to another. For example, CPW in a given parcel might be slowly declining from some initial condition, and then at some point in the simulation the parcel is selected as an offset and management starts. From that point onwards, the trajectory of the CPW changes and starts improving based on the curve for either *high* or *low intensity management* (and it is assumed once a parcel is offset, management continues for the remaining duration of the simulation). The other change that can occur is when a parcel is developed, but in this case is it a simple transition as it goes straight to zero and then remains at zero for the duration of the simulation.

Thirdly, the plant growth form richness and cover values were combined into a vegetation integrity score, based on the equations given in the section "Calculating the Vegetation Integrity Score", above. The vegetation integrity scores of each pixel of CPW were then summed, and it is the change of summed vegetation integrity score over time that provides the *trends* for extent and condition of CPW.

SCENARIOS

To address the purpose of the trend analysis, the following scenarios were modelled:

1. Do nothing — continuation of typical private land activities, with no development or offsetting.
2. Development only — development in Growth Areas, with no offsets. Development occurs at an approximately constant rate such that all parcels in the development region are developed by the end of the 37 years of simulation. All subsequent scenarios use the same development model.
3. Development in Growth Areas with strategic offsets secured early, subject to low intensity management. In the simulation, offsets are all implemented in the first time-step of the model.
4. Development in Growth Areas with strategic offsets secured incrementally, subject to low intensity management. In the simulation, offsets are implemented at an approximately constant rate, such that all parcels are offset by the end of the 37 years of simulation.
5. Development in Growth Areas with strategic offsets secured early, subject to high intensity management. This is the same as Scenario 3, but with offsets subject to high intensity management.
6. Development in Growth Areas with strategic offsets secured incrementally, subject to high intensity management. This is the same as Scenario 4, but with offsets subject to high intensity management.

Four additional scenarios were also defined: scenarios 3A, 4A, 5A, and 6A. These are identical to scenarios 3-6, respectively, except that only half the parcels in the strategic offset area are implemented as offsets. This models the case where not all landholders in the strategic offset area are willing to secure biodiversity offsets on their land. The parcels that are selected as offsets are randomly chosen, meaning that the total area of vegetation offset differs slightly for each model realization of scenarios 3A, 4A, 5A, and 6A.

While it is recognised that the assumptions under some of the scenarios may not be realistic, the scenarios represent a set of outer bounds for what is likely to occur in practice. This is appropriate because it is more likely to allow clear differences in the scenarios to be identified, making the results of the analysis more useful. As the outputs of the modelling are subject to significant uncertainty, it is not meaningful to distinguish between a larger number of potentially more realistic, but more similar scenarios. This is due to the range of underlying uncertainties, and the variation inherent in multiple model realizations due to random processes (such as the selection of parcels to develop or offset in a given time step) may mean there is very little to distinguish difference in performance between the scenarios.

RESULTS

EXPERT ELICITATION

The expert elicitation resulted in predictions that could be used from five experts (see ‘Expert Elicitation’ section above) regarding how CPW changes under the three management regimes.

Appendix A shows how the expert estimates of the different components that make up the BAM vegetation integrity score are predicted to change over time under the three different management regimes. As described above, for each management regime, predictions are made for four different initial condition states of CPW. The components of the BAM vegetation integrity score for which estimates were made were tree; grass (and grass-like); and forb richness; as well as cover of trees; and cover of grass and grass-like. The curves resulting from each expert, along with the mean over all experts, are shown for each component in Figures A1- A5 (Appendix A).

In some cases, there can be considerable variation among the expert's predictions, such as how tree richness is predicted to change under high intensity management when CPW is initially in *low condition* (Figure A1), or how tree cover is predicted to change under high intensity management starting from the *medium 1 condition* (Figure A4). In other cases, the expert's predictions were much more similar, such as how forb richness will change under high intensity management, starting in the *medium 1* condition (Figure A3). These results in general can be used to determine the likely outcomes of restoration under low or high intensity management (as defined in the BAM), or to predict declines under no management.

As described above, the components elicited can be combined by transforming, weighting and adding together to produce a vegetation integrity score similar to that defined in the BAM (OEH, 2017). This was done for all the elicited components and combined into a single curve, representing how the vegetation integrity score varies with time for each initial condition, and management combination. As noted above, the vegetation integrity score presented here is only an approximation of the vegetation integrity score defined in the BAM, as there are additional components in the BAM version that were not included in the elicitation (OEH, 2017).

Figure 3 shows how the vegetation integrity score is predicted to change under management, based on the mean values elicited across all experts. The way the vegetation integrity score is calculated (see above), results in a vegetation community in its pristine benchmark state having a vegetation integrity score 100. This benchmark value is shown with a horizontal green line in Figure 3. For each initial condition state, undertaking no management results in approximately linear declines due to ongoing threats from typical private landholder activities. High intensity management delivered significantly greater gains in vegetation integrity over time, compared to low intensity management. In most cases, high intensity management resulted in the vegetation integrity score plateauing, as components approached their benchmark values. In some cases, the experts predicted that richness or cover values for some growth form groups could exceed their benchmark values (see Appendix A), resulting in vegetation integrity scores greater than 100. This is most prominent for high management applied to CPW initially in the *medium 1* condition (top right plot; Figure 3). This suggests that high intensity management is predicted to deliver significant restoration gains from a low or medium initial condition. This is not the case for low intensity management, which provides much smaller gains, especially if the starting condition is low.

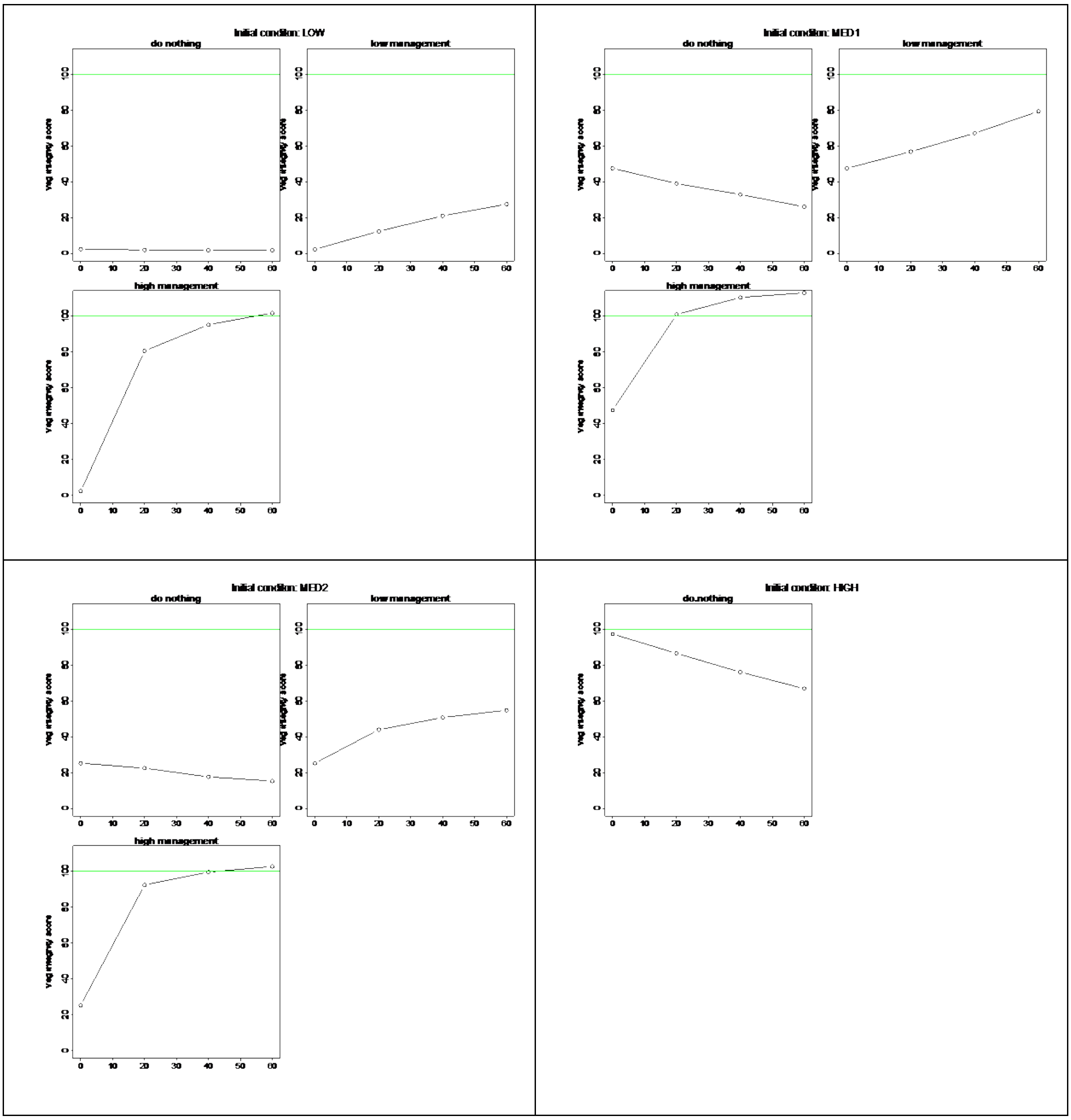

Figure 10. Results of the expert elicitation showing how the modelled version of the BAM vegetation integrity score (y-axis) changes with time (x-axis), for different management regimes and different initial conditions. Each plot shows the vegetation integrity score calculated by taking the mean value across all experts for each component that makes up the score. The top left plots show results for CPW starting in *low condition*, while the remaining plots show results for starting in *medium 1*, *medium 2* and *high conditions* (clockwise from top left). Note that for vegetation in high condition, only the do nothing scenario was elicited, as it was assumed that any management would retain the vegetation in high condition. The green horizontal line in the plots indicate the vegetation integrity score that CPW would have its pristine benchmark state (a value of 100.0).

SIMULATION OF DEVELOPMENT AND OFFSETTING

The main metric used to evaluate performance of the different scenarios is the summed BAM vegetation integrity score over the region of interest as a function of time.

The model produces a map at each time step, showing the condition of each patch of CPW, as well as the locations where development has occurred (where it is assumed that all CPW is removed) and where offsets were implemented (where it is assumed that CPW is managed under high or low intensity management).

Figure 11 shows the final maps generated by the simulation on the last time step for scenario 1 (on the left) and scenario 2 (on the right), where the condition of CPW is depicted by the shade of green (representing the modelled vegetation integrity score), and development is shown in red.

Figure 12 shows maps generated on the last time step for scenarios 3-6, after all development and offsetting has been applied. These plots show the offset regions in blue, where all parcels with CPW in the strategic offset area are implemented as offsets (left plot in Figure 12) and where only half the parcels (randomly selected) are implemented as offsets (right plot).

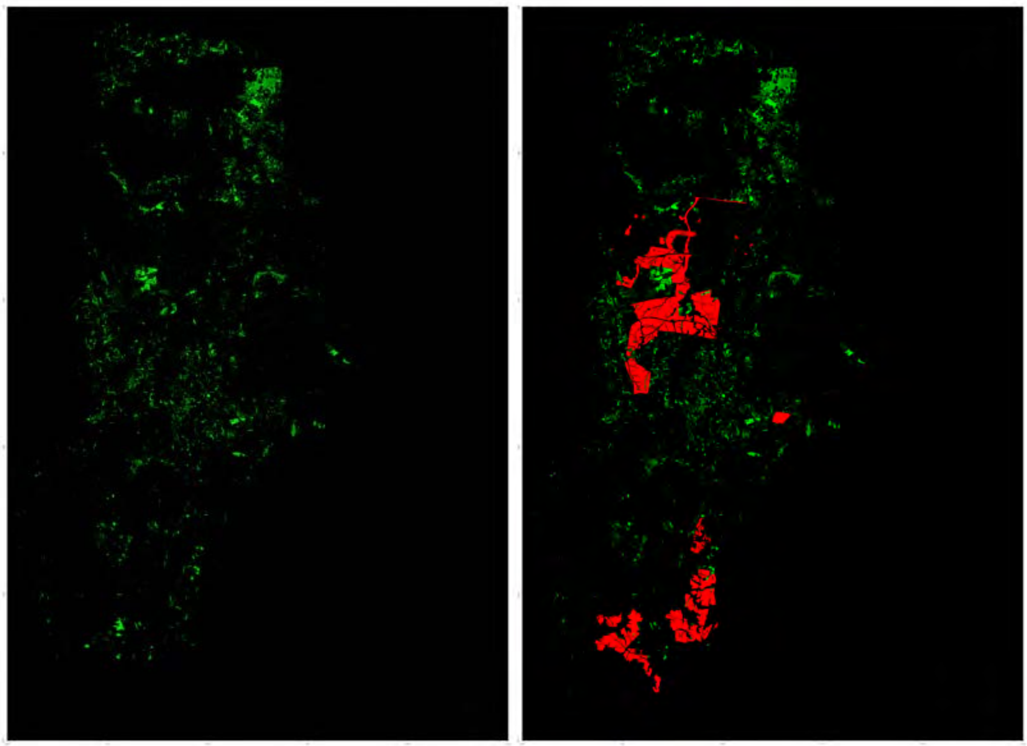

Figure 11. Maps showing modelling outputs for scenario 1 (S1: no development), and scenario 2 (S2: development only). CPW is shown in green with the lighter colour representing a higher vegetation integrity score. Developed parcels are shown in red. Maps show the results at the last time step when all development has been implemented.

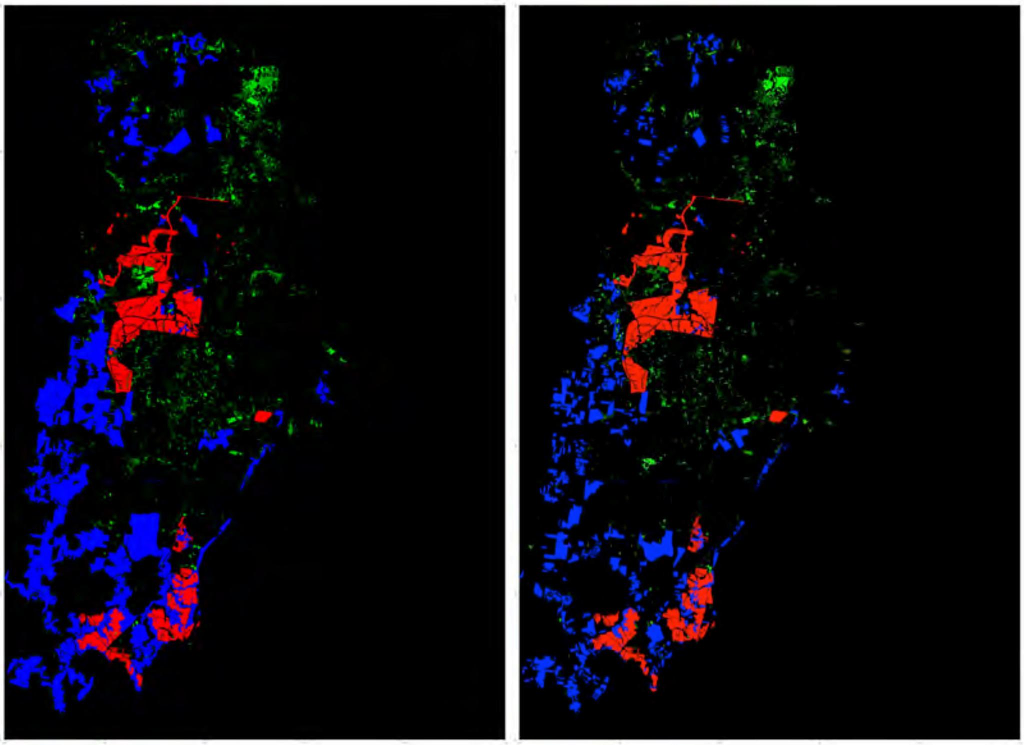

Figure 12. Maps showing outputs for scenarios with both offsetting and development. CPW is shown in green with the lighter colour representing a higher vegetation integrity score. Developed parcels are shown in red, and offset parcels are shown in blue. The map on the left shows the result when all parcels in the strategic offset area are implemented as offsets (scenarios 3-6), and the plot on the right shows one realization of the case where only half the parcels in strategic offsets area are implemented as offsets (scenarios 3A-6A). Maps show the results at the last time step when all development and offsetting has been implemented.

The predicted changes to the summed ecological integrity scores under each of the scenarios are shown in Figures 13-15 in relation to 'landscape scale and 'program scale' results.

The ***landscape scale*** results show the summed vegetation integrity score for the whole Cumberland subregion, including development and offset areas, other conservation areas and existing Biobank sites, as well as remaining areas on private and public land where the vegetation is assumed to be unmanaged.

The ***program scale*** results show the summed vegetation integrity score just for the parcels developed and offset.

The ***landscape scale*** results allow the contribution of development and offsetting to be evaluated relative to overall trends in the Cumberland subregion, while the ***program scale*** results allow an evaluation of the impacts on CPW just in the regions where development and offsetting is occurring (the program area).

Program scale results in Figures 14 and 15 are shown in terms of 'outcomes' and 'impacts'. The outcome plots show the absolute trajectory of the summed vegetation integrity score over time, starting from its initial (current) value and indicating how this value changes with time. The end point of each line shows the final summed vegetation integrity score predicted to occur under a given scenario (incorporating development losses and background declines due to ongoing typical private land activities).

The impact plots show the ***difference of each scenario relative to the counterfactual of S1*** (do nothing—ongoing private land impacts). Thus, for impact plots, values greater than zero indicate better performance relative to S1, and a value less than zero indicates worse performance than S1.

Assessing whether a scenario ***achieves No Net Loss in terms of mitigating the impacts of the development is done by determining when a scenario has an impact greater than zero on the impact plots***. Determining whether a scenario ***mitigates both development impacts and ongoing background declines is done by comparing the trajectory relative to the starting point on the outcome plots***. Where the trajectory is below the starting point, this indicates that both development and background declines have not been compensated for.

While outcome plots are provided at the landscape and program scale, the impact of the scenarios is the same at these scales. This is because the impact is the difference between a given scenario and S1 (i.e. *SX – S1*, for some scenario *X*). Everything occurring outside the program area (offset and development regions) is the same for S1 and all other scenarios, comprising management of Biobank and other conservation sites as well as ongoing decline for vegetation in other areas (i.e. SX – S1 = 0 outside the program areas). Thus, taking the difference of any given scenario, (SX) with S1 just provides the difference between what is occurring in the program area, as the summed vegetation integrity score outside the program area is the same in both scenarios. In other words, ***the impact of all scenarios at the program and landscape scale is the same***.

For all the results presented below it was assumed that existing protected areas had low intensity management and Biobank sites had high intensity management, and everywhere else outside development and offset footprints had no management. Each scenario was run 10 times (10 ***realizations***), and due to the random process in which parcels are selected for offsetting and development in a given time step, each realization has some variation in the summed vegetation integrity score over time due to different parcels being selected in different time steps. The plots show each realization as a fine line and the mean over all realizations for a given scenario as a thick line. Each scenario is shown in a different colour.

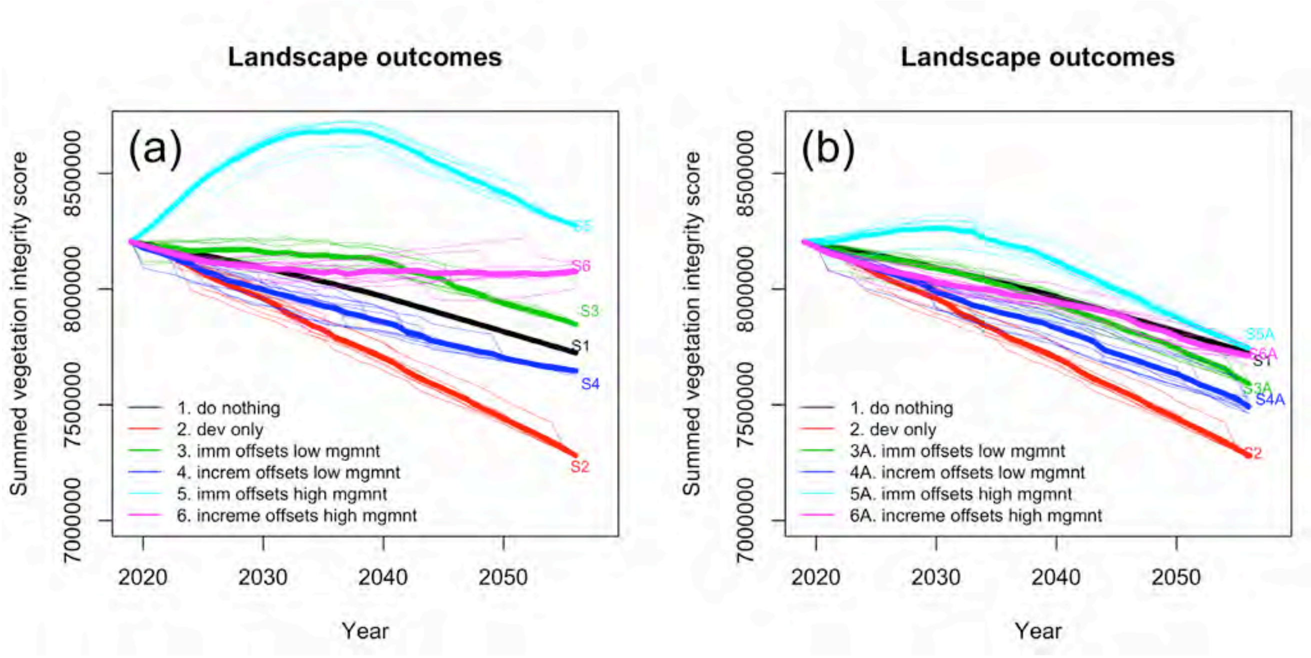

Figure 13. Landscape scale outcomes for 10 realisations of each scenario. The mean of each scenario is shown as the bold line and each individual realization is shown as a thin line. (a) depicts the case where all parcels in the strategic offset region are implemented as offsets, while (b) shows the case where only half of the parcels (randomly selected) in the strategic offset region are implemented as offsets.

Landscape scale ***outcomes*** are shown in Figure 13. When all parcels in the strategic offset area are implemented (Figure 13(a)), all scenarios except S5 result in losses in summed vegetation integrity relative to the initial state. The high intensity management of offsets and their early implementation mean S5 results in initial improvements, however once these gains stop accruing, the ongoing losses in the rest of the landscape result in S5 declining after about 2037, finishing slightly above the initial starting condition. S3 initially outperforms S6, but the high intensity management means that eventually S6 overtakes S3 resulting in a higher summed vegetation integrity score at 2055. The relative ranking of the scenarios is the same for the scenarios where only half the offsets are implemented (Figure 13(b)). However, in this case all scenarios result in ongoing landscape losses except S5A which has small initial gains, which then decline after approximately 2035. In this case, all scenarios end with summed ecological integrity below the current starting state.

Figure 14 shows program scale ***outcomes*** when the vegetation integrity score is summed over the program area (development and offset areas). For the scenarios where only half the parcels in the strategic offset area are implemented (Figure 14(b)), the offset program area is reduced compared to when all parcels in the offset area are implemented as offsets (Figure 14(a)), resulting the plots starting from a lower initial value. Note that in Figure 14(b) there are different starting values for each realization, due to the fact the offset parcels are randomly selected and will have different total area for each realization. When all offsets are implemented (Figure 14(a)), the relative performance of all scenario outcomes at the program scale is similar to the landscape scale outcomes (Figure 13). However, in this case S5 and S6 result in gains relative to the initial starting state, and S3 results in a small gain which eventually declines to approximately the stating state by the end of the simulation, while S4 results in declines relative to the initial state for the duration of the simulation. When half the offsets are implemented (Figure 14(b)), all scenarios result in losses by the end of the simulation relative to the starting state. S5A provides some initial gains but eventually drops below the initial state by the end of the simulation. The difference between each scenario is much more reduced compared to Figure 14(a), with the variation between model realizations providing significant overlaps between the scenarios.

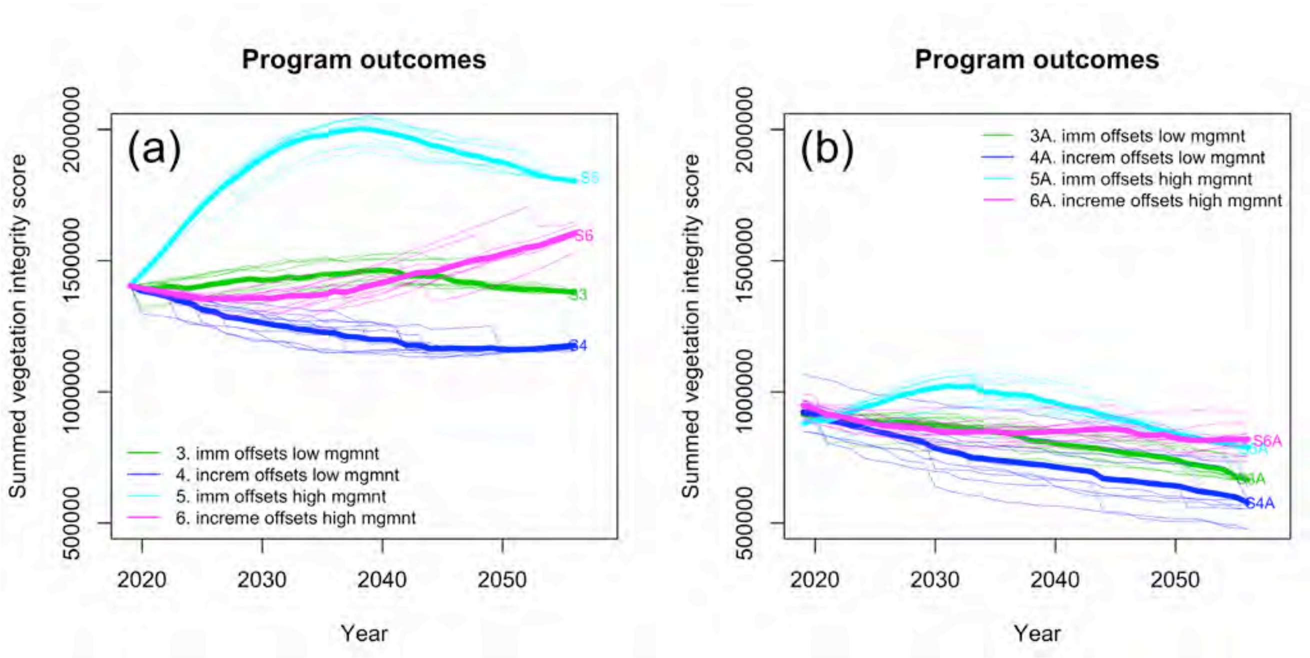

Figure 14. Program scale outcomes for 10 realisations of each scenario, with the mean of each scenario shown as a bold line and each individual realization shown as a thin line. (a) depicts the case where all parcels in the strategic offset region are implemented as offsets, while (b) shows the case where only half of the parcels (randomly selected) in the strategic offset region are implemented as offsets. Note that scenarios 1 and 2 are not shown as these scenarios do not have offsets and thus the 'program scale' (consisting of the offset and development area) is do not have offset areas defined.

The ***impact*** of each scenario is shown in Figure 15, depicting how each scenario performs relative to S1 without any offsets or development. As discussed above, this shows ***the extent to which the development impacts alone are compensated***. When all parcels in the strategic offset area are implemented (Figure 15(a)), S3, S5 and S6 always result in positive impacts, with S6 resulting in initial losses for the first 8 years or so. S3 initially outperforms S6, but the high intensity management of S6 means it eventually overtakes S3. S4 results in initial losses, which then improve but remain negative for the duration of the simulation meaning that low intensity management with offsets implemented incrementally is likely to result in losses relative to no development or offsets (S1). When only half the parcels in the offset area are implemented (Figure 15(b)), gains are significantly reduced for all offset scenarios, with only S6A ending with a value slightly higher than zero but S5A is also very close to zero. This means that when only half the parcels in the strategic offsets area are implemented as offsets, only scenarios with high intensity management (S5A and S6A) compensate for development losses.

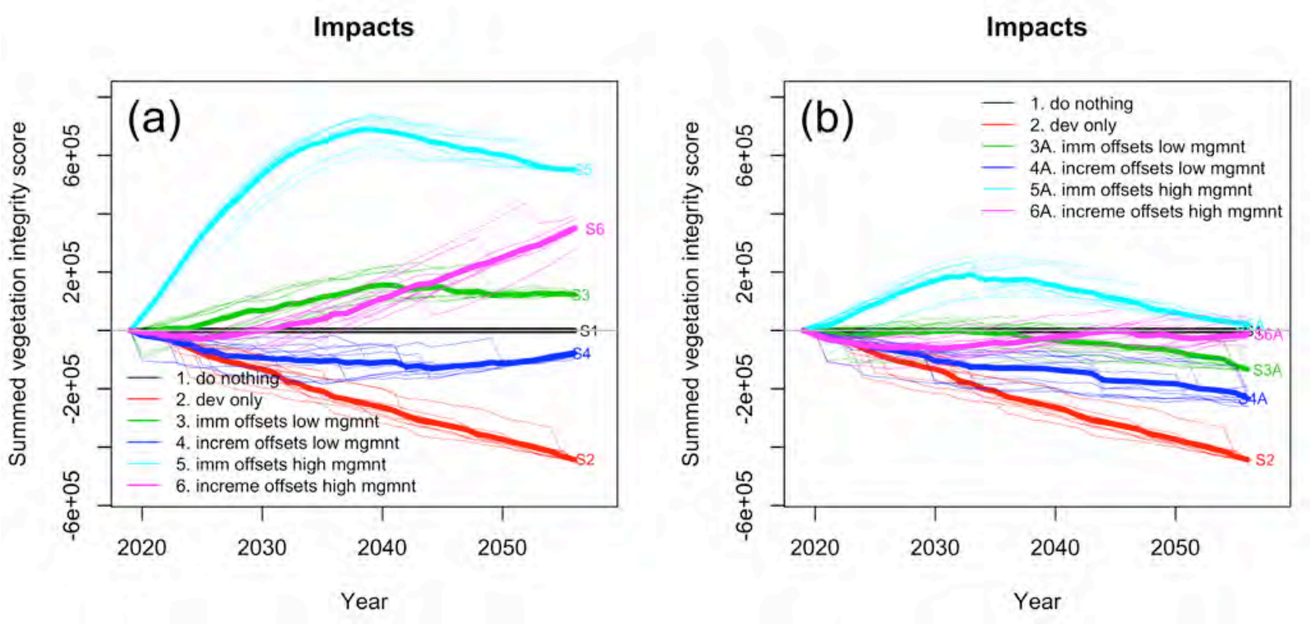

Figure 15. Impacts of the offset and development scenarios, relative to the counterfactual baseline of S1. This shows the performance of each scenario in terms of compensating for development losses alone. Ten realizations of each scenario are shown, with the mean of each scenario depicted as a bold line and each individual realization shown as a thin line. S1 is shown as a horizontal line with impact of zero (a) depicts the case where all parcels in the strategic offset region are implemented as offsets, while (b) shows the case where only half of the parcels (randomly selected) in the strategic offset region are implemented as offsets.

Table 6 summarizes all the results, showing the final summed vegetation integrity score for each scenario at the end of the simulation (year 2056). It also shows the percentage change of each scenario relative to summed vegetation integrity score of S1 on the last time step (middle column) as well as the percentage change relative to initial starting condition of all scenarios at the landscape scale (last column).

Table 6 indicates that under S1, there is a 5.8 % drop in summed vegetation integrity score at the landscape scale due to ongoing private land activities and other degrading process. When development is included, this adds an additional impact of almost the same magnitude (5.78 %) (seen by comparing the percentage change between S1 and S2). Thus, we see the impact of development is almost the same as the projected declines under S1 at the scale of Cumberland subregion from landscape scale threats.

From Table 6 it can also be seen that by the year 2056, only S5 and S6 provide gains at the landscape scale relative to the starting condition, and that S3, S5, S6, S5A and (almost) S6A provide gains, or achieve No Net Loss of summed vegetation integrity relative to do nothing (S1).

Table 6. The percentage change of each scenario relative to Scenario 1 (do nothing) on the last time step of the simulation.

Scenario	Mean summed vegetation integrity score on the last time step and landscape scale	Percentage change relative to value of Scenario 1 on the last time step	Percentage drop relative to starting condition
S1 – Do nothing	7,724,857	0 %	-5.8 %
S2 – Development only	7,281,680	- 5.7 %	-11.2 %
Offsets implemented in all of the parcels in the strategic offset area			
S3 – Imm offsets low management	7,847,765	+ 1.6 %	-4.3 %
S4 – Increm offsets low management	7,646,977	- 1.0 %	-6.8 %
S5 – Imm offsets high management	8,275,312	+7.1 %	+0.86 %
S6 – Increm offsets high management	8,074,270	+ 4.5 %	-1.6 %
Offsets implemented in half of the parcels in the strategic offset area			
S3A – Imm offsets low management	7,591,975	-1.7 %	-7.5 %
S4A – increm offsets low management	7,491,923	-3.0 %	-8.7 %
S5A – Imm offsets high management	7,745,532	+0.27 %	-5.6 %
S6A – Increm offsets high management	7,712,384	-0.16 %	-6.0 %

DISCUSSION

This report presents the results of a trend analysis examining the potential impacts of development and offsetting in the Cumberland subregion on the native vegetation community *Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion* (PCT 849; referred to here as CPW). It consisted of two parts: a formal expert elicitation to gather quantitative knowledge regarding how CPW will change over time under different management scenarios; and quantitative modelling to simulate the urban development within designated Growth Areas, compensation via managing areas as biodiversity offsets in a strategically defined offset region, and the ecological response of CPW over the whole Cumberland subregion. The main points that can be concluded from the trend analysis results are discussed below.

The landscape scale accounts for all parcels in the whole Cumberland subregion, including the parcels that are not part of the program and subject to ongoing declines due to typical private land activities. At this scale, only one scenario results in a gain of summed vegetation integrity of CPW relative to the current state over the whole Cumberland subregion (Figure 13). The gain occurs when offsets are implemented immediately with high intensity management and all parcels in the strategic offsets area are assumed to be secured. In this scenario, there are initial gains, but by the end of the 37-year time period, scenario 5 has dropped to be just above the initial value of the summed vegetation integrity score.

All other scenarios at the landscape scale result in losses of summed vegetation integrity over the whole Cumberland subregion, right from the start. This is due to the predicted large and ongoing condition declines of all the vegetation left unmanaged on private land, as the Plan only influences a proportion of the subregion. The predicted declines in vegetation integrity for unmanaged areas subject to typical private landholder activities can be seen in Figure 13, with scenario 1 line (black line in figure) showing how this plays out relative to the offset and development scenarios. By comparing Figure 13(a) and 13(b) it is clear that if only 50 % of the parcels in the strategic offset area can be implemented as offsets, CPW declines relative to its current condition will be notably larger by the end of the simulation.

The program scale accounts for only the parcels of land where development and offsetting occurs. At this scale, it is only possible to maintain the current state (or better) if all parcels in the strategic offset area are managed, *and* high intensity management *or* immediate offsets are implemented (scenarios 3, 5 and 6; Figure 14). If only half the offsets in the strategic offset area are implemented, all scenarios eventually fall below the current state (Figure 14(b)).

If all offsets in the strategic offset area are implemented, scenarios 3, 5, and 6 also offer the potential of achieving No Net Loss relative to the do nothing scenario (S1: no offsets or development; Figure 15). However, only scenario 5 can reliably deliver no let loss relative to scenario 1 where only half of the parcels in the offset area are secured (Figure 15(b)). In the case where only half the parcels are secured as offsets, all other scenarios result in losses relative to scenario 1, meaning that, in this case, the net impact of development and offsets results in a net loss.

From these results it is clear that high intensity management and implementing offsets as early as possible are both factors in ensuring offsets deliver the greatest gains. However, the importance of high intensity management relative to implementing offsetting early depends on the time horizon over which gains are evaluated. Implementing all offsets immediately with low intensity management delivers greater gains in the short term (1-2 decades), but the simulations show that implementing offsets incrementally with high intensity management eventually delivers greater gains. Clearly, the best conservation outcomes occur with high intensity management and immediate offsets (scenario 5), which results in notably better performance compared to all other scenarios.

The negative impact of development can be seen by comparing scenarios 1 and 2 in Figure 13 (the black and red lines, respectively) which shows the landscape outcomes of CPW of the whole Cumberland subregion. The only difference between these scenarios is the loss of vegetation due to development. Comparison of these two lines in Figure 13 indicates that development in the Growth Areas is having a large negative impact on CPW, and this impact is of similar in magnitude to the declines occurring over the whole Cumberland subregion (a decline of 5.7% in the summed vegetation integrity score (Table 6)).

The results of the expert elicitation reveal there is significant potential for restoring CPW if high intensity management (as defined in Table 3) is implemented. As shown in Figure 10, the expert elicitation revealed that the vegetation integrity score can be significantly improved under the high intensity management regime, even when starting from the low initial condition state. However, if low intensity management is implemented (as described in Table 2), then the gains are significantly reduced and do not reach the point of plateauing within the 60-year time horizon of the elicitation.

It should be noted that the effects of climate change were *not* included in this analysis. While this was discussed in some detail during the expert elicitation workshop, it was agreed that the other degrading processes considered in the elicitation are likely to have a greater determinantal effect than climate change over shorter time frames. In addition, there is a much greater ability control these processes compared to climate change. These factors, along with the significant uncertainties around the impacts of climate change, led to excluding climate change as a degrading process in the modelling.

There are many uncertainties and assumptions in a modelling exercise such as presented here, which have been detailed throughout the report. They include uncertainties in the model inputs, such as the spatial data characterizing the location and initial condition of CPW, and the expert predictions of how ecological factors of CPW will change over time (which varied considerably between experts in some cases). There are also uncertainties in the assumptions of the structure of the model, for example around management being constant and continuous and equally effective over all parcels being managed. Finally, there are many assumptions built into the scenario definitions, which, as discussed above, represent outer bounds of different realistic options for offsetting. While these assumptions and uncertainties may limit the actual predictive ability of a modelling exercise such as this, it is impossible to model so far into the future and on such as large scale without making a wide range of assumptions.

The utility of an exercise such as this is that it allows the relative performance of different scenarios to explored with respect to a clearly-articulated system model, including its uncertainties and assumptions. Thus, scenarios can at least be evaluated with respect to these system models, providing a transparent set of assumptions as how the evidence underlying mitigation decisions were generated. For evaluating mitigation strategies over such large spatial and temporal scales, there is no other alternative.

OVERALL KEY MESSAGES

The key findings of this analysis for CPW are summarized below.

- Landscape-scale threats across the Cumberland subregion, such as weed invasion, grazing, rubbish dumping, and disturbance from recreational activities are causing significant declines.
- The negative impact of development in the Growth Areas is of a similar scale to ongoing declines from landscape scale threats across the whole Cumberland subregion over 37 years. Landscape scale threats across the subregion are projected to result in a 5.8 % drop in summed vegetation integrity score over 37 years (scenario 1, Table 6). The additional impact of development adds further losses of almost the same magnitude (another 5.78 %; Table 6).
- The Plan is generally unlikely to reverse declines from landscape scale threats across the whole Cumberland subregion because the magnitude of these threats is large and the Plan only influences a proportion of the subregion. The only scenario where declines were always reversed at the landscape scale was scenario 5 (Figure 13, Table 6), where it was assumed that: (i) all parcels in the strategic offset area are implemented as offsets, (ii) all offsets were implemented immediately; and (iii) all offsets had high-intensity management. This comprises the outer bound of the best-case scenario, and may not be feasible to implement.
- In terms of whether the Plan addresses the impacts of development in the Growth Areas alone within the program area (ignoring declines from landscape scale threats), two of the four offset scenarios (scenarios 5 and 6) provided adequate compensation irrespective of whether 100% or 50% of the CPW was secured as offsets in the strategic offset area (Figure 15, S5 and 5A, S6 and 6A). When 100% of the CPW available in the strategic offset area is secured as an offset, three of the four offset scenarios compensate for development impacts (all except scenario 4). When 50% of the CPW available in the strategic offset area is secured as an offset, only two of the four offset scenarios (S5 and S6) provide adequate compensation.
- In terms of whether the Plan addresses the impacts of development in the Growth Areas as well as declines from landscape scale threats within the program area, three of the four offset scenarios (scenarios 3, 5, and 6) compensate for both these impact types when 100% of the CPW in the strategic offset area is secured (Figure 14(a)). However, none of the offset scenarios can compensate for both these impact types in the program area if only 50% of the CPW in the strategic offset area is secured (Figure 14(b)).

- The timing of offset implementation and the level of management intensity make a significant difference to the gains able to be achieved by offsets, with early implementation/high intensity management always performing best.
- The relative benefit of early implementation compared to high intensity management depends on the time period over which gains are evaluated. The results suggest that (Figure 15):
  - Early implementation with low or high intensity management delivers greater gains in the short term (1 to 2 decades).
  - Early implementation with high intensity management delivers the greatest gains in the long term.
- Results of expert elicitation (Figure 10) indicate that high intensity management provides significant potential for providing restoration gains for CPW, even when starting from a low initial condition. However, low intensity management has limited capacity to improve the ecological condition of CPW, especially when starting from a low initial condition.

Care will need to be taken in extrapolating these results to other PCTs. However, it is likely that the overall findings will have relevance and will provide useful context to the discussion of long-term trends in native vegetation change within the Cumberland subregion.

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APPENDICES

APPENDIX A – DETAILED RESULTS OF THE EXPERT ELICITATION

Below, the key results of the expert elicitation are summarized. They show the *best estimates* of each expert for how tree richness (Figure A1), grass richness (Figure A2), forb richness (Figure A3), tree cover (Figure A4), and grass cover (Figure A5) change over time. This is presented using four different starting conditions (low; medium 1; medium 2; high) and three management regimes (do nothing; low; and high management)— see main text for details of starting conditions and management. In each of the plots below, the results for each individual expert is shown with a thin, coloured line. The mean over all experts for is shown with a dashed black line. For the results presented in the main report, the mean value is across all experts is used for calculating the vegetation integrity score, as described above.

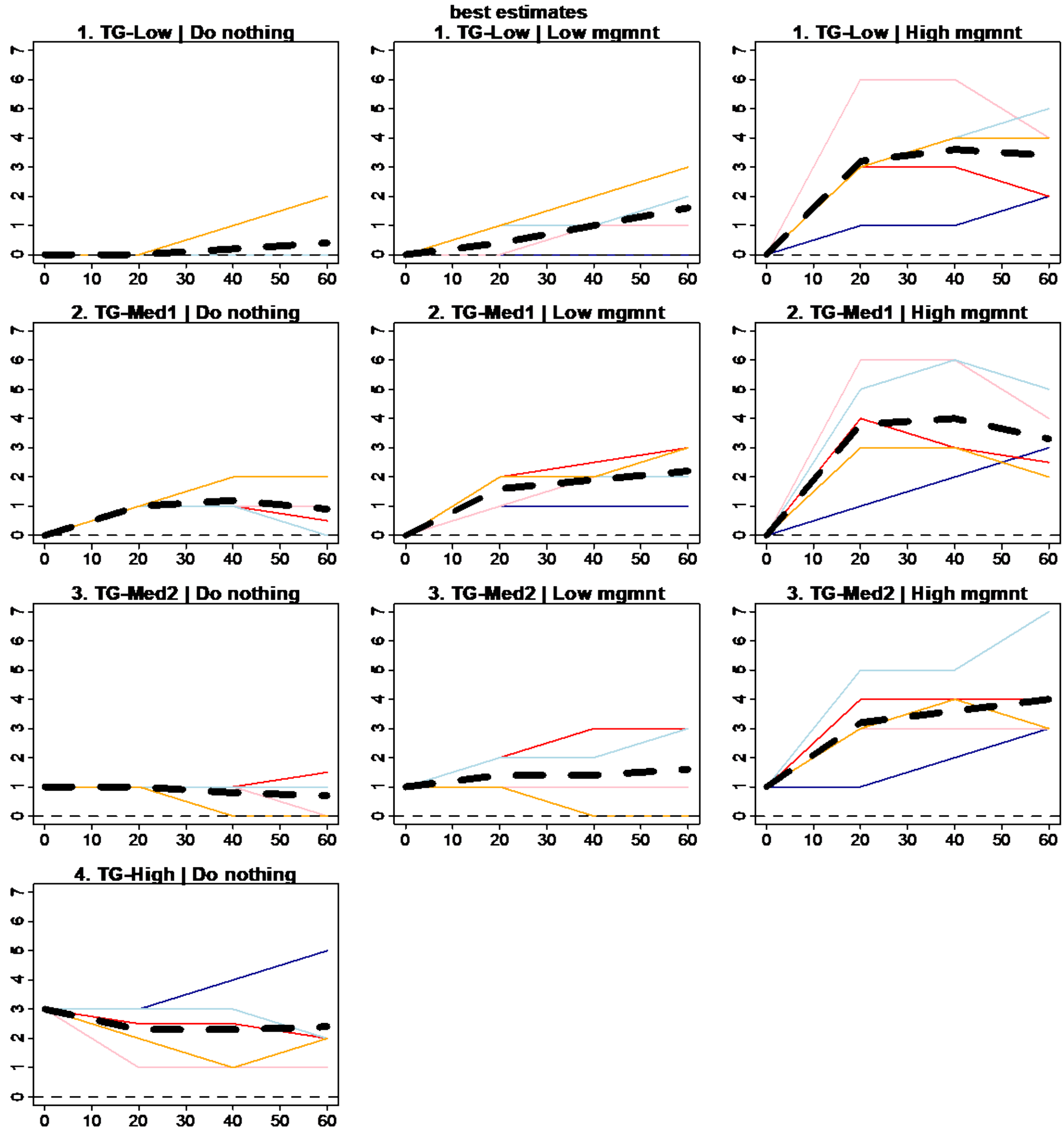


Figure A1. Results of the expert elicitation showing how tree richness (y-axis) for CPW is predicted to change over time (x-axis) for different initial conditions and management regimes in 20-year increments. The left column shows results for the do-nothing management scenario, while the middle and right columns show results for the low and high management regimes, respectively. The top row shows results for vegetation starting in the low condition, the second and third rows show results for vegetation starting in the medium 1 and medium 2 condition, respectively. The bottom plot shows results for vegetation starting in the high condition under do-nothing. Note, results were not elicited for vegetation starting in the high condition under high or low management, as it was assumed that with management, it would retain its richness score. Y-axis value on all plots is the count of species of trees in a notional 20 m x 20 m plot. X-axis (time) values were identified at t=0, t=20, t=40 and t=60.

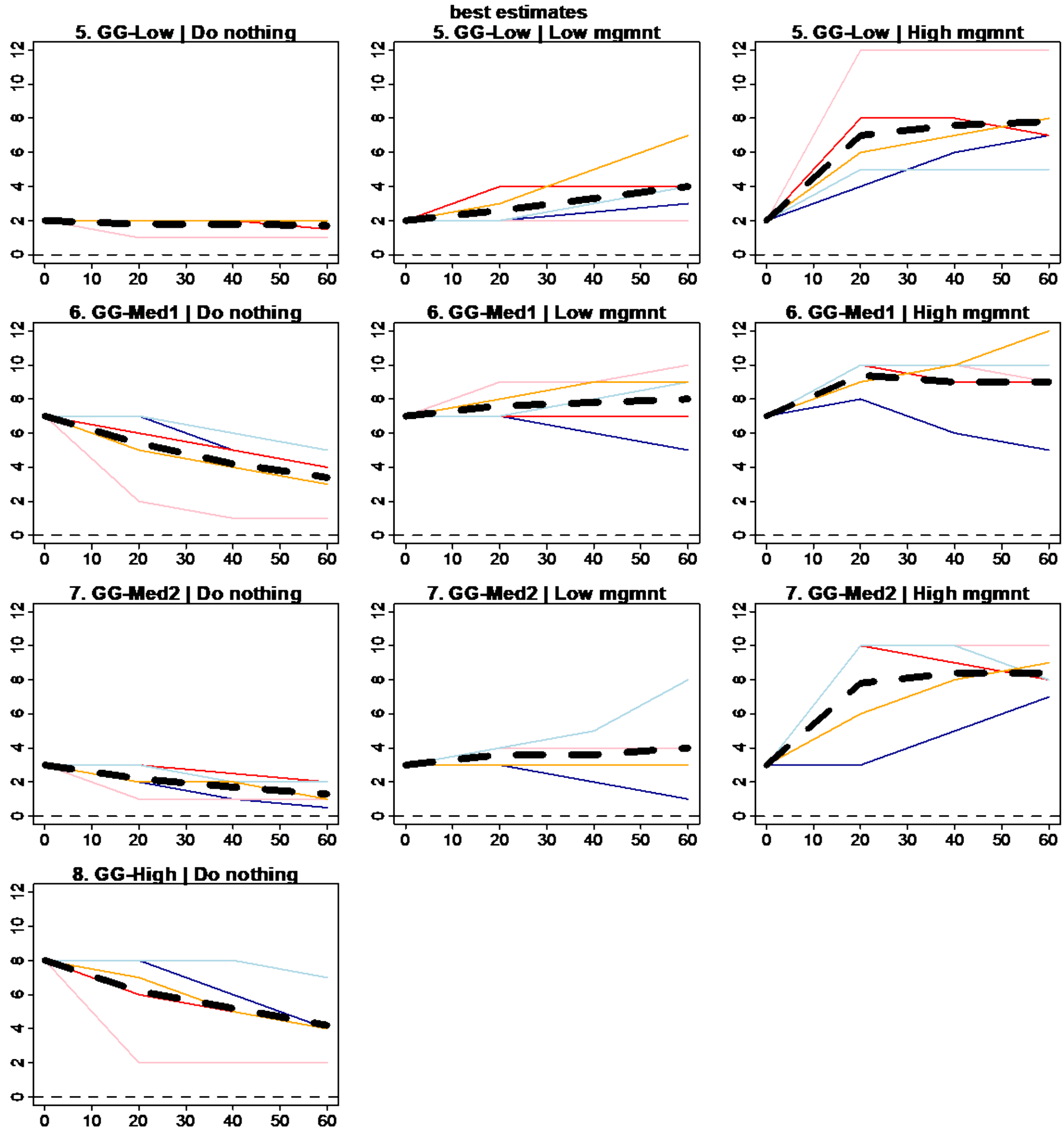


Figure A2. Results of the expert elicitation showing how grass-growth-form-group species richness (y-axis) for CPW is predicted to change over time (x-axis) for different initial conditions and management regimes in 20-year increments. The left column shows results for the do-nothing management scenario, while the middle and right columns show results for the low and high management regimes, respectively. The top row shows results for vegetation starting in the low condition, the second and third rows show results for vegetation starting in the medium 1 and medium 2 condition, respectively. The bottom plot shows results for vegetation starting in the high condition under do-nothing. Note, results were not elicited for vegetation starting in the high condition under high or low management, as it was assumed that with management, it would retain its richness score.

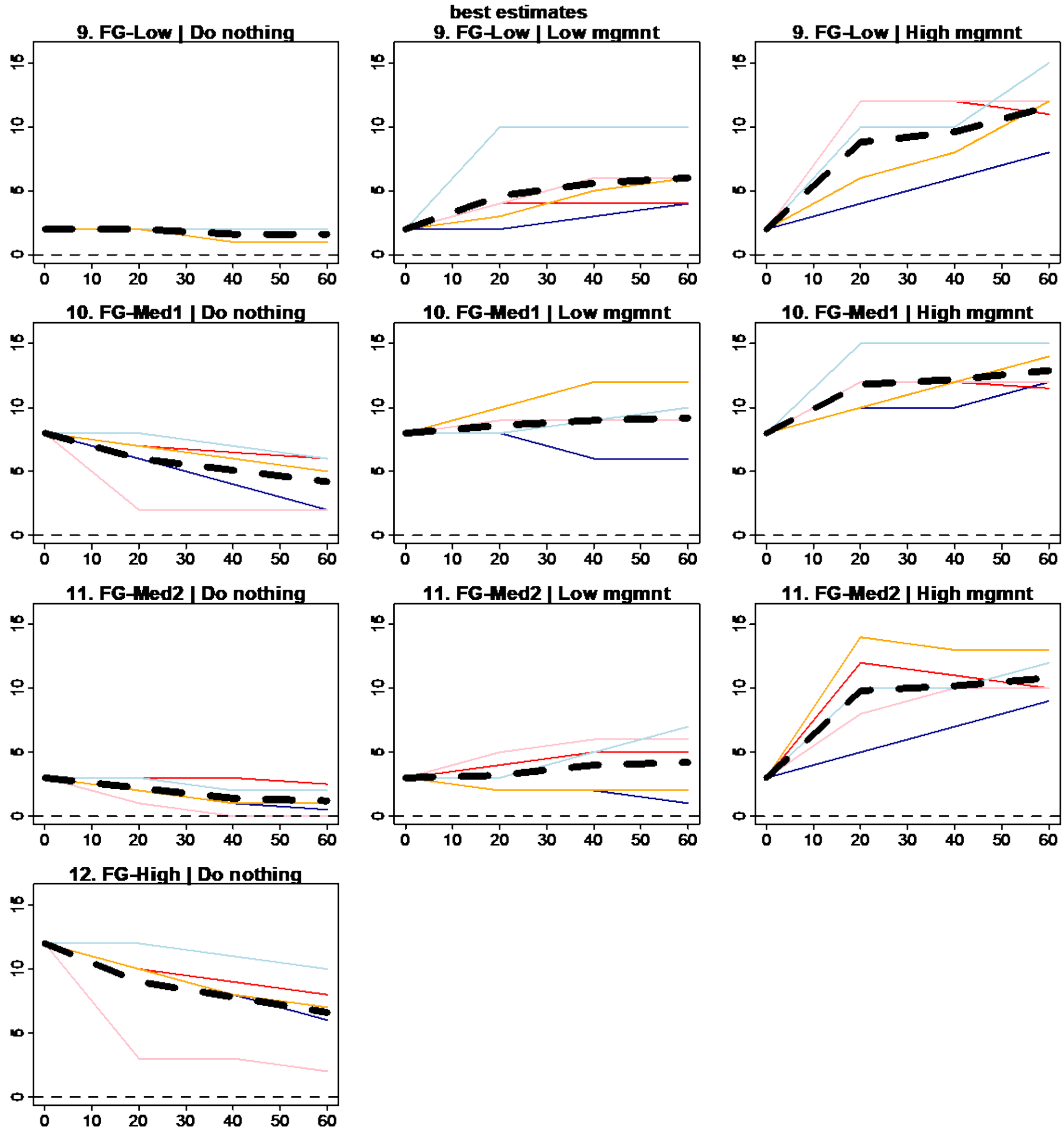


Figure A3. Results of the expert elicitation showing how <u>forb species richness</u> (y-axis) for CPW is predicted to change over time (x-axis) for different initial conditions and management regimes in increments of t=20. The left column shows results for the do-nothing management scenario, while the middle and right columns show results for the low and high management regimes, respectively. The top row shows results for vegetation starting in the low condition, the second and third rows show results for vegetation starting in the medium 1 and medium 2 condition, respectively. The bottom plot shows results for vegetation starting in the high condition under do-nothing. Note, results were not elicited for vegetation starting in the high condition under high or low management, as it was assumed that with management, it would retain its richness score.

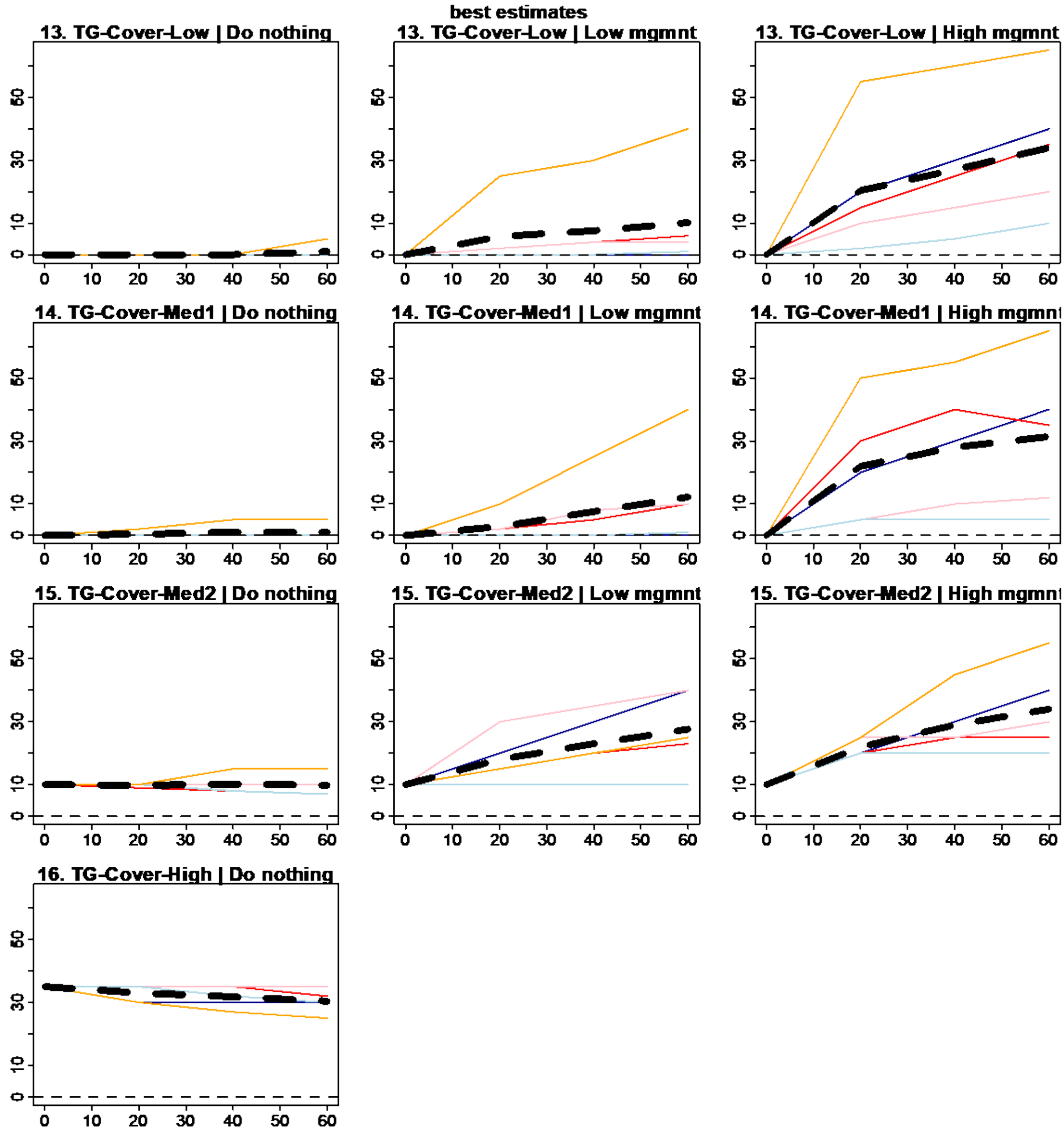


Figure A4. Results of the expert elicitation showing how tree crown cover (y-axis) for CPW is predicted to change over time (x-axis) for different initial conditions and management regimes in increments of t=20. The left column shows results for the do-nothing management scenario, while the middle and right columns show results for the low and high management regimes, respectively. The top row shows results for vegetation starting in the low condition, the second and third rows show results for vegetation starting in the medium 1 and medium 2 condition, respectively. The bottom plot shows results for vegetation starting in the high condition under do-nothing. Note, results were not elicited for vegetation starting in the high condition under high or low management, as it was assumed that with management, it would retain its cover score.

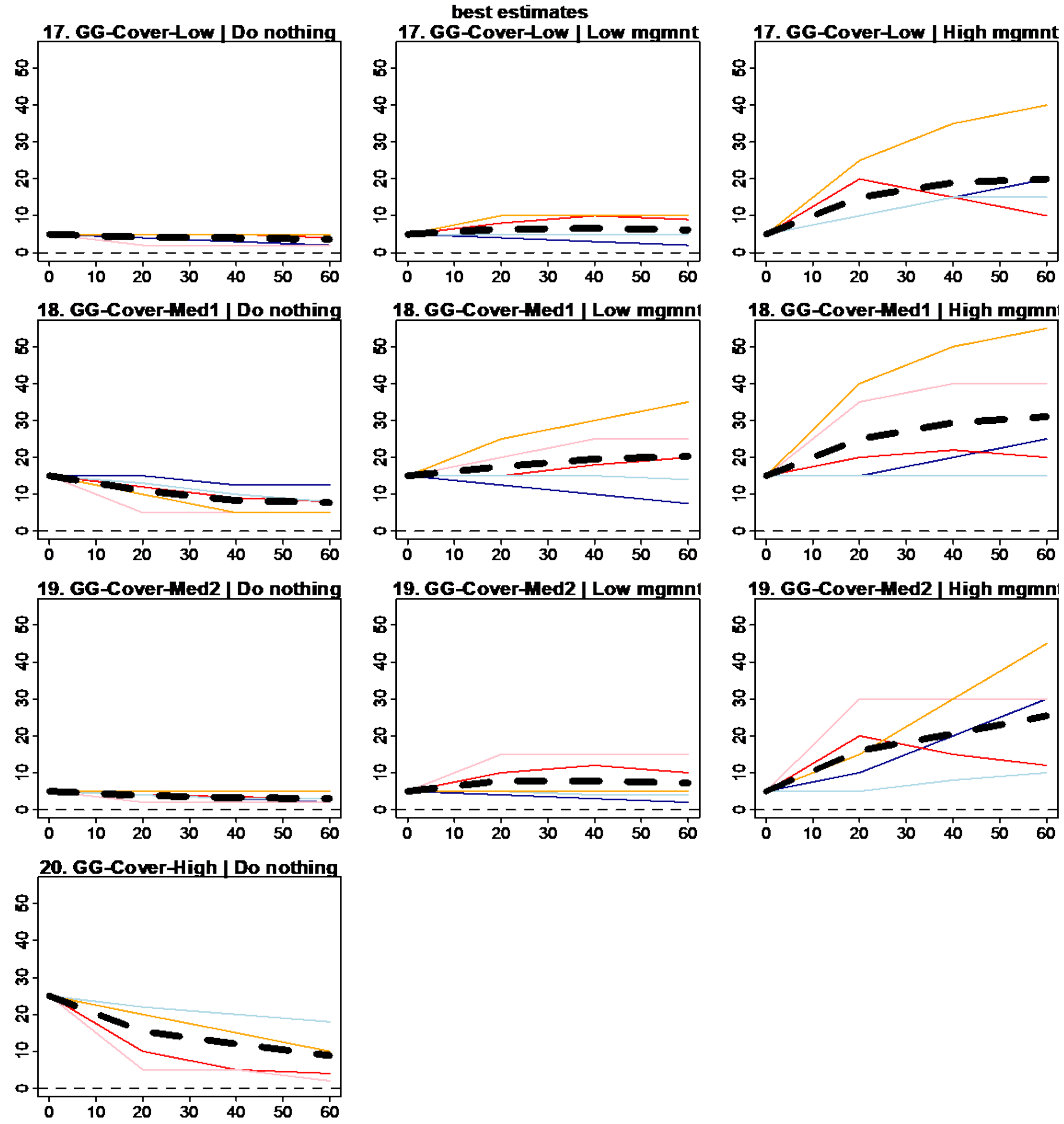


Figure A5. Results of the expert elicitation showing how <u>grass crown cover</u> (y-axis) for CPW is predicted to change over time (x-axis) for different initial conditions and management regimes in increments of t=20. The left column shows results for the do-nothing management scenario, while the middle and right columns show results for the low and high management regimes, respectively. The top row shows results for vegetation starting in the low condition, the second and third rows show results for vegetation starting in the medium 1 and medium 2 condition, respectively. The bottom plot shows results for vegetation starting in the high condition under do-nothing. Note, results were not elicited for vegetation starting in the high condition under high or low management, as it was assumed that with management, it would retain its cover score.

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document E – Biodiversity credit report

Supporting document E – Contents

Biodiversity credit report – GMAC

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00013050/BAAS18134/18/00013052	Western Sydney Strategic Biodiversity Certification - Greater Macarthur Growth Area	04/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Jane Raithby-Veall	05/06/2020	27
Assessor Number	**BAM Case Status**	**Date Finalised**
BAAS18134	Open	To be finalised
Assessment Revision	**Assessment Type**	
3	Biocertification	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone	Vegetation	Area (ha)	Constant	Species sensitivity to gain class (for	Biodiversity	Potential SAII	Ecosystem credits
Cumberland moist shale woodland								
1	830_Thinned	20.1	0.1	0.25	High Sensitivity to Potential Gain	2.00		1
							Subtotal	**1**
Cumberland riverflat forest								
2	835_Intact	76.6	0.2	0.25	High Sensitivity to Potential Gain	2.00		8
3	835_Thinned	57.1	5.0	0.25	High Sensitivity to Potential Gain	2.00		143
4	835_Scattered_tre	68.7	0.1	0.25	High Sensitivity to Potential Gain	2.00		4
17	835_NO_grassland	13.5	19.2	0.25	High Sensitivity to Potential Gain	2.00		0
							Subtotal	**155**
Cumberland shale - sandstone Ironbark forest								
13	1395_Intact	72.9	31.6	0.25	High Sensitivity to Potential Gain	2.50	TRUE	1441
14	1395_Thinned	63.9	70.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	2810
15	1395_Scattered_tr	30.0	30.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	570
16	1395_DNG	28.4	31.5	0.25	High Sensitivity to Potential Gain	2.50	TRUE	557
20	1395_NO_grasslan	5.4	447.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**5378**
Cumberland shale hills woodland								
9	850_Intact	58.1	8.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	292
10	850_Thinned	41.9	44.5	0.25	High Sensitivity to Potential Gain	2.50	TRUE	1166
11	850_Scattered_tre	38.1	17.2	0.25	High Sensitivity to Potential Gain	2.50	TRUE	409
12	850_DNG	25.7	14.2	0.25	High Sensitivity to Potential Gain	2.50	TRUE	228
19	850_NO_grassland	12.3	441.5	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**2095**
Cumberland shale plains woodland								
5	849_Intact	53.9	13.5	0.25	High Sensitivity to Potential Gain	2.50	TRUE	453

6	849_Thinned	42.3	31.7	0.25	High Sensitivity to Potential Gain	2.50	TRUE	838
7	849_Scattered_tre	18.3	31.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	359
8	849_DNG	24.1	32.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	486
18	849_NO_grassland	10.1	1283.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**2136**
							Total	**9765**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk	Potential SAII	Species credits
Acacia bynoeana / Bynoe's Wattle (Flora)						
1395_Intact	72.9	17.29	0.25	2	False	630
1395_Thinned	63.9	27.93	0.25	2	False	893
1395_Scattered_trees	30.0	10.14	0.25	2	False	152
1395_DNG	28.4	7.68	0.25	2	False	109
					Subtotal	**1784**
Acacia pubescens / Downy Wattle (Flora)						
835_Intact	76.6	0.19	0.25	2	False	7
835_Thinned	57.1	1.01	0.25	2	False	29
849_Intact	53.9	6.28	0.25	2	False	169
849_Thinned	42.3	21.51	0.25	2	False	455
849_Scattered_trees	18.3	12.7	0.25	2	False	116
849_DNG	24.1	12.68	0.25	2	False	153
1395_Intact	72.9	17.92	0.25	2	False	653
1395_Thinned	63.9	30.51	0.25	2	False	975
1395_Scattered_trees	30.0	10.65	0.25	2	False	160
1395_DNG	28.4	8.17	0.25	2	False	116

835_Scattered_trees	68.7	0.11	0.25	2	False	4
					Subtotal	**2837**
Callocephalon fimbriatum / Gang-gang Cockatoo (Fauna)						
849_Intact	53.9	1.19	0.25	2	False	32
1395_Intact	72.9	1.61	0.25	2	False	59
					Subtotal	**91**
Calyptorhynchus lathami / Glossy Black-Cockatoo (Fauna)						
1395_Intact	72.9	7.2	0.25	2	False	262
					Subtotal	**262**
Cercartetus nanus / Eastern Pygmy-possum (Fauna)						
835_Intact	76.6	0.21	0.25	2	False	8
849_Intact	53.9	5.63	0.25	2	False	152
850_Intact	58.1	2.96	0.25	2	False	86
1395_Intact	72.9	24.72	0.25	2	False	901
					Subtotal	**1147**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)						
830_Thinned	20.1	0	0.25	3	True	0
835_Intact	76.6	0.21	0.25	3	True	12
835_Thinned	57.1	4.9	0.25	3	True	210
849_Intact	53.9	13.45	0.25	3	True	544
849_Thinned	42.3	21.11	0.25	3	True	670
850_Intact	58.1	7.85	0.25	3	True	342
850_Thinned	41.9	39.07	0.25	3	True	1228
1395_Intact	72.9	31.62	0.25	3	True	1729
1395_Thinned	63.9	70.21	0.25	3	True	3366
					Subtotal	**8101**
Epacris purpurascens var. purpurascens / Epacris purpurascens var. purpurascens (Flora)						

1395_Intact	N/A	328	0.25	1.5	False	492
1395_Thinned	N/A	565	0.25	1.5	False	848
					Subtotal	**1340**
Eucalyptus benthamii / Camden White Gum (Flora)						
849_Intact	53.9	0	0.25	2	False	0
					Subtotal	**0**
Grevillea parviflora subsp. parviflora / Small-flower Grevillea (Flora)						
1395_Intact	72.9	0.08	0.25	2	False	3
1395_Thinned	63.9	0.98	0.25	2	False	31
					Subtotal	**34**
Haliaeetus leucogaster / White-bellied Sea-Eagle (Fauna)						
835_Intact	76.6	0.21	0.25	2	False	8
849_Intact	53.9	0.79	0.25	2	False	21
850_Intact	58.1	0.14	0.25	2	False	4
1395_Intact	72.9	7.59	0.25	2	False	277
					Subtotal	**310**
Heleioporus australiacus / Giant Burrowing Frog (Fauna)						
1395_Intact	72.9	0.29	0.25	1.5	False	8
					Subtotal	**8**
Hibbertia fumana / Hibbertia fumana (Flora)						
849_Intact	53.9	0.07	0.25	3	True	3
849_DNG	24.1	0.07	0.25	3	True	1
1395_Intact	72.9	1.32	0.25	3	True	72
1395_Thinned	63.9	6.91	0.25	3	True	331
849_NO_grassland	10.1	0.07	0.25	3	True	1
					Subtotal	**408**
Hibbertia puberula / Hibbertia puberula (Flora)						

849_Intact	53.9	0.07	0.25	2	False	2
849_DNG	24.1	0.07	0.25	2	False	1
1395_Intact	72.9	1.32	0.25	2	False	48
1395_Thinned	63.9	6.91	0.25	2	False	221
849_NO_grassland	10.1	0.07	0.25	2	False	0
					Subtotal	**272**
Hieraaetus morphnoides / Little Eagle (Fauna)						
1395_Intact	72.9	11.55	0.25	1.5	False	316
1395_Thinned	63.9	0.02	0.25	1.5	False	0
1395_Scattered_trees	30.0	1.07	0.25	1.5	False	12
1395_DNG	28.4	0.11	0.25	1.5	False	1
1395_NO_grassland	5.4	1.65	0.25	1.5	False	3
					Subtotal	**332**
Lophoictinia isura / Square-tailed Kite (Fauna)						
1395_Intact	72.9	11.55	0.25	1.5	False	316
1395_Thinned	63.9	0.02	0.25	1.5	False	0
1395_Scattered_trees	30.0	1.07	0.25	1.5	False	12
1395_DNG	28.4	0.11	0.25	1.5	False	1
1395_NO_grassland	5.4	1.65	0.25	1.5	False	3
					Subtotal	**332**
Marsdenia viridiflora subsp. viridiflora - endangered population / Marsdenia viridiflora R. Br. subsp. viridiflora population in the Bankstown, Blacktown,						
830_Thinned	20.1	0.01	0.25	2	False	0
835_Intact	76.6	0.21	0.25	2	False	8
835_Thinned	57.1	1.03	0.25	2	False	29
849_Intact	53.9	1.06	0.25	2	False	29
849_Thinned	42.3	8.26	0.25	2	False	175
850_Intact	58.1	1.64	0.25	2	False	48

850_Thinned	41.9	8.64	0.25	2	False	181
1395_Intact	72.9	0.73	0.25	2	False	27
1395_Thinned	63.9	6.28	0.25	2	False	201
					Subtotal	**698**
Melaleuca deanei / Deane's Paperbark (Flora)						
1395_Intact	72.9	17.24	0.25	2	False	628
1395_Thinned	63.9	28.43	0.25	2	False	909
1395_Scattered_trees	30.0	10.5	0.25	2	False	158
					Subtotal	**1695**
Meridolum corneovirens / Cumberland Plain Land Snail (Fauna)						
830_Thinned	20.1	0.09	0.25	2	False	1
835_Intact	76.6	0.21	0.25	2	False	8
835_Thinned	57.1	5.02	0.25	2	False	143
849_Intact	53.9	5.94	0.25	2	False	160
849_Thinned	42.3	26.59	0.25	2	False	562
850_Intact	58.1	6.96	0.25	2	False	202
850_Thinned	41.9	36.91	0.25	2	False	773
1395_Intact	72.9	22.11	0.25	2	False	806
1395_Thinned	63.9	58.34	0.25	2	False	1865
					Subtotal	**4520**
Myotis macropus / Southern Myotis (Fauna)						
830_Thinned	20.1	0.09	0.25	2	False	1
835_Thinned	57.1	2.85	0.25	2	False	81
849_Intact	53.9	8.7	0.25	2	False	235
849_Thinned	42.3	19.71	0.25	2	False	417
849_Scattered_trees	18.3	20.04	0.25	2	False	183
850_Intact	58.1	1.75	0.25	2	False	51

850_Thinned	41.9	27.59	0.25	2	False	578
850_Scattered_trees	38.1	8.67	0.25	2	False	165
1395_Intact	72.9	7.02	0.25	2	False	256
1395_Thinned	63.9	34.42	0.25	2	False	1100
1395_Scattered_trees	30.0	17.18	0.25	2	False	258
					Subtotal	**3325**
Ninox connivens / Barking Owl (Fauna)						
1395_Intact	72.9	0	0.25	2	False	0
					Subtotal	**0**
Ninox strenua / Powerful Owl (Fauna)						
850_Intact	58.1	0.25	0.25	2	False	7
					Subtotal	**7**
Persoonia bargoensis / Bargo Geebung (Flora)						
849_Intact	53.9	3.87	0.25	2	False	104
849_Thinned	42.3	4.34	0.25	2	False	92
1395_Intact	72.9	15.09	0.25	2	False	550
1395_Thinned	63.9	18.69	0.25	2	False	597
					Subtotal	**1343**
Petaurus norfolcensis / Squirrel Glider (Fauna)						
830_Thinned	20.1	0.02	0.25	2	False	0
835_Intact	76.6	0.21	0.25	2	False	8
835_Thinned	57.1	0.13	0.25	2	False	4
849_Intact	53.9	3.49	0.25	2	False	94
849_Thinned	42.3	9.9	0.25	2	False	209
849_Scattered_trees	18.3	1.62	0.25	2	False	15
850_Intact	58.1	2.24	0.25	2	False	65
850_Thinned	41.9	24.5	0.25	2	False	513

850_Scattered_trees	38.1	3.57	0.25	2	False	68
1395_Intact	72.9	23.62	0.25	2	False	861
1395_Thinned	63.9	39.9	0.25	2	False	1275
1395_Scattered_trees	30.0	9.26	0.25	2	False	139
					Subtotal	**3251**
Phascolarctos cinereus / Koala (Fauna)						
830_Thinned	20.1	0.09	0.25	2	False	1
835_Thinned	57.1	0.08	0.25	2	False	2
849_Intact	53.9	12.63	0.25	2	False	341
849_Thinned	42.3	9.99	0.25	2	False	211
849_Scattered_trees	18.3	0.37	0.25	2	False	3
850_Intact	58.1	1.12	0.25	2	False	33
850_Thinned	41.9	28.84	0.25	2	False	604
1395_Intact	72.9	31.19	0.25	2	False	1137
1395_Thinned	63.9	58.79	0.25	2	False	1879
1395_Scattered_trees	30.0	0.81	0.25	2	False	12
					Subtotal	**4223**
Pimelea spicata / Spiked Rice-flower (Flora)						
830_Thinned	20.1	0.08	0.25	2	False	1
849_Intact	53.9	3.32	0.25	2	False	90
849_Thinned	42.3	3.63	0.25	2	False	77
849_Scattered_trees	18.3	1.55	0.25	2	False	14
849_DNG	24.1	0.84	0.25	2	False	10
850_Intact	58.1	5.17	0.25	2	False	150
850_Thinned	41.9	4.83	0.25	2	False	101
850_Scattered_trees	38.1	3.12	0.25	2	False	59
850_DNG	25.7	0.58	0.25	2	False	7

1395_Intact	72.9	1.79	0.25	2	False	65
1395_Thinned	63.9	1.67	0.25	2	False	53
1395_Scattered_trees	30.0	0.46	0.25	2	False	7
849_NO_grassland	10.1	4.87	0.25	2	False	25
850_NO_grassland	12.3	21.6	0.25	2	False	133
1395_NO_grassland	5.4	2.74	0.25	2	False	7
					Subtotal	**799**
Pomaderris brunnea / Brown Pomaderris (Flora)						
835_Intact	76.6	0.2	0.25	2	False	8
835_Thinned	57.1	0.72	0.25	2	False	21
1395_Intact	72.9	4.1	0.25	2	False	149
1395_Thinned	63.9	13.25	0.25	2	False	424
					Subtotal	**602**
Pseudophryne australis / Red-crowned Toadlet (Fauna)						
1395_Intact	72.9	5.75	0.25	1.5	False	157
					Subtotal	**157**
Pterostylis saxicola / Sydney Plains Greenhood (Flora)						
849_Intact	53.9	8.4	0.25	2	False	226
1395_Intact	72.9	22.94	0.25	2	False	836
					Subtotal	**1062**
Pultenaea pedunculata / Matted Bush-pea (Flora)						
849_Intact	53.9	0.07	0.25	2	False	2
849_Thinned	42.3	0.56	0.25	2	False	12
849_Scattered_trees	18.3	4.29	0.25	2	False	39
850_Thinned	41.9	0.86	0.25	2	False	18
850_Scattered_trees	38.1	0.94	0.25	2	False	18
1395_Intact	72.9	2.52	0.25	2	False	92

1395_Thinned	63.9	15.93	0.25	2	False	509
1395_Scattered_trees	30.0	2.57	0.25	2	False	39
					Subtotal	**729**
Tyto novaehollandiae / Masked Owl (Fauna)						
850_Intact	58.1	0.32	0.25	2	False	9
1395_Intact	72.9	0.01	0.25	2	False	0
1395_Thinned	63.9	0.04	0.25	2	False	1
					Subtotal	**10**

Biodiversity credit report – GPEC

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated
00013050/BAAS18134/18/00013054	Western Sydney Strategic Biodiversity Certification - Greater Penrith to Eastern Creek	18/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Jane Raithby-Veall	24/06/2020	29
Assessor Number	**BAM Case Status**	**Date Finalised**
BAAS18134	Open	To be finalised
Assessment Revision	**Assessment Type**	
3	Biocertification	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone	Vegetation	Area (ha)	Constant	Species sensitivity to gain class (for BRW)	Biodiversity	Potential	Ecosystem credits
Castlereagh Ironbark forest								
4	725_Intact	49.2	15.2	0.25	High Sensitivity to Potential Gain	2.00	TRUE	373
5	725_Thinned	43.3	10.1	0.25	High Sensitivity to Potential Gain	2.00	TRUE	219
							Subtotal	**592**
Castlereagh shale - gravel transition forest								
1	724_Intact	61.7	8.0	0.25	High Sensitivity to Potential Gain	2.00		247
2	724_Thinned	44.1	24.8	0.25	High Sensitivity to Potential Gain	2.00		545
3	724_Scattered_tre	17.8	0.1	0.25	High Sensitivity to Potential Gain	2.00		1
							Subtotal	**793**
Coastal freshwater wetland								
6	781_Thinned	62.5	2.0	0.25	High Sensitivity to Potential Gain	2.00		63
							Subtotal	**63**
Cumberland riverflat forest								
7	835_Intact	76.6	11.6	0.25	High Sensitivity to Potential Gain	2.00		444
8	835_Thinned	57.1	111.5	0.25	High Sensitivity to Potential Gain	2.00		3185
9	835_Scattered_tre	68.7	2.6	0.25	High Sensitivity to Potential Gain	2.00		90
18	835_NO_grassland	13.5	434.4	0.25	High Sensitivity to Potential Gain	2.00		0
							Subtotal	**3719**
Cumberland shale hills woodland								
14	850_Thinned	41.9	15.9	0.25	High Sensitivity to Potential Gain	2.50	TRUE	416
15	850_Scattered_tre	38.1	2.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	49
16	850_DNG	25.7	23.0	0.25	High Sensitivity to Potential Gain	2.50	TRUE	368
20	850_NO_grassland	12.3	219.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**833**
Cumberland shale plains woodland								
10	849_Intact	53.9	4.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	144

11	849_Thinned	42.3	110.9	0.25	High Sensitivity to Potential Gain	2.50	TRUE	2930
12	849_Scattered_tre	18.3	4.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	50
13	849_DNG	24.1	8.8	0.25	High Sensitivity to Potential Gain	2.50	TRUE	132
19	849_NO_grassland	10.1	755.2	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**3256**
Cumberland Swamp Oak riparian forest								
17	1800_Thinned	46.6	8.2	0.25	High Sensitivity to Potential Gain	2.00		191
							Subtotal	**191**
							Total	**9447**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk	Potential SAII	Species credits
Acacia bynoeana / Bynoe's Wattle (Flora)						
725_Thinned	43.3	1.69	0.25	2	False	37
					Subtotal	**37**
Acacia pubescens / Downy Wattle (Flora)						
724_Intact	61.7	0.93	0.25	2	False	29
724_Thinned	44.1	8.45	0.25	2	False	186
724_Scattered_trees	17.8	0.02	0.25	2	False	0
725_Thinned	43.3	2.34	0.25	2	False	51
835_Intact	76.6	5.22	0.25	2	False	200
835_Thinned	57.1	42.1	0.25	2	False	1203
835_Scattered_trees	68.7	2.51	0.25	2	False	86
849_Intact	53.9	0.03	0.25	2	False	1
849_Thinned	42.3	90.32	0.25	2	False	1910
849_Scattered_trees	18.3	3.74	0.25	2	False	34

849_DNG	24.1	6.39	0.25	2	False	77
					Subtotal	**3777**
Allocasuarina glareicola / Allocasuarina glareicola (Flora)						
724_Intact	61.7	0.91	0.25	3	True	42
724_Thinned	44.1	8.37	0.25	3	True	277
725_Thinned	43.3	2.59	0.25	3	True	84
					Subtotal	**403**
Callocephalon fimbriatum / Gang-gang Cockatoo (Fauna)						
724_Intact	61.7	0.01	0.25	2	False	0
725_Intact	49.2	0.02	0.25	2	False	0
835_Intact	76.6	0.01	0.25	2	False	0
849_Intact	53.9	0	0.25	2	False	0
					Subtotal	**0**
Cercartetus nanus / Eastern Pygmy-possum (Fauna)						
835_Intact	76.6	9.31	0.25	2	False	357
849_Intact	53.9	4.03	0.25	2	False	109
					Subtotal	**466**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)						
849_Thinned	42.3	0.93	0.25	3	True	29
					Subtotal	**29**
Dillwynia tenuifolia / Dillwynia tenuifolia (Flora)						
724_Intact	61.7	5.76	0.25	2	False	178
724_Scattered_trees	17.8	0.02	0.25	2	False	0
724_Thinned	44.1	16.42	0.25	2	False	362
725_Intact	49.2	15.06	0.25	2	False	371
725_Thinned	43.3	6.21	0.25	2	False	134
849_DNG	24.1	2.79	0.25	2	False	34

849_Intact	53.9	0.01	0.25	2	False	0
849_Scattered_trees	18.3	1.28	0.25	2	False	12
849_Thinned	42.3	53.77	0.25	2	False	1137
					Subtotal	**2228**
Grevillea juniperina subsp. juniperina / Juniper-leaved Grevillea (Flora)						
724_Intact	61.7	7.97	0.25	1.5	False	184
724_Thinned	44.1	20	0.25	1.5	False	330
724_Scattered_trees	17.8	0.02	0.25	1.5	False	0
725_Intact	49.2	15.15	0.25	1.5	False	280
725_Thinned	43.3	6.21	0.25	1.5	False	101
835_Intact	76.6	5.9	0.25	1.5	False	170
835_Thinned	57.1	12.12	0.25	1.5	False	260
835_Scattered_trees	68.7	0.94	0.25	1.5	False	24
849_Intact	53.9	4.21	0.25	1.5	False	85
849_Thinned	42.3	94.25	0.25	1.5	False	1495
849_Scattered_trees	18.3	3.41	0.25	1.5	False	23
849_DNG	24.1	6.39	0.25	1.5	False	58
835_NO_grassland	13.5	0.65	0.25	1.5	False	3
					Subtotal	**3013**
Grevillea parviflora subsp. parviflora / Small-flower Grevillea (Flora)						
724_Intact	61.7	0.02	0.25	2	False	1
724_Thinned	44.1	3.9	0.25	2	False	86
725_Thinned	43.3	0.08	0.25	2	False	2
					Subtotal	**89**
Haliaeetus leucogaster / White-bellied Sea-Eagle (Fauna)						
724_Intact	61.7	0	0.25	2	False	0
835_Intact	76.6	5.16	0.25	2	False	198

849_Intact	53.9	0.01	0.25	2	False	0
					Subtotal	**198**
Heleioporus australiacus / Giant Burrowing Frog (Fauna)						
725_Intact	49.2	0	0.25	1.5	False	0
					Subtotal	**0**
Hibbertia puberula / Hibbertia puberula (Flora)						
724_Thinned	44.1	2.53	0.25	2	False	56
725_Thinned	43.3	0.06	0.25	2	False	1
849_Thinned	42.3	0.59	0.25	2	False	12
849_NO_grassland	10.1	1.49	0.25	2	False	8
					Subtotal	**77**
Hieraaetus morphnoides / Little Eagle (Fauna)						
724_Intact	61.7	0	0.25	1.5	False	0
724_Thinned	44.1	0.03	0.25	1.5	False	0
835_Intact	76.6	0.14	0.25	1.5	False	4
835_Thinned	57.1	2.64	0.25	1.5	False	57
849_Thinned	42.3	0.05	0.25	1.5	False	1
850_Thinned	41.9	0.15	0.25	1.5	False	2
781_Thinned	62.5	0	0.25	1.5	False	0
1800_Thinned	46.6	0.04	0.25	1.5	False	1
					Subtotal	**65**
Litoria aurea / Green and Golden Bell Frog (Fauna)						
724_Intact	61.7	0.08	0.25	2	False	2
724_Thinned	44.1	0.09	0.25	2	False	2
835_Intact	76.6	0.94	0.25	2	False	36
835_Thinned	57.1	0.14	0.25	2	False	4
849_Intact	53.9	0.8	0.25	2	False	22

849_Thinned	42.3	0.6	0.25	2	False	13
835_NO_grassland	13.5	4.93	0.25	2	False	33
					Subtotal	**112**
Lophoictinia isura / Square-tailed Kite (Fauna)						
724_Intact	61.7	1.15	0.25	1.5	False	27
725_Intact	49.2	3.14	0.25	1.5	False	58
835_Intact	76.6	5.16	0.25	1.5	False	148
835_Thinned	57.1	1.14	0.25	1.5	False	24
849_Intact	53.9	1.91	0.25	1.5	False	39
849_Thinned	42.3	0.01	0.25	1.5	False	0
					Subtotal	**296**
Marsdenia viridiflora subsp. viridiflora - endangered population / Marsdenia viridiflora R. Br. subsp. viridiflora population in the Bankstown, Blacktown,						
724_Intact	61.7	0.93	0.25	2	False	29
724_Thinned	44.1	8.46	0.25	2	False	186
725_Thinned	43.3	2.59	0.25	2	False	56
835_Intact	76.6	6.44	0.25	2	False	247
835_Thinned	57.1	54.79	0.25	2	False	1565
849_Intact	53.9	0.03	0.25	2	False	1
849_Thinned	42.3	91.8	0.25	2	False	1941
850_Thinned	41.9	13.75	0.25	2	False	288
1800_Thinned	46.6	7.77	0.25	2	False	181
					Subtotal	**4494**
Maundia triglochinoides / Maundia triglochinoides (Flora)						
781_Thinned	62.5	0.91	0.25	2	False	28
1800_Thinned	46.6	7.42	0.25	2	False	173
					Subtotal	**201**
Meridolum corneovirens / Cumberland Plain Land Snail (Fauna)						

724_Intact	61.7	7.78	0.25	2	False	240
724_Thinned	44.1	17.53	0.25	2	False	386
725_Intact	49.2	14.67	0.25	2	False	361
725_Thinned	43.3	5.75	0.25	2	False	125
835_Intact	76.6	11.33	0.25	2	False	434
835_Thinned	57.1	81.86	0.25	2	False	2339
849_Intact	53.9	3.73	0.25	2	False	101
849_Thinned	42.3	101.72	0.25	2	False	2151
850_Thinned	41.9	14.43	0.25	2	False	302
					Subtotal	**6439**
Micromyrtus minutiflora / Micromyrtus minutiflora (Flora)						
724_Intact	61.7	0.93	0.25	2	False	29
724_Thinned	44.1	7.61	0.25	2	False	168
725_Thinned	43.3	2.58	0.25	2	False	56
					Subtotal	**253**
Myotis macropus / Southern Myotis (Fauna)						
724_Intact	61.7	0.49	0.25	2	False	15
724_Thinned	44.1	6.49	0.25	2	False	143
724_Scattered_trees	17.8	0.09	0.25	2	False	1
725_Intact	49.2	1.68	0.25	2	False	41
725_Thinned	43.3	3.56	0.25	2	False	77
835_Intact	76.6	5.66	0.25	2	False	217
835_Thinned	57.1	96.5	0.25	2	False	2757
835_Scattered_trees	68.7	2.18	0.25	2	False	75
849_Intact	53.9	0.05	0.25	2	False	1
849_Thinned	42.3	70.22	0.25	2	False	1485
849_Scattered_trees	18.3	2.66	0.25	2	False	24

850_Thinned	41.9	12.37	0.25	2	False	259
850_Scattered_trees	38.1	1.97	0.25	2	False	38
1800_Thinned	46.6	8.08	0.25	2	False	188
					Subtotal	**5321**
Ninox connivens / Barking Owl (Fauna)						
724_Intact	61.7	0	0.25	2	False	0
					Subtotal	**0**
Ninox strenua / Powerful Owl (Fauna)						
724_Intact	61.7	0	0.25	2	False	0
					Subtotal	**0**
Persicaria elatior / Tall Knotweed (Flora)						
835_Thinned	57.1	40.25	0.25	2	False	1150
835_Scattered_trees	68.7	0.95	0.25	2	False	33
1800_Thinned	46.6	5.81	0.25	2	False	135
					Subtotal	**1318**
Persoonia nutans / Nodding Geebung (Flora)						
724_Intact	61.7	0.93	0.25	2	False	29
724_Thinned	44.1	8.69	0.25	2	False	191
724_Scattered_trees	17.8	0.02	0.25	2	False	0
725_Intact	49.2	0.33	0.25	2	False	8
725_Thinned	43.3	5.31	0.25	2	False	115
					Subtotal	**343**
Petaurus norfolcensis / Squirrel Glider (Fauna)						
724_Intact	61.7	0.93	0.25	2	False	29
724_Thinned	44.1	6.64	0.25	2	False	146
724_Scattered_trees	17.8	0	0.25	2	False	0
725_Thinned	43.3	1.39	0.25	2	False	30

835_Intact	76.6	6.46	0.25	2	False	248
835_Thinned	57.1	55.1	0.25	2	False	1574
835_Scattered_trees	68.7	1.19	0.25	2	False	41
849_Intact	53.9	0.03	0.25	2	False	1
849_Thinned	42.3	62.66	0.25	2	False	1325
849_Scattered_trees	18.3	0.78	0.25	2	False	7
850_Thinned	41.9	3.25	0.25	2	False	68
1800_Thinned	46.6	0.91	0.25	2	False	21
					Subtotal	**3490**
Pimelea curviflora var. curviflora / Pimelea curviflora var. curviflora (Flora)						
724_Intact	61.7	7.63	0.25	2	False	235
724_Thinned	44.1	13.47	0.25	2	False	297
849_Intact	53.9	3.3	0.25	2	False	89
849_Thinned	42.3	48.57	0.25	2	False	1027
					Subtotal	**1648**
Pimelea spicata / Spiked Rice-flower (Flora)						
849_Intact	53.9	4.22	0.25	2	False	114
849_Thinned	42.3	52.02	0.25	2	False	1100
849_Scattered_trees	18.3	0.19	0.25	2	False	2
849_DNG	24.1	4.95	0.25	2	False	60
850_Thinned	41.9	3.09	0.25	2	False	65
850_Scattered_trees	38.1	0	0.25	2	False	0
850_DNG	25.7	0.65	0.25	2	False	8
724_Intact	61.7	2.58	0.25	2	False	80
724_Thinned	44.1	2.8	0.25	2	False	62
724_Scattered_trees	17.8	0.05	0.25	2	False	0
725_Thinned	43.3	0.02	0.25	2	False	0

835_Intact	76.6	0.86	0.25	2	False	33
835_Thinned	57.1	5.18	0.25	2	False	148
1800_Thinned	46.6	0.02	0.25	2	False	0
835_NO_grassland	13.5	7.8	0.25	2	False	53
849_NO_grassland	10.1	20.18	0.25	2	False	102
850_NO_grassland	12.3	6.1	0.25	2	False	38
					Subtotal	**1865**
Pseudophryne australis / Red-crowned Toadlet (Fauna)						
724_Intact	61.7	0	0.25	1.5	False	0
					Subtotal	**0**
Pterostylis saxicola / Sydney Plains Greenhood (Flora)						
849_Thinned	42.3	0.93	0.25	2	False	20
					Subtotal	**20**
Pultenaea parviflora / Pultenaea parviflora (Flora)						
724_Intact	61.7	7.97	0.25	2	False	246
724_Thinned	44.1	20.09	0.25	2	False	443
725_Intact	49.2	15.04	0.25	2	False	370
725_Thinned	43.3	5.88	0.25	2	False	127
849_Intact	53.9	0.5	0.25	2	False	13
849_Thinned	42.3	2.01	0.25	2	False	43
849_Scattered_trees	18.3	0.01	0.25	2	False	0
					Subtotal	**1242**
Pultenaea pedunculata / Matted Bush-pea (Flora)						
724_Intact	61.7	0.97	0.25	2	False	30
724_Thinned	44.1	10.12	0.25	2	False	223
724_Scattered_trees	17.8	0.02	0.25	2	False	0
725_Thinned	43.3	3.95	0.25	2	False	86

849_Intact	53.9	0.03	0.25	2	False	1
849_Thinned	42.3	53.01	0.25	2	False	1121
849_Scattered_trees	18.3	2.69	0.25	2	False	25
					Subtotal	**1486**
Tyto novaehollandiae / Masked Owl (Fauna)						
835_Thinned	57.1	0.52	0.25	2	False	15
					Subtotal	**15**

Biodiversity credit report – Wilton

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00013050/BAAS18134/18/00013051	Western Sydney Strategic Biodiversity Certification - Wilton Growth Area	18/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Jane Raithby-Veall	02/07/2020	29
Assessor Number	**BAM Case Status**	**Date Finalised**
BAAS18134	Open	To be finalised
Assessment Revision	**Assessment Type**	
3	Biocertification	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone	Vegetation	Area (ha)	Constant	Species sensitivity to gain class (for	Biodiversity	Potential SAII	Ecosystem credits
Cumberland shale - sandstone Ironbark forest								
7	1395_Intact	72.9	13.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	605
8	1395_Thinned	63.9	84.7	0.25	High Sensitivity to Potential Gain	2.50	TRUE	3385
9	1395_Scattered_tr	30.0	20.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	378
10	1395_DNG	28.4	205.8	0.25	High Sensitivity to Potential Gain	2.50	TRUE	3647
13	1395_NO_grasslan	5.4	331.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**8015**
Cumberland shale hills woodland								
5	850_Scattered_tre	38.1	0.9	0.25	High Sensitivity to Potential Gain	2.50	TRUE	22
6	850_DNG	25.7	151.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	2423
12	850_NO_grassland	12.3	12.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**2445**
Cumberland shale plains woodland								
1	849_Intact	53.9	1.6	0.25	High Sensitivity to Potential Gain	2.50	TRUE	53
2	849_Thinned	42.3	22.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	592
3	849_Scattered_tre	18.3	24.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	275
4	849_DNG	24.1	139.5	0.25	High Sensitivity to Potential Gain	2.50	TRUE	2098
11	849_NO_grassland	10.1	653.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**3018**
							Total	**13478**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk	Potential SAII	Species credits
Acacia bynoeana / Bynoe's Wattle (Flora)						
1395_Intact	72.9	3.05	0.25	2	False	111

1395_Thinned	63.9	31.29	0.25	2	False	1000
1395_Scattered_trees	30.0	11.12	0.25	2	False	167
1395_DNG	28.4	76.73	0.25	2	False	1088
					Subtotal	**2366**
Acacia pubescens / Downy Wattle (Flora)						
849_Thinned	42.3	4.31	0.25	2	False	91
849_Scattered_trees	18.3	4.69	0.25	2	False	43
849_DNG	24.1	27.65	0.25	2	False	333
1395_Intact	72.9	3.65	0.25	2	False	133
1395_Thinned	63.9	33.8	0.25	2	False	1080
1395_Scattered_trees	30.0	12.01	0.25	2	False	180
1395_DNG	28.4	80.25	0.25	2	False	1138
849_NO_grassland	10.1	1.12	0.25	2	False	6
					Subtotal	**3004**
Callocephalon fimbriatum / Gang-gang Cockatoo (Fauna)						
849_Intact	53.9	0.04	0.25	2	False	1
1395_Intact	72.9	0.62	0.25	2	False	23
					Subtotal	**24**
Calyptorhynchus lathami / Glossy Black-Cockatoo (Fauna)						
1395_Intact	72.9	1.5	0.25	2	False	55
					Subtotal	**55**
Cercartetus nanus / Eastern Pygmy-possum (Fauna)						
849_Intact	53.9	1.31	0.25	2	False	35
1395_Intact	72.9	6.65	0.25	2	False	242
					Subtotal	**277**
Chalinolobus dwyeri / Large-eared Pied Bat (Fauna)						
849_Intact	53.9	1.56	0.25	3	True	63

849_Thinned	42.3	22.38	0.25	3	True	710
849_Scattered_trees	18.3	0.06	0.25	3	True	1
849_DNG	24.1	0.26	0.25	3	True	5
1395_Intact	72.9	13.28	0.25	3	True	726
1395_Thinned	63.9	84.71	0.25	3	True	4062
849_NO_grassland	10.1	1.22	0.25	3	True	9
					Subtotal	**5576**
Epacris purpurascens var. purpurascens / Epacris purpurascens var. purpurascens (Flora)						
1395_Intact	N/A	72	0.25	1.5	False	108
1395_Thinned	N/A	624	0.25	1.5	False	936
					Subtotal	**1044**
Grevillea parviflora subsp. parviflora / Small-flower Grevillea (Flora)						
1395_Intact	72.9	0.7	0.25	2	False	26
1395_Thinned	63.9	3.24	0.25	2	False	104
					Subtotal	**130**
Haliaeetus leucogaster / White-bellied Sea-Eagle (Fauna)						
1395_Intact	72.9	2.04	0.25	2	False	74
					Subtotal	**74**
Heleioporus australiacus / Giant Burrowing Frog (Fauna)						
1395_Intact	72.9	0.3	0.25	1.5	False	8
					Subtotal	**8**
Hibbertia fumana / Hibbertia fumana (Flora)						
849_Intact	53.9	0.05	0.25	3	True	2
849_Thinned	42.3	0.57	0.25	3	True	18
849_DNG	24.1	0.12	0.25	3	True	2
1395_Intact	72.9	4.03	0.25	3	True	220
1395_Thinned	63.9	12.23	0.25	3	True	586

1395_Scattered_trees	30.0	0.7	0.25	3	True	16
1395_DNG	28.4	5.62	0.25	3	True	120
849_NO_grassland	10.1	0.39	0.25	3	True	3
1395_NO_grassland	5.4	2.19	0.25	3	True	9
					Subtotal	**976**
Hibbertia puberula / Hibbertia puberula (Flora)						
849_Thinned	42.3	0.57	0.25	2	False	12
849_DNG	24.1	0.12	0.25	2	False	1
1395_Intact	72.9	3.6	0.25	2	False	131
1395_Thinned	63.9	12.23	0.25	2	False	391
1395_Scattered_trees	30.0	0.7	0.25	2	False	11
1395_DNG	28.4	5.62	0.25	2	False	80
849_NO_grassland	10.1	0.33	0.25	2	False	2
1395_NO_grassland	5.4	2.19	0.25	2	False	6
					Subtotal	**634**
Melaleuca deanei / Deane's Paperbark (Flora)						
1395_Intact	72.9	3.35	0.25	2	False	122
1395_Thinned	63.9	31.62	0.25	2	False	1011
1395_Scattered_trees	30.0	11.13	0.25	2	False	167
1395_DNG	28.4	0.19	0.25	2	False	3
					Subtotal	**1303**
Meridolum corneovirens / Cumberland Plain Land Snail (Fauna)						
849_Intact	53.9	1.22	0.25	2	False	33
849_Thinned	42.3	12.88	0.25	2	False	272
849_DNG	24.1	0.47	0.25	2	False	6
1395_Intact	72.9	10.1	0.25	2	False	368
1395_Thinned	63.9	76.97	0.25	2	False	2460

1395_DNG	28.4	0.19	0.25	2	False	3
849_NO_grassland	10.1	1.16	0.25	2	False	6
					Subtotal	**3148**
Myotis macropus / Southern Myotis (Fauna)						
849_Intact	53.9	1.1	0.25	2	False	30
849_Thinned	42.3	10.57	0.25	2	False	224
849_Scattered_trees	18.3	10	0.25	2	False	91
850_Scattered_trees	38.1	0.39	0.25	2	False	7
1395_Intact	72.9	4.75	0.25	2	False	173
1395_Thinned	63.9	51.71	0.25	2	False	1653
1395_Scattered_trees	30.0	14.25	0.25	2	False	214
					Subtotal	**2392**
Ninox connivens / Barking Owl (Fauna)						
1395_Intact	72.9	0	0.25	2	False	0
					Subtotal	**0**
Ninox strenua / Powerful Owl (Fauna)						
1395_Intact	72.9	0	0.25	2	False	0
					Subtotal	**0**
Persoonia bargoensis / Bargo Geebung (Flora)						
849_Intact	53.9	0	0.25	2	False	0
849_Thinned	42.3	2.95	0.25	2	False	62
1395_Intact	72.9	3.24	0.25	2	False	118
1395_Thinned	63.9	32.82	0.25	2	False	1049
849_NO_grassland	10.1	0.37	0.25	2	False	2
					Subtotal	**1231**
Petaurus norfolcensis / Squirrel Glider (Fauna)						
849_Intact	53.9	0.05	0.25	2	False	1

849_Thinned	42.3	1.69	0.25	2	False	36
849_Scattered_trees	18.3	0.75	0.25	2	False	7
849_DNG	24.1	0.11	0.25	2	False	1
1395_Intact	72.9	5.22	0.25	2	False	190
1395_Thinned	63.9	45.86	0.25	2	False	1466
1395_Scattered_trees	30.0	10.58	0.25	2	False	159
					Subtotal	**1860**
Phascolarctos cinereus / Koala (Fauna)						
849_Intact	53.9	1.56	0.25	2	False	42
849_Thinned	42.3	21.8	0.25	2	False	461
1395_Intact	72.9	13.27	0.25	2	False	484
1395_Thinned	63.9	79.36	0.25	2	False	2537
1395_Scattered_trees	30.0	0.67	0.25	2	False	10
					Subtotal	**3534**
Pimelea spicata / Spiked Rice-flower (Flora)						
849_Intact	53.9	1.43	0.25	2	False	39
849_Thinned	42.3	20.53	0.25	2	False	434
849_Scattered_trees	18.3	19.49	0.25	2	False	178
849_DNG	24.1	102.41	0.25	2	False	1233
1395_Intact	72.9	1.18	0.25	2	False	43
1395_Thinned	63.9	26.1	0.25	2	False	834
1395_Scattered_trees	30.0	4.59	0.25	2	False	69
1395_DNG	28.4	39.72	0.25	2	False	563
849_NO_grassland	10.1	129.86	0.25	2	False	656
1395_NO_grassland	5.4	51.77	0.25	2	False	141
					Subtotal	**4190**
Pomaderris brunnea / Brown Pomaderris (Flora)						

1395_Intact	72.9	2.62	0.25	2	False	96
1395_Thinned	63.9	13.7	0.25	2	False	438
					Subtotal	**534**
Pseudophryne australis / Red-crowned Toadlet (Fauna)						
1395_Intact	72.9	3.27	0.25	1.5	False	89
					Subtotal	**89**
Pterostylis saxicola / Sydney Plains Greenhood (Flora)						
849_Intact	53.9	1.35	0.25	2	False	36
1395_Intact	72.9	12.02	0.25	2	False	438
1395_Thinned	63.9	0.77	0.25	2	False	25
1395_DNG	28.4	0.19	0.25	2	False	3
					Subtotal	**502**
Pultenaea pedunculata / Matted Bush-pea (Flora)						
849_Intact	53.9	1.08	0.25	2	False	29
849_Thinned	42.3	1.85	0.25	2	False	39
849_Scattered_trees	18.3	0.72	0.25	2	False	7
850_Scattered_trees	38.1	0.11	0.25	2	False	2
1395_Intact	72.9	3.53	0.25	2	False	129
1395_Thinned	63.9	18.26	0.25	2	False	584
1395_Scattered_trees	30.0	5.14	0.25	2	False	77
					Subtotal	**867**
Tyto novaehollandiae / Masked Owl (Fauna)						
1395_Intact	72.9	0	0.25	2	False	0
1395_Thinned	63.9	0.01	0.25	2	False	0
					Subtotal	**0**

Biodiversity credit report – WSA

BAM Credit Summary Report

Proposal Details

Assessment Id	Proposal Name	BAM data last updated *
00013050/BAAS18134/18/00013053	Western Sydney Strategic Biodiversity Certification - Western Sydney Aerotropolis	18/06/2020
Assessor Name	**Report Created**	**BAM Data version ***
Jane Raithby-Veall	01/07/2020	29
Assessor Number	**BAM Case Status**	**Date Finalised**
BAAS18134	Open	To be finalised
Assessment Revision	**Assessment Type**	
3	Biocertification	

* Disclaimer: BAM data last updated may indicate either complete or partial update of the BAM calculator database. BAM calculator database may not be completely aligned with Bionet.

Ecosystem credits for plant communities types (PCT), ecological communities & threatened species habitat

Zone	Vegetation zone	Vegetation	Area (ha)	Constant	Species sensitivity to gain class (for	Biodiversity	Potential SAII	Ecosystem credits
Castlereagh Ironbark forest								
3	725_Intact	49.2	0.4	0.25	High Sensitivity to Potential Gain	2.00	TRUE	10
4	725_Thinned	43.3	8.2	0.25	High Sensitivity to Potential Gain	2.00	TRUE	178
5	725_Scattered_tre	19.6	3.0	0.25	High Sensitivity to Potential Gain	2.00	TRUE	29
							Subtotal	**217**
Castlereagh shale - gravel transition forest								
1	724_Thinned	44.1	19.3	0.25	High Sensitivity to Potential Gain	2.00		424
2	724_Scattered_tre	17.8	0.1	0.25	High Sensitivity to Potential Gain	2.00		1
							Subtotal	**425**
Coastal freshwater wetland								
6	781_Thinned	62.5	0.1	0.25	High Sensitivity to Potential Gain	2.00		2
							Subtotal	**2**
Cumberland riverflat forest								
7	835_Intact	76.6	0.4	0.25	High Sensitivity to Potential Gain	2.00		15
8	835_Thinned	57.1	18.6	0.25	High Sensitivity to Potential Gain	2.00		532
9	835_Scattered_tre	68.7	15.1	0.25	High Sensitivity to Potential Gain	2.00		518
21	835_NO_grassland	13.5	488.0	0.25	High Sensitivity to Potential Gain	2.00		0
							Subtotal	**1065**
Cumberland shale hills woodland								
14	850_Intact	58.1	0.0	0.25	High Sensitivity to Potential Gain	2.50	TRUE	1
15	850_Thinned	41.9	5.7	0.25	High Sensitivity to Potential Gain	2.50	TRUE	149
16	850_Scattered_tre	38.1	2.1	0.25	High Sensitivity to Potential Gain	2.50	TRUE	49
17	850_DNG	25.7	0.2	0.25	High Sensitivity to Potential Gain	2.50	TRUE	3
23	850_NO_grassland	12.3	10.0	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**202**

Cumberland shale plains woodland								
10	849_Intact	53.9	10.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	351
11	849_Thinned	42.3	170.7	0.25	High Sensitivity to Potential Gain	2.50	TRUE	4511
12	849_Scattered_tre	18.3	65.4	0.25	High Sensitivity to Potential Gain	2.50	TRUE	747
13	849_DNG	24.1	58.6	0.25	High Sensitivity to Potential Gain	2.50	TRUE	882
22	849_NO_grassland	10.1	2443.3	0.25	High Sensitivity to Potential Gain	2.50	TRUE	0
							Subtotal	**6491**
Cumberland Swamp Oak riparian forest								
18	1800_Intact	43.2	0.2	0.25	High Sensitivity to Potential Gain	2.00		5
19	1800_Thinned	46.6	10.4	0.25	High Sensitivity to Potential Gain	2.00		242
20	1800_Scattered_tr	41.2	0.4	0.25	High Sensitivity to Potential Gain	2.00		8
							Subtotal	**255**
							Total	**8657**

Species credits for threatened species

Vegetation zone name	Habitat condition (HC)	Area (ha) / individual (HL)	Constant	Biodiversity risk	Potential SAII	Species credits
Acacia bynoeana / Bynoe's Wattle (Flora)						
725_Intact	49.2	0.36	0.25	2	False	9
725_Thinned	43.3	5.37	0.25	2	False	116
725_Scattered_trees	19.6	2.58	0.25	2	False	25
					Subtotal	**150**
Acacia pubescens / Downy Wattle (Flora)						
724_Thinned	44.1	16.96	0.25	2	False	374
724_Scattered_trees	17.8	0.07	0.25	2	False	1
725_Intact	49.2	0.36	0.25	2	False	9
725_Thinned	43.3	5.46	0.25	2	False	118

725_Scattered_trees	19.6	2.58	0.25	2	False	25
835_Intact	76.6	0.11	0.25	2	False	4
835_Thinned	57.1	12.65	0.25	2	False	361
835_Scattered_trees	68.7	7.96	0.25	2	False	274
849_Intact	53.9	3.01	0.25	2	False	81
849_Thinned	42.3	136.99	0.25	2	False	2897
849_Scattered_trees	18.3	46.71	0.25	2	False	427
849_DNG	24.1	50.77	0.25	2	False	611
					Subtotal	**5182**
Cercartetus nanus / Eastern Pygmy-possum (Fauna)						
835_Intact	76.6	0.39	0.25	2	False	15
849_Intact	53.9	10.2	0.25	2	False	275
					Subtotal	**290**
Dillwynia tenuifolia / Dillwynia tenuifolia (Flora)						
724_Scattered_trees	17.8	0.07	0.25	2	False	1
724_Thinned	44.1	14.64	0.25	2	False	323
725_Intact	49.2	0.35	0.25	2	False	9
725_Scattered_trees	19.6	2.05	0.25	2	False	20
725_Thinned	43.3	4.11	0.25	2	False	89
849_DNG	24.1	13.57	0.25	2	False	163
849_Intact	53.9	2.14	0.25	2	False	58
849_Scattered_trees	18.3	22.85	0.25	2	False	209
849_Thinned	42.3	14.51	0.25	2	False	307
					Subtotal	**1179**
Grevillea juniperina subsp. juniperina / Juniper-leaved Grevillea (Flora)						
724_Thinned	44.1	16.81	0.25	1.5	False	278
724_Scattered_trees	17.8	0.01	0.25	1.5	False	0

725_Intact	49.2	0.36	0.25	1.5	False	7
725_Thinned	43.3	5.36	0.25	1.5	False	87
725_Scattered_trees	19.6	2.58	0.25	1.5	False	19
835_Thinned	57.1	8.99	0.25	1.5	False	193
835_Scattered_trees	68.7	7.11	0.25	1.5	False	183
849_Intact	53.9	3.09	0.25	1.5	False	62
849_Thinned	42.3	142.97	0.25	1.5	False	2267
849_Scattered_trees	18.3	45.5	0.25	1.5	False	312
849_DNG	24.1	47.68	0.25	1.5	False	430
850_Thinned	41.9	0	0.25	1.5	False	0
1800_Thinned	46.6	0	0.25	1.5	False	0
850_Intact	58.1	0	0.25	1.5	False	0
835_NO_grassland	13.5	0.05	0.25	1.5	False	0
849_NO_grassland	10.1	0.02	0.25	1.5	False	0
					Subtotal	**3838**
Grevillea parviflora subsp. parviflora / Small-flower Grevillea (Flora)						
724_Thinned	44.1	4.32	0.25	2	False	95
725_Intact	49.2	0.04	0.25	2	False	1
725_Thinned	43.3	2.66	0.25	2	False	58
					Subtotal	**154**
Haliaeetus leucogaster / White-bellied Sea-Eagle (Fauna)						
835_Intact	76.6	0.39	0.25	2	False	15
849_Intact	53.9	0	0.25	2	False	0
1800_Intact	43.2	0.23	0.25	2	False	5
					Subtotal	**20**
Hibbertia fumana / Hibbertia fumana (Flora)						
725_Intact	49.2	0.03	0.25	3	True	1

725_Thinned	43.3	2.28	0.25	3	True	74
725_Scattered_trees	19.6	0.09	0.25	3	True	1
835_NO_grassland	13.5	0.52	0.25	3	True	5
849_NO_grassland	10.1	0.19	0.25	3	True	1
					Subtotal	**82**
Hibbertia puberula / Hibbertia puberula (Flora)						
725_Intact	49.2	0.03	0.25	2	False	1
725_Thinned	43.3	2.28	0.25	2	False	49
725_Scattered_trees	19.6	0.09	0.25	2	False	1
835_NO_grassland	13.5	0.52	0.25	2	False	4
849_NO_grassland	10.1	0.19	0.25	2	False	1
					Subtotal	**56**
Hieraaetus morphnoides / Little Eagle (Fauna)						
724_Thinned	44.1	0.07	0.25	1.5	False	1
725_Thinned	43.3	0.01	0.25	1.5	False	0
835_Intact	76.6	0.07	0.25	1.5	False	2
835_Thinned	57.1	0.52	0.25	1.5	False	11
849_Intact	53.9	0.3	0.25	1.5	False	6
849_Thinned	42.3	0.06	0.25	1.5	False	1
1800_Thinned	46.6	0.11	0.25	1.5	False	2
					Subtotal	**23**
Lophoictinia isura / Square-tailed Kite (Fauna)						
835_Intact	76.6	0.39	0.25	1.5	False	11
849_Intact	53.9	0	0.25	1.5	False	0
1800_Intact	43.2	0.23	0.25	1.5	False	4
					Subtotal	**15**
Marsdenia viridiflora subsp. viridiflora - endangered population / Marsdenia viridiflora R. Br. subsp. viridiflora population in the Bankstown, Blacktown,						

724_Thinned	44.1	16.96	0.25	2	False	374
725_Intact	49.2	0.36	0.25	2	False	9
725_Thinned	43.3	5.46	0.25	2	False	118
835_Intact	76.6	0.39	0.25	2	False	15
835_Thinned	57.1	16.8	0.25	2	False	480
849_Intact	53.9	3.28	0.25	2	False	88
849_Thinned	42.3	140.55	0.25	2	False	2972
850_Thinned	41.9	5.47	0.25	2	False	115
1800_Thinned	46.6	8.42	0.25	2	False	196
1800_Intact	43.2	0.23	0.25	2	False	5
					Subtotal	**4372**
Maundia triglochinoides / Maundia triglochinoides (Flora)						
781_Thinned	62.5	0.07	0.25	2	False	2
1800_Thinned	46.6	8.84	0.25	2	False	206
1800_Intact	43.2	0.22	0.25	2	False	5
					Subtotal	**213**
Meridolum corneovirens / Cumberland Plain Land Snail (Fauna)						
724_Thinned	44.1	19.25	0.25	2	False	424
725_Intact	49.2	0.06	0.25	2	False	1
725_Thinned	43.3	7.95	0.25	2	False	172
835_Intact	76.6	0.39	0.25	2	False	15
835_Thinned	57.1	18.05	0.25	2	False	516
849_Intact	53.9	10.21	0.25	2	False	275
849_Thinned	42.3	151.54	0.25	2	False	3204
850_Thinned	41.9	4.99	0.25	2	False	105
					Subtotal	**4712**
Micromyrtus minutiflora / Micromyrtus minutiflora (Flora)						

724_Thinned	44.1	9.24	0.25	2	False	204
725_Thinned	43.3	1.67	0.25	2	False	36
					Subtotal	**240**
Myotis macropus / Southern Myotis (Fauna)						
724_Thinned	44.1	16.92	0.25	2	False	373
724_Scattered_trees	17.8	0.07	0.25	2	False	1
725_Intact	49.2	0.28	0.25	2	False	7
725_Thinned	43.3	5.06	0.25	2	False	110
725_Scattered_trees	19.6	1.63	0.25	2	False	16
781_Thinned	62.5	0.05	0.25	2	False	2
835_Intact	76.6	0.37	0.25	2	False	14
835_Thinned	57.1	16.58	0.25	2	False	474
835_Scattered_trees	68.7	13.44	0.25	2	False	462
849_Intact	53.9	8.97	0.25	2	False	242
849_Thinned	42.3	159.49	0.25	2	False	3372
849_Scattered_trees	18.3	52.53	0.25	2	False	480
850_Thinned	41.9	5.69	0.25	2	False	119
850_Scattered_trees	38.1	1.6	0.25	2	False	31
1800_Intact	43.2	0.23	0.25	2	False	5
1800_Thinned	46.6	9.31	0.25	2	False	217
1800_Scattered_trees	41.2	0.23	0.25	2	False	5
					Subtotal	**5930**
Ninox strenua / Powerful Owl (Fauna)						
835_Intact	76.6	0.06	0.25	2	False	2
					Subtotal	**2**
Persicaria elatior / Tall Knotweed (Flora)						
781_Thinned	62.5	0.07	0.25	2	False	2

835_Intact	76.6	0	0.25	2	False	0
835_Thinned	57.1	0	0.25	2	False	0
1800_Thinned	46.6	0.06	0.25	2	False	1
					Subtotal	**3**
Persoonia nutans / Nodding Geebung (Flora)						
724_Thinned	44.1	16.96	0.25	2	False	374
724_Scattered_trees	17.8	0.07	0.25	2	False	1
725_Intact	49.2	0.36	0.25	2	False	9
725_Thinned	43.3	5.46	0.25	2	False	118
725_Scattered_trees	19.6	2.58	0.25	2	False	25
					Subtotal	**527**
Pimelea spicata / Spiked Rice-flower (Flora)						
849_Intact	53.9	8.66	0.25	2	False	234
849_Thinned	42.3	92.96	0.25	2	False	1966
849_Scattered_trees	18.3	19.45	0.25	2	False	178
849_DNG	24.1	30.49	0.25	2	False	367
850_Thinned	41.9	1.77	0.25	2	False	37
850_Scattered_trees	38.1	0.23	0.25	2	False	4
835_Thinned	57.1	6.25	0.25	2	False	179
835_Scattered_trees	68.7	1.93	0.25	2	False	66
1800_Thinned	46.6	1.07	0.25	2	False	25
835_NO_grassland	13.5	45.88	0.25	2	False	310
849_NO_grassland	10.1	65.79	0.25	2	False	332
850_NO_grassland	12.3	0.66	0.25	2	False	4
					Subtotal	**3702**
Pultenaea parviflora / Pultenaea parviflora (Flora)						
724_Thinned	44.1	16.96	0.25	2	False	374

725_Intact	49.2	0.36	0.25	2	False	9
725_Thinned	43.3	5.49	0.25	2	False	119
725_Scattered_trees	19.6	0	0.25	2	False	0
					Subtotal	**502**
Pultenaea pedunculata / Matted Bush-pea (Flora)						
724_Thinned	44.1	18.51	0.25	2	False	408
724_Scattered_trees	17.8	0.07	0.25	2	False	1
725_Intact	49.2	0.41	0.25	2	False	10
725_Thinned	43.3	6.4	0.25	2	False	139
725_Scattered_trees	19.6	2.95	0.25	2	False	29
849_Intact	53.9	0.1	0.25	2	False	3
849_Thinned	42.3	29.36	0.25	2	False	621
849_Scattered_trees	18.3	20.7	0.25	2	False	189
					Subtotal	**1400**

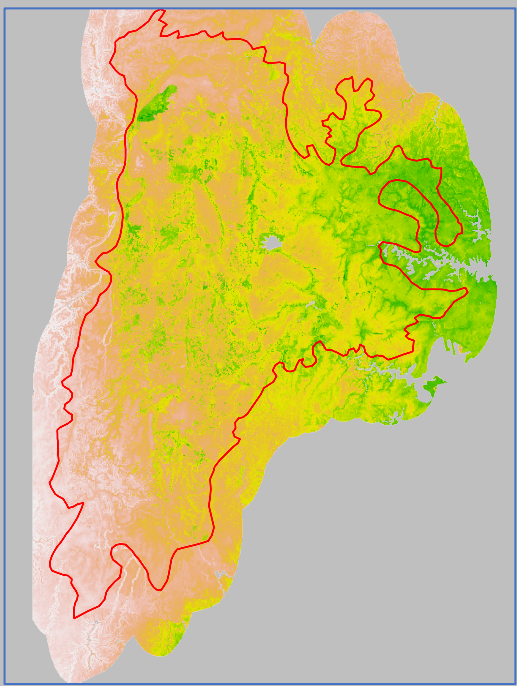
AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document F – SDM Report

23 NOVEMBER 2018

WESTERN SYDNEY STRATEGIC PLAN - SPECIES DISTRIBUTION MODELLING



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PREPARED FOR THE NSW DEPARTMENT OF
PLANNING AND ENVIRONMENT, BIOSIS, AND OPEN LINES

RMIT UNIVERSITY

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Ascelin Gordon is an RMIT University Vice Chancellor's Senior Research Fellow within the ICON Science research group that sits within the Centre for Urban Research, in the School of Global Urban and Social Studies. He undertakes research on a range of conservation problems with a particular focus on ecological modelling, decision making for conservation, and biodiversity offsetting.

Vira Koshkina is undertaking a PhD at RMIT University in mathematical sciences within the School of Science. Her PhD focuses on developing new approaches for species distribution modelling that integrates different data sources and can better account for spatial correlations.

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Table of Contents

Summary

The NSW Government is planning for the future growth of Sydney, and as part of the planning process the Department of Planning and Environment are preparing the Western Sydney Strategic Sustainability Plan (WSSSP). The WSSSP includes a conservation plan for the Cumberland Subregion (IBRA 7), and within this, habitat mapping is being undertaken for all Category 1 EPBC Act listed species. This report details the process to develop species distribution models (SDMs) for 19 EPBC listed species (6 fauna species and 13 flora species), which were deemed suitable for this approach.

Occurrence data for the species were obtained from BioNet, and 21 spatial predictors layers were selected to as likely covariates that could be used to develop models to predict the likelihood of occurrence of the species. SDMs were developed using the software 'Maxent'.

An approach was developed to account for the different levels of bias likely present in the species occurrence records from BioNet. This resulted in three maps with different assumptions regarding bias in the occurrence data, depicting the likelihood of occurrence for each species. These maps were then combined to produce a single risk-based SDM with three classes of occurrence for each species: "unlikely to occur" - none of the SDMs showed the species occurring; "potential to occur"- at least one on the SDMs showed the species occurring; and "likely to occur" - all 3 of the SMDs showed the species as occurring.

Results for all species are presented, and the limitations of the approach are discussed in detail. Options for improving the resulting SDMs also presented. Software to undertake the analysis was developed in R, and is available via GitHub. All SDMs produced are available for download as raster files for use in subsequent analysis, and the predictor layers used in generating the SDMs are also available.

Introduction

The NSW Government is planning for the future growth of Sydney to provide new jobs, homes, services and transport links in the West and South West Districts of Western Sydney. As part of the planning process, priority growth areas (PGAs) have been defined, and the NSW Department of Planning and Environment (DPE) is preparing the Western Sydney Strategic Sustainability Plan (WSSSP).

The WSSSP will provide an overarching strategy for managing environmental and development outcomes in the West and South West Districts of Western Sydney and will consist of three components: (i) a strategic conservation plan (ii); a green infrastructure plan; and (iii) an urban sustainability plan. The strategic conservation plan will be utilized to support strategic avoidance and mitigation of development impacts, and also to increase persistence of biodiversity values in Western Sydney through identifying the most suitable patches of native vegetation for protection. The plan will be assessed strategically at both the NSW and Commonwealth level through:

- Biodiversity certification under the NSW Biodiversity Conservation Act 2016 (BC Act);

- A strategic assessment under the Commonwealth's Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

As part of the conservation plan, DPE is undertaking habitat mapping across the Cumberland Subregion (IBRA 7) for all Category 1 EPBC Act species. This is being done through one of two methods: (i) species distribution models (SDMs; the focus of this report); and (ii) an expert knowledge-based approach (where SDMs are not possible), undertaken by Biosis (not dealt with any further here). In addition to the subregion mapping, detailed mapping is being undertaken within the PGAs as part of the NSW Biodiversity Assessment Methodology (BAM) process.

SDMs are statistical models used to estimate the relationship between species records at sites and the environmental and/or spatial characteristics of those sites (Franklin 2010). Once this relationship has been estimated, the statistical model can be used to predict other locations in the landscape where the species is likely to occur. Thus, SDMs are useful as they can provide estimates over large areas of where a species (or its habitat) is likely to occur. SDMs are used in broad range of applications including the management of threatened species, conservation planning, predicting the impacts of threatening processes such as development or climate change and to manage landscapes (Guillera-Arroita et al. 2015).

In this context of the WSSSP, it is envisaged that SDMs will be used in three ways:

1. They will provide context for the detailed impact analysis being undertaken within the PGAs. For example, they will provide information about the relative importance of habitat within the PGAs compared to the rest of the Cumberland Subregion;

2. They will enable an indicative impact assessment for transport corridors. Transport corridors will be intersected with the SDM predictions to provide an indication of possible impacts on Matters of National Environmental Significance. It is critical to note the transport corridors will be surveyed in detail as part of future NSW biodiversity approvals process, and that the SDM outputs are for indicative impact assessment only;

3. They will help evaluate proposed conservation measures by providing indicative information about the amount of habitat available for biodiversity offsetting. It is critical to note that any sites proposed for offsets or other measures will be surveyed prior to being secured. Thus, the SDM outputs are for indicative evaluation of offsets or other conservation measures.

Undertaking species distribution modelling to produce accurate predictions regarding where a species, or its habitat, is likely to occur can be challenging for a number of reasons. Firstly, the species occurrence data used for modelling is often highly biased (Elith et al. 2006). In regions where there are no species occurrences, it's often not clear whether the species really doesn't occur there, or whether no one has looked. Secondly, spatial data capturing appropriate predictors that are driving the species occurrences needs to be available. Thirdly detectability may be an issue, where if a species is present, it may be less likely to be seen in some parts or its range than in others, further biasing the presence records (Guillera-Arroita 2016). Finally, a species may not occur in every location where its environmental niche is present, due to interactions with other species, or historical accidents.

On top this, SDMs are more challenging in human dominated regions such as the Cumberland Plain. This landscape has a long history of human use that has resulted in it becoming increasing modified, and placing great importance on the remaining biodiversity values. These landscape modifications mean that there are a range of additional anthropogenic other factors driving where species currently occur, such as land clearing and invasive species. The species occurrence records in the Cumberland Plain may be driven by all the above factors. This means the predictions derived from SDMs will be predicting some combination of where species originally occurred, and where it is now due to current anthropogenic threats.

Given the limitation of this approach, SDMs should be supplemented with expert derived methods. However, the advantage of this approach is that it is data-driven, systematic, repeatable, and easily able to be updated once further data on species locations is gathered or improved predictor layers becomes available.

Species distribution models using 'Maxent'

Developing a species distribution model starts with collecting observations of species occurrences and data on environmental factors that are thought to affect the occurrence of the species. The locations are then linked to the values of the environmental predictors, and the values of the predictors at the locations of the specific observations are extracted to a table along with the results of the survey. A statistical, machine learning, or another type of model describing the relationship between species occurrence and environmental data is then fitted to the data. The model coefficients that are estimated during the model fitting process are then applied to the environmental data to produce a prediction map of the species habitat (Franklin 2010). There are two common types of species occurrence data which can be used to build SDMs: presence-background data and site-occupancy data (Phillips et al. 2006).

The two types differ by the collection method and have various levels of reliability. *Site - occupancy data i*s collected during a planned survey, when the researchers split the geographical domain of interests into fixed sized areas called survey sites. The sites are then inspected looking for the species of interest and either the presence or absence of the species is recorded. In many cases, researchers conduct repeated surveys to ensure that the individuals present at the site have been detected. Critically the absence of a species at a location is also available from this type of data.

Presence-background (PB) data consists of "presence-only" data which comprises a set of locations where individuals of the species under investigation have been observed, combined with some background points selected from the areas where the species has not been detected. The presence only data is often collected opportunistically from surveys and is usually added to online publicly accessible databases which aggregate presence only data from multiple sources. To use this data in modelling, "background points" are needed and these are randomly selected from the area where predictions are to be made (Merow et al. 2013). There are multiple ways that points can be sampled to generate the background data. Due to being the most widely available, presence-background data is the most common data used in SDMs.

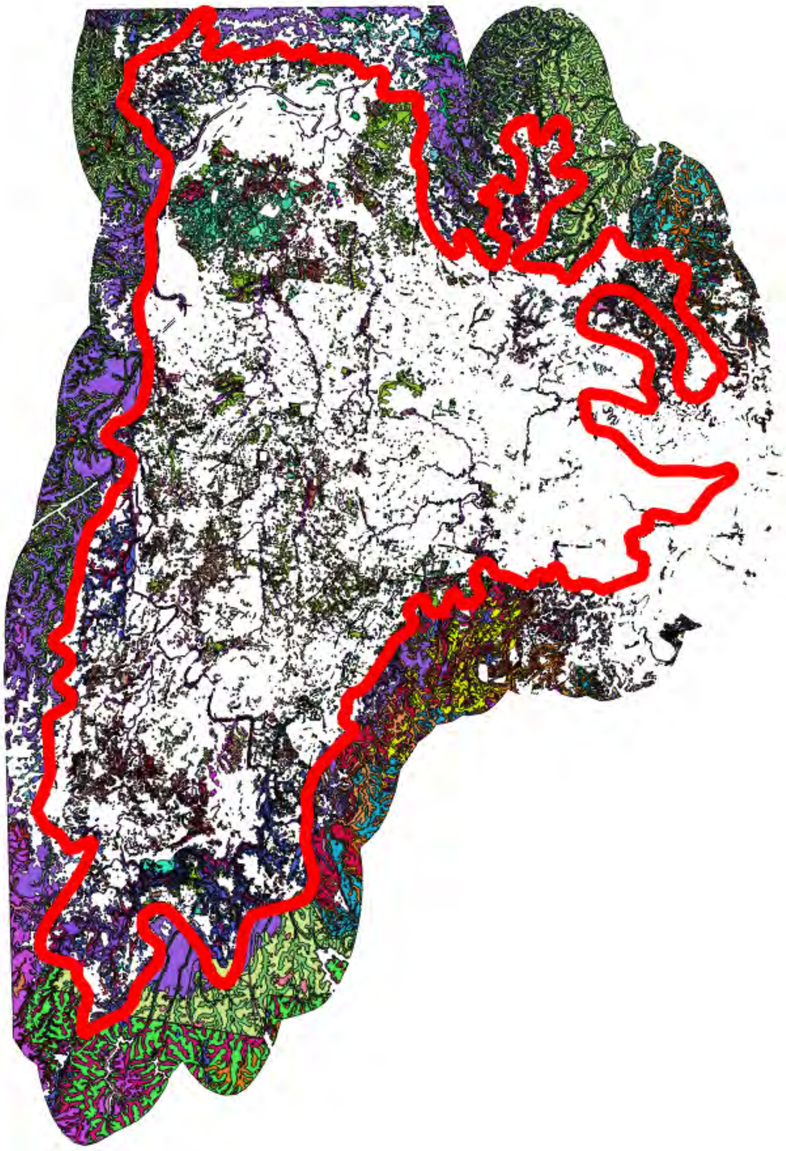


Figure 1 The map of the study area: a 10 km buffer around was placed around the Cumberland Subregion (the Cumberland Subregion outline is shown as a red line). A map of native vegetation is overlaid. The vegetation is classified by Plant Community Type. Areas the north and south-west are visible where the buffer was reduced due to limited data.

While PB data is pervasive, it can have high levels of bias since the observations are done in non-structured fashion and locations of species detections are likely to correlate with the areas that are more accessible by humans (Phillips and Dudík 2008a). Using this data without accounting for these biases can lead to a model that predicts the probability of a species being detected by humans rather than the likelihood of a species being present in the area. This effect is called overfitting, meaning that while the model is doing an excellent job at fitting the coefficients that explain the observed presence data, it does a poor job of predicting the probability of a species being present at other locations. To avoid overfitting, ecologists choose background points in the PB data according to the bias that is present in the presence records (Elith et al. 2011). This is described further below.

All the models presented here were built using Maxent, which is a free software that has been widely used and evaluated in the peer reviewed literature, and is accepted as a powerful method for generating SDMs with PB data (Phillips and Dudík 2008b; Elith et al. 2011; Merow, Smith, and Silander 2013; Phillips et al. 2017). It estimates the probability of the species presence in each point of the landscape based in the environmental parameters of that point relative to the values of the same parameters in locations where the species is known to occur.

Maxent estimates species distribution by trying to achieve the most uniform distribution (i.e maximum entropy) of the parameters in the predicter areas of likely occurrence, while obeying the constraints that the expected number of species in each location closely matches the observed presences (Phillips et al 2006). To do that, the method heavily relies on the background points selected from the study area in the locations where the species has not been observed.

In this report we present the results of using Maxent with PB data for 19 EPBC-listed species in the Cumberland Subregion consisting of 6 fauna species and 13 flora species.

Methods

Study area

For the study area we chose an area that includes a 10 km buffer around the Cumberland (IBRA 7) Subregion (Figure 1). The study area does not include the full 10km buffer around the all areas of the Cumberland Subregion due to some areas in the buffer lacking appropriate vegetation and soil data. Thus, the buffer is reduced in areas to the north and south west of the Cumberland Subregion (Figure 1).

Species occurrence data

Occurrence data used in the analysis was obtained from BioNet, a repository for biodiversity data products managed by the NSW Office of Environment and Heritage (http://www.bionet.nsw.gov.au). The BioNet Atlas application contains data collections comprising (i) species sightings; (ii) systematic surveys; (iii) threatened biodiversity; and (iv) species names. The initial list of species considered for the modelling is shown in Table 1, and BioNet sighting records were extracted for a 100km buffer around the Cumberland Subregion for initial analysis.

Scientific name	Common name	Order	Kingdom
Acacia pubescens	Downy Wattle	Flora	Plantae
Persoonia nutans	Nodding Geebung	Flora	Plantae
Pimelea spicata	Spiked Rice-flower	Flora	Plantae
Phascolarctos cinereus	Koala	Diprotodonta	Animalia
Pultenaea parviflora	NA	Flora	Plantae
Pteropus poliocephalus	Grey-headed Flying-fox	Chiroptera	Animalia
Eucalyptus benthamii	Camden White Gum	Flora	Plantae
Casuarina glauca	Swamp Oak	Flora	Plantae
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	Flora	Plantae
Persoonia bargoensis	Bargo Geebung	Flora	Plantae
Micromyrtus minutiflora	NA	Flora	Plantae
Litoria aurea	Green and Golden Bell Frog	Anura	Animalia
Acacia bynoeana	Bynoe's Wattle	Flora	Plantae
Lathamus discolor	Swift Parrot	Psittaciformes	Animalia
Melaleuca deanei	Deane's Paperbark	Flora	Plantae
Chalinolobus dwyeri	Large-eared Pied Bat	Chiroptera	Animalia
Pomaderris brunnea	Brown Pomaderris	Flora	Plantae
Petauroides volans	Greater Glider	Diprotodonta	Animalia
Commersonia prostrata	Dwarf Kerrawang	Flora	Plantae
Pommerhelix duralensis	Dural Woodland Snail	Eupulmonata	Animalia
Persoonia hirsuta	Hairy Geebung	Flora	Plantae
Allocasuarina glareicola	NA	Flora	Plantae
Dasyurus maculatus	Spotted-tailed Quoll	Dasyuromorphia	Animalia
Syzygium paniculatum	Magenta Lilly Pilly	Flora	Plantae
Botaurus poiciloptilus	Australasian Bittern	Ciconiiformes	Animalia
Anthochaera phrygia	Regent Honeyeater	Passeriformes	Animalia
Persoonia mollis subsp. maxima	NA	Flora	Plantae
Cynanchum elegans	White-flowered Wax Plant	Flora	Plantae
Persoonia glaucescens	Mittagong Geebung	Flora	Plantae
Pimelea curviflora var. curviflora	NA	Flora	Plantae
Pterostylis saxicola	Sydney Plains Greenhood	Flora	Plantae
Darwinia biflora	NA	Flora	Plantae
Leucopogon exolasius	Woronora Beard-heath	Flora	Plantae
Heleioporus australiacus	Giant Burrowing Frog	Anura	Animalia
Lasiopetalum joyceae	NA	Flora	Plantae
Acacia gordonii	NA	Flora	Plantae
Rostratula australis	Australian Painted Snipe	Charadriiformes	Animalia
Eucalyptus camfieldii	Camfield's Stringybark	Flora	Plantae
Genoplesium baueri	Bauer's Midge Orchid	Flora	Plantae
Haloragodendron lucasii	NA	Flora	Plantae
Macquaria australasica	Macquarie Perch	Perciformes	Animalia

Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	Peramelemorphia	Animalia
Thesium australe	Austral Toadflax	Flora	Plantae
Hoplocephalus bungaroides	Broad-headed Snake	Squamata	Animalia
Pterostylis gibbosa	Illawarra Greenhood	Flora	Plantae
Eucalyptus sp. Cattai	NA	Flora	Plantae
Haloragis exalata subsp. exalata	Square Raspwort	Flora	Plantae
Trachystoma petardi	Pinkeye Mullet; Fresh Water Mullet	Mugiliformes	Animalia
Hibbertia spanantha	Julian's Hibbertia	Flora	Plantae
Acacia terminalis subsp. terminalis	Sunshine Wattle	Flora	Plantae
Prostanthera marifolia	Seaforth Mintbush	Flora	Plantae
Caladenia tessellata	Thick Lip Spider Orchid	Flora	Plantae
Leptospermum deanei	NA	Flora	Plantae
Thelymitra kangaloonica	Kangaloon Sun Orchid	Flora	Plantae
Hibbertia sp. Bankstown	NA	Flora	Plantae
Deyeuxia appressa	NA	Flora	Plantae
Rhizanthella slateri	Eastern Australian Underground Orchid	Flora	Plantae
Prototroctes maraena	Australian Grayling	Osmeriformes	Animalia

Table 1. The initial list of species considered for modelling.

Species were then excluded due to a range of factors. This included having a small number of records (in general more than 50 occurrences was required for modelling, though an indicative SDM has been produced for the White-flowered Wax Plant (Cynanchum elegans) with only 23 records—see below) and the fact they were generalist species for which appropriate predictor layers were not available to predict occurrence. It was also found that some candidate species were considered based on erroneous records, so that after a manual review of the records (see below) very few legitimate records remained. Table 2 shows the final species for which SDMs were undertaken using Maxent.

The data extracted from Bionet included records up until the 14 August, 2018. Records were filtered so that only records with a spatial accuracy of 100m or less were retained. No filter was applied to exclude records older than a specified date, as it was deemed that the 100m accuracy filter would remove all old records with low accuracy.

It was found that there were various errors in the species occurrence data derived from BioNet. To address this, external consultants were contracted to undertake a manual review of the occurrence records for all records up until 14 Aug 2018. Steve Douglass (Ecological Surveys & Planning) reviewed the flora records, and Paul Burcher (Aquila Ecological Surveys) reviewed the fauna records.

Scientific name	Common name	Order	Kingdom
Acacia bynoeana	Bynoe's Wattle	Fabaceae (Mimosoideae)	Flora
Acacia pubescens	Downy Wattle	Fabaceae (Mimosoideae)	Flora
Botaurus poiciloptilus	Australasian Bittern	Ardeidae	Fauna

Cynanchum elegans	White-flowered Wax Plant	Apocynaceae	Flora
Darwinia biflora	NA	Myrtaceae	Flora
Eucalyptus benthamii	Camden White Gum	Myrtaceae	Flora
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	Proteaceae	Flora
Heleioporus australiacus	Giant Burrowing Frog	Myobatrachidae	Fauna
Litoria aurea	Green and Golden Bell Frog	Hylidae	Fauna
Micromyrtus minutiflora	NA	Myrtaceae	Flora
Persoonia bargoensis	Bargo Geebung	Proteaceae	Flora
Persoonia hirsuta	Hairy Geebung	Proteaceae	Flora
Persoonia nutans	Nodding Geebung	Proteaceae	Flora
Phascolarctos cinereus	Koala	Phascolarctidae	Fauna
Pimelea spicata	Spiked Rice-flower	Thymelaeaceae	Flora
Pomaderris brunnea	Brown Pomaderris	Rhamnaceae	Flora
Pommerhelix duralensis	Dural Woodland Snail	Camaenidae	Fauna
Pteropus poliocephalus	Grey-headed Flying-fox	Pteropodidae	Fauna
Pultenaea parviflora	NA	Fabaceae (Faboideae)	Flora

Table 2. The final list of species for which SDMs were undertaken.

The data review process involved a manual review of occurrence records, and updating information associated with species occurrence records, or removing the record as appropriate. The process consisted of:

- addressing erroneous records which could occur through
    - misidentification;
    - data entry error (wrong species input);
    - incorrect spatial data (co-ordinates and/or location description);
    - inappropriate spatial accuracy assignment (too coarse, too fine, depending on data quality);
    - plantings or naturalisations
- for some of the very old records, there was sufficient information to allow them to be located with high accuracy in remnant habitats (such as urban bushland) in highly developed suburbs, in these cases the records were kept and the locations and accuracy records were updated.

The fauna data cleaning also involved marking records as to whether or not they should be counted as 'informative' or not for the modelling. This was based on whether the record was in breeding habitat for the species, or whether it was likely to in foraging habitat, or in locations of where the species was dispersing outside its habitat (or possibly road kill). Specifically:

- for the Grey-headed Flying-fox (*Pteropus poliocephalus*), only records associated with roosts where retained;
- for the Koala (*Phascolarctos cinereus*), only records associated with native vegetation were retained, due to the male koalas being known to disperse through non-native habitat after the breeding season;

- for Australasian Bittern, records were only retained if they were in or close to appropriate mapped native vegetation, and records associated with open water were excluded.

The number of records for each of the species being modelled is displayed below in Table 3, including a breakdown the proportion of records overlapping native vegetation and the number within the Cumberland Subregion.

Scientific name	Common name	Total number of presences in study area	Number of presences in Cumberland	Percentage of presences in areas with native vegetation (%)
Litoria aurea	Green and Golden Bell Frog	13496	12587	0.6
Acacia pubescens	Downy Wattle	5344	5138	85
Phascolarctos cinereus	Koala	3983	1191	76.9
Pteropus poliocephalus	Grey-headed Flying-fox	2590	1639	54.6
Persoonia nutans	Nodding Geebung	1559	1511	88.6
Pimelea spicata	Spiked Rice-flower	1312	1312	93.5
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	1292	1089	97.3
Pultenaea parviflora	NA	1221	1211	79.4
Darwinia biflora	NA	1181	27	11.1
Eucalyptus benthamii	Camden White Gum	582	577	72.3
Persoonia hirsuta	Hairy Geebung	503	38	68.4
Persoonia bargoensis	Bargo Geebung	390	271	80.4
Acacia bynoeana	Bynoe's Wattle	268	113	77
Micromyrtus minutiflora	NA	190	188	66.5
Heleioporus australiacus	Giant Burrowing Frog	134	13	30.8
Pommerhelix duralensis	Dural Woodland Snail	79	16	87.5
Pomaderris brunnea	Brown Pomaderris	75	71	88.7
Botaurus poiciloptilus	Australasian Bittern	56	34	44.1
Cynanchum elegans	White-flowered Wax Plant	23	23	82.6

Table 3. Number of occurrence records in BioNet for each species after the data cleaning was completed. For each species, the total number of records in the study area is shown, the number within the Cumberland Subregion, and the percentage of the records that overlap with native vegetation.

Environmental predictors

Through discussions with a range of experts on the flora and fauna of the Cumberland Plain, and drawing on similar studies utilizing SDMs in NSW (Kujala at al. 2016) a range of potential predictors layers were selected. The experts providing feedback into the selection of predictors included staff members of NSW Government Departments (OEH and DPE) as well as a range of consultants involved in WSSSP. The list of the initial 37 predictors considered in the analysis is shown in Table 4.

Predictor code	Predictor description
vegetation	Native vegetation
ct_temp_maxsum	Average daily max temperature - Summer
ct_tempannrnge	Temperature Annual Range: difference between bio5 and bio6 (bio7)
cw_precipann	Annual Precipitation (bio12)
gp_k_fillspl	filtered potassium (K), gaps filled in using geograhically weighted regession model and spline function
lf_aspect_tr	Beer's Apsect- transformation of aspect to a continuous scaled variable. Changed for the southern hemisphere by setting maximum value (2) to SE slopes (coolest) and minimum (0) to NW slopes (warmest).
lf_cti	Compound topographic index or CTI also known as wetness index, topographic wetness index. Based on DEM-H (for flow direction and accumulation)
lf_rough0100	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 100 m neighbourhood. Derived from DEM-S
lf_tpi0120	Topographic position index using neighbourhood of 120m radius
dl_lat_grid	Latitude (surrogate for location, disperal, isolation)
dl_long_grid	Longitude (surrogate for location, dispersal, isolation)
ce_radhp	Highest Period Radiation (bio21)
ce_radlp	Lowest Period Radiation (bio22)
ct_frostdays_lt2	Number of days/annum with minimum temperature less than 2 degrees
ct_temp_maxwin	Average daily max temperature - Winter
ct_temp_minsum	Average daily min temperature - Summer
ct_temp_minwin	Average daily min temperature - Winter
ct_tempdiurn	Mean Diurnal Range (Mean(period max-min)) (bio2)
ct_tempmtcp	Min Temperature of Coldest Period (bio6)
ct_tempmtwp	Max Temperature of Warmest Period (bio5)
cw_etaaann	Average areal actual evapotranspiration - Annual
cw_etapann	Average areal potential evapotranspiration - Annual
dl_strmdstge2	Euclidean distance to 2nd order streams and above
dl_strmdstge4	Euclidean distance to 4th order streams and above
dl_strmdstge6	Euclidean distance to 6th order streams and above
gp_u_fillspl	filtered uranium (U), gaps filled in using geograhically weighted regession model and spline function
lf_rough0500	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 500 m neighbourhood. Derived from DEM-S
ct_tempann	Mean annual temperature (ANUCLIM)
ct_tempmtcp	Mean temperature of the coldest period (ANUCLIM)
ct_tempmtwp	Mean temperature of the hottest period (ANUCLIM)
cw_precipann	Mean annual rainfall (ANUCLIM)
cw_precipseas	Precipitation of Seasonality: Coefficient of Variation (ANUCLIM)

ce_radann	Mean annual solar radiation (ANUCLIM)
DEM	The altitude of a cell above sea level
lf_slope_deg	The slope of a cell (derived from Altitude)
lf_rough1000	Topographic ruggedness (standard deviation in altitude) in a 1000 metres m radius (derived from Altitude)
lf_cti	Compound topographic index (derived from Altitude)

Table 4. List of the predictors recommended by experts considered for modelling.

The vegetation layer used as a predictors consisted of data from the Sydney Metropolitan Area vegetation mapping "SydneyMetroArea_v2_0_2013_E_3817" (see https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/BioNet/bionet-vegetation-map-data-release-notes-170144.pdf) and the 2013 update to the western parts of the Remnant Vegetation of the Cumberland Plain "CumberlandPlainWest_2013_E_4207" (see https://datasets.seed.nsw.gov.au/dataset/e0bed919-8e8b-45a0-803d-bcfb2a2d47e3). In addition, vegetation mapping from the PGAs undertaken by Biosis was also included in the analysis. The original vegetation maps are shape files, and the analysis used the Plant Community Type (PCT) attribute in the shape file to convert merge the above layers and convert them to a single raster layer.

The soil data used was from the NSW Soil Conservation Services 1:100,000 map series, sourced from eSpade (https://www.environment.nsw.gov.au/eSpade2Webapp). See Appendix 4 for a description of the numerical codes used for the modelling for each soil type. The soil type map was originally a shape file, and was converted to a raster file based on the soil type. Detailed consideration was given to the appropriateness of using the soil data in the modelling due to it known to be relatively coarse, and to contain some errors. On balance, it was decided the importance soil as predictor means the models are likely to be better with soil data included, compared to leaving it out.

All other predictors were provided by the NSW Department of Planning and Environment and were already in raster format.

The predictor layers were rasterized to 27m meter resolution (matching the resolution of many of the existing predictor layers) for subsequent use in the analysis, and cropped to the study area.

Checking for collinearity

Multicollinearity of predictors is a term that refers to a situation when two or more covariates are strongly correlated (Farrar and Glauber 1967). These strong correlations can have a negative effect on coefficient estimates during modelling. It can lead to situations where small changes in the data may cause large changes in estimated coefficients, resulting unreliable predictions of species occurrence (Renner and Warton 2013; Dormann et al. 2013).

The correlation coefficients for all combinations of potential predictors were calculated (see Appendix 3 for details of the correlations between predictor pairs). The correlations between predictors were estimated using the Pearson correlation, except for categorical variables, where Goodman and Kruskal's tau measure was used (Appendix 3).

If two predictors had a correlation coefficient larger than 0.8, one of them was removed. To select which predictor to remove, the following procedure was used: (i) the predictors were ranked based on the number of other predictors they are correlated with; (ii) the predictors with the highest ranks were then removed until all the remaining predictors had a correlation of less than 0.8.

After this process was completed, there were 21 predictor layers remaining, which are listed in Table 5.

Predictor code	**Predictor description**
ce_radann	Annual Mean Radiation
ce_radhp	Highest Period Radiation
ce_radlp	Lowest Period Radiation
ct_frostdays_lt2deg_1	Number of days/annum with minimum temperature less than 2 degrees
ct_tempann_1	Mean annual temperature
ct_tempseas_1	Temperature of Seasonality: Coefficient of Variation
cw_precipseas	Precipitation of Seasonality: Coefficient of Variation
DEM_c	The altitude of a cell above sea level
dl_lat_grid	Latitude (surrogate for location, disperal, isolation)
dl_strmdstge2	Euclidean distance to 2nd order streams and above
dl_strmdstge4	Euclidean distance to 4th order streams and above
dl_strmdstge6	Euclidean distance to 6th order streams and above
gp_k_fillspl	filtered potassium (K), gaps filled in using geograhically weighted regession model and spline function
lf_aspect_tr	Beer's Apsect
lf_slope_deg_c	The slope of a cell (derived from Altitude)
lf_cti	Compound topographic index
lf_rough0100	Neighbourhood topographical roughness based on the standard deviation of elevation in a circular 100 m neighbourhood.
lf_tpi0120	Topographic position index using neighbourhood of 120m radius
sfc_aut_b_95	Seasonal Fractional Cover representing proportions of green (g), bare (b), and non
soil	Soil type (see Appendix 4 for correspondence between numerical codes and soil code
vegitation_pct_b	Native vegetation (PCT)

Table 5. The final list of predictor layers used in the analysis.

SDM approach

Maxent requires as inputs a list of the species presences and a set of spatial predictor layers. The after running, the software produces its spatial layers depicting likelihood of species occurrence, and also returns the value for the contributions for each of the environmental predictors used for model fitting. The higher the value of the contribution the more important the predictor is fitting the model to the data, and therefor for predicting the species occurrence.

For the categorical variables (vegetation and soil type) the software returns the contribution of the individual categories. For example, for the vegetation the output is the contribution of each individual PCT, depicting which PCTs are most strongly associated with the locations of the species.

Modelling

The full inputs required for Maxent are (i) the locations of the presence and background points used for model training, (ii) the location of the presence and background points that are to be used for model validation and (iii) the spatial layers of the environmental covariates that are thought to explain species occurrences (Phillips et al., 2006).

The main output of Maxent is a spatial layer of the predicted likelihood of occurrence. Each point in this layer is assigned a value between 0 and 1 that represent the likelihood of the species being present there. Note that this is the *relative likelihood* and not a probability of occurrence, meaning it is just an estimate of how likely the species is to occur there, relative the other locations in the study area and not an absolute probability of the species being present (Phillips and Dudík 2008b; Elith et al. 2011). These values can then thresholded to obtain a binary map of likely and unlikely occurrence areas. There are multiple ways to select a threshold values (Liu, White, and Newell 2013). The threshold value was selected so the sum of the sensitivity (i.e. the true positive rate) and specificity (i.e. the true negative rate) is highest, as this has been shown to perform well compared to other approaches (Liu, White, and Newell 2013).

When running Maxent, all presence records for each species were split in 2 parts: 80% of the points were used in the modelling process to fit the modes (‘training data’), and 20% was used as ‘testing data’. The test data was used to evaluate the performance of the model by understanding how well it predicts data points it hasn’t been trained on.

The models were evaluated using ROC curves, a commonly used approach for evaluating the performance of models for binary data (Franklin 2010) . The ROC curve plots the true positive rate (correctly identified presences) against the false positive rate for different threshold (cut off) settings (Liu et al. 2016). The accuracy of the model prediction can then be measured by the *Area under the ROC curve (AUC)* metric, where a value of 1 implies a model perfectly predicts presences and absences, and the lower the value the worse the model performance.

The AUC metric was originally utilized for the site-occupancy data, to determine how well the model could predict presences and absences in data it hadn’t been trained on. In cases of PB data, AUC uses background points instead of absences and compares presences to background data. Therefore, it provides a measure for how well the model is predicting the presences locations not used to train the model.

Predictor selection

To select the predictor layers to use for the SDMs for each species a model selection process was used. Model selection starts with the list of the final environmental predictors shown in Table 5. An automated variable selection process was then undertaken for each of the species individually which consisted of the following steps:

1. The model is fitted to the training data using all the covariates in Table 5
2. The AUC for the model and the covariates contributions are calculated
3. Covariates with the lowest contribution (less than 0.02) are removed from the predictor list

4. The model is refitted with the updated predictor list and new AUC and variable contribution are calculated
5. If the AUC of the new model has either increased, or has not become lower by more than 0.05, then a new iteration starting at step 3 is undertaken to remove another predictor
6. If the AUC has decreased by more than 0.05, then the final model is selected using the predictors from the previous iteration before the AUC decreased
7. However, if there are no covariates with contribution less than 0.02 the final model is selected from this iteration

This process results in a set of predictors that unique to each species, that allows Maxent predictions that are most accurate in predicting the 20% of data that was not used in training the maxent model.

Dealing with biases in the occurrence data

Background and summary of the problem

When using PB data in the modelling, we need to compare the set of recorded presences with a set of points selected from the area where the species has not been detected.

The approach Maxent uses is randomly selecting "background points" from throughout the study area where species occurrence is to be predicted. If the presence points are unbiased (meaning people just looked in random locations and reported the species when they saw it), then this approach works well and with enough presences, can give a good prediction of the species locations.

However, the occurrence data is not unbiased as the locations where species are recorded are not randomly selected. This is due to a combination of many factors: they may be close to roads or in more easily accessible locations, they can result from targeted surveys undertaken where the species is thought likely to occur, there may be far more records on public land than on private land, etc.

Maxent provides a method to help account for these potential biases in the occurrence data. It allows users to provide a spatial layer (called a "bias layer") describing the bias in where the species locations are recorded. It tells Maxent that in certain locations, no one ever looked for the species. Maxent then uses this bias layer to select its background points. If the bias layer is known correctly, then including the bias layer can greatly improve the SDM predictions. The problem is that while it's likely that the occurrence records for each species in Cumberland Subregion are biased, we don't exactly how they are biased, and the bias may be different for each species.

Using multiple bias layers

Our proposed solution to this problem was to undertake three models for each species, each with different assumptions regarding the potential bias in the records:

1. *Bias layer 1*: assumes the records are unbiased and that the species was searched for at random locations in the landscape with only presences recorded. Thus, the bias layer is the whole study area.

2. *Bias layer 2*: assumes that there are biases in where the species were searched for, but that it is the same for all species. It aggregates the records of all species together,

buffers them, and assumes this provides a good description of the bias in where species were searched for.

3. *Bias layer 3*: assumes there are biases in where the species where searched for, but that this may vary between species. It generates a separate bias layer for each species, by buffering just presence locations of the species being modelled, and assumes this is a good description of where the species was searched for.

While none of these bias layers are going be an accurate description of where the species was searched for, our assumption is that for each species, one of these bias layers is going to be a reasonable approximation in describing the biases in the presence records. Thus, our approach is to run 3 maxent models, with each of the 3 bias layers above. Though it should be noted, that the model selection process as described above was used to select the predictors for each species using *bias layer 1*. These same selected predictors were then used in generating the models with *bias layer 2* and *bias layer 3*. Thus, the three different SDMs all had the same set of predictors, making comparing and summarizing the predictor contributions more appropriate across the three SDMs.

For each of these SDMs, generated with a different bias layer, were then converted into a binary presence-absence layer (using maxent's build-in method that selects a threshold based on getting the same rate of false presences and false absences; see above). This produced 3 binary layers which can be aggregated into to a single layer with 3 possible values:

0 ("***unlikely to occur***") - locations where none of the binary maps showed the species occurring

1 ("***potential to occur***") - locations where at least one on the maps showed the species occurring

3 ("***likely to occur***") - locations where all 3 of the maps showed the species to occur

Interpretation

"Unlikely to occur" areas are where none of the binary maps predicted that the species is likely to be present. "Potential to occur" is a conservative estimate showing everywhere the species could potentially occur, accounting for the different plausible assumptions about how we could approximate the biases in the data. "Likely to occur" shows only areas that were predicted to be habitat under all 3 assumptions regarding how the data would be biased. This is likely to miss some locations where the species occurs, but as these areas always come up no matter what we assume regarding the biases, they can more robustly be assumed to capture the presence of the species.

This can also be seen as a risk-based approach where (subject to model assumptions), "potential to occur" minimizes the risk of missing an area where the species occurs, and "likely to occur" minimizes the risk of selecting an area where the species doesn't occur. Thus "potential to occur" is more appropriate for assessing the impacts on species, while "likely to occur" is more appropriate targeting conservation actions such as offsets.

Source code and data availability

The analysis was undertaken using open source statistical programming language R (version 3.5.1), and utilized the following packages:

- rJava version 0.9-10
- caTools version 1.17.1.1
- ENMeval version 0.3.0

- dismo version 1.1-4
- maptools version 0.9-4
- raster version 2.6-7
- rgdal version 1.3-4
- sp version 1.3-1
- knitr version 1.20

The knitr_1.20 package was used to generate the automated reports presented in Appendices 1 and 2.

All the source code to undertake the analysis is available via Github at: https://github.com/thekoshkina/WSSSP-Modelling/tree/master/SDM

The spatial layers for the covariates used in the analysis are available at: http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/covariates.zip

Results

The full results for all species are presented in Appendix 1 and 2. Appendix 1 contains the SDMs produced by Maxent for each species with each of the three different bias layers. For each of 19 species, the Appendix 1 presents:

- Summary information for the species
- A table with the predictor layers used for the species (the three SDMs with the different bias layer all use the same predictors)
- Maps of the Maxent output for the each of the three bias layers showing:
    - The relative likelihood of occurrence map produced for the species, and then this map thresholded into a binary presence/absence map such that false presence absence and false presence rates are the same
    - The AUC value for the SDMs
    - These two maps are shown with and without the species presences overlaid as blue dots
- The contribution of each predictor layer for each the three SDMs with different bias layers
- For layers where the categorical variables of soil and vegetation are used, the contributions of each of the soil and vegetation categories are given.

Appendix 2 then presents the single SDMs for each species aggregated from the SDMs generated with the three bias layers, as described above. For each of the 19 species, the Appendix 2 shows:

- Summary information for the species, and
- A table with the predictor layers used for the species
- A table with average contribution of each predictors across the 3 SDMs with the different bias layers, and the 3 highest contributing soil types and PCTs for across the 3 SDMs (where vegetation and soil type were included as predictors)
- The three-category risk-based occurrence map for the species, both with and without the species occurrences overlaid

Figure 2 – Figure 4 show example output SDMs for *Pultenaea parviflora* for the three different bias layers, with the occurrences of the species shown as blue points. The SDM results for bias layers 1 and 2 are similar (Figure 2 and Figure 3), however using bias layer 3 (where the background points are chosen from the areas around the recorded presences the species), results in a significantly different SDM with areas of higher likelihood of occurrence spread over a much larger area (Figure 4). This trend of the bias layers 1 and 2 producing more similar results and bias layer 3 producing a significantly different result was a common result across most of the species modelled (Appendix 1). However, for the Grey-headed Flying-fox (*Pteropus poliocephalus*) all three bias layers resulted in more similar results (Appendix 1) and for the Australasian Bittern (*Botaurus poiciloptilus*), bias layer 2 resulted in a significantly different result, while bias layers 1 and 3 were more similar (Appendix 1).

The results from the three bias layers are then combined to produce the three-category risk-based map shown in for the example of *Pultenaea parviflora* (Figure 5). In this case, the areas depicted where the species are “most likely to occur” overlaps the vast majority of the species occurrences.

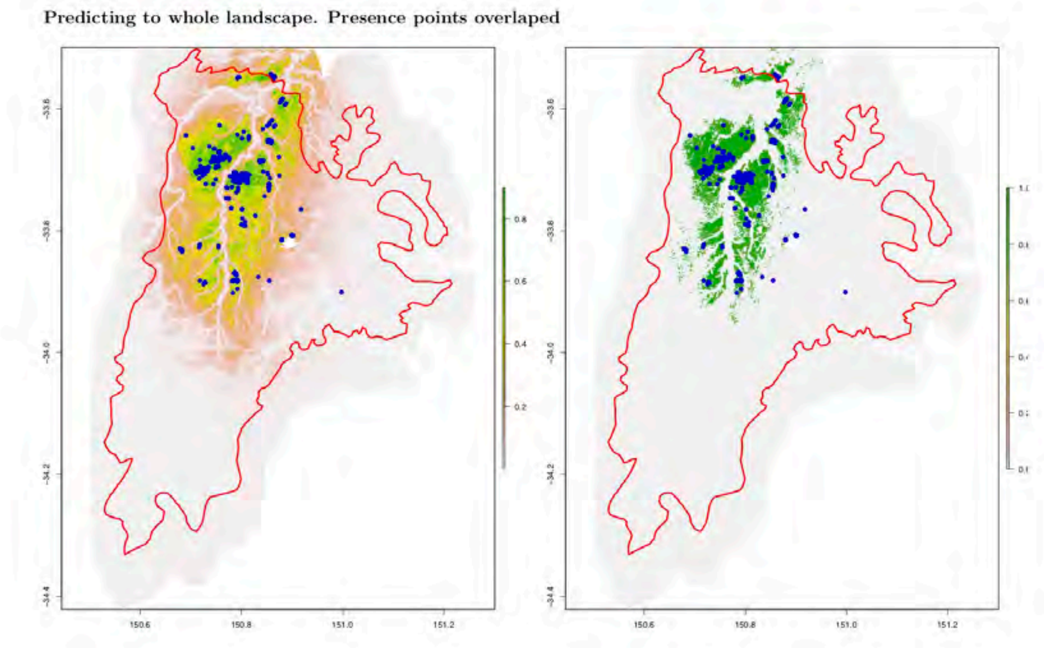


Figure 2 Predicted likelihood of occurrence map generated by Maxent for *Pultenaea parviflora* using bias layer 1. The left figure shows the raw likelihood of occurrence map generated by Maxent, the right figure shows the version of the map where it has been thresholded to produce a binary map of predicted presence/absence of the species based on selecting a threshold level such that false presence and false absence rate are the same. Occurrences of the species are shown as blue points.

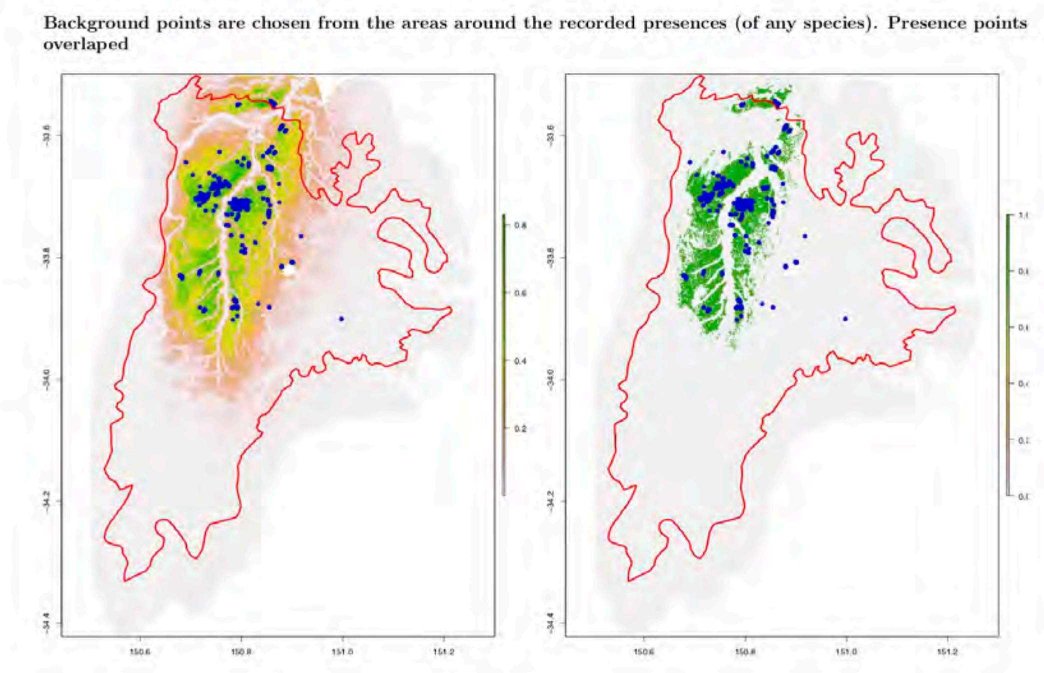


Figure 3 Predicted likelihood of occurrence map generated by Maxent for *Pultenaea parviflora* using bias layer 2. The left figure shows the raw likelihood of occurrence map generated by Maxent, the right figure shows the version of the map where it has been thresholded to produce a binary map of predicted presence/absence as described in Figure 2. Occurrences of the species are shown as blue points.

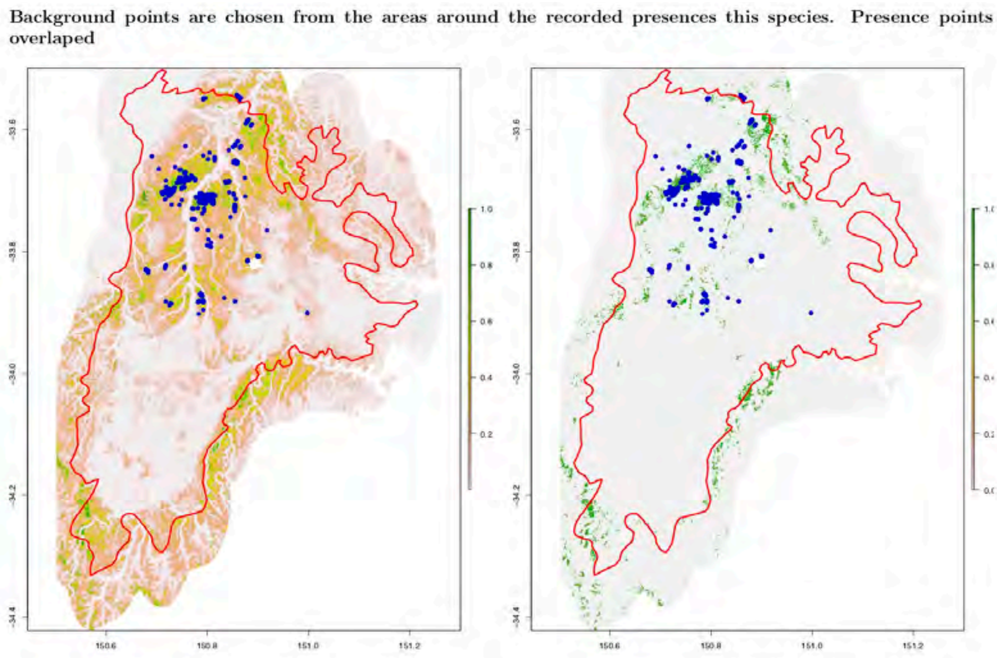


Figure 4 Predicted likelihood of occurrence map generated by Maxent for *Pultenaea parviflora* using bias layer 3. The left figure shows the raw likelihood of occurrence map generated by Maxent, the right figure shows the version of the map where it has been thresholded to produce a binary map of predicted presence/absence as described in Figure 2. Occurrences of the species are shown as blue points.

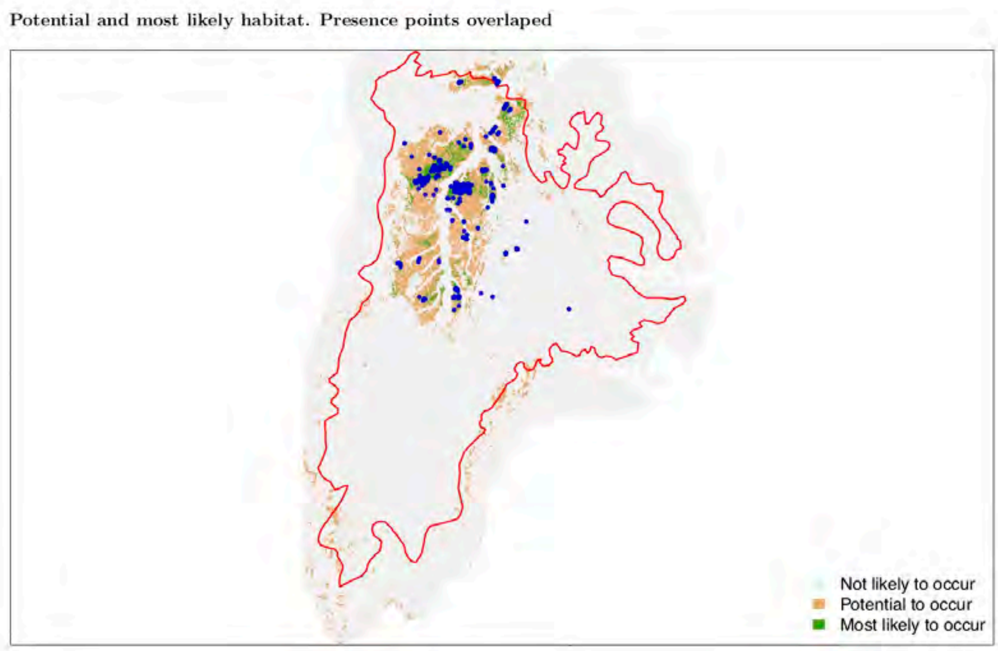


Figure 5 The final risk-based likelihood of occurrence map for *Pultenaea parviflora*. This is generated from maps in the three previous figures as described in the methods, and indicates areas where the species is "not likely to occur" (none of the previous three maps thresholded maps predicted occurrence), has "potential to occur" (at least one of the previous three maps thresholded maps predicted occurrence) and is "most likely to occur" (all three of the previous thresholded maps predicted occurrence). Occurrences of the species are shown as blue points.

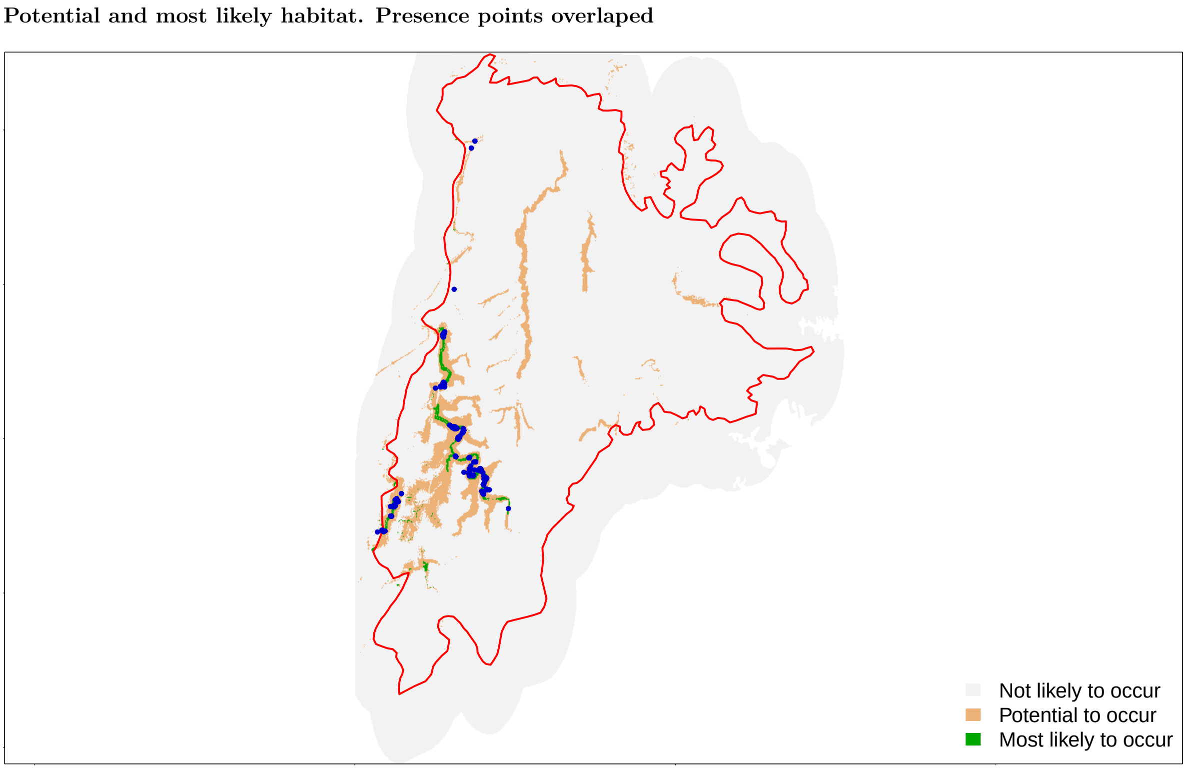


Figure 6 The risk-based SMD output for the Camden White Gum (*Eucalyptus benthamii*). Occurrences of the species are shown as blue points.

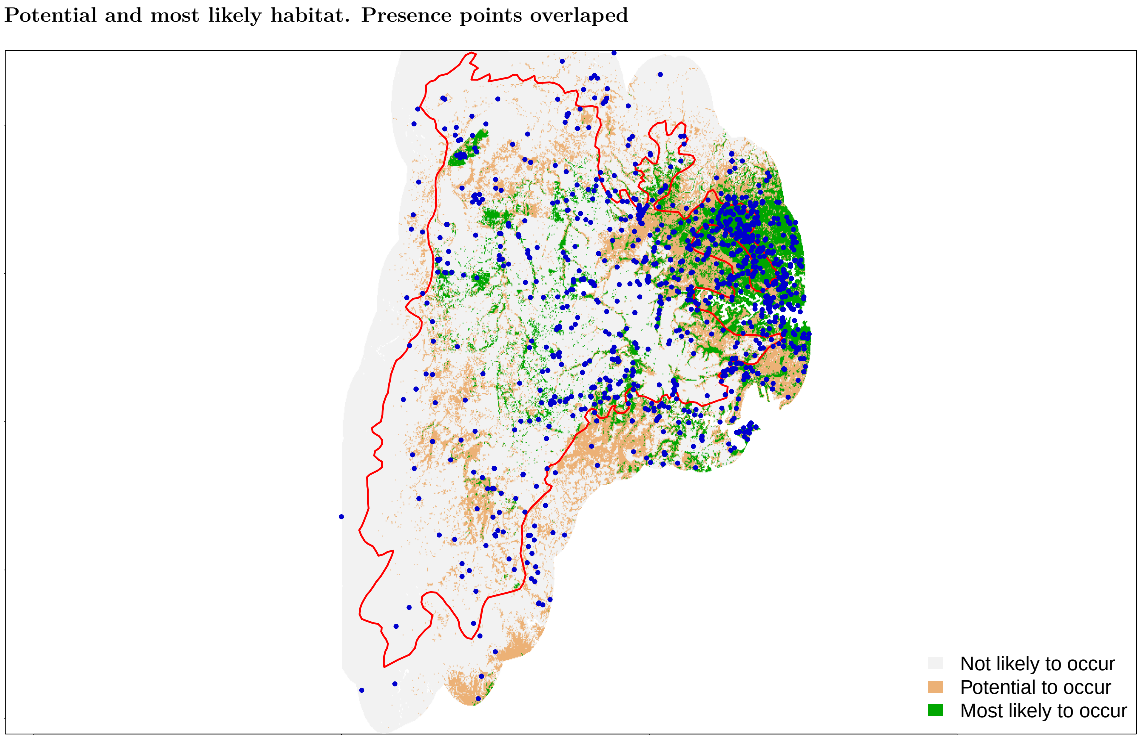
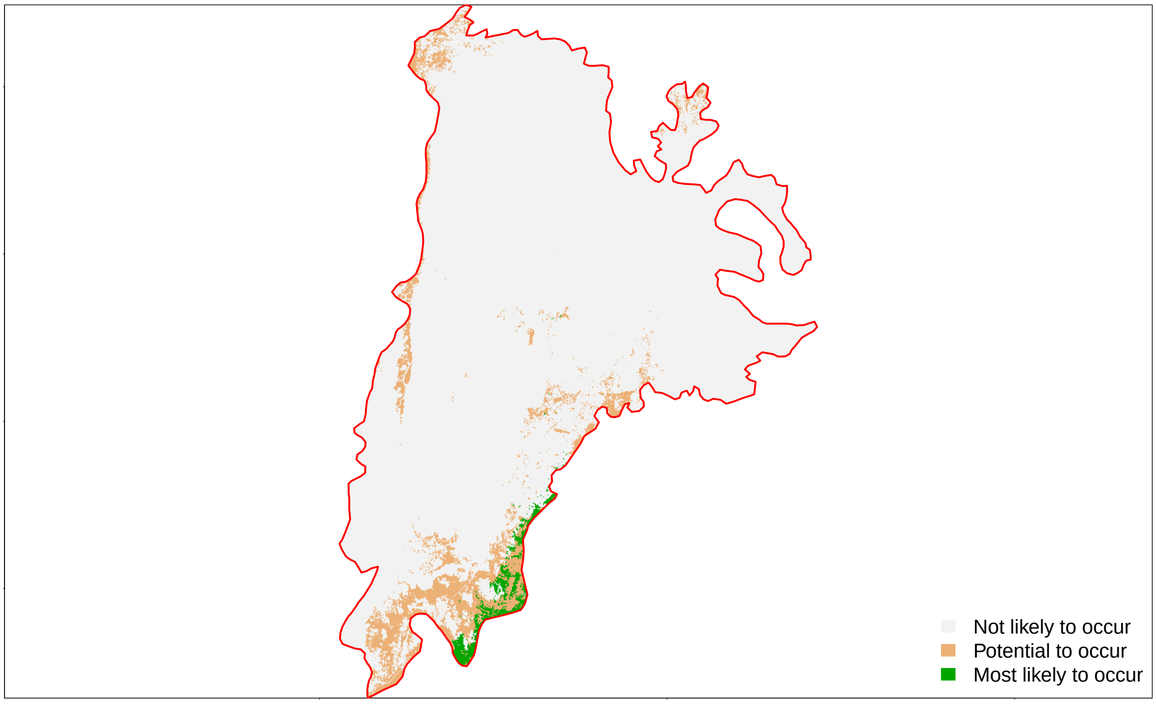


Figure 7 The risk-based SMD output for the Grey-headed Flying-fox (*Pteropus poliocephalus*). Occurrences of the species are shown as blue points.

Potential and most likely habitat



Potential and most likely habitat. Presence points overlaped

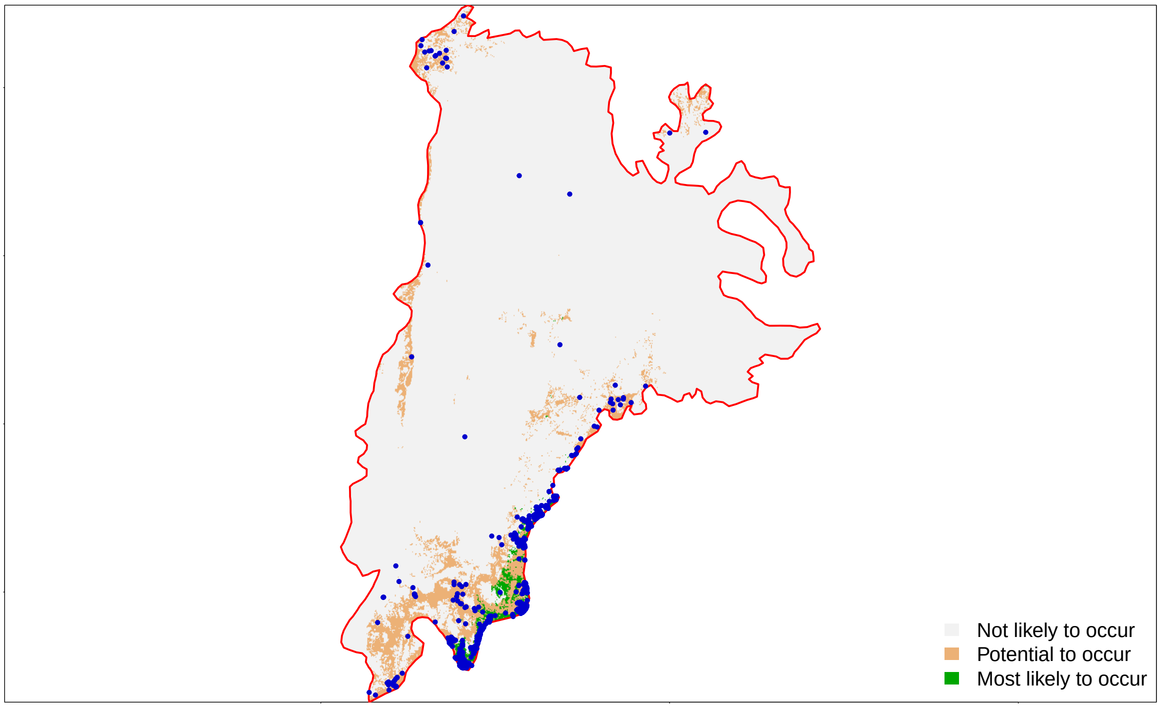


Figure 8 The risk-based SMD output for the Koala (Phascolarctos cinereus). For clarity the SDM outputs are presented with (bottom plot) and without (top plot) the occurrences of the species (shown as blue points).

Figures 6–Figure 8, show three additional examples of the risk-based SDMs for the Camden White Gum, the Grey-headed Flying-fox and Koala, respectively. These show a SDM outputs for a more localised species (Camden White Gum; Figure 6), compared to the wide spread presence sighting of the Grey-headed Flying-fox (Figure 7). For the Grey-headed Flying-fox, only records associated with colonies were used and for this species it's clear that a greater proportion of the records do overlap the potential or likely to occur areas in the risk-based SDM. Figure 8 shows the results for the Kola. Due to the large number of presence records (915 used in the modelling), the SDM is shown for clarity both with and without the Koala presences overlaid. It should be noted that unlike the other species the Koala SDM was only undertaken for the Cumberland Subregion, excluding the buffer (see Discussion). For the Koala, only records associated with native vegetation were used, to exclude records associated with dispersing males outside their habitat. In this case almost all of the records overlapped areas of potential and most likely habitat.

The predictors with the highest contributions varied for each species, and while the same predictors were used in the SDMs for each of the three bias layers, their relative contributions are often differed between the SDMs with the three different bias layers. The number of predictors used for each species could also vary, due to the model selection process (described above). Species had as low as 5 predictors (e.g. the Bargo Geebung *Persoonia bargoensis*) or as many as 15 (e.g. the Giant Burrowing Frog *Heleioporus australiacus*) (see Appendix 2). While soil type and vegetation were important predictors for many of the species they were not always the ones with the largest contributions.

Figure 9 shows the AUC values for SDMs produced for each species, with the AUC values for each of the bias layers shown in a different colour. In general, SDMs with bias layer 3 tended to have lower AUC scores. There is only one poor performing model, which is for the Australasian Bittern (*Botaurus poiciloptilus*), when using bias layer 3 (results in an AUC score of 0.57; Figure 9). All other SDMs across species and bias layers have AUC scores greater than 0.7, with the majority of them having AUC score greater than 0.9 (Figure 9).

Results availability online

The full results presented here are available by contacting the authors or online as follows.

Pdf documents containing all risk-based maps are available here:
http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/risk-based-occurence-maps.pdf

A pdf document containing the all the SDMs with different bias layers is available here:
http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/full-SDMs-for-all-spp.pdf

Raster files of the Maxent risk-based SMDs are available here:
http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/risk-based-occurence-maps_tiffs.zip

Raster files of the Maxent SMDs with the three bias layers are available here:
http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/full-SDMs-for-all-spp.zip

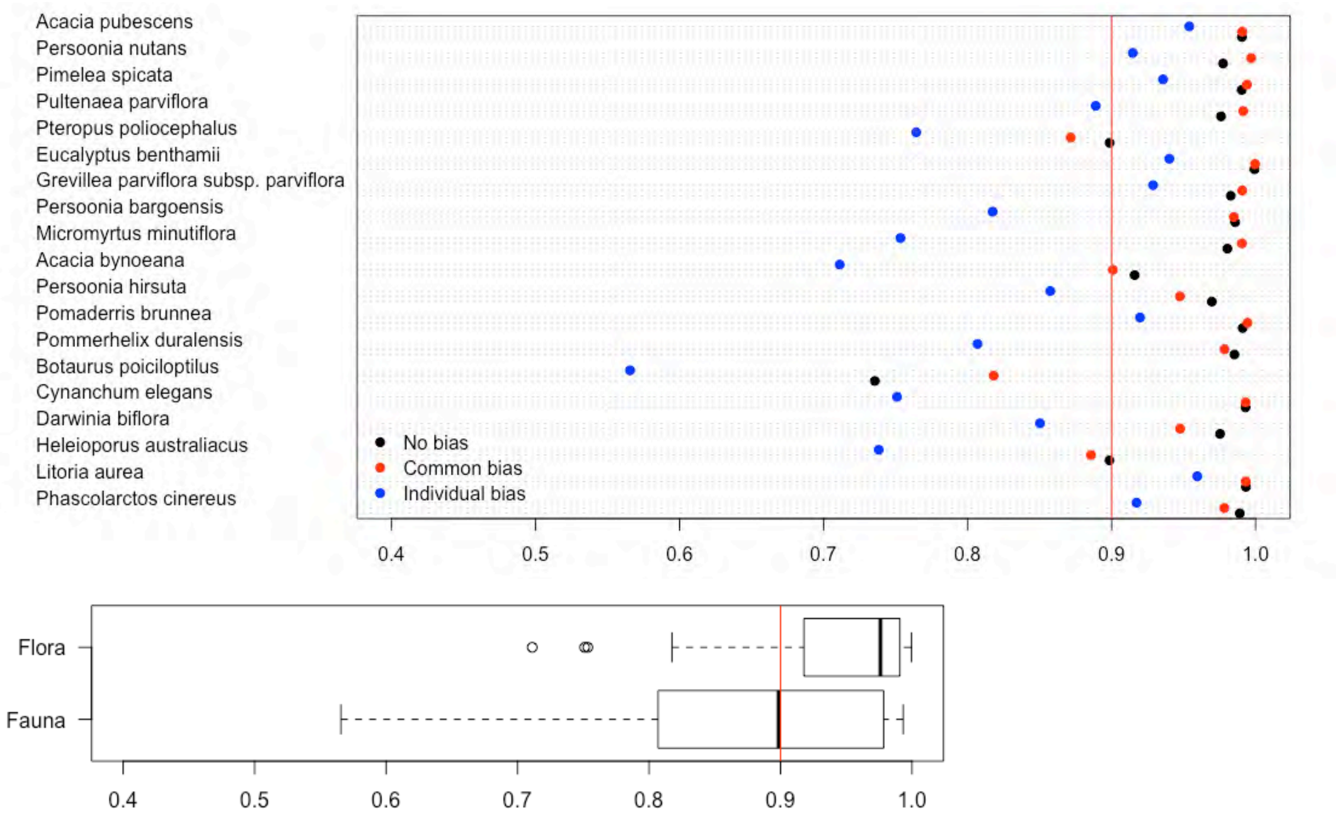


Figure 9 The AUC values for the SDMs for all species. The results for the 3 bias layers are shown in black (bias layer 1–no bias), red (bias layer 2–common bias) and blue (bias layer 3–individual bias). The lower plot shows the distribution of AUC scores for all flora and all fauna, as box plots.

Discussion

We have presented SDMs for 13 flora species and 6 fauna species for the Cumberland Subregion (IBRA 7). Using the risk-based approach we have produced maps using the Maxent species distribution modelling package that depict where a species is likely to occur using three classes of: “unlikely to occur”, "potential to occur" and "likely to occur".

Species maps

All the resulting SDMs tended to have high AUC scores (the majority of them were over 0.9 with only one model less than 0.7; Figure 9). This means that in most cases the resulting models accurately predicted the locations of records that were not used to train the model. However, a high AUC score does not necessarily mean it should be concluded that the resulting SDM is an accurate representation of the true species likelihood of occurrence. It just means that it is an accurate representation of the presence records used to train the model. If these species records are highly biased, an SDM output may have a high AUC score and still provide a highly biased result. We have tried to control for bias in the occurrence data by using different bias layers in Maxent as described above.

In general, the approach to generating SDMs may over-predict the habitat for species. This may be partly due to anthropogenic factors limiting the current distribution of species, and the fact that predictors capturing these factors were not incorporated due to lack of available data. In other cases, errors in the occurrence data and/or covariate layers (particularly vegetation and soil) mean that Maxent may pick up associations between species and PCTs or soil types that are artefacts. However, the "likely to occur" regions of the SDMs are significantly reduced compared to the "potential to occur" regions and thus are less likely to involve over-predictions.

It should be noted that risk-based SMD results do not always predict regions for "likely to occur" and "potential to occur" that overlap every single species presence record used in the modelling. There can be numerous reasons for this. However, the general point is that Maxent is designed to produce a probability layer that does not "overfit" the data (see methods). A model that is overfitted produce an SDM that predicts to all occurrences used to train the model accurately, while predicting to locations not used to train the model poorly. The result of not overfitting (achieved through using the "maximum entropy distributions") is that while most species occurrences will be located in predicted and likely/potential to occur areas, not all presences will be in these areas.

Below we discuss some of the SDMs for specific species.

Fauna

The koala is a difficult species to model, and more detailed modelling of its potential feed trees is being undertaken by OEH. The SDM presented here results from the records used from BioNet (which may be highly biased away from the heavily cleared and fragmented parts of Cumberland Plain) and their associations with the available predictors. As discussed above, records not associated with native vegetation were excluded from the model, as it was hypothesized that in many cases these would correspond to dispersing male koalas (a known behaviour after breeding) and would not be associated with breeding habitat. In addition, it's important to note the SDM here differs from the other SDMs in that we exclude the 10km buffer around the Cumberland Plain when modelling this species, and only use the records within the Cumberland Subregion. The reason for this was that there were a large number of additional Koala records located in the buffer region (>2700 records). This large number of records outside the Cumberland Subregion, skewed the model to predict only a small amount of habitat within the Cumberland Subregion, compared to modelling the species just with the Cumberland Subregion. While the model trained just on the presences for the Cumberland Subregion, predicts a greater amount of koala habitat, it still predicts an absence of koala occurrence on most of the Cumberland Plain. While there may not be koalas in many of these areas now due to fragmentation and anthropogenic threats, there may much more theoretically sound potential habitat on the plain in terms of PCTs on the Cumberland Plain then is currently depicted by the SDM produced here.

After some consideration it was decided to undertake an SDM for the Green and Golden Bell Frog (*Litoria aurea*). However, the resulting predictions should be used with some caution as there are important factors driving its distribution for which appropriate predictors were not available. For example, Chytridiomycosis is known to impact where the species occurs. In addition, the Green and Golden Bell Frog is known not to be restricted to areas surrounded by native vegetation and has been found in quarries, constructed ponds, and small bodies of the water on the ground (Enhua Lee, OEH, personal communication).

As the Grey-headed Flying-fox (Pteropus poliocephalus), forages widely, it was decided to exclude foraging records and only use those associated with colonies, as otherwise without this constraint, the whole region may be potential foraging habitat for the species. In the resulting SDMs, there is more habitat than expected, so the model may be over predicting slightly (Paul Burcher, personal communication).

Further the SDM for Dural Woodland Snail may have overestimated most ‘potential to occur’ habitat as the species is thought to be restricted to the northern margins of the sub-region at the shale/sandstone interface (Paul Burcher, personal communication).

Plants

The White-flowered Wax Plant (*Cynanchum elegans*) has 23 records that were used for the modelling. Due to the small number of records, the SDM resulting from this species should be treated with some caution.

Hairy Geebung (*Persoonia hirsute*), and *Darwinia biflora* have a small proportion of their records within the Cumberland Subregion (most records being in the 10km buffer region) and the resulting SDMs estimate that a small proportion of their habitat occurs inside the Cumberland subregion.

Several of the SDM layers are expected to over-predict the likely areas where the species occur. While this may be acceptable from a precautionary approach, in some cases the models are predicting likely occurrences beyond the range where the species is known to occur. For example, the *Persoonia nutans*, the habitat map predicts the potential for the species to occur in too far south and to the northeast. It has never been known to occur in the Hornsby Plateau, and is confined to the Cumberland Plain except for an outlier in the North West, and an outlier in the South, both in close proximity to the Plain (Steve Douglas, personal communication). Likewise, the model for *Acacia pubescens* likely over-predicts potential habitat and the model for *Acacia bynoeana* may also predict more potential habitat than would be expected based on soils and PCTs (Steve Douglas, personal communication).

Limitations

As discussed earlier in this report, there are multiple factors that limit the SDM approach for the fauna and flora species in the Cumberland Subregion.

Firstly, for some of the species, this study area only involves a small part of the species range, in which case we may be missing parts of species’ niche and making poor predictions. Initially this project planned to model species within a 100km buffer of the Cumberland Subregion, however at the time undertaking this analysis, vegetation maps containing PCT information was not available for all of this region. There was also not full coverage of this region for soil data (see https://www.environment.nsw.gov.au/eSpade2Webapp). Thus, we limited the study area to a 10 km buffer around the Cumberland Subregion (constrained to where PCT information was available). For these wider ranging species, modelling over a great proportion of their range may result in improved SDMs. However, the ranges of some of the other species modelled here are very range restricted and are limited to within or near the Cumberland Subregion. This species also pose other challenges to model as historical accidents and competition with other species could be driving their current locations, both factors that are unaccounted for in most SDMs (however see Pollock et al. 2014).

The highly-modified landscapes with the Cumberland Subregion mean that in many areas there are high level of fragmentation and anthropogenic threats. This may result in the standard assumptions regarding a species occupying its niche not to apply, meaning that large areas of previous potential habitat may no longer be occupied.

As discussed there is an unknown but potentially large amounts bias in the occurrence records. Here we have first to cleaned the data, and then used multiple bias layers in an attempt to deal with different amount of bias.

Another point to note is that the analysis presented her should be considered purely as attempting to model where the species are *likely to occur*. It does not attempt to model the most effectively locations to conserve the species in the Cumberland Subregion. To do this would require multiple additional factors to be incorporated, including connectivity between locations where the species is likely to occur, and other factors known to affect the viability of the species such as the size of habitat patches, the surrounding landuses and the presence of threats to the species. To undertake this type of analysis there are a range of spatial prioritization tool that can be used such as Zonation (Gordon et al. 2009), however such an analysis is beyond the scope is this project.

Other issues that may also limit or confound the outputs of the SDMs are:

- The fact that detectability may be an issue for some species, meaning they are more likely to be observed in some locations than others (Guillera-Arroita 2016)
- Although we used the best available soil mapping, it is known to be relatively coarse and to contain some errors
- For some of the species, there may be false associations between records and PCTs. This due to spatial errors in the point locations and and/or the PCT maps (Steve Douglas, personal communication)

Extensions of this work

This work could be extended in several ways to improve the predictions produced by the Maxent SDMs. When PCT information is available for all of NSE, it will be possible to model many of the species over a greater area. This may result in improved predictions within the Cumberland Subregion.

For some flora species, there are survey results that incorporate both presence and absence of the species. Having presence and absence data can result in more accurate SDM predictions and there are now approaches where models can be fit with presence-absence data and presence only data simultaneously, making better use of all available data (Koshkina et al. 2017).

It is likely that some of the SDMs presented here over-predict the locations of species beyond their known range. One solution to this issue would be to use expert-derived estimates of the predicted range of the species and then only use SDMs to make predictions to areas within the this predicted range. These range maps would likely capture all the presence records of the species, and constrain the SDM predictions reducing the amount they over-predict.

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Appendix 1 - Maxent model results for all species and all bias layers

All maps and tables are contained in the supporting document "full-SDMs-for-all-spp.pdf" supplied with this report. This file is also available by contacting the authors or from http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/full-SDMs-for-all-spp.pdf. Summary information supplied in this document:

- A table with the predictor layers used for the species (the three SDMs with the different bias layer all use the same predictors)
- Maps of the Maxent output for the each of the three bias layers showing:
    - The relative likelihood of occurrence map produced for the species, and then this map thresholded into a binary presence/absence map such that false presence absence and false presence rates are the same
    - The AUC value for the SDMs
    - These two maps are shown with and without the species presences overlaid as blue dots
- The contribution of each predictor layer for each the three SDMs with different bias layers
- For layers where the categorical variables of soil and vegetation are used, the contributions to the of each of the soil and vegetation categories are given.

Appendix 2 - Risk-based 3-category SDMs for each species

All maps and tables are contained in the supporting document "risk-based-occurence-maps.pdf" supplied with this report. This file is also available by contacting the authors or from http://glass.eres.rmit.edu.au/tzar_input/sydney-cumberland-plain-SDM/risk-based-occurence-maps.pdf. Summary information supplied in this document:

- Summary information for the species, and a table with the predictor layers used for the species
- A table with average contribution of each predictors across the 3 SDMs with the different bias layers, and the 3 highest contributing soil types and PCTs for across the 3 SDMs (where vegetation and soil type were included as predictors)
- The three-category risk-based occurrence map for the species, both with and without the species occurrences overlaid.

Appendix 3 - Correlations between predictor variable

The correlations between predictors were estimated using the Pearson correlation, except for categorical variables, where Goodman and Kruskal's tau measure was used. Figure A3.1 shows the correlations between the categorical predicators. Table A3.1 shows the Person correlation between all other predictors.

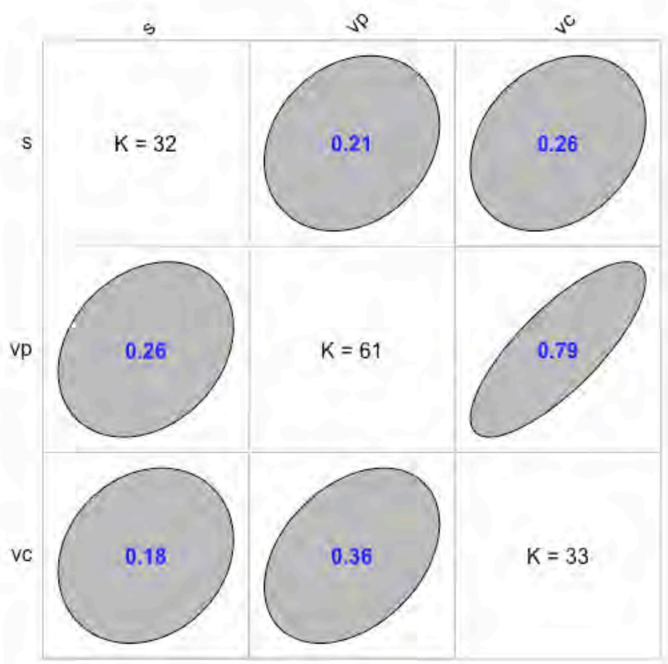

Figure A3.1 TS – The correlations between the categorical predictor layers used in the analysis. In this plot, S is soil, Vp is vegetation PCT, Vc, vegetation community. K is the number of categories in of the categorical predictors.

	ce_radann_c	ce_radhp_c	ce_radlp_c	ct_frostdays_lt2deg_1_c	ct_temp_maxsum_1_c	ct_temp_maxwin_1_c	ct_temp_minsum_1_c	ct_temp_minwin_1_c	ct_tempann_1_c	ct_tempannrnge_1_c	ct_tempdiurn_1_c	ct_tempmtcp_1_c	ct_tempmtwp_1_c	ct_tempseas_1_c	cw_etaaann_1_c	cw_precipann_1_c	cw_precipseas_c	DEM_c	dl_lat_grid_c	dl_long_grid_c	dl_strmdstge2_c	dl_strmdstge4_c	dl_strmdstge6_c	gp_k_fillspl_c	gp_u_fillspl_c	lf_aspect_tr_c	lf_cti_c	lf_rough0100_c	lf_slope_deg_c	lf_tpi0120_c	sfc_aut_b_95_c	soil_c	vegitation_pct_b_c	lf_rough0500_c	lf_rough1000_c	lf_tpi0250_c	lf_tpi0500_c	vegetation_merged_c	vegitation_vegcom_b_c
ce_radann_c	1.0	0.7	0.7	0.2	0.5	0.3	-0.1	-0.5	0.2	0.7	0.7	-0.4	0.7	0.6	-0.1	-1.0	0.3	-0.4	0.0	-0.5	-0.2	-0.3	-0.7	-0.1	-0.2	0.0	0.1	-0.2	-0.2	0.0	-0.2	-0.2	-0.5	-0.2	-0.2	0.0	0.0	0.3	-0.4
ce_radhp_c	0.7	1.0	0.0	0.2	-0.1	0.0	-0.2	-0.3	0.0	0.3	0.3	-0.3	0.1	0.2	0.2	-0.8	-0.4	-0.1	-0.5	-0.3	-0.2	-0.2	-0.5	0.1	0.0	-0.1	0.1	0.0	0.0	0.0	-0.1	0.0	-0.3	0.0	0.0	0.0	0.0	0.3	-0.4
ce_radlp_c	0.7	0.0	1.0	-0.1	0.9	0.6	0.3	-0.2	0.6	0.6	0.6	-0.1	0.9	0.5	-0.6	-0.5	0.8	-0.6	0.7	-0.2	-0.1	-0.1	-0.3	-0.5	-0.5	0.0	0.2	-0.3	-0.2	0.0	-0.1	-0.3	-0.5	-0.3	-0.3	0.0	0.0	0.3	-0.2
ct_frostdays_lt2deg_1_c	0.2	0.2	-0.1	1.0	-0.3	-0.8	-0.9	-0.9	-0.8	0.7	0.6	-0.9	0.1	0.7	0.8	-0.4	0.2	0.7	-0.5	-0.9	-0.4	-0.4	-0.4	0.6	0.5	0.0	-0.1	0.3	0.3	0.0	-0.5	0.0	0.1	0.4	0.5	0.0	0.0	-0.2	0.1
ct_temp_maxsum_1_c	0.5	-0.1	0.9	-0.3	1.0	0.8	0.4	-0.1	0.7	0.4	0.5	0.1	0.9	0.4	-0.7	-0.4	0.8	-0.7	0.8	0.0	0.0	0.0	-0.3	-0.6	-0.6	0.0	0.2	-0.3	-0.3	0.0	0.0	-0.3	-0.4	-0.4	-0.4	0.0	0.0	0.3	-0.2
ct_temp_maxwin_1_c	0.3	0.0	0.6	-0.8	0.8	1.0	0.9	0.5	0.9	-0.2	-0.1	0.6	0.5	-0.3	-0.9	0.0	0.3	-0.9	0.7	0.5	0.3	0.2	0.0	-0.7	-0.7	0.0	0.2	-0.4	-0.4	0.0	0.3	-0.2	-0.4	-0.5	-0.5	0.0	0.0	0.4	-0.2
ct_temp_minsum_1_c	-0.1	-0.2	0.3	-0.9	0.4	0.9	1.0	0.9	0.9	-0.6	-0.6	0.9	0.0	-0.7	-0.8	0.4	0.0	-0.8	0.6	0.9	0.4	0.4	0.3	-0.7	-0.6	0.0	0.1	-0.3	-0.3	0.0	0.5	-0.1	-0.2	-0.4	-0.5	0.0	0.0	0.3	-0.1
ct_temp_minwin_1_c	-0.5	-0.3	-0.2	-0.9	-0.1	0.5	0.9	1.0	0.6	-0.9	-0.9	1.0	-0.4	-0.9	-0.6	0.7	-0.4	-0.5	0.3	1.0	0.5	0.5	0.6	-0.4	-0.4	0.0	0.0	-0.2	-0.2	0.0	0.5	0.1	0.1	-0.3	-0.3	0.0	0.0	0.1	0.0
ct_tempann_1_c	0.2	0.0	0.6	-0.8	0.7	0.9	0.9	0.6	1.0	-0.2	-0.2	0.7	0.4	-0.3	-0.9	0.0	0.2	-1.0	0.7	0.6	0.3	0.2	0.0	-0.8	-0.7	0.0	0.2	-0.4	-0.4	0.0	0.4	-0.2	-0.4	-0.5	-0.5	0.0	0.0	0.4	-0.2
ct_tempannrnge_1_c	0.7	0.3	0.6	0.7	0.4	-0.2	-0.6	-0.9	-0.2	1.0	1.0	-0.9	0.8	1.0	0.2	-0.8	0.7	0.1	0.0	-0.9	-0.4	-0.5	-0.6	0.2	0.1	0.0	0.0	0.1	0.1	0.0	-0.5	-0.2	-0.2	0.1	0.1	0.0	0.0	0.0	-0.1
ct_tempdiurn_1_c	0.7	0.3	0.6	0.6	0.5	-0.1	-0.6	-0.9	-0.2	1.0	1.0	-0.8	0.8	1.0	0.2	-0.8	0.7	0.1	0.0	-0.9	-0.4	-0.5	-0.6	0.1	0.0	0.0	0.0	0.1	0.1	0.0	-0.5	-0.2	-0.3	0.1	0.1	0.0	0.0	0.0	-0.1
ct_tempmtcp_1_c	-0.4	-0.3	-0.1	-0.9	0.1	0.6	0.9	1.0	0.7	-0.9	-0.8	1.0	-0.3	-0.9	-0.6	0.6	-0.3	-0.6	0.4	1.0	0.5	0.5	0.5	-0.5	-0.4	0.0	0.1	-0.3	-0.3	0.0	0.5	0.0	0.0	-0.3	-0.4	0.0	0.0	0.2	0.0
ct_tempmtwp_1_c	0.7	0.1	0.9	0.1	0.9	0.5	0.0	-0.4	0.4	0.8	0.8	-0.3	1.0	0.7	-0.4	-0.6	0.8	-0.5	0.6	-0.4	-0.2	-0.2	-0.4	-0.4	-0.4	0.0	0.1	-0.2	-0.2	0.0	-0.2	-0.3	-0.4	-0.2	-0.2	0.0	0.0	0.2	-0.2
ct_tempseas_1_c	0.6	0.2	0.5	0.7	0.4	-0.3	-0.7	-0.9	-0.3	1.0	1.0	-0.9	0.7	1.0	0.3	-0.7	0.7	0.2	0.0	-0.9	-0.4	-0.5	-0.5	0.2	0.1	0.0	0.0	0.1	0.1	0.0	-0.5	-0.2	-0.2	0.1	0.2	0.0	0.0	0.0	-0.1
cw_etaaann_1_c	-0.1	0.2	-0.6	0.8	-0.7	-0.9	-0.8	-0.6	-0.9	0.2	0.2	-0.6	-0.4	0.3	1.0	-0.1	-0.3	0.8	-0.8	-0.6	-0.3	-0.3	-0.2	0.8	0.7	0.0	-0.1	0.4	0.3	0.0	-0.4	0.1	0.3	0.5	0.5	0.0	0.0	-0.4	0.2
cw_precipann_1_c	-1.0	-0.8	-0.5	-0.4	-0.4	0.0	0.4	0.7	0.0	-0.8	-0.8	0.6	-0.6	-0.7	-0.1	1.0	-0.2	0.1	0.2	0.7	0.3	0.4	0.8	-0.1	0.0	0.0	-0.1	0.1	0.1	0.0	0.3	0.1	0.4	0.1	0.1	0.0	0.0	-0.2	0.3
cw_precipseas_c	0.3	-0.4	0.8	0.2	0.8	0.3	0.0	-0.4	0.2	0.7	0.7	-0.3	0.8	0.7	-0.3	-0.2	1.0	-0.2	0.7	-0.4	-0.1	-0.1	-0.2	-0.3	-0.3	0.1	0.0	0.0	0.0	0.0	-0.2	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.1	-0.1
DEM_c	-0.4	-0.1	-0.6	0.7	-0.7	-0.9	-0.8	-0.5	-1.0	0.1	0.1	-0.6	-0.5	0.2	0.8	0.1	-0.2	1.0	-0.6	-0.5	-0.2	-0.2	0.1	0.7	0.7	0.0	-0.2	0.4	0.4	0.1	-0.4	0.3	0.4	0.5	0.5	0.1	0.1	-0.4	0.2
dl_lat_grid_c	0.0	-0.5	0.7	-0.5	0.8	0.7	0.6	0.3	0.7	0.0	0.0	0.4	0.6	0.0	-0.8	0.2	0.7	-0.6	1.0	0.4	0.2	0.2	0.2	-0.6	-0.6	0.0	0.1	-0.2	-0.2	0.0	0.2	-0.3	-0.2	-0.3	-0.3	0.0	0.0	0.2	0.0
dl_long_grid_c	-0.5	-0.3	-0.2	-0.9	0.0	0.5	0.9	1.0	0.6	-0.9	-0.9	1.0	-0.4	-0.9	-0.6	0.7	-0.4	-0.5	0.4	1.0	0.4	0.5	0.6	-0.5	-0.4	0.0	0.0	-0.2	-0.2	0.0	0.5	0.1	0.0	-0.2	-0.3	0.0	0.0	0.1	0.0
dl_strmdstge2_c	-0.2	-0.2	-0.1	-0.4	0.0	0.3	0.4	0.5	0.3	-0.4	-0.4	0.5	-0.2	-0.4	-0.3	0.3	-0.1	-0.2	0.2	0.4	1.0	0.5	0.3	-0.2	-0.2	0.0	0.0	-0.1	-0.1	0.0	0.4	0.1	-0.1	-0.2	-0.2	0.1	0.1	0.2	0.1
dl_strmdstge4_c	-0.3	-0.2	-0.1	-0.4	0.0	0.2	0.4	0.5	0.2	-0.5	-0.5	0.5	-0.2	-0.5	-0.3	0.4	-0.1	-0.2	0.2	0.5	0.5	1.0	0.4	-0.2	-0.1	0.0	0.0	-0.1	-0.1	0.0	0.4	0.1	-0.1	-0.1	-0.2	0.0	0.0	0.1	0.1
dl_strmdstge6_c	-0.7	-0.5	-0.3	-0.4	-0.3	0.0	0.3	0.6	0.0	-0.6	-0.6	0.5	-0.4	-0.5	-0.2	0.8	-0.2	0.1	0.2	0.6	0.3	0.4	1.0	-0.1	-0.1	0.0	-0.1	0.1	0.1	0.0	0.3	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.2
gp_k_fillspl_c	-0.1	0.1	-0.5	0.6	-0.6	-0.7	-0.7	-0.4	-0.8	0.2	0.1	-0.5	-0.4	0.2	0.8	-0.1	-0.3	0.7	-0.6	-0.5	-0.2	-0.2	-0.1	1.0	0.8	0.0	-0.1	0.4	0.3	0.0	-0.3	0.1	0.2	0.4	0.5	0.0	0.0	-0.3	0.0
gp_u_fillspl_c	-0.2	0.0	-0.5	0.5	-0.6	-0.7	-0.6	-0.4	-0.7	0.1	0.0	-0.4	-0.4	0.1	0.7	0.0	-0.3	0.7	-0.6	-0.4	-0.2	-0.1	-0.1	0.8	1.0	0.0	-0.1	0.2	0.2	0.0	-0.3	0.2	0.4	0.3	0.3	0.0	0.0	-0.4	0.2
lf_aspect_tr_c	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	-0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
lf_cti_c	0.1	0.1	0.2	-0.1	0.2	0.2	0.1	0.0	0.2	0.0	0.0	0.1	0.1	0.0	-0.1	-0.1	0.0	-0.2	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	1.0	-0.4	-0.4	-0.3	0.0	-0.1	-0.1	-0.3	-0.3	-0.3	-0.3	0.1	0.0
lf_rough0100_c	-0.2	0.0	-0.3	0.3	-0.3	-0.4	-0.3	-0.2	-0.4	0.1	0.1	-0.3	-0.2	0.1	0.4	0.1	0.0	0.4	-0.2	-0.2	-0.1	-0.1	0.1	0.4	0.2	0.1	-0.4	1.0	1.0	0.0	-0.2	0.0	0.2	0.8	0.7	0.0	0.0	-0.1	0.1
lf_slope_deg_c	-0.2	0.0	-0.2	0.3	-0.3	-0.4	-0.3	-0.2	-0.4	0.1	0.1	-0.3	-0.2	0.1	0.3	0.1	0.0	0.4	-0.2	-0.2	-0.1	-0.1	0.1	0.3	0.2	0.1	-0.4	1.0	1.0	0.0	-0.2	0.0	0.2	0.8	0.6	0.0	0.0	-0.1	0.1
lf_tpi0120_c	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.9	0.7	0.0	-0.1
sfc_aut_b_95_c	-0.2	-0.1	-0.1	-0.5	0.0	0.3	0.5	0.5	0.4	-0.5	-0.5	0.5	-0.2	-0.5	-0.4	0.3	-0.2	-0.4	0.2	0.5	0.4	0.4	0.3	-0.3	-0.3	0.0	0.0	-0.2	-0.2	0.0	1.0	0.1	-0.1	-0.2	-0.3	0.0	0.0	0.1	0.0
soil_c	-0.2	0.0	-0.3	0.0	-0.3	-0.2	-0.1	0.1	-0.2	-0.2	-0.2	0.0	-0.3	-0.2	0.1	0.1	-0.3	0.3	-0.3	0.1	0.1	0.1	0.2	0.1	0.2	0.0	-0.1	0.0	0.0	0.0	0.1	1.0	0.3	0.1	0.1	0.1	0.1	-0.2	-0.1
vegitation_pct_b_c	-0.5	-0.3	-0.5	0.1	-0.4	-0.4	-0.2	0.1	-0.4	-0.2	-0.3	0.0	-0.4	-0.2	0.3	0.4	-0.2	0.4	-0.2	0.0	-0.1	-0.1	0.2	0.2	0.4	0.0	-0.1	0.2	0.2	0.0	-0.1	0.3	1.0	0.2	0.2	-0.1	-0.1	-0.8	0.2
lf_rough0500_c	-0.2	0.0	-0.3	0.4	-0.4	-0.5	-0.4	-0.3	-0.5	0.1	0.1	-0.3	-0.2	0.1	0.5	0.1	-0.1	0.5	-0.3	-0.2	-0.2	-0.1	0.0	0.4	0.3	0.1	-0.3	0.8	0.8	0.0	-0.2	0.1	0.2	1.0	0.9	0.0	0.0	-0.2	0.0
lf_rough1000_c	-0.2	0.0	-0.3	0.5	-0.4	-0.5	-0.5	-0.3	-0.5	0.1	0.1	-0.4	-0.2	0.2	0.5	0.1	0.0	0.5	-0.3	-0.3	-0.2	-0.2	0.0	0.5	0.3	0.1	-0.3	0.7	0.6	0.0	-0.3	0.1	0.2	0.9	1.0	0.0	0.0	-0.2	0.0
lf_tpi0250_c	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.9	0.0	0.1	-0.1	0.0	0.0	1.0	0.9	0.0	-0.1
lf_tpi0500_c	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.3	0.0	0.0	0.7	0.0	0.1	-0.1	0.0	0.0	0.9	1.0	0.1	-0.1
vegetation_merged_c	0.3	0.3	0.3	-0.2	0.3	0.4	0.3	0.1	0.4	0.0	0.0	0.2	0.2	0.0	-0.4	-0.2	0.1	-0.4	0.2	0.1	0.2	0.1	0.0	-0.3	-0.4	0.0	0.1	-0.1	-0.1	0.0	0.1	-0.2	-0.8	-0.2	-0.2	0.0	0.1	1.0	0.0
vegitation_vegcom_b_c	-0.4	-0.4	-0.2	0.1	-0.2	-0.2	-0.1	0.0	-0.2	-0.1	-0.1	0.0	-0.2	-0.1	0.2	0.3	-0.1	0.2	0.0	0.0	0.1	0.1	0.2	0.0	0.2	0.0	0.0	0.1	0.1	-0.1	0.0	-0.1	0.2	0.0	0.0	-0.1	-0.1	0.0	1.0

Table A3.1 The Pearson correlations between all initial non-categorical predictor layers. Coloured cells represent high negative (light- or dark-blue) correlations or high positive (light- or dark-orange) correlations. See Table 4 for descriptions of each predictor.

Appendix 4 - Soil landscape codes and corresponding numerical values

The spoil landscape codes and corresponding numerical value used when quoting soil type results for the SDMs. See https://www.environment.nsw.gov.au/topics/land-and-soil/information/soil-maps for further information.

LANDSCAPE code	Numerical representation
AEab	1
AEnh	2
AEnp	3
AEtg	4
AEww	5
ALbg	6
ALbp	7
ALdc	8
ALfr	9
ALlc	10
ALmk	11
ALri	12
ALsc	13
ALtp	14
ALup	15
BEna	16
COha	17
COhw	18
COpn	19
COwb	20
COwn	21
COwp	22
DTxx	23
ERgn	24
ERgy	25
ERgy/ERla	26
ERla	27
ERlu	28
ERwl	29
ERya	30
ESmc	31
REbt	32
REbu	33

REfb	34
REho	35
REkg	36
REIh	37
REmd	38
REso	39
REvo	40
SWba	41
SWbs	42
SWet	43
SWwa	44
TRof	45
WATER	46

Appendix 5 - AUC values for each SDM under each of the three different bias layers

Scientific name	Common name	AUC for bias layer 1 (whole landscape)	AUC for bias layer 2 (common bias)	AUC for bias layer 3 (individual bias)
Acacia pubescens	Downy Wattle	0.9905	0.9908	0.9539
Persoonia nutans	Nodding Geebung	0.9775	0.9969	0.9147
Pimelea spicata	Spiked Rice-flower	0.9903	0.994	0.9357
Pultenaea parviflora	NA	0.976	0.9914	0.889
Pteropus poliocephalus	Grey-headed Flying-fox	0.8986	0.8716	0.7643
Eucalyptus benthamii	Camden White Gum	0.9992	0.9996	0.9401
Grevillea parviflora subsp. parviflora	Small-flower Grevillea	0.9827	0.9907	0.9288
Persoonia bargoensis	Bargo Geebung	0.9858	0.9849	0.8174
Micromyrtus minutiflora	NA	0.9804	0.9905	0.7534
Acacia bynoeana	Bynoe's Wattle	0.916	0.9009	0.7112
Persoonia hirsuta	Hairy Geebung	0.9696	0.9475	0.8574
Pomaderris brunnea	Brown Pomaderris	0.991	0.9943	0.9197
Pommerhelix duralensis	Dural Woodland Snail	0.9853	0.9784	0.8069
Botaurus poiciloptilus	Australasian Bittern	0.7356	0.8181	0.5656
Cynanchum elegans	White-flowered Wax Plant	0.993	0.993	0.751
Darwinia biflora	NA	0.9753	0.9476	0.8503
Heleioporus australiacus	Giant Burrowing Frog	0.8985	0.8857	0.7383
Litoria aurea	Green and Golden Bell Frog	0.9933	0.9932	0.9595
Phascolarctos cinereus	Koala	0.989	0.9783	0.9173

AUGUST 2020

CUMBERLAND PLAIN ASSESSMENT REPORT

Supporting document G – Implications of the 2019/20 bushfires

DOCUMENT TRACKING

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Contents

1 Introduction

NSW experienced extensive bushfires throughout the spring and summer of 2019-20. As of 3rd February 2020, the fires had burnt 5.37 million hectares of land (approximately 7 per cent of NSW). This includes (DPIE, 2020):

- 37 per cent of the national park estate, including 81 per cent of the Greater Blue Mountains World Heritage Area
- 42 per cent of state forests
- 52% of heathland, 50% of wet sclerophyll and 37% of rainforest vegetation formations in NSW
- 25% of the most suitable koala habitat in eastern NSW (moderate, high and very high suitable habitat), particularly areas on the north coast, central and southern tablelands, central coast and the south coast

Of the fire affected national parks, 23 per cent were subject to full canopy damage, 36 per cent had partial canopy damage, and for 27 per cent the canopy was unburnt. Note that areas where the canopy was unburnt may have been affected by fire through the understorey (DPIE, 2020).

The fires also affected large areas of species habitat where species have been recorded and are known to occur. A total of 680 threatened flora species have records within fire affected areas. Of these:

- 61 species (approximately 9 per cent) have more than 80 per cent of their records within fire affected areas, including 19 with more than 30 per cent of records in areas where the canopy was fully damaged
- 37 species have 50 to 80 per cent of records within fire affected areas

A total of 293 threatened fauna species have records within fire affected areas. Of these:

- 5 species have more than 80 per cent of records within fire affected areas, including:
  - *Petaurus australis* (Yellow-bellied Glider) endangered population on Bago Plateau
  - *Petauroides volans* (Greater Glider) endangered population in Eurobodalla
- 99 species have more than 10 per cent of records within fire affected areas

The long-term survival of flora and fauna after fire is complex and the full impact of the fires on biodiversity will not be understood for some time (EES, 2020). Fauna recovery depends on factors such as access to food, water and habitat recovery, which depend on fire severity and future weather conditions. Flora recovery depends on drought, fire frequency and severity, and impacts from pest animals, weeds and pathogens on regrowth (EES, 2020).

Because the extent and intensity of the 2019-20 fires in NSW were so substantial, ultimate recovery of some species impacted by the fires is uncertain and could be affected. This means that:

- The fires may increase the significance of the impacts of the development under the Plan for some species
- Additional commitments under the Plan may be needed for some species to help address the impacts of the fires

An initial assessment of the implications of the fires for the Plan has been undertaken based on available information. The assessment will be reviewed as further information on the impacts of the fires becomes available.

The initial assessment did not address TECs as TECs potentially impacted by the Plan are generally restricted to the Cumberland subregion or surrounding areas and were not broadly affected by the fires. In addition, the mapping of many of the TECs (as PCTs) beyond the nominated areas is of varying and inconsistent quality.

2 Purpose of initial assessment

The purpose of the initial assessment was to identify species where:

- A high percentage (>10 per cent) of NSW records have been affected by fires of the 2019-2020 period, and
- The Cumberland subregion is already important for species persistence in NSW and/or has the potential to become more important for persistence because of the impacts of the fires to other areas of habitat, and
- The Plan has known or likely impacts to the species

Where these three criteria are met, the implication of the fires in relation to the Plan, including the need for commitments to address impacts, should be considered. The rationale for this approach is that:

- Where a species is not reliant on the Cumberland subregion, the Plan has limited opportunity to help address the impacts of the fires on the species or influence conservation outcomes for the species
- Where a species is not being impacted by development under the Plan, the impacts of the fires and consideration of the need for commitments specific to the species, is not directly relevant to the Plan

3 Approach to initial assessment

The approach to the initial assessment involved:

- Identifying each listed threatened species potentially impacted by the Plan (these are Category 1 Commonwealth-listed species and NSW-listed candidate species-credit species and ecosystem-credit species – see Chapter 11)
- Determining the percentage of NSW records within fire-affected areas. This was done by:
  - Obtaining spatial data on fire extent over the 2019-20 period from the GEEBAM dataset available on SEED (DAWE, 2020)
  - Obtaining species records from NSW BioNet (under a licenced extract to get as-held data)
  - Overlaying fire extent with species records and analysing the data using GIS. All records within 100 m of the fire footprint boundary were included as impacted by the fire to account for level of record accuracy and fire-ground extent accuracy
- Determining the percentage of total records in NSW that occur within the Cumberland subregion. This provides an indication of the importance of the subregion for persistence of the species in NSW, although the data density is skewed towards the greater Sydney area due to opportunity for observation and high survey effort
- Identifying whether each species has life-history traits that make the species more susceptible to fire or relies on habitat features that are likely to be affected by fires. This was done based on existing knowledge and/or information in literature or government databases, such as BioNet species profiles

Data was also obtained from the Commonwealth Department of Agriculture, Water and the Environment (DAWE) on the estimated extent of fire impacts on the known or predicted distribution of Commonwealth listed species at a national scale.

The importance of the Cumberland subregion for species persistence was estimated on the basis of record counts. Where the subregion has greater than 10 per cent of existing total NSW records, it was considered that the subregion:

- Is already important for species persistence, and/or
- Has the potential to become more important as a result of the impacts of the fires on the species habitat elsewhere (as it is likely that a reasonable amount of suitable habitat exists in the subregion for the species)

A relatively high figure of 10 per cent was chosen for this threshold because the Cumberland subregion is well surveyed compared to other parts of NSW, meaning that the relative importance of the records as an indicator of the importance of a subregion for persistence increases in distance from Sydney. Using a high percentage recognises that the likelihood of having a record from the Cumberland subregion is higher than for any other subregion, and considers the relative area of the subregion as a proportion of the state (0.3 per cent by area).

4 Limitations

The key limitations of the initial assessment are:

- Reliance on records and record accuracy to provide an indication of species distribution and reliance on the subregion. Records are often only an indicator of survey effort relating to development assessments and ease of accessibility, and are likely to be bias towards iconic and more observable species, in particular birds and mammals
- No age cut-off was applied to the records despite increasing spatial inaccuracy for older records
- Each record may relate to one individual or a much larger population, so the overall significance of a record being impacted by the fires is difficult to quantify

- Impacts within the fire extent are likely to be variable and uneven, and to include areas of low intensity and less damaging burns, small refugia and patches of unburnt habitat
- Treating all of the populations in NSW as a single entity and not recognising bioregional or genetic separations in determining the impact upon a species by the fires

5 Results of initial assessment

The results of the initial assessment are summarised in Table 1. The table shows:

- Species assessed under the Plan with greater than 10 per cent of NSW records affected by fires. It is ordered to show the species with the greatest proportion of NSW records affected to the least
- Percentage of total NSW records for the species that occur in the Cumberland subregion

Species with both greater than 10 per cent of records affected by fires in NSW and greater than 10 per cent of total NSW records within the Cumberland subregion are highlighted in blue. For these species, further comment is made about:

- The risk of impacts of the Plan on the species, drawing on the assessments in this Assessment Report
- The significance of the impacts of the fires on the species
- The adequacy of the commitments in the Plan to helping address the impacts of the fires

These species are:

- *Scoteanax rueppellii* (Greater Broad-Nosed Bat)
- *Grevillea parviflora* subsp. *parviflora* (Small-flower Grevillea)
- *Pomaderris brunnea* (Brown Pomaderris)
- *Persoonia bargoensis* (Bargo Geebung)
- *Acacia bynoeana* (Bynoe's Wattle)
- *Eucalyptus benthamii* (Camden White Gum)
- *Commersonia prostrata* (Dwarf Kerrawang)
- *Myotis macropus* (Southern Myotis)

Koala did not have both greater than 10 per cent of records affected by fires in NSW and greater than 10 per cent of total NSW records within the Cumberland subregion. However, further comment was made about Koala because of the importance of the population in the subregion and the known impacts of the fires on Koala habitat across eastern NSW.

Table 1: Analysis of implications of fires for species relevant to the Plan with greater than 10% of records affected

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
Petauroides volans	Greater Glider	V	-	82.28%	0.16%	10-30%	-
Petaurus australis	Yellow-bellied Glider	-	V	59.49%	0.1%	No data	-
Persoonia hirsuta	Hairy Geebung	E	E	57.28%	7.2%	30-50%	-
Calyptorhynchus lathami	Glossy Black-cockatoo	-	V	49.20%	0.5%	No data	-
Falsistrellus tasmaniensis	Eastern False Pipistrelle	-	V	45.96%	4.9%	No data	-
Tyto novaehollandiae	Masked Owl	-	V	42.83%	1.4%	No data	-
Dasyurus maculatus maculatus (SE pop)	Spotted-tailed Quoll	E	V	40.27%	0.5%	10-30%	-
Callocephalon fimbriatum	Gang-gang Cockatoo	-	V	36.63%	1.8%	No data	-
Ninox strenua	Powerful Owl	-	V	31.08%	6.6%	No data	-
Maundia triglochinoides		-	V	30.04%	0.4%	No data	-
Persoonia glaucescens	Mittagong Geebung	V	E	28.75%	2.1%	30-50%	-

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires: Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	Comments on implications of the fires for the Plan
Hoplocephalus bungaroides	Broad-headed Snake	V	E	27.19%	1.3%	50-80%	-
Petroica boodang	Scarlet Robin	-	V	26.38%	1.9%	No data	-
Scoteanax rueppellii	Greater Broad-Nosed Bat	-	V	25.41%	11.1%	No data	The species is an ecosystem credit species that is examined in this Assessment Report in terms of impacts to associated PCTs (see Chapter 21). It is predicted to occur in Wilton and GMAC only. The species generally roosts in tree hollows and is more common in tall wet forests. These areas are generally limited within the nominated areas to avoided lands along the edges of Wilton and through the edges and middle of GMAC (associated with gullies and waterways) and will not generally be impacted under the Plan While no species-specific offset is provided for this species under the Plan, the Plan includes commitments (through offset targets for each impacted PCT/NSW TEC) to protect land within the SCAs that contains substantial areas of potential habitat for the species Given the Plan has a low likelihood of impacts to the species and will lead to the protection of substantial areas of potential habitat, the Plan is considered to adequately address impacts to this species in the context of the fires
Grevillea parviflora subsp. *parviflora*	Small-flower Grevillea	V	V	23.98%	21.3%	No data	The risk of residual adverse direct impacts on this species from the Plan is low (see Chapter 29). The area of potential habitat impacted is a small proportion of available habitat for the species in the Plan Area and no records are directly impacted or fragmented While no species-specific offset is provided for this species under the Plan, the Plan includes commitments to protect land within the SCAs that contains 2,975 ha of potential habitat for the species Given the Plan will only have a low risk of impacts on the species and will lead to the protection of substantial areas of potential

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
							habitat, the Plan is considered to adequately address impacts to this species in the context of the fires
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	23.83%	4.3%	10-30%	-
Petroica phoenicea	Flame Robin	-	V	21.32%	0.6%	No data	-
Cynanchum elegans	White-flowered Wax Plant	E	E	21.02%	4.9%	30-50%	-
Cercartetus nanus	Eastern Pygmy-possum	-	V	20.99%	0.9%	No data	-
Miniopterus schreibersii oceanensis (= M. orianae oceanensis)	Large (Eastern) Bent-winged Bat	-	V	20.78%	9.2%	No data	-
Miniopterus australis	Little Bent-winged Bat	-	V	19.07%	1.8%	No data	-
Pomaderris brunnea	Brown Pomaderris	V	E	18.64%	64.4%	50-80%	The risk of residual adverse direct impacts on this species from the Plan is low (see Chapter 29). The area of potential habitat impacted is a small proportion of available habitat for the species in the Plan Area and no records are directly impacted or fragmented The species occurs within the footprint of the OSO and Metro Rail Future Extension tunnels. The Plan contains a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to this species as a result of tunnel construction, which is considered adequate to protect the individuals within the footprint While no species-specific offset is provided for this species under

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
							the Plan, the Plan includes commitments to protect land within the SCAs that contains 7,605 ha of potential habitat for the species. Furthermore, three known populations of the species occur within the proposed Georges River Koala Reserve Given the Plan will only have a low risk of impacts on the species and will lead to the protection of substantial areas of potential habitat and several populations, the Plan is considered to adequately address impacts to this species in the context of the fires
Daphoenositta chrysoptera	Varied Sittella	-	V	17.93%	5.9%	No data	-
Persoonia bargoensis	Bargo Geebung	V	E	17.86%	70.9%	10-30%	The risk of residual adverse direct impacts on this species from the Plan is low (see Chapter 29). The area of potential habitat impacted is a small proportion of available habitat for the species in the Plan Area and no records are directly impacted or fragmented While no species-specific offset is provided for this species under the Plan, the Plan includes commitments to protect land within the SCAs that contains 5,174 ha of potential habitat for the species Given the Plan will only have a low risk of impacts on the species and will lead to the protection of substantial areas of potential habitat, the Plan is considered to adequately address impacts to this species in the context of the fires
Heleioporus australiacus	Giant Burrowing Frog	V	V	17.10%	1.2%	30-50%	-
Glossopsitta pusilla	Little Lorikeet	-	V	16.88%	4.0%	No data	-
Varanus rosenbergi	Rosenberg's Monitor	-	V	16.27%	1.4%	No data	-

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
Acacia bynoeana	Bynoe's Wattle	V	E	15.73%	16.4%	10-30%	The risk of residual adverse direct impacts on this species from the Plan is very low (see Chapter 29). The area of potential habitat impacted is a small proportion of available habitat for the species in the Plan Area and no records are directly impacted or fragmented While no species-specific offset is provided for this species under the Plan, the Plan includes commitments to protect land within the SCAs that contains 5,842 ha of potential habitat for the species Given the Plan will only have a very low risk of impacts on the species and will lead to the protection of substantial areas of potential habitat, the Plan is considered to adequately address impacts to this species in the context of the fires
Ninox connivens	Barking Owl	-	V	15.13%	1.7%	No data	-
Eucalyptus benthamii	Camden White Gum	V	V	13.73%	84.1%	30-50%	The risk of residual adverse direct impacts on this species from the Plan is low (see Chapter 29). The area of potential habitat impacted is a small proportion of available habitat for the species in the Plan Area and no records are directly impacted, although a small area of potential habitat connected to records will be fragmented The species occurs within the footprint of the OSO and Metro Rail Future Extension tunnels. The Plan contains a species-specific commitment (Commitment 4.1) to avoid and minimise impacts to this species as a result of tunnel construction, which is considered adequate to protect the individuals within the footprint While no species-specific offset is provided for this species under the Plan, the Plan includes commitments to protect land within the SCAs that contains 1,495 ha of potential habitat for the species Given the Plan will only have a low risk of impacts on the species and will lead to the protection of substantial areas of potential habitat, the Plan is considered to adequately address impacts to this species in the context of the fires

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires: Species with > 10% of NSW records affected	Records/habitat affected by fires: % of NSW records that occur in the Cumberland subregion	Records/habitat affected by fires: % distribution affected by fires at national scale	Comments on implications of the fires for the Plan
Petaurus norfolcensis	Squirrel Glider	-	V	13.00%	0.8%	No data	-
Commersonia prostrata	Dwarf Kerrawang	E	E	12.94%	12.4%	No data	There is no risk of residual direct impacts on this species from the Plan (see Chapter 29). There will be no direct impacts or fragmentation of potential habitat for the species As there are no risks of impacts to the species, the impacts of the fires on this species are not relevant to the Plan
Myotis macropus	Southern Myotis	-	V	11.53%	10.7%	No data	Many records for the species occur in the Plan Area and relatively large areas of potential habitat are impacted by the Plan (see Chapter 23), including water bodies (see Chapter 24) While the fires have affected large areas of habitat containing records, it is important to note that high record density for the species in the Cumberland subregion is likely to be a result of high survey effort rather than an indication of substantial reliance on the subregion The Plan recognises the potential impacts to this species from development under the Plan and includes several commitments to reduce these impacts. These commitments include a species-specific offset to secure 2 offset locations for the species, as well as several other measures to minimise impacts to habitat features that the species relies on (see Chapter 8 and Chapter 15) Furthermore, the Plan includes other commitments to protect land within the SCAs that contain substantial areas (5,475 ha) of potential habitat for the species These commitments are substantial and are considered to adequately address impacts to this species in the context of the fires
Melithreptus gularis gularis	Black-Chinned	-	V	10.95%	2.6%	No data	-

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
	Honeyeater						
Anthochaera phrygia	Regent Honeyeater	CE	CE	10.94%	5.2%	10-30%	-
Pseudophryne australis	Red-crowned Toadlet	-	V	10.91%	3.6%	No data	-
Phascolarctos cinereus	Koala	V	V	10.32%	2.7%	10-30%	The impacts of the fires on this species are likely to be significant, particularly to populations on the north coast, central and southern tablelands, central coast and the south coast (DPIE, 2020) The fires also increase the significance of the impacts of the Plan on this species. The Southern Sydney Koala population is now likely to be the only population in NSW currently largely unaffected by disease that also remains unaffected by the fires The Plan already recognises the significance of the Southern Sydney Koala population and includes a broad range of commitments to ensure the population persists and the condition of habitat improves in the areas within the Cumberland subregion most likely to support long-term viability (see Sub-Plan B, and Chapter 31). These commitments include: • Avoiding the vast majority (92%) of important Koala habitat (primary and secondary corridors) within the nominated areas • Establishing a large reserve specifically for Koala to secure the north-south movement corridor along the Georges River between Appin and Kentlyn • Funding to plant 100,000 trees as part of ecological restoration of Koala habitat including within the Koala reserve • 120 km of Koala exclusion fencing within Wilton and GMAC to protect Koalas from vehicle strike and dog attacks

Scientific name	Common name	Cth status	NSW status	Records/habitat affected by fires			Comments on implications of the fires for the Plan
				Species with > 10% of NSW records affected	% of NSW records that occur in the Cumberland subregion	% distribution affected by fires at national scale	
							• A range of other measures to manage threats These commitments are substantial and are considered to adequately address impacts to this species in the context of the fires A detailed assessment of the adequacy of the commitments under the Plan for Koala is provided in Chapter 30

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