# Ingleside Bushfire Evacuation Study

Covering Letter Prepared by the Office of Chief Engineer
Department of Planning Industry & Environment

## Introduction

This covering letter pertains to the report prepared by AECOM titled "Ingleside Bushfire Evacuation Study – Traffic Assessment" (dated 1 July 2020). This report was commissioned by the Department of Planning, Industry & Environment (DPIE) to assess the road network performance during bushfire events, and to further investigate the road performance during the bushfire events under several differing scenarios. This covering letter has been written to provide clarity over the purpose of the commissioned report and to provide a tabulated response to comments received from stakeholders.

The study is founded on several assumptions regarding resident behaviour in the event of a bushfire and emergency service response. A key distinction is made within the study between 'physical' and 'remote' emergency services assistance: the former involving a physical presence to aid evacuation, the latter comprising remote emergency warnings and communication via mediums such as tv, radio, websites, phone applications, SMS, and telephone calls.

Physical assistance is not provided in the vicinity of the Ingleside Precinct and traffic generated by the proposed development uplift does not evacuate via routes reliant upon any physical, in-person presence of emergency services. To test the efficacy of assistance in catering for the existing wider population catchment, physical assistance is assumed to the east of the study area towards the Mona Vale town centre.

Definition of the term 'assistance' in the context of emergency services intervention in the event of a bushfire can be confusing. Communication of the definition of 'assistance' has broadly been advised as having been "assumed in assessing development uplift of the Ingleside Precinct." Crucially however, physical, in-person emergency services assistance was only assumed at locations to test the efficacy of evacuation of the **existing** population catchment and not to support that of the uplift of the Ingleside Precinct.

The precinct planning process has undertaken regular engagement with key stakeholders to inform the broader precinct planning methodology, including DPIE, Northern Beaches Council (NBC), NSW Rural Fire Service (RFS), NSW Police Force, Local Emergency Management Committee, Transport for NSW, Traffic Management Centre (TMC), National Parks and Wildlife Service and Fire & Rescue NSW.

The potential uplift analysis assumes remote assistance, in the form of emergency warning messages via a variety of communication channels, is diligently adhered to by existing and proposed residents of the Ingleside Precinct, with no physical assistance in the form of management of traffic control points provided to assist or ensure evacuation.

The primary evacuation route for existing and proposed residents of the Ingleside Precinct has been identified through consultation with stakeholders, including emergency services, as southbound along Powderworks Road, given the proximity of large sections of the Mona Vale Road state corridor to bushfire prone land.

The AECOM Study therefore tested evacuation via this route and identified the intersection with Kalang Road to be the limiting pinch point at which the progression of traffic travelling southwards along Powderworks Road would be constrained. Conservative analysis of performance at this intersection

identified that traffic generated by up to 800 – 1,000 additional dwellings could satisfactorily use this route when assessed against agreed upon criteria, as defined by the project team in consultation with DPIE.

The AECOM Study acknowledges that bushfire behaviour is highly variable and dependent upon multiple factors which are difficult to foresee. The assessment and modelling use a wealth of observed input data, research, surveys, and industry expertise to test a unique set of conditions that are considered representative of how an event may unfold, though does not constitute a prediction, nor claim to be wholly encompassing of the potential outcomes of any bushfire event in the study area.

## The AECOM Report

The title of the AECOM report (AREP), "Ingleside Bushfire Evacuation Study – Traffic Assessment", may be misinterpreted and this covering letter seeks to clarify this issue. The AREP is **NOT** an evacuation management plan. Such a plan is better prepared by local stakeholders and the local emergency stakeholder. The AREP provides analysis of traffic and predicted responses to traffic scenarios based on well-established engineered traffic modelling methods.

Genesis of the modelled scenarios is documented in the AREP, but for this letter the meeting held on 10/09/2019 attended by DPIE, NBC, NSW Police, RFS and TMS is referenced. At this meeting, the base case of the existing local road network and conditions and the bushfire scenarios were presented. The results indicated a failed local road network with traffic experiencing queuing back into the fire zone. It was unanimously agreed that having evacuating traffic queuing into the fire zone was unacceptable. Participants at that meeting stated "we would not allow that to happen". Aware of this result, those at the meeting sought to find a solution to prevent traffic queuing on the local network in the fire zone. The resultant temporary remote modifications to the local network were modelled.

Modelling of the suggestions to the existing local road network did indicate that queuing into the bushfire affected area would be prevented.

The modelled suggestions in fact indicted that there was spare capacity in the existing local road network based on the agreed remote temporary modifications. These conditions were further modelled to better quantify the spare capacity in the local road network. The results of this scenario are presented in the AREP.

Assessment determined the proposed 980 additional dwellings of the Structure Plan, located south of Mona Vale Road in the vicinity of Powderworks Road, in addition to the 130 existing dwellings, will generate 1,372 vehicle trips in the event of a bushfire evacuation.

This determination is based on assumptions informed by demographic and behavioural characteristics of the population catchment, as informed by 2016 census data and behavioural research.

The siting of development around the Powderworks Road corridor, south of Mona Vale Road, is informed by stakeholder consultation and a preference to locate potential uplift suitably close to the primary evacuation route, that being southwards via Powderworks Road. Development north of Mona Vale Road is not considered for several reasons, though primarily given access to the evacuation route would likely require physical, in-person emergency services assistance which cannot be guaranteed.

This engineering report and the AREP acknowledges bushfire behaviour is highly variable and dependent upon multiple factors which are difficult to foresee. A wealth of observed input data, research, surveys and industry expertise to test a unique set of conditions that are considered representative of how an event may unfold, though does not constitute a prediction, nor claim to be wholly encompassing of the potential outcomes of any bushfire event.

**The Planning Results**

Planning for potential development of the Ingleside Precinct started in 2013, with a draft Land Use and Infrastructure Strategy (Strategy) exhibited for consultation between December 2016 and February 2017. During consultation, submissions were received raising concern over the risk of bushfires in the area.

In response to these submissions and considering the Findings of the NSW Bushfire Inquiry: 1994 Coroner's Report (1994 Bushfire Inquiry), the DPIE further investigated the safety of the Strategy by engaging independent consultants Meridian Urban in 2018 to produce a Bushfire Risk Assessment (Risk Assessment). The conclusion of this Risk Assessment was that the Strategy may expose additional residents to unacceptable bushfire risks. Accordingly, DPIE and NBC determined that rezoning should not proceed on the entire exhibited Strategy, thus excluding development north of Mona Vale Road.

In order to further assess bushfire risks and the potential for existing and potential new residents of the Ingleside Precinct and surrounding area to evacuate in the event of a bushfire, DPIE commissioned AECOM and Meridian Urban to develop a bushfire traffic study of the Ingleside Precinct (AECOM Study).

This study has since been completed and is under internal governmental review. Its findings have led to a redesign of the Ingleside Precinct to provide approximately 800 – 1,000 residential dwellings, located south of the Mona Vale Road state corridor near Powderworks Road.

To support the revised precinct plan, DPIE requested assessment into the ability for new residents of the revised Structure Plan to evacuate in the event of a bushfire.

**References pertaining to this Engineering Report**

In preparing this report, reference has been made to the following documents, guidelines, and standards:

- Bushfire Risk Assessment for the Ingleside Planned Precinct, Meridian Urban, 2018 (Risk Assessment).
- Ingleside Bushfire Evacuation Study: Traffic Assessment, AECOM and Meridian Planning 2019 (AECOM Study).
- Preliminary Bushfire Risk & Development Feasibility Review, Eco Logical, 2020 (Eco Logical Review).
- Strategic Bushfire Study, Eco Logical, 2020 (Eco Logical Study).
- Rural Fires Act 1997 No 65, NSW Government.
- Planning for Bushfire Protection, NSW Rural Fire Service (RFS) November 2019 (PBP 2019).
- State Emergency Management Plan, Evacuation Management Guidelines, NSW Government, 2014 (SEMP 2014).
- State Bush Fire Plan, A Sub Plan of the State Emergency Management Plan, NSW Government, 2017 (SBFP 2017).
- Public Information Services Function Area Supporting Plan, NSW Government, 2019 (PISFASC 2019).

- Community Preparedness and Response to the 2017 New South Wales Bushfires, Whittaker and Taylor February 2018 (Whittaker and Taylor).
- Final Report of the NSW Bushfire Inquiry, Owens and O'Kane, 2020 (2020 Bushfire Inquiry).
- Australian Bureau of Statistics Quick Stats 2016 (ABS Quick Stats).
- Austroads Guide to Traffic Management Part 3 Transport Study and Analysis Methods, Austroads April 2020 (Austroads Guide).
- RMS Guide to Traffic Generating Development 2002 (RMS Guide).
- RMS Technical Direction TDT 2013/04a - Guide to Traffic Generating Developments, Updated Traffic Surveys (RMS Guide Update).

Should further clarification be required of this covering letter and attached comments and responses please do not hesitate to contact DPIE.

Yours faithfully

**Rex Wightley** BE MBT FIEAust CPEng NER APEC

**Chief Engineer**
**Department of Planning, Industry and Environment**

Appendices

- Appendice 1 - Comments and responses
- Appendice 2 - AECOM Report

| Agency comment | Department's consideration | Acceptance | Closed /Open |
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| **Northern Beaches Council** | | | |
| Generally, the Traffic Study is thorough and evidence-based, having considered a range of fire weather for the modelling of fire impacting the Precinct and has acknowledged a focus on modelling against the planned Precinct without improvement of road and traffic infrastructure or bushfire mitigation. Council's Manager Transport Network agrees with the following:<br>• The assumptions made to provide the modelling outcomes<br>• The methodology based on the assumptions and inputs that have been discussed in the report. | Thanking you. | N/A | Closed |
| **Council's primary concerns** | | | |
| 1. The report identified several pinch points that will need to be actively managed by emergency services during an evacuation to allow the road network to perform satisfactorily. From an emergency management perspective, and on behalf of the Local Emergency Management Committee and the Bush Fire Management Committee (coordinated by the state agencies), these key pinch points should be clearly identified to determine the traffic control measures/ locations that can increase the evacuation efficacy in the event of a fire for both north and south of Mona Vale Road, and addressing it to allow the active management under existing conditions. | Concerns will be addressed when received from stakeholders. This has been considered and will be addressed. Details of closures are tabulated in the report.<br><br>For avoidance of doubt, the subject report and associated appendices, were prepared to review the current road network and to explore whether there is availability on the network to allow for further safe evacuation. It is not intended as a draft emergency management plan, rather to inform a land use planning exercise only.<br><br>Further to discussions with relevant stakeholders, the 'stress' on the pinch points may be reduced and can be better clearly identified as design progresses. | | Open |

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| **a.** The model does not address the impact of the evacuation traffic travelling south east down Powderworks Road beyond Kalang Road as this has the potential to produce queuing that can impact on the second hour of the peak evacuation, especially with the upper expectation of the development yield (1000 dwellings). | As discussed, the modelling and reporting on that modelling has to be defined at appropriate points on the network. This has been discussed with NBC. Consistent with previous projects, including modelling projects relevant to NBC, e.g. Western Harbour Tunnel, WestConnex and other NBC projects (Frenchs Forest) Northern Beaches Hospital & New Harbour Tunnel Crossing NBH modelling works were modelled as far as Stanley St, Warringah Road.<br><br>Traffic models ultimately must end at a given location (NBC Phil Devon to concur). The project team held workshops with several stakeholders during the early stages of developing the methodology (10/05/2019, 09/08/2019 and 09/08/2019) at which NBC was well represented. At these meetings, the proposed study area was put forth and feedback received.<br><br>It has been considered that the extents identified were a suitable point of extent of modelling. Coding of the Kalang Road roundabout is very conservative as a result. | | Open |
| **b.** The additional work on modelling the intersections between Powderworks and Kalang Road intersection and Garden Street and Pittwater Road and to Elanora Road and Wakehurst Parkway as a secondary route needs to be addressed. | See Department's previous comment above. | | |
| **c.** The existing road network within the area needs to be defined against the model with any options to improve the egress from the future land release area. This could be that the area is treated as a greenfield site from a future road network perspective. | Please specify the local road network that needs to be considered, beyond the DPIE works. | | |

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| d. During the 2nd workshop it was identified that the intersection of Mona Vale Road and Pittwater Road was a key restriction to the egress flows along the corridor to the south of the intersection. No mention was made of this issue in the report. | Noted and to be reviewed by DPIE.<br>It has been assumed this intersection is released via emergency traffic measures.<br>At the time of this workshop, the primary evacuation route from the bushfire was via this intersection, which in turn resulted in significant congestion.<br>Following a later workshop on 10/09/2019, emergency services advised this congestion would be unfavourable and the project team identified measures by which it could be mitigated.<br>As the project evolved, it was eventually determined all evacuating traffic should route southwards via Powderworks Road.<br>As such, no evacuating traffic routes via Mona Vale Road / Pittwater Road and therefore discussion was not required within the report. | | |
| **e.** Any future development south of Mona Vale Road will need to demonstrate that it doesn't impact population north of Mona Vale Road from evacuating safely. | Traffic has been model tested and increased uplift modelled to ensure local network perform and has been demonstrated. | | |
| **2.** The Local Emergency Management Committee (LEMC) – role and acceptance.<br>I note that the LEMC has now been provided a copy of the report for their consideration given that the risks are transferred to the Emergency Services. It is critical to the program progressing that LEMC support has been obtained. Additionally, the report needs to be updated in the following areas: - with respect may DPIE address the LEMC. | Following recent feedback and as noted in the cover letter, reporting has clarified that the potential uplift assumes remote assistance, in the form of emergency warning messages via a variety of communication channels, is diligently adhered to by existing and proposed residents of the Ingleside Precinct, with no physical assistance in the form of management of traffic control points provided to assist or ensure evacuation. | | |

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| **3.** The report flags a significant issue for existing residents and people north of Mona Vale Road. The scenario testing has determined that evacuation is not able to be achieved for people north of Mona Vale Road in the event of a fire above an FFDI of 64 (Ten Rivers p. 4). The failure threshold for people north of Mona Vale Road may in fact, be lower than FFDI 64; thereby representing a significant issue for those authorities responsible for risk management. The study, however, has not identified any measures that can be put in place to facilitate evacuation north of Mona Vale Road within a 2 – 3-hour time window (identified in the Ten Rivers report p21). | DPIE has ruled out urban zonings North of Mona Vale Road.<br><br>The scope of the report was to examine potential uplift and not to address how to improve evacuation performance of the existing residential population. | | |
| **Points for clarification:**<br>**1.** Naming of "Westpac Conference and Training Centre", and "Ingleside Park" and "32A Ingleside Road" are incorrectly named. The correct names are Sydney Conference and Training Centre and Ingleside Chase Reserve respectively. | Thanking you for clarification. | | |
| **2.** The report states "*Resident of suburbs to the west of Kuringai NP and Terrey Hills were considered to favour evacuation westward away from NP and Ingleside'* (pg.9). On what basis was this information derived and how will this change due to a bush fire occurring to the west of Terrey Hills /Duffys Forest/ Belrose affecting other major evacuation routes such as Forest Way? | This assumption was informed by bushfire modelling isotope images for the adopted FFDI scenario, which identified Mona Vale Road would be most critically impacted in the vicinity of Kimbriki Road. As such, evacuation eastwards would be untenable.<br>It is reiterated that the study assesses a given set of defined bushfire and behavioural characteristics, and notes a limitation that these characteristics and assumptions adopted in the report are subject to degrees of variability.<br>Under different bushfire conditions, residents would respond accordingly. | | |

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| **3.** Further discussion/clarification is required (within the report) on the evacuation of the properties with large animals, particularly given the current land use and large number of agistment properties that exist in the subject site. | Comment appreciated however should be addressed at a later stage.<br>The aim of the report is to clarify the traffic/road performance and demonstrate any "spare compacity" Traffic performance report not an evacuation plan.<br>Whilst not specifically discussed, the study adopts conservative methodology in several areas of traffic demand estimation as mechanism for offsetting such nuanced details. | | |
| **4.** The report states that Option 4 relies upon "likely actions" to facilitate evacuation such as intersection and traffic management etc. It would be beneficial to understand the consequences if for some reason the emergency services were unable provide these likely actions in their entirety. This should be treated as a risk management exercise therefore, likelihood, consequence, residual risk etc should be examined. | Ditto.<br>The evacuation scenario was discussed with RFS, Police, DPIE and the current evacuation scenario was adopted and considered feasible. The report gives the combat emergency services agencies a baseline on challenges and risks. Those agencies, in particular the Regional Emergency Management Officer, will be able to adjust their operational planning for emergencies.<br>It is reiterated the report was developed for a land use planning exercise only and is not intended to support emergency management decisions or protocols. | | |
| **5.** The report states that evacuation of nursing home uses 0.6 cars per person model as they are likely to use buses. This requires further discussion and investigation as the evacuation of nursing homes is a significant operational and logistical activity. Whilst it may be feasible to evacuate some residents by buses, many high care residents will require transportation via ambulances. In addition, given the known risks on resident health associated with evacuation of nursing | Being a traffic study, the report has focussed on ensuring conservatism in the network-wide trip generation to gain a wholistic representation of the state of the road network in the event of a bushfire.<br>It is agreed and acknowledged that logistical challenges are more so for certain types of developments.<br>Vulnerable facilities such as nursing homes | | |

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| homes, emergency plans for these facilities may include a preference to internally relocate rather than evacuation. It is acknowledged that it may be difficult to make assumptions to this effect, however the report must reflect the limit of these assumptions and provide further discussion as to the complexity of managing evacuations in these types of facilities. | generally have bespoke emergency management procedures which are far better placed to comment on and assess the nuances of a single site's evacuation than the subject land use planning study. | | |
| **6.** The report states that other areas will likely be evacuating by the same event and accessing the same road network at the same time, and that the ability of surrounding suburbs to evacuate should be maintained and not worsened, by any development undertaken in Ingleside. This appears to be in conflict with the assumptions made around preferred evacuation routes for areas such as Terrey Hills and Duffys Forest etc (pg. 9) and referenced in point 4 above. | See earlier response to point 4. | | |
| 7. The report removes trips by residents who will not return home by 29% based on a previous survey (pg.67). Concern is raised regarding the confidence levels of this data given the limited sample size of only 95 respondents. It is preferred to take a conservative approach in this regard, on the basis that it is unclear if this data can be suitably applied to the subject proposal. | Comment taken on notice but if NBC has any better or superior advice, it would be appreciated by DPIE.<br>The project time have engaged with stakeholders throughout the study to ensure a collaborative approach in developing the methodology for such an innovative study.<br>The subject assumption was presented at the 20/08/19 workshop for feedback, which was attended by 10 NBC representatives, including from LEMC. No such concerns were raised. | | |
| Council notes that the program for Ingleside now involves a smaller development area therefore a future design exercise to masterplan a smaller development area focussing on resilience and bushfire safety. | Correct. | | |

| NSW Rural Fire Service | | | |
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| I have reviewed the study provided by Meridian and the only significant issue that I currently have is that it appears as if the evacuation modelling for any new developments has been predicated on the assumption that traffic would go from two-directional to one-way-directional. | Please see Aecom report.<br>This is an engineering intuitive assumption. | | |
| The sensitivity of results needs to be tested using two-way traffic flow since new development needs to be provided with adequate and appropriate infrastructure and cannot rely on operations during emergency situations. | Whole of network in study area will be considered as design progresses. | | |
| It is not appropriate to base bush fire safety for new development on operational assumptions since required resources may not be available in times of need. | This comment is consistent with other agencies. When public exhibition is complete this will be addressed. However, all recent natural disasters within Australia have proven by demonstration that protecting lives has been the main priority for all emergency services especially in recent fire events.<br>The potential uplift analysis assumes remote assistance, in the form of emergency warning messages via a variety of communication channels, is diligently adhered to by existing and proposed residents of the Ingleside Precinct, with no physical assistance in the form of management of traffic control points provided to assist or ensure evacuation. | | |
| If DPIE can obtain service-level guarantees from the police, Roads and Maritime and any other services required to evacuate during bush fires then I am happy to reconsider using those assumptions. | Noted. | | |

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| **Northern Sydney Local Health District (NSLHD)** | | | |
| Thank you for the opportunity to review this Ingleside Bushfire Evacuation Study. The report states that evacuation of nursing home uses a 0.6 cars per person model as they are likely to use buses. While there is acknowledgement of limitation of the planning assumptions, it is suggested that further exploration occurs regarding the methodology of evacuating nursing homes particularly given the known risks on residents health associated with evacuation of nursing homes, timeliness, type of transport required, number of transport vehicles required per population. | See earlier response regarding nursing homes. | | |
| It is further recommended that the planning considerations address the number of persons whom reside in the area and have health complex care needs and or disability. These community members may also need to evaluate the associated transport considerations. | Any future information that NSLHD has would be appreciated.<br>A conservative approach in the determination of evacuation traffic demand has been adopted as a means of providing some resilience in the study against such considerations. | | |
| While I acknowledge that it is challenging to define these variables, the report must reflect the limit of these assumptions and provide further discussion as to the complexity of managing evacuations in these types of facilities and residents of the community. | Noted. | | |
| **NSW Police** | | | |
| They have recommended 'no objection', pending resource availability and actual emergency situation prevailing at any point in time that the plan may be enacted. | Noted. | | |

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| **Fire and Rescue NSW (FRNSW)** | | | |
| After reviewing the study documentation and having participated in the consultation process, FRNSW does have concerns on the evacuation process based on the bushfire impact modelling and the listed assumption of:<br>"Evacuation of current population is possible, but requires emergency services intervention to facilitate the evacuation process" | The potential uplift analysis assumes remote assistance, in the form of emergency warning messages via a variety of communication channels, is diligently adhered to by existing and proposed residents of the Ingleside Precinct, with no physical assistance in the form of management of traffic control points provided to assist or ensure evacuation. | | |
| Whilst emergencies services priorities are the saving and preserving of life, the response of emergency services during a bushfire emergency as per the various scenario testing models cannot be guaranteed. This is due to the finite firefighting resources that are available and unknown and varying complexities that could be generated as a result of such a bushfire event. It is also noted that further investigation is required for an uplift in additional dwellings, specifically to south of Mona Vale Road. | Noted (see above response). | | |
| Based on the information provided and having consulted with other Northern Beaches Local Emergency Management Committee members, FRNSW supports the NSW RFS position in relation to the Ingleside Evacuation Study re not appropriate to base bush fire safety for new development on operational assumptions since required resources may not be available in times of need. It is understood that this position is available to be reviewed based on the supplying of additional information. | Noted (see above response). | | |
| **Transport for NSW (TfNSW)** | | | |
| **Report – Section 4.2.4 (Priority – note)**<br>Dynamic assignment type parameters appear to be modified from the default VISSIM values. These should be | Noted.<br>RMS Traffic Modelling Guidelines do not make recommendations on convergence criteria. | | |

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| documented within the report.<br>In addition, the adopted convergence criteria does not align with the typical requirements 95% of path travel times changes by less than 20% for at least four consecutive runs (TfL guidelines). However, as mentioned in the report, there is limited route choice in this model which should not affect the convergence results. | Limited route choice in model so impact would be minor. | | |
| **Report – Section 4.2.5 (Priority – minor)**<br>Mona Vale Road is a B-double route. It should be confirmed that during the modelled period (Sunday midday) there is not a high amount of larger trucks (e.g. semis, B-double) as this may affect vehicle behaviour and performance. | Heavy vehicle proportions identified by existing traffic counts undertaken in May 2019. | | |
| **Report – Section 4.2.7 / 4.2.15 (Priority – minor)**<br>Do driver behaviours change during evacuation – e.g. panic, aggressive driving behaviour, etc.? Should there be consideration to this in the evacuation scenarios? | Driver behaviour characteristics do not change during the evacuation. If TfNSW has advice as to how they might do so, please provide. | | |
| **Report – Section 4.2.10 / 4.4.2 (Priority – medium)**<br>It would be recommended to adopt vehicle actuated signal control, particularly as the signal controls would need to adapt to the unique changes to travel demand that is likely to occur due to an evacuation procedure. In addition, TfNSW will also check to see if we have an evacuation signal control plan that can be adopted. | Traffic signals are manually adjusted during evacuation scenarios to reflect their response to changeable road network conditions, which is considered appropriate. | | |
| **Report – Section 4.2.12 (Priority – medium)**<br>The modelled traffic demands are recommended to be verified against existing data to ensure origin-destination travel patterns are reflected in the model. | Existing origin-destination travel patterns are not representative of behaviour and route choice in the event of a bushfire, which is inherently atypical. | | |

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| **Report – Section 4.2.14 (Priority – medium)**<br>Additional information on the adopted traffic profile is recommended. It is unclear whether global or zone-specific profiles have been adopted for both time interval and heavy vehicle profiles. The profiles should consider the likely differences in profiles based on their geographic location / representation (i.e. local roads vs major roads, residential vs commercial/industrial). | Global profiling was applied to light and heavy vehicles, per findings of the 2009 Victorian Bushfires (Black Saturday). | | |
| **Report – Section 4.3 (Priority – note)**<br>The report does not include explanation on whether a seed number was selected, or median seed was selected to extract/report the model results. | RMS recommended random seeds adopted. | | |
| **Report – Section 4.4.1 (Priority – minor)**<br>Report should include plots of observed vs modelled hourly flows with slope equation and $R^2$ value indicated.<br>Report does not provide any definition of the core area. However, it appears to have included all intersections along Mona Vale Road within the modelled network area as the core area which is considered sufficient. | Calibration and validation adherence is presented within the report and is considered to meet RMS criteria and be satisfactory. The entire study area was considered the core area. | | |
| **Report – Section 4.4.3 (Priority – medium)**<br>Travel time routes for validation purposes exclude the Mona Vale Road / Pittwater Road and Barrenjoey Road / Pittwater Road intersections. Based on the congestion locations identified on the day of the survey (Section 4.1.6), the primary congestion/queuing were observed at these two intersections on a 'typical' Sunday. Furthermore, given that the main evacuation point is via Mona Vale Road and Pittwater Road at the eastern end of the model network, travel time validation route should include these two key intersections within model network | Travel time validation extends to the Mona Vale Road / Pittwater Road intersection, thus delay experienced on Mona Vale Road (west) leg is reflected in validation.<br>Only short sections of Pittwater Road and Barrenjoey Road are coded, making travel time validation challenging.<br>Powderworks Road was not initially expected to form an evacuation route, and thus its validation was not considered necessary. | | |

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| In addition, commentary with regards to excluding Powderworks Road from validation, travel time route has been discussed in Item 25 of this document. | | | |
| **Report – Section 4.4.3 (Priority – minor)**<br>The report does not include any explanation on how the queue survey results were used to assist in development of the base model. However, it is noted that validation against the queue survey results is not a requirement but consider as a good model development practice. | Queue data were used; however, RMS does not have mandatory statistical guideline criteria for queue length comparison and thus discussion was not made within the report. | | |
| **Report – Sections 4.4 (Priority – note)**<br>All turning movements and travel time results have been extracted and analysed accurately. | Noted. | | |
| **Report – Section 4.5 (Priority – medium)**<br>Dot point 2 – refer Item 4, consider the use of vehicle actuated signal control using VAP.<br>Dot point 4 – refer Item 2.<br>Dot point 6 – refer Item 3, has there been consideration to other factors which may affect driver behaviour? Considering the comments in dot point 7, this could be done in the form of sensitivity tests. | Refer above responses. | | |
| **Report – General (Priority – note)**<br>It is suggested that a summary of base network performance, such as network statistics and/or density plots, should formulate part of the modelling report.<br>In addition, it would be recommended that the report presents information on traffic survey data. | Noted. | | |

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| **Model – Network Coding (Priority – note)**<br>It is noted that the background images used to code the base network were not included in the model file provided. However, dimensions of the road links coded within the model have been checked against a combination of Nearmap, Google street view, and Bing map aerial images which confirmed that the modelled network has been coded to scale. | Noted. | | |
| **Model – Network Coding (Priority – minor)**<br>A review of Google street view indicates that the kerbside parking is permitted during the model peak period along the following sections of the network:<br>• Pittwater Road northbound carriageway between Mona Vale Road and Barrenjoey Road. This section has been coded partially as a bus lane in the model (however noting that model peak period appears to be outside the bus lane time restriction of 3:00pm to 7:00pm on Monday to Friday) which effectively replicates kerbside parking.<br>• Mona Vale Road on both sides of the carriageways between Pittwater Road and Bungan Street.<br>• Pittwater Road north of intersection with Barrenjoey Road<br>It is recommended that length of kerbside parking be checked against the model or commentary on the coding decisions should be included in the report. | Noted. Minor impact to model outcomes. | | |
| **Model – Reduced Speed area (Priority – minor)**<br>Reduced speed area on the kerbside lane appears to be missing on the left turn from Mona Vale Road to Pittwater Road. | Noted. Minor impact to model outcomes. | | |

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| **Model – Priority Rule (Priority – medium)**<br>Priority rule appears to be missing on the Mona Vale Road east approach entering the roundabout of Mona Vale Road/Ponderosa Road. | Contested – priority rule present in latest model version. | | |
| **Model – Priority Rule (Priority – minor)**<br>A review of the coded priority rules suggests the default setting of 3 seconds gap time has been used for majority of locations. It is TfNSW's recommendation that the gap times to be updated in accordance with Table 3.5 from Austroads Guide to Road Design Part 4A 'Unsignalised and Signalised Intersections', particularly movements accessing Pacific Highway or based on the site observations and traffic data. | Noted. Minor impact to model outcomes. | | |
| **Model – Signal Head Coding (Priority – minor)**<br>Signal heads on the Pittwater Road north approach at the intersection with Mona Vale Road appears to be located further north than what aerial images indicate. | Noted. Minor impact to model outcomes. | | |
| **Model – Signal Control (Priority – minor)**<br>Due to the lack of available data, this review was unable to accurately assess the performance of signalised intersections throughout the network. However, based on a review of the signal coding, 2 to 5 seconds minimum green time with 3 seconds flashing red time has been adopted for pedestrian. Pedestrian phase time assumptions are not documented in the report. Nonetheless, sufficient flashing red time should be provided for pedestrians to safely complete the crossing. | Noted. | | |

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| **Model – Signal Control (Priority – minor)**<br>Appropriate intergreen time should be provided for right turn phase after the diamond phase at the intersections of Mona Vale Road / Powderworks Road intersection. | Noted. Minor impact to model outcomes. | | |
| **Model Signal Control (Priority – minor)**<br>The signal phasing assumptions for the new signalised intersection at Mona Vale Road / Ponderosa Parade / Samuel Street has not been included in the report. The signal head for the left turn from Mona Vale Road to Ponderosa Parade appear to be located after the pedestrian crossing point. Further, the signal group for this left turn and the pedestrian crossing appear to run in the same phase which would not occur in reality and pedestrians would not be safe from left turning vehicles. In addition, this left turn should not run in the north split phase. | Noted. Minor impact to model outcomes. Residential uplift evacuation traffic do not pass through this intersection. | | |
| **Model – Scenario Demands (Priority – medium)**<br>While the report provides detailed explanation of the demand development process, there are some gaps on the actual assumptions adopted to develop the VISSIM demand inputs to enable a detailed peer review of the resultant VISSIM demands.<br>Notwithstanding, the evacuation demand (both static route and matrices) in Scenario 3 and 4 appears to include demands to Mona Vale Road west although the report indicates that the demands were redistributed to evacuate via Pittwater Road (Section 7.2.5). | Noted. | | |
| **Model – Scenario Demands (Priority – major)**<br>Although the report states that “It assumed all residents in the new development would add to those evacuating | Noted. | | |

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| via Powderworks Road southbound and avoid the use of Mona Vale Road which would be closed.“ (Section 7.6), the new development evacuation demands (Scenario 4) include destination to Mona Vale Road west. | | | |
| **Model – Scenario 4 (Priority – major)**<br>In Scenario 4, the report states that the new development evacuation demands are solely depending on the Powderworks Road as an evacuation route. However, the base model calibration and validation excluded Powderworks Road and the report includes a commentary that all side roads to Powderworks Road (with exception of Kalang Road) have been included for illustrative purpose only (Section 2.3). It is acknowledged that these side roads are not expected to carry significant amount of traffic to Powderworks Road in comparison to Mona Vale Road. However, based on Google map information, it appears that Powderworks Road between Mona Vale Road and Kalang Road is potentially providing primary accesses to various land uses including:<br>• golf club,<br>• library<br>• place of worship.<br>It is noted that the peak site generated traffic for the above land uses is potentially during the model peak period (Sunday midday). As such, the model's capability to accurately replicating the congestion level on Powderworks Road is questionable. | Noted.<br><br>These side arms and land uses are expected to generate low evacuation traffic volumes. Assessment of the intersection of Powderworks Road with Kalang Road has been deliberately conservative as a means of offsetting against such considerations. | | |
| **Model Simulation – Scenario 3 (Priority – major)**<br>Screenshots of the model simulation have been taken from a model run using seed no. 43 which was determined to be the median seed number based on the base model results of VHT. Screenshot of the model have been included in | Noted:<br>- Evacuation strategy, not failure.<br>- Correct.<br>- Agreed – good.<br>- Agreed – good.<br>- Noted. | | |

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| Attachment A.<br><br>The report does not include any explanation as to how the model results/simulation were used to provide the conclusion on the evacuation performance. As such, confirmation or explanation on the following comments/interpretation of the model simulation below should be provided.<br><br>Review of the model simulation indicated the following:<br><br>• The evacuation demand from Terrey Hills and Duffys Forest Travel Zones representing traffic evacuating via Mona Vale Road west to Pittwater Road (as described in Section 7.2.5) appears to be stuck at the western end of the Mona Vale Road (west of Kibiriki Road) by a physical closure modelled to replicate the proposed road closure after 12:30pm. It is unclear if this indicates failure in evacuation for residents from these Travel Zones as Duffys Forest Travel zones evacuation volumes are not included within Table 21 (Section 7.2.6) or does this form part of the adopted evacuation strategy.<br><br>• The vehicles shown on Ponderosa Parade are not considered as a representation of failure to evacuate the area as the report stated (Table 22, Section 7.5) that the evacuation route for these vehicles is not via Mona Vale Road and it is anticipated that this emergency service road closure was implemented in the model with physical closures rather than matrix adjustments.<br><br>• Queue length captured on screenshot on Samuel Street (Figure 6 in Attachment A) at 1:00pm cleared within the green time and no delays were observed.<br><br>• The screenshots at 1:00pm indicate some vehicles are still travelling on the network which are expected as | - Agreed – good. | | |

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| the evacuation demand profile assumption indicated that 29% (Section 7.2.1) would evacuate after fire has arrived at the Ingleside Precinct.<br>• Foley Street appears to be closed after 12:30pm although Table 22 in Section 7.5 of the report does not indicate closure of this street. However, it is noted that only two buses appear to be blocked from entering the Mona Vale Road which is not expected to have major impact on the network performance.<br>• No significant queues and delays are observed on Mona Vale Road, Powderworks Road and all local roads within the network with exceptions of comments above.<br>The comment in Section 8.2 of the report, "results in the ability for the road network, particularly Mona Vale Road and Powderworks Road and lower-order roads, to be clear of vehicles prior to the time of estimated fire arrival." cannot be confirmed until further clarification of the above is provided. | | | |
| **Model Simulation – Scenario 4 (Priority – major)**<br>As per Scenario 3, screenshots of the model simulation have been taken from a model run with a median seed number 43. Screenshot of the model have been included in Attachment A.<br>Similarly to the Item 26 above, confirmation or explanation on the following comments/ interpretation of the model simulation below should be provided. | Noted. | | |
| Review of the model simulation indicated the following:<br>• As per Item 26 comments above.<br>• No queues are generated from evacuating vehicles that travel southwards along Powderworks Road which | - Agreed.<br>- Noted – agreed. | | |

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| indicates that the criteria described in Section 7.6 in the report has been achieved.<br>• Crawling queues observed on Wattle Road at 1:00pm indicates that the new residential development evacuation demands are not able to evacuate before the fire arrival. However, at 1:30pm no queues/delays are observed. | | | |
| **Additional concerns**<br>**1.** The Modelling outcomes heavily depend upon many key assumptions applied in this study. Some of those assumptions (discussed below) would indicate that the model scenarios may not be the 'worst case' scenarios. | Noted. | | |
| **2.** AECOM should clarify why the modelling results (network and node/intersection performance) are not included within the models and in the report. Spot checks of Scenario 3 model and Scenario 4 model identified high number of unreleased vehicles, and rather low Mona Vale Road traffic westbound (close to western model boundary) and eastbound (at the Mona Vale Road eastern end), both substantially lower than the existing (background) traffic. Note, these spot check findings were not extracted from AECOM modelling results since modelling results were not supplied. | Determination of criteria for "a successful outcome" in the event of a bushfire does not follow any accepted and established performance criteria, such as Levels of Service. As such, the presentation of such outcomes was not considered appropriate as a means of assessing performance.<br>The metrics determined were agreed with DPIE and outputs presented accordingly. | | |
| **3.** Background traffic demand discounting (reduction and diversion) described in the report's Section 7.2.2 may be to some degree justified, but it also may indicate that the demand does not represent the 'worst case' scenario. | The study strikes a balance between placing a strong emphasis on conservatism whilst also remaining realistic. The assumptions made were discussed at workshops at which TfNSW (formerly RMS) were represented and no such concerns raised. | | |

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| **4.** We note the Speed Profiles within Section 4.2.8 and the Traffic speed distribution shown in Table 11 of the report together with the statement *"The impact of smoke on driver behaviour is not considered or factored into assessment"* (AECOM Report, page 13), indicates modelled traffic capacity (likely in a range of 1500-2000 vehicles per lane per hour). Therefore, the overall traffic performance doesn't seem appropriate for bushfire evacuation conditions but rather for 'normal conditions' in good weather. This is further supported by the attached paper (Bushfire Evacuation Modelling – aop-nid59826.pdf) - Urban structure and evacuation times in a city fringe bushfire: Modelling three scenarios in Bendigo, Victoria, whereby you can see on page 6 that they had reduced evacuation speeds due to visibility hindered by smoke - see weblink below:<br><br>https://apo.org.au/sites/default/files/resource-files/2013-11/apo-nid59826.pdf | The referenced study has simply made this assumption, but it is not referenced or informed by any behavioural research to quantify the impact of smoke.<br><br>Given bushfire modelling informing the study does not assess smoke, the extent of smoke impact across the study area could not be ascertained with a degree of confidence to quantify its impact on driver performance.<br><br>As such, in the absence of any research or data inputs, this is noted as a limitation. | | |
| **5.** TfNSW questions whether Powderworks Road has been established as 'bushfire free' – is it actually 'a safe zone'. Note: TfNSW checked Planning Portal bushfire vegetation risk rating and found large/western portions of Powderworks Road to be in the highest bushfire vegetation risk category (see attachment – Ingleside Bushfire Risk Layer – planning Spatial Viewer.docx). We strongly recommend DPIE consults with RFS or their bushfire consultant for more accurate risk rating when describing the bushfire safety risks of Powderworks Road. It would also be good if AECOM could overlay the traffic model queues at the key time periods of the modelling over the bushfire risk layer map for Ingleside. | Noted. DPIE has consulted with the bushfire consultant, architect, and relevant stakeholders to ensure bushfire mitigation along the Powderworks Road corridor is suitably addressed. | | |

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| **6.** To our knowledge, we note that emergency agencies haven't endorsed acceptance/failure parameters. This needs to be clarified noting that any defined evacuation performance metrics are not within TfNSW remit nor are they 'normal'/typical network performance parameters. | Noted – to be addressed elsewhere. | | |
| **7.** The study was also completed pre-COVID 19. It is likely that as we come out post-COVID 19, there will be increased workers working from home during the weekday (noting that this is occurring now). This analysis hasn't accounted for these changes to weekday evacuation risk in order to verify if weekday evacuation risk would now be deemed as worst case. | The vast majority of the study was delivered prior to COVID-19.<br>If TfNSW have data to suggest how travel patterns are set to change in the wake of COVID-19 these should be provided. | | |
| **8.** Based on our review / assessment to date it has not been satisfactorily demonstrated whether Powderworks Road is safe for queueing during a bushfire. | Noted. DPIE are satisfied with the outcomes of the study. | | |
| **9.** We are also assuming that DPIE will ensure that other key and relevant stakeholders / agencies will check, review and comment on the AECOM Ingleside Bushfire Evacuation Study – Traffic Assessment too. | Correct. | | |
| **Additional comments**<br>Further to Friday's email response, we understand that Andy Yung (SCT Consulting) is preparing a Transport plan<br>for the precinct (non-evacuation transport considerations). It is currently understood that it has been assumed that recent upgrades to Mona Vale Road would accommodate the trips generated by the revised suggested yield (800 – 1000 dwellings), though some local road upgrades are likely to be recommended. | | | |

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| We are assuming that as part of any future exhibited Precinct that a supporting contributions mechanism / plan for both local and state infrastructure would be provided. Therefore, to assist with the likely infrastructure recommendations, we have the following “active transport” based infrastructure recommendations for consideration / inclusion within a local and state-based contributions mechanism/plan.<br><br>Some notes regarding walking and cycling infrastructure (please also see attachment):<br><br><u>Cycling</u><br>• The cost per km is = $3.0 mil for a bicycle separated from traffic in the outer Sydney area.<br>• Cycling links to the PBN<br>  ○ As noted, there the PBN didn’t deal with new population growth but we are looking to fix that modelling in the future. This area was discussed though internally and with stakeholders. A few key links to the PBN on regional and state routes are noted in the attachment.<br>  ○ St Ives to Mona Vale – This could become a key regional route to connect Strategic Centres.<br>  ○ Frenchs Forest to Narrabeen – Via Wakehurst Parkway.<br><br><u>Walking infrastructure</u><br>• Pedestrian signalisation on our regional and state networks are key to ensuring the safety of our pedestrians and school children when traveling to public transport services or key points of interest.<br>• Increasing public transport usage has a strong | | | |

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| correlation to safe walking infrastructure, i.e. the provision of footpaths, crossings, and bus shelters increases the use of these services.<br>• Signalisation costs vary greatly per treatment type and safety quality. This can range from un-signalised crossing costs of $0.200 million to signalised crossings of $5.50 million per treatment. Pedestrian bridges can cost millions of dollars as well.<br>• Average cost per km for footpath is $0.405 million per km. | | | |

# Ingleside Bushfire Evacuation Study

## Traffic Assessment

# Ingleside Bushfire Evacuation Study

Traffic Assessment

Client: Department of Planning, Industry and Environment

ABN: 38 755 709 681

Prepared by

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01-Jul-2020

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| | | | Name/Position | Signature |
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# Table of Contents

# Executive Summary

## Part A – Overview

The Ingleside Precinct (Precinct) has been designated a planning investigation area in the North District Plan and has been under consideration since mid-2013. The Department of Planning, Industry and Environment (Department) has been working closely with Northern Beaches Council (Council) to progress a land use plan for Ingleside.

A preliminary draft Structure Plan for Ingleside was prepared following community master-planning workshops in 2014. This plan was revised and supporting technical documents prepared during 2015-2016. The draft Ingleside Land Use and Infrastructure Strategy and Draft Structure Plan were released in December 2016 for community consultation, which closed at the end of February 2017.

Following consultation, a number of the technical studies were revised, and additional studies undertaken. In response to submissions raising bushfire concerns and considering the 1994 Bushfires Coronial Inquiry and other fire events, the Department further investigated the safety of the Ingleside plan by engaging an independent consultant to produce a Bushfire Risk Assessment. The conclusion of this assessment was that the proposed plan may expose additional residents to unacceptable bushfire risks. Accordingly, the Department and the Council determined that rezoning should not proceed based on the exhibited plan.

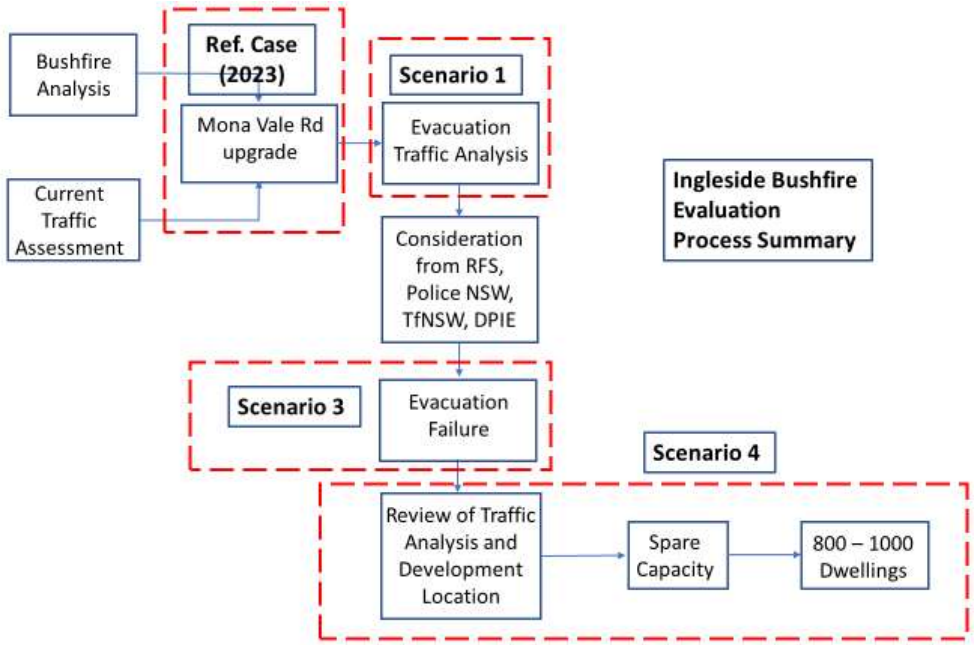
At the request of the Department modelling was undertaken to assess the potential impact of bushfire evacuation safety and strategy for residents of the Ingleside Precinct and surrounding population catchment. The stated objectives of the project were to:

1. Develop a traffic model to determine if, and how, the existing population at Ingleside and the broader catchment, may be evacuated as a result of the bushfire conditions represented in the model;
2. Suggest improvements in the road network and bushfire defences to reduce life and property risks for existing dwellings; and
3. Determine, via the conditions included in the modelling, whether additional homes may be built, in terms of quantum and the broad distribution of dwellings.

A fit-for-purpose technical methodology was developed to examine the evacuation of the existing and some possible future population. This included bushfire modelling, evacuation assumptions and parameters drawn from national and state guidance, requirements prescribed by Planning for Bushfire Protection 2019, and strategic direction provided by agency stakeholders. Methodology parameters were tested and confirmed with the Project Steering Committee throughout the project.

Multiple scenarios were tested, based on PSC direction. Modelled results are articulated below:

| Scenario | Description | Modelling Result & Observations |
|---|---|---|
| **1** | Existing population only – no additional development<br>Amended traffic signal timings<br>2023 road layout: Mona Vale Road East upgrade included<br>Mona Vale Road west of McCarrs Creek Road closed in both directions<br>Powderworks Road northbound closed at Wilga Street<br>All traffic evacuates via Pittwater Road | Evacuation of current population under modelled conditions **fails** |
| **2** | Existing population only – no additional development<br>Tested a variety of traffic management measures which arose from a stakeholder workshop and adopted 'present day - 2019' demands and road network, some of which was in the process of being upgraded. | Due to the network limitations and imminent upgrades the value of the assessment was considered limited and hence is not included in the report. |
| **3** | Existing population only – no additional development<br>Amended traffic signal timings<br>2023 road layout: Mona Vale Road East upgrade included<br>Mona Vale Road west of McCarrs Creek Road closed in both directions<br>Powderworks Road northbound closed at Wilga Street<br>Traffic evacuates via Pittwater Road and local roads<br>Further road closures enforced to better manage evacuation | Evacuation of current population is **possible**, but requires emergency services intervention to facilitate the evacuation process<br>Considered a suitable mitigation arrangement in response to the potential existing risk of bushfire in the existing Ingleside precinct |
| **4** | Existing population only and development to south of Mona Vale road only (drawn from original draft Structure Plan)<br>Emergency service support to traffic management<br>Amended traffic signal timings<br>2023 road layout: Mona Vale Road East upgrade included<br>Mona Vale Road west of McCarrs Creek Road closed in both directions<br>Powderworks Road northbound closed at Wilga Street<br>Traffic evacuates via Pittwater Road and local roads<br>Further road closures enforced to better manage evacuation | Evacuation of current population and some development uplift (800 -1000) is **possible**, but requires emergency services intervention to facilitate the evacuation process<br>Development uplift relies upon emergency services intervention to manage the increased risk – no associated uplift to road infrastructure to support the further development |




Scenario 4, which considers further development south of Mona Vale Road, is anticipated to place added burden on emergency services. However ultimately, this would need to be decided by emergency services agencies, and involving the Local Emergency Management Committee.

The Department, in partnership with NSW Rural Fire Service, will need to determine whether Scenario 4 satisfies the strategic planning principles and strategic planning assessment considerations of PBP 2019, specifically those identified above, in the manner intended by PBP 2019.

On the basis of the above, the following recommendations are identified:

1. The Department together with NSW Rural Fire Service should consider the nature of risk transfer posed by Scenario 4 to emergency services, to determine whether this scenario satisfies the Part 4 provisions of the Planning for Bush Fire Protection 2019 statutory guideline, in the manner the provisions are intended.
2. The 'likely actions' of emergency services used to inform Scenarios 3 and 4 of this study (intersection and traffic management in an emergency) should be incorporated into the suite of emergency and bushfire management plans for the area, if not already included.

**Project Governance and Stakeholders**

A Project Steering Committee (PSC) was established at the outset to provide inter-agency oversight of the entire project. This involved guiding the progression of the study, give technical input and insight, and form the key decision-making body with regards to the methodology adopted.

The PSC was comprised of one or more representatives of the following agencies:

- The Department of Planning, Industry and Environment (Department)
- Northern Beaches Council (Council)
- New South Wales Rural Fire Service (NSW RFS)

Furthermore, technical insight and knowledge was provided by:

- NSW Police
- Transport for New South Wales Traffic Management Centre (TMC)
- Roads and Maritime Services (Roads and Maritime)

*During the course of the project* Roads and Maritime Services *was restructured to form part of* Transport for New South Wales (TfNSW). *Given the timing of this this, it is referred to as Roads and Maritime herein.*

Engagement with the above agencies was frequent and regular throughout the delivery of this study, advising on key inputs and performance of outputs to determine next steps and actions.

It should be noted that this study was driven by a land use planning exercise for the Ingleside Precinct growth area in the Northern Beaches Local Government Area (LGA). It was not intended to advise on emergency service planning or procedures in the event of a bushfire. These are determined by the relevant parties involved.

# Part B - Report Summary

## Study Area

Despite the study being driven by land use planning of the Precinct, a bushfire in the area would likely impact a much broader population catchment than only the Precinct, and so a wider catchment was considered when determining evacuation traffic demand. Travel Zones which would likely be impacted by a bushfire that would also impact the Precinct were identified and agreed with internal stakeholders at a workshop 10 May 2019

The Ingleside Precinct growth area spreads across four ABS Travel Zones, namely:

- Ingleside Scout Camp;
- Ingleside - Lane Cove Rd and Walter Rd;
- Westpac Training College Ingleside; and
- Ingleside Park.

The remaining Travel Zones were all considered as potential areas from which a portion of the population might evacuate during a bushfire in Ku-ring-gai Chase or Garigal National Parks (NP).

Suburbs north of Newport, towards Palm Beach, were not considered as 'at risk' in the event of a bushfire in the abovementioned National Parks, given separation offered by Pittwater, thus the population residing in these Travel Zones was **not** considered.

Residents of suburbs to the west of Ku-ring-gai Chase NP and Terrey Hills were considered to favour evacuation westwards, away from the National Parks and Ingleside Precinct, in the event of a bushfire. As such, they would not impact the Precinct's ability to evacuate as they would not use the same part of the road network, thus they were not considered.

## Road Network

Despite much of the Northern Beaches population catchment being considered as potentially evacuating during a bushfire, the modelled road network only covered the key intersections local to the Precinct, the performance of which would directly impact the Precinct's ability to evacuate.

The model study area covered Mona Vale Road between, and inclusive of, intersections with Kimbriki Road and Pittwater Road. The Pittwater Road intersection with Barrenjoey Road was also included, as is a length of Powderworks Road to a point just south of Kalang Road.

All priority and signalised side arms along Mona Vale Road were included, though those along Powderworks Road were primarily included for illustrative purposes only, given traffic counts were only obtained for Powderworks Road intersections with Mona Vale Road and Kalang Road.

## Demographics

Details of the population demographics within the study area were determined from 2016 census statistics providing information on age and residents / household. This also data that was used to identify the Estimated Resident Population (ERP) and number of Occupied Private Dwellings (OPD) in 2019 and 2023, the two traffic assessment years considered in this study, for all the Travel Zones.

2016 census data reports the Northern Beaches LGA private motor vehicle ownership rates as **0.66 vehicles per person** (10% higher than Sydney average) and **1.75 vehicles per dwelling** (6% higher than Sydney average). Applying these rates to ERP and OPD determines two similar values for the total number of vehicles in each Travel Zone, which were averaged to remove bias.

Once 2016, 2021 and 2026 estimated motor vehicle ownership was known, linear interpolation was used to identify respective 2019 and 2023 vehicle ownership.

## Traffic Data

Historic data indicate that there was no clear growth trend in traffic volumes along Mona Vale Road over the past few years, with AADT in 2013 representing the second highest average over the past six recorded years. The highest AADT was recorded in 2018 at 31,375 vehicles per day, with the following

2019 value reducing by over 6,000 to 25,176; it is acknowledged however that 2019 values were an average of January and February only.

Across the Travel Zones considered as potentially containing residents who would evacuate onto the road network in the event of a bushfire, there are an estimated 21,495 vehicles in 2019 and 23,072 by 2023.

Given the study area's proximity to the coastline and numerous summer resorts and facilities, a review was undertaken to identify seasonal traffic variability in the study area. Data from the Roads and Maritime permanent count site was analysed.

This indicated a trend of reduced traffic volumes during winter months and higher volumes during summer months. This pattern is particularly prominent when assessing midday weekend data for the entirety of 2018, in which November – January generally experience higher traffic volumes than other months.

Balancing the requirements for high home occupancy and busy roads upon which the local population would be required to evacuate, a model time period of **Sunday Midday** was identified. This ensured that many of the local population would not be working, whilst reflecting a time of day during which 'typical' traffic volumes are high.

A more detailed assessment was undertaken using traffic signal detector counts at the critical intersection of Mona Vale Road / Pittwater Road (TCS 587) to validate the permanent counter findings. Data from three Sundays in December 2018 was compared with data from Sundays in May 2019 to determine percentage differences and the scale of seasonal variability in the study area. May was selected as it represents the month in which observed traffic counts used in the study were obtained, with December chosen as it represents the month in which the maximum average traffic volumes were recorded. Only data for the hours 12:00 – 14:00 were assessed, as this represents the model study period.

An increase in traffic volumes in December 2019 was recorded for all movements at TCS 587 when compared to May 2018. Some movements recorded much higher increases than others, with the Mona Vale Road approach recording an average of 26.4% increase, whereas the Pittwater Road (south) approach average increase is only 3.3%. The average overall intersection traffic growth was 10.5%.

**Base Model Development**

A traffic model of the study area was developed to assess traffic performance during the given evacuation conditions. This required the development of a Base model which reflects current year (2019) conditions, against which evacuation scenarios were compared and assessed.

Following data collection, the Base model network was coded to scale. All network features are layered onto the model network, before model inputs were entered. These inputs were classified intersection turning counts (derived through traffic surveys of peak periods) and signal timings (derived through SCATS History data provided by Roads and Maritime) and used to calibrate the model.

The final task is model validation, which compares the model outputs against independently gathered data that is not used as an input. For this scheme, travel times recorded along Mona Vale Road were used to validate the model. Once satisfactory calibration and validation was achieved, it was considered that the model would produce reasonable predictions for the future year testing.

**Model Time Period**

The assessment aims to robustly test the road network's ability to accommodate evacuation traffic by modelling the time during the week that would have the greatest impact on road network operation.

Assessment of traffic counts, recorded by a Roads and Maritime permanent count site (ID: 57024) located on Mona Vale Road just west of Powderworks Road, identified weekday Tuesday AM and PM peaks as containing the highest 'typical' east and westbound traffic volumes.

Bushfire evacuation traffic demand is however atypical in nature and consequently, existing traffic counts do **not** form a reliable basis upon which to identify the assessment time period. As indicated earlier, it was determined that the period over mid-day on a Sunday would provide the time when the evacuation of residents would have most impact on the busy road network.

During an evacuation, 'typical' trips are unlikely to enter the road network as they otherwise would, and it is expected that there would be a significant increase in local population traffic joining the road network to evacuate. As such, and in order to test a worst-case scenario, the assessment time period necessitates a period during which a large proportion of the local population would be at home.

Traffic surveys and site understanding identified that the primary congestion location on a 'typical' Sunday afternoon in May is at Mona Vale Road and Barrenjoey Road intersections with Pittwater Road.

The Base model was calibrated and validated to observed traffic data determined from traffic surveys on Sunday 19th May 2019 and Tuesday 21st May 2019. These two periods were chosen following assessment, and PSC discussion and agreement, as to the worst-case time of day for an evacuation to occur.

It was also determined that evacuation of such a catchment would likely take a considerable amount of time, and so a two-hour model peak period was assessed, with a one-hour warm-up and 30-minute cool down period. These periods are summarised below, and were agreed at a Project Steering Committee (PSC) workshop with stakeholders on 10 May 2019:

Warm up: 11:00 – 12:00

**Peak hour 1: 12:00 – 13:00**

**Peak hour 2: 13:00 – 14:00**

Cool down: 14:00 – 14:30

This two-hour period was identified through use of the Roads and Maritime permanent counter observations

**Road Network and Demand**

The road network developed comprises Mona Vale Road between, and inclusive of, Kimbriki Road (to the west) and Pittwater Road (to the east). It extends north along Pittwater Road to include the intersection with Barrenjoey Road, and south along Powderworks Road to the intersection with Kalang Road. All posted speed limits, traffic signal details, geometric considerations and public transport information were included.

Intersection turning counts were processed to identify 30-minute matrices for each individual intersection within the study area, broken down into Lights and Heavies. Processing allowed for flow discrepancies between intersections to be identified prior to matrix estimation to ensure no inaccuracies were present. Warm up (11:00 – 12:00) volumes were coded as 95% of the respective peak hour volume between 12:00 – 13:00, for example the 11:00 – 11:30 matrix was derived as 95% of the 12:00 – 12:30 matrix. Cool down matrices were calculated similarly, as 90% of the final peak half-hour matrix, thus 14:00 – 14:30 volumes are derived as 90% of 13:30 – 14:00.

The model was shown to be stable and was calibrated and validated to Roads and Maritime criteria.

**Model Limitations**

A number of limitations of the model were identified such as:

- The project is driven by land use planning for the Ingleside Precinct and the modelled road network therefore covers the surrounding locality and primary roads used by the Precinct. Intersections outside of the study area may be adversely impacted during an evacuation, as will local roads, however these impacts are not assessed as part of this exercise.

  This approach conservatively assumes that there will be no traffic withheld at local road intersections, and that all traffic from remoter residential premises will be able to access the assessed road network without hindrance.

- Modelling is not sophisticated enough to reflect individual premises' evacuation protocols, with the broader population catchment assumed as using the average household car ownership rates. As such, evacuation traffic in the evacuation assessment is all comprised of 'Cars'. There are no special considerations made for individual properties or premises that may use alternative vehicles, such as buses, to evacuate.

Despite this and given that the evacuation traffic demand is informed by population census data, the approach is considered robust. To use an example, a nursing home may evacuate 30 residents on a single bus. The approach adopted would assume these 30 residents use the average car occupancy rate per person (0.66 for the Northern Beaches) and so 20 cars would be assumed as accessing the road network for evacuation. 20 cars would have a greater impact on traffic than a single bus.

- The impact of smoke on driver behaviour is not considered or factored into assessment.
- A key limitation of the study is that evacuation during a bushfire is highly dependent upon human behaviour. The study draws upon behavioural surveys, anecdotal evidence and first-hand discussions with stakeholders in the area; however, it is acknowledged that there may be a notable variance between what people say they will do, and what they actually do or are able to do.
- Fire arrival', or the duration of the evacuation window, has been defined as certain fire conditions are prevalent in the Ingleside Precinct; however, it is acknowledged that this duration would be different for premises across the study area and that in reality, a staged evacuation may be more likely in which residents of certain suburbs are required to evacuate before others.
- Whilst the gridded ignition approach removes bias, it is that an approach balancing this with a strategic assessment of fire history and fire input, that is what happens during singular ignitions, may nuance the conservative approach of landscape fire.
- NSW RFS have specific models which have not been used for the purpose of this study.

  Bushfire modelling assumes no suppression occurs, that is no intervention by emergency services to influence the rate of fire progression.

**Bushfire Evacuation Considerations**

Following the release of the Draft Ingleside Structure Plan by the former Department of Planning and Environment (now Department of Planning, Industry and Environment) in 2017, community consultation highlighted ongoing concerns regarding the area's bushfire hazard. Following consultation, the Department commissioned a land use planning-based bushfire risk assessment[1] to analyse the risk profile of Ingleside, in consideration of the Draft Structure Plan. The Bushfire Risk Assessment determined that:

> *'Overall and having regard to the 'inappropriate' development benchmarks prescribed by state-level policy in Planning for Bush Fire Protection (PBP 2018), the scale and complexity of the competing, compounding and cascading risks to life and property indicated by the Draft Structure Plan, supported by the evidence based presented by this risk assessment, determines that currently available mitigation measures are unable to reduce the risk profile created by the Draft Structure Plan to a level which is universally acceptable to DPE, NSW RFS or Northern Beaches Council.'*

The recommendations of the bushfire risk assessment further identified the need for the forward planning pathway for Ingleside to be clearly identified, including addressing the existing risk profile to strengthen community resilience.

This traffic assessment is undertaken in concordance with the above recommendations, filling a gap in the current evidence base in relation to the performance of the road network during bushfire emergency.

One of the key challenges in considering the level of performance is the behavioural aspects of people. Whilst the NSW RFS clearly communicates each year the importance of household survival plans, many residents across NSW's bushfire prone areas do not maintain such a plan or they adopt a 'wait and see' approach.

It is not possible to test every potential scenario that may prevail on any given day.

[1] Bushfire Risk Assessment for the Ingleside Planned Precinct, Meridian Urban, 2018

The bushfire modelling prepared as part of this traffic assessment is for the express purpose of understanding the potential worst-case evacuation window for Ingleside, from the time of ignition to arrival of the fire front at Ingleside, under a range of conditions. Thus, the modelling remains for a very specific purpose, in support of land use planning and engineering considerations, and cannot be used, interpreted or applied for any other purpose

A Fire Danger Rating system is in place which translates forecast fire weather into more easily communicable and understood Fire Danger Ratings. There is a total of six Fire Danger Rating categories, each with associated messaging pertaining to what community members should do.

Where there is a risk from bushfire, the NSW RFS uses Bushfire Alerts to provide information to affected communities using radio, television, and the internet. However, NSW RFS also notes that fires can threaten suddenly and encourages communities not to rely on a single source for emergency information, and the importance of being prepared and ready to act.

Some fires start and spread so quickly that there is no time for any warning at all. NSW RFS encourages individuals to be prepared to put bushfire survival plans into action with little or no warning, and to use Bushfire Alerts in bushfire survival plans as triggers to leave early or prepare to stay and defend where appropriate.

**Emergency Management Legislation and Regulation**

NSW RFS, along with other emergency management agencies in NSW, are required to carry out and abide by a range of statutory emergency management activities to plan for prevention, preparation, response and recovery (PPRR).

The responsibilities of the NSW RFS are set out under the Rural Fires Act 1997 (Act). Part 4 of the Act sets out the agencies' responsibilities in relation to bushfire prevention. This includes the NSW RFS duty to prevent bushfires, to plan for and undertake bushfire hazard reduction, declaration of general and local bushfire danger periods, declaration provisions for total fire bans (known as TOBANS), land use planning provisions and development controls provisions, vegetation clearing, and so on.

The regional offices are involved across a range of prevention and preparation responsibilities, including risk assessments, evacuation planning including liaison and coordination, and working alongside NSW Policy and the local emergency management committee (LEMC) at Council.

It is critical to note this work, which must be considered in parallel to the purposes of this study, is in support of a land use planning activity which considers emergency management, rather than an emergency management activity in itself.

**The Evacuation Process**

Following the 2009 Victorian Bushfires Royal Commission (Commission), national policy regarding messaging around bushfire evacuations has changed. Prior to February 2009, the core message was 'stay or go' however, that message has now been changed to 'leave early, or stay and defend a well-prepared property'. This does not apply in Catastrophic fire danger contexts, where leaving early is the only option to ensure survival.

In Catastrophic situations, when systems fail, communities may not receive emergency alerts for a variety of reasons – the telecommunications networks may be damaged or lost, electricity is lost, or the fire situation may be so dynamic that systems are not keeping pace.

The Australian Institute for Disaster Resilience (AIDR) in 2017 released Handbook 4 – Evacuation Planning, as part of its Handbook Series. This handbook incorporates guidelines and considerations for developing community evacuation plans underpinned by an all-hazards approach. It uses the nationally recognised five stages of the evacuation process as a framework for planning an evacuation. The purpose of the handbook is to guide pre-event community evacuation planning, which will in turn maximise the efficiency and effectiveness of evacuation processes.

The five stages of the evacuation process as follows:

1. Decision to evacuate

2. Warning
3. Withdrawal
4. Shelter
5. Return.

After a fire is reported and fire services respond, the behaviour of the bushfire is assessed. Over time, authorities may decide to issue a warning which may require evacuation action. That action may either be:

- self-determined by the individual based on the nature of information available, potentially framed by previous experience, or
- advice to evacuate may be issued by fire authorities once a decision by authorities is reached and communicated.

In either case, stages one and two of the evacuation process will take some time.

Individuals will seek to confirm evacuation warning information with neighbours, consult social media, online news websites, mobile phone apps or other sources. All of this occurs *before* a decision is made to evacuate.

Once the decision is made, people will take time to collect personal items, load them and their family into vehicles and leave their property. Most of those who decide to evacuate doing so within 2 hours of the fire arrival time, and 20% attempting to leave *after* the fire had arrived.

Once individuals have moved onto the road network to evacuate, limitations of the road network to handle the capacity of surge vehicle volumes will be felt as it may be impacted by vehicle accidents, fallen trees, fallen power lines or other non-typical conditions caused by the bushfire. This may extend the period in which some vehicles are on the road network. In some cases, those evacuating may not be able to utilise the road network. In these cases, residents would need to take shelter in-situ.

Neighbourhood safer places could be an option in this regard.

One of the stages of the AIDR handbook focuses on evacuation shelters and planning their location and the facilities available. The first policy for evacuation in NSW is to encourage persons to travel to the homes of family or friends in the first instance. Many evacuees will evacuate without a destination in mind; their priority will simply be to get to safety. Evacuees on a part of the road network that is not exposed to or flanked by a hazard, thus not at risk, is an acceptable outcome.

In this case, it is likely any evacuation centres opened would be south of Ingleside on the Northern Beaches, rather than to the west or north (towards Palm Beach). To this end, it is reasonable to expect most traffic evacuation from, or through, Ingleside will evacuate to the east and/or south.

**Bushfire Modelling**

The purpose of the bushfire modelling component of this traffic assessment was to understand a potential worst-case evacuation window, that is the duration from time of ignition to fire front arrival at Ingleside. The reason for this was to guide performance of traffic models assessing possible bushfire behaviour.

Critical to formulating an understanding of a worst-case evacuation window, there are two central aspects:

- fire weather conditions; and
- location of ignition.

Both aspects are highly variable. Fire weather conditions change remarkably across hours and minutes throughout the day. Likewise, the location of an ignition point cannot be foreseen, however some locations can have a higher likelihood, for example: along bushland-flanked and remote roads, camping sites, access tracks and trails.

Due the high variability of fire ignition circumstances it was necessary to undertake a series of scenario-based bushfire models to understand the variability of bushfire behaviour across different instances of fire weather and ignition location. However, it is not possible to model every possible fire

circumstance or scenario which may prevail on any given day. To this end, an approach which reflects a range of potential scenarios, across different fire weather circumstances, and different ignition locations across the wider region was adopted and detailed in the report.

Based on the fire weather circumstances and ignition location methodologies, a total of **93 discrete bushfire behaviour scenarios** were undertaken. The 93 bushfire modelling scenarios were input into the fire modelling software (Phoenix Rapid Fire) and the assessment results provided as part of this report. The modelling remains for a very specific purpose, in support of land use planning and engineering considerations, and cannot be used, interpreted or applied for any other purpose

From a strategic perspective, it is critical to note the closer ignition points to Ingleside through this modelling process will impact on Ingleside or surrounds more quickly than those which are further away. However, the purpose of this exercise is to determine the potential worst-case evacuation window.

Across different fire weather scenarios, the determined evacuation window varies from 2 hours 30 minutes to 4 hours. This does not include the effect of smoke on the ability to evacuate, noting reduced visibility from considerable smoke impact may lead to early road closures.

Mona Vale Road to the west of Ingleside is likely to be impacted by fire between 2 hours 30 minutes and 3 hours from ignition in each fire weather scenario. In certain conditions Mona Vale Road is likely to be directly impacted in several locations by conflagration moving out of Ku-ring-gai Chase National Park. This is not only relevant to consider in terms of impact on the ability for the residents of Ingleside to evacuate, but also the residents of Terrey Hills and Duffys Forest to the west.

This particular aspect of likely impact on Mona Vale Road is commonly known by local emergency services, and emergency management arrangements are in place to manage Mona Vale Road in case of an emergency.

**The Evacuation Window**

The assessment was presented to the PSC for consideration. In advance of this, a separate discussion was held directly with NSW RFS on the technical nature of the modelling performed. Based upon the exclusive purpose or nature of the modelling, NSW RFS was satisfied with the processes undertaken.

The PSC requested a detailed identification of the relevant evacuation window. In order to determine this, there were several component elements for consideration, one of the key issues being which fire weather scenario of the three (FFDI 64, 77 or 116) should be considered for the purposes of understanding a worst-case evacuation window. Whilst FFDI 116 is a worst-case fire weather scenario, it may *not* represent a worst-case scenario from a traffic perspective. That is to say, more people may remain home in an FFDI of 77 than FFDI 116, meaning more people would need to evacuate during the evacuation window under FFDI 77 fire weather conditions.

**On the basis of FFDI 77, a worst-case evacuation window of between 2 hours and 20 minutes and 2 hours 40 minutes was identified.**

**Evacuation Assessment**

4 traffic evacuation scenarios were assessed to provide an indication of prevailing traffic conditions under the bushfire scenarios considered in the study area. Scenarios tested are listed below:

- **Reference Case (2023) – 'Base' conditions – Existing population only**
    - Evacuation traffic demand
    - Amended traffic signal timings
    - 2023 road layout: Mona Vale Road East upgrade included
- **Scenario 1 (2023) – Existing population only**
    - Evacuation traffic demand
    - Amended traffic signal timings
    - 2023 road layout: Mona Vale Road East upgrade included

- Mona Vale Road west of McCarrs Creek Road closed in both directions
- Powderworks Road northbound closed at Wilga Street
- All traffic evacuates via Pittwater Road

- **Scenario 2 (2019) – Existing population only**
  - This scenario was identified to include a variety of traffic management measures which arose from a stakeholder workshop and adopted 'present day' demands and road network, some of which was in the process of being upgraded and hence the results were of limited value. It was not included in the scope of works provided by the Department and therefore, detailed assessment summaries are not included as part of the report.
- **Scenario 3 (2023) – Existing population only**
  - Evacuation traffic demand
  - Amended traffic signal timings
  - 2023 road layout: Mona Vale Road East upgrade included
  - Mona Vale Road west of McCarrs Creek Road closed in both directions
  - Powderworks Road northbound closed at Wilga Street
  - Traffic evacuates via Pittwater Road and local roads
  - Further road closures enforced to better manage evacuation
- **Scenario 4 (2023) – Existing population only and some development from draft Structure Plan**
  - Evacuation traffic demand + development to south of Mona Vale road only
  - Emergency service support to traffic management
  - Amended traffic signal timings
  - 2023 road layout: Mona Vale Road East upgrade included
  - Mona Vale Road west of McCarrs Creek Road closed in both directions
  - Powderworks Road northbound closed at Wilga Street
  - Traffic evacuates via Pittwater Road and local roads
  - Further road closures enforced to better manage evacuation

**Traffic Demand**

The Report sets out in detail how the traffic demand was established from the various sources of data that were used and defines the temporal profiling process that was adopted to reflect the anticipated evacuation stages that were identified previously. These included:

- Seasonal uplift
- Adjustment of demand to reflect behavioural response
- Removal of trips for residents who will not return home
- Re-routeing of trips prior to fire arrival
- Reduced commuter trips
- Removal of trips from inside study area destined outside the study area

The report then sets out how the evacuation traffic demand was derived via assessment of the resident population and visitors. For residents this considered their access points on the network, dwelling occupancies, evacuation departure time profile, proportion that may 'stay and defend' and the

private vehicle usage during evacuation. For visitors the numbers visiting in the Summer as reviewed and scaled in consideration of those who may evacuate during the model period.

**Scenario Routeing of Traffic**

Details of the methodology adopted to assign the traffic through the network under the different conditions that were assessed are described. The network changes made from the Reference Case, in which no closures were applied, through the various modifications that were implemented from test to test, and their impact on traffic routeing, are described.

In addition, details of the number of trips generated from within the study area as a result of the evacuation are provided.

**Reference Case (2023)**

This scenario represents the anticipated traffic conditions of the road network during a bushfire evacuation in the event that all roads are open and accessible for evacuation. This means the bushfire has **not** impacted any roads such that vehicles cannot use them, nor have any road closures been enforced by emergency services.

This case is so named as it forms a reference against which further scenarios can be compared, and differs from the Base in that traffic demand has changed to reflect residents' response to the bushfire; that is whereas traffic conditions in the Base are 'typical' of a Sunday afternoon, traffic conditions in the Reference Case are those considered representative of bushfire.

Traffic signals were modified from the Base to reflect SCATS response to changing traffic conditions; however, no special signal plans or exceptional operations were implemented.

An assessment year of 2023 was adopted to incorporate planned road infrastructure upgrades along the Mona Vale Road corridor, specifically the Mona Vale Road East upgrade between Manor Road, Ingleside to Foley Street, Mona Vale for which completion is expected in 2022[2].

An associated planned upgrade of Mona Vale Road West, between McCarrs Creek Road, Terrey Hills and Powderworks Road, Ingleside, has **not** been considered.

**Scenario 1 (2023)**

This scenario draws upon findings of the bushfire assessment and discussion with emergency services to represent and assess informed potential traffic conditions during a bushfire evacuation. Components of this scenario were presented and agreed at a PSC workshop 10 May 2019.

Noted below are differences from the Reference Case.

Bushfire assessment identified severance of Mona Vale Road may occur under the assessed conditions. Consideration was given as to how severance would impact the road corridor under assessment, with the decision taken to assume Mona Vale Road was affected and thus closed at a point between McCarrs Creek Road and Forest Way.

This prevents residents from evacuating westbound along Mona Vale Road, thus all vehicles would be forced to route eastbound towards Mona Vale. The specific location was chosen to ensure all Terrey Hills and Duffys Forest residents would also be required to evacuate eastbound, as a closure east of McCarrs Creek Road would allow these residents to leave the area westbound and via Forest Way.

The concept of assuming closure of an entire direction to evacuating traffic was adopted to ensure the assessment considered the worst-case traffic conditions, as it conservatively routes all traffic evacuating from the area eastbound, resulting in poorer road network performance. Retaining access east and westbound along Mona Vale Road would offer more evacuation possibilities to residents and result in generally better road network performance.

Limited emergency service response was also reflected through the forced closure of Powderworks Road northbound at Wilga Street, done to reflect emergency responders' likely requirement to prevent vehicles travelling towards high risk areas, which significantly limits northbound traffic along Powderworks Road.

[2] https://www.rms.nsw.gov.au/projects/mona-vale-road/mvreast/index.html

Traffic signals were modified from the Reference Case to reflect SCATS response to changing traffic conditions; however no special signal plans or exceptional operations were implemented.

**Scenario 3**

Scenario 1 findings were presented at a PSC workshop 20 August 2019, with agreement made that Scenario 3 should incorporate emergency service response to Scenario 1 performance.

A follow up workshop was held with emergency service representatives from NSW RFS, NSW Police, TMC and Council at which the traffic performance of Scenario 1 was presented, and emergency services' feedback sought to identify their likely actions to mitigate poor traffic performance and accelerate evacuation.

Measures implemented focused on two key areas: the first was reconsideration of evacuating residents' chosen evacuation routes. The second was the implementation of road closures by emergency services in response to prevailing Scenario 1 traffic conditions, in order to clear traffic from high risk areas as quickly as possible.

Full discussion of possible actions that would be taken in response to Scenario 1 traffic performance can be found in workshop minutes provided in Appendix C.

Whilst some of the closures noted are at intersections outside of the model network, they were important to note as they impacted on traffic arriving into the model network at downstream model input locations.

**Scenario 4**

Scenario 4 took on board the outcomes and measures applied from Scenario 3 and considered the opportunities for additional development in the area. In considering accessibility to / from Mona Vale Road, and the impact of any pre-existing evacuation concerns, it was agreed that in this case, only the area to the south of Mona Vale Road should include development. From this location development traffic was afforded better opportunities for evacuation without having a further detrimental impact on Mona Vale Road.

Incremental testing of additional traffic from the potential residential development to the south of Mona Vale Road was undertaken to identify the network's capacity to accommodate vehicles from a combination of existing and new residents evacuating in the event of a bushfire. It assumed all residents in the new development would add to those evacuating via Powderworks Road southbound and avoid the use of Mona Vale Road which would be closed.

The assessment determined that that the addition of 800 – 1,000 residential dwellings, of the same average density as the existing Northern Beaches LGA, may be built, whilst satisfying the following criteria:

- In the event of an evacuation, vehicles from these dwellings, which are evacuating southwards along Powderworks Road towards Pittwater Road, would not generate queuing that extends back towards, and interrupt the flow on Mona Vale Road.
- Additional queuing generated in the southbound direction along Powderworks Road would not negatively impact residents evacuating via Powderworks Road from Mona Vale Road.
- All residents who intend to evacuate would be able to access the road network and commence their evacuation before the fire arrived.

This assessment focused solely on the ability of residents to evacuate from a bushfire whilst meeting the above criteria and makes no comment on other constraints or considerations.

Development of any dwellings would be subject to the full and proper planning process, led by the Department of Planning, Industry and Environment.

**Scenario 1 Observations – *Evacuation of current population under modelled conditions fails***

Having regard to the outputs, and noting the application of bushfire modelling represents a potential worst case scenario, the performance of the road network in this scenario indicated that vehicles may remain queued in traffic, awaiting signal changes at key intersections whilst evacuating east and south-east.

The ability to clear the road network of vehicles prior to possible fire arrival is challenged. This results in those vehicles being unable to evacuate prior to the arrival of the modelled fire.

This is noting the scenario relates to the catchment area which includes the existing community of Ingleside as well as the surrounding locations, including Terrey Hills and Duffys Forest, which may evacuate east and add further traffic onto the road network. This approach was adopted for the purposes of considering a worst-case, but possible, traffic situation in a time of emergency evacuation.

The limitation on evacuation capability largely relates to the limited number of evacuation route options, being mainly Mona Vale Road and Powderworks Road.

The Scenario relies solely on the performance of the road network without any emergency services intervention at all to assist evacuation. Therefore, it is evident that the design and capacity of the road network as assumed, designed and modelled in themselves may not be sufficient to support the complete evacuation of the Ingleside precinct.

In order to address this issue, Scenario 3 traffic modelling was undertaken to establish the evacuation ability in a situation involving emergency services intervention.

**Scenario 3 – *Evacuation of current population is possible, but requires emergency services intervention to facilitate the evacuation process***

Scenario 3 responds to the previous findings and introduces 'likely actions' of emergency services during an evacuation emergency. This relates to the traffic management and intersection control measures set out in the report.

Having regard to the 2023 road network, the outcomes of Scenario 3 demonstrate the intervention of emergency services, in evacuation traffic management, results in the ability for the road network, particularly Mona Vale Road and Powderworks Road and lower-order roads, to be clear of vehicles prior to the time of estimated fire arrival.

The modelling indicated that existing residents would be able to evacuate to safety in a bushfire emergency under this scenario, should the modelled bushfire event (with limited warning time) eventuate.

Again, it must be noted this study relates only to a limited series of modelled events, noting a vast range of situations could prevail on any given day and the content of this report cannot be relied upon to inform the decision making of individuals in informing their bushfire survival plans. This study is undertaken for the express purposes of informing land use planning, and nothing further.

As this scenario relates to the current population only, compliance with Planning for Bush Fire Protection 2019 is not required as no development is proposed. Rather, its focus was on mitigation of the existing situation, should certain extreme events occur. This results in the need for further examination of operational evacuation planning by the responsible combat agency(ies) to support evacuation of the current population.

**Scenario 4 – *Evacuation of current population and some development uplift is possible, but requires emergency services intervention to facilitate the evacuation process***

Scenario 4 considers the 2023 road network condition (Mona Vale Road upgraded) and the 'likely actions' of emergency services to consider the potential for 'development uplift' in Ingleside. The most appropriate location for new development, based solely on the result of traffic modelling, was considered to be south of Mona Vale Road and east of Powderworks Road. However other hazard or risk, planning, environmental or servicing considerations need to be applied, consequently detailed consideration of these factors is required.

Based on the conditions adopted in the modelling, and the iterative process of demand loading, this suggested that there is potential for a level of development uplift of between 800 and 1,000 new

dwellings where an on-site emergency services role in managing the road network during an evacuation procedure is in place.

This principally relates to mitigation and risk transfer, and satisfaction of the strategic planning principles set out at Part 4 of the 2019 Planning for Bush Fire Protection statutory guideline.

**Compliance with Planning for Bush Fire Protection 2019 for Scenario 4**

Planning for Bush Fire Protection 2019 (PBP 2019) incorporates a series of strategic planning principles and provisions for consideration. Those principles which are relevant in this context include:

- 'providing adequate infrastructure associated with emergency evacuation and firefighting operations'.

PBP 2019 also provides a range of identifiers of inappropriate development and these were discussed at length in the 2018 Bushfire Risk Assessment for the Ingleside Planned Precinct. Those indicators relevant to this study include:

- 'the development is likely to be difficult to evacuate during a bushfire due to its siting in the landscape, access limitations, fire history and / or size and scale;
- the development will adversely affect other bushfire protection strategies or place existing development at increased risk'.

Having regard to Table 4.2.1 of PBP 2019 and the access and egress assessment considerations associated with the conduct of a Bush Fire Strategic Study, it requires that a 'study of the existing and proposed road networks both within and external to the masterplan area or site layout' is undertaken, with specific regard to the following:

- 'the capacity for the proposed road network to deal with evacuating residents and responding emergency services, based on the existing and proposed community profile;
- the location of key access routes and direction of travel; and
- the potential for development to be isolated in the event of bush fire'.

Additionally, PBP 2019 also provides assessment considerations on the future impact of new development on emergency services. These include a consideration of increase in demand for emergency services responding to a bush fire event.

**Conclusion and Recommendations**

In relation to the first principle identified above, Scenario 4 does not introduce any additional road network connections or intersection changes. The natural constraints make it challenging to consider new road corridors.

Having regard to the provision of adequate infrastructure associated with emergency evacuation, the study has relied upon the existing / committed upgrades to the established road network which, for Scenarios 1-3 is elementary. This becomes more complex in relation to Scenario 4 which investigates development uplift in the absence of an associated uplift to road network infrastructure to support increased development. This scenario is, instead, considered on the basis of emergency services intervention.

If for any reason, insufficient emergency resources were available to implement the 'likely actions' identified above, it may be feasible that additional development may affect the evacuation ability of existing residents.

In terms of the indicators of potentially inappropriate development, it is noted the Ingleside Precinct:

- is constrained by surrounding vegetation and topography;
- is constrained by its ability to be serviced by new road infrastructure due to surrounding vegetation and topography, as well as existing development; and
- has a history of fire activity which has led to property loss.

The identification of evacuation processes in certain circumstances which trigger actions by emergency services in response to existing risk is acceptable pursuant to Scenario 3, and is a suitable mitigation arrangement in response to a potential existing risk.

However, in the case of Scenario 4, and the consideration of additional development in a situation which relies upon emergency services intervention rather than a planning / built environment / infrastructure-based solution to resolve future risk, requires further contemplation.

From a land use planning perspective, Scenario 4 does not include any associated uplift to road infrastructure to support further development. As such, the land use planning and infrastructure process, pursuant to this scenario, cannot effectively mitigate the risk and instead, proposes a transfer to emergency management in order to support development potential.

This may be considered to place added burden on emergency services however ultimately, this would need to be decided by emergency services agencies, and involving the Local Emergency Management Committee.

The Department, in partnership with NSW Rural Fire Service, will need to determine whether Scenario 4 satisfies the strategic planning principles and strategic planning assessment considerations of PBP 2019, specifically those identified above, in the manner intended by PBP 2019.

A further element for consideration is the potential for additional development in the Ingleside Precinct, pursuant to Scenario 4, to absorb the redundancy of the road network system in the event of an emergency evacuation which may inadvertently limit further development elsewhere in the catchment (beyond the bounds of the Ingleside Precinct). The cumulative impact of development in other locations which may rely on evacuation through Ingleside may, over time, further compound the ability of the network to function in an emergency.

On the basis of the above, the following recommendations are identified:

1. The Department of Planning, Industry and Environment together with NSW Rural Fire Service should consider the nature of risk transfer posed by Scenario 4 to emergency services, to determine whether this scenario satisfies the Part 4 provisions of the Planning for Bush Fire Protection 2019 statutory guideline, in the manner the provisions are intended.
2. The ‘likely actions’ of emergency services used to inform Scenarios 3 and 4 of this study (intersection and traffic management in an emergency) should be incorporated into the suit of emergency and bushfire management plans for the area, if not already included.

The report acknowledges that bushfire behaviour is highly variable and dependent upon multiple factors which are difficult to foresee. From ignition location and time of day, to prevailing weather conditions and fire fuel load, factors associated with bushfire progression are unique to individual events, rendering testing of all possible outcomes impossible.

This assessment uses a wealth of observed input data, research, behavioural surveys and industry expertise to test a unique set of conditions that are considered representative of how an event may unfold in the study area, though does not constitute a prediction, nor claim to be wholly encompassing of the potential outcomes of any future bushfire event in the region.

# 1.0 Introduction

## 1.1 Background

The NSW Government is working to deliver new sustainable, liveable and connected communities, improved transportation networks, and employment opportunities across Greater Sydney to accommodate the city's growing population. The Ingleside Precinct (Precinct) has been designated a planning investigation area in the North District Plan and has been under consideration since mid-2013. The Department of Planning, Industry and Environment (Department) has been working closely with Northern Beaches Council (Council) to progress a land use plan for Ingleside.

A preliminary draft Structure Plan for Ingleside was prepared following community master-planning workshops in 2014. This plan was revised and supporting technical documents prepared during 2015-2016. The draft Ingleside Land Use and Infrastructure Strategy and Draft Structure Plan were released in December 2016 for community consultation, which closed at the end of February 2017.

Following consultation, a number of the technical studies were revised, and additional studies undertaken. In response to submissions raising bushfire concerns and considering the 1994 Bushfires Coronial Inquiry and other more recent fire events, the Department further investigated the safety of the Ingleside plan by engaging an independent consultant to produce a Bushfire Risk Assessment.

The conclusion of this assessment was that the proposed plan may expose additional residents to unacceptable bushfire risks. Accordingly, the Department and the Council determined that rezoning should not proceed based on the exhibited plan.

As safety of life and assets is at the heart of the Department's planning processes, the Department, in conjunction with Council and the New South Wales Rural Fire Service (NSW RFS) are now looking at ways to improve bushfire resilience for current residents.

## 1.2 Objectives

AECOM was commissioned by the Department in March 2019 to commence an assessment into the road network performance during a bushfire. The aim of the project is to provide the NSW Government with advice on the possible impact of bushfire evacuation safety and strategy for residents of the Ingleside Precinct and surrounding population catchment. Specifically, the stated objectives are:

1. Develop a traffic model to determine if, and how, the existing population at Ingleside and the broader catchment, may be evacuated as a result of the bushfire conditions represented in the model;
2. Suggest improvements in the road network and bushfire defences to reduce life and property risks for existing dwellings; and
3. Determine, via the conditions included in the modelling, whether additional homes may be built, in terms of quantum and the broad distribution of dwellings.

This Traffic Assessment (Assessment) documents the methodology and findings of investigation into bushfire evacuation of the Ingleside Precinct and surrounds based on a given set of circumstances. It should be noted that while advice was sought from emergency services relating to the evacuation advice given to residents, and efforts were made to apply these in the modelling, circumstances on the day would dictate what would actually be implemented.

## 1.3 Project Steering Committee

A Project Steering Committee (PSC) was established at the outset to provide inter-agency oversight of the entire project. This involved guiding the progression of the study, give technical input and insight, and form the key decision-making body with regards to the methodology adopted.

The PSC was comprised of one or more representatives of the following agencies:

- The Department of Planning, Industry and Environment (Department)

- Northern Beaches Council (Council)
- New South Wales Rural Fire Service (NSW RFS)

Furthermore, technical insight and knowledge was provided by:

- NSW Police
- Transport for New South Wales Traffic Management Centre (TMC)
- Roads and Maritime Services (Roads and Maritime)

Roads and Maritime Services *has recently been restructured to form part of* Transport for New South Wales (TfNSW)*. Given this restructuring occurred midway through delivery of this project, it is referred to as Roads and Maritime herein.*

Engagement with the above agencies was frequent and regular throughout the delivery of this study, advising on key inputs and performance of outputs to determine next steps and actions.

## 1.4 Report structure

Sections in this report are set out below:

**Section 1**: **Introduction** provides background information and study objectives.

**Section 2: Study area** identifies the Ingleside Precinct boundary and broader catchment considered.

**Section 3**: **Existing conditions** establishes the existing transport context near the Ingleside Precinct.

**Section 4: Base model** documents the methodology adopted in developing the Base traffic model.

**Section 5: Bushfire modelling** provides the methodology adopted in developing the fire model.

**Section 6: Evacuation assessment** presents findings of evaluation of multiple evacuation scenarios.

**Section 7**: **Conclusion** summarises findings of the report.

# 2.0 Study area

## 2.1 Ingleside Precinct growth area

This study is driven by a land use planning exercise for the Ingleside Precinct growth area, which is in the Northern Beaches Local Government Area (LGA) as illustrated in Figure 1 below. It is not intended to advise on emergency service planning or procedures in the event of a bushfire. These are determined by the relevant parties involved.

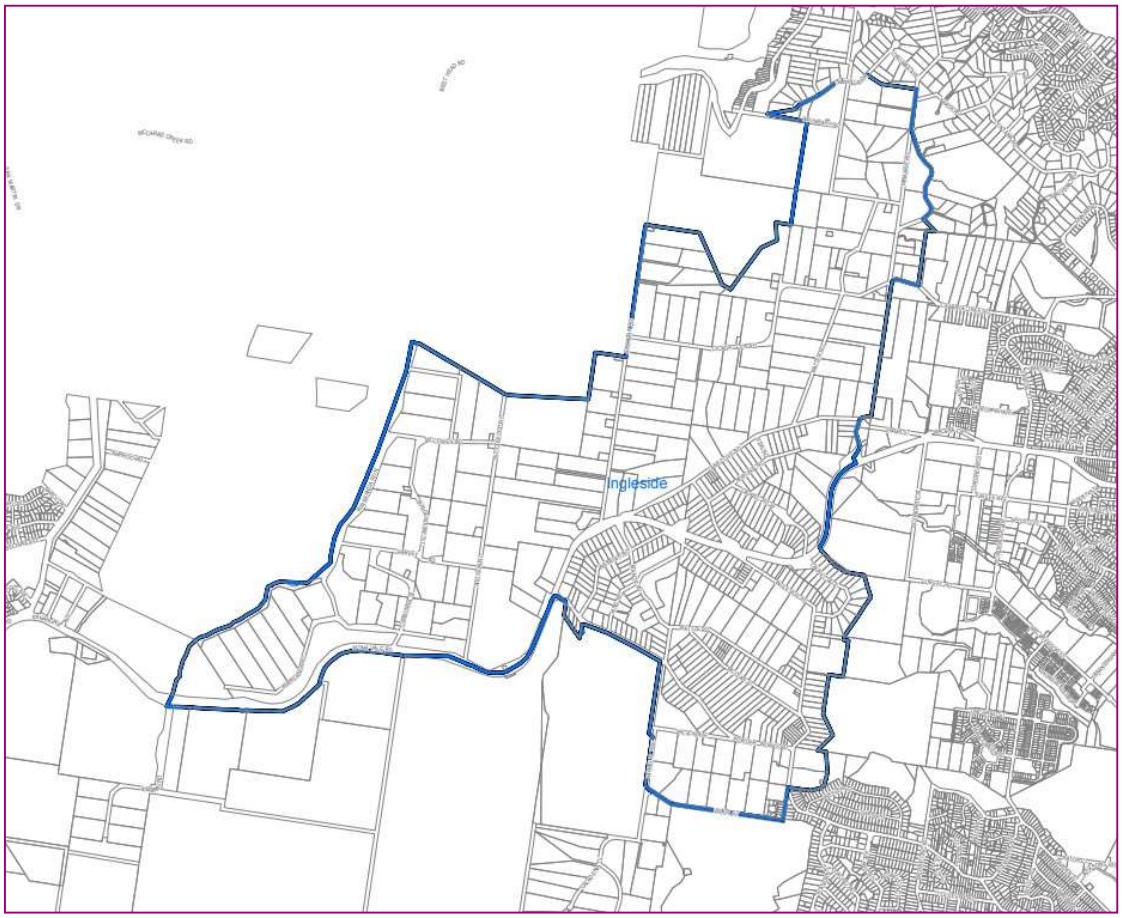



**Figure 1: Ingleside Precinct boundary *(source: Department website)***

The Precinct is bounded by Mona Vale Road, Powderworks Road and Wilga Street to the south, residential properties along Ingleside Road, Walter Road and Minkara Road to the east, and Wirreanda Road North and Chiltern Road to the north west.

## 2.2 Population catchment

Despite the study being driven by land use planning of the Precinct, a bushfire in the area would likely impact a much broader population catchment than only the Precinct, and so a wider catchment was considered when determining evacuation traffic demand (discussed further in Section 7.2).

The Australian Bureau of Statistics (ABS) terms the finest level of spatial areas as Travel Zones; given ABS census data forms the basis for evacuation traffic determination, it is from a number of Travel Zones across the Northern Beaches that traffic will be generated during an evacuation.

Travel Zones which would likely be impacted by a bushfire that would also impact the Precinct were identified and agreed with internal stakeholders at a workshop 10 May 2019, as illustrated in Figure 2:

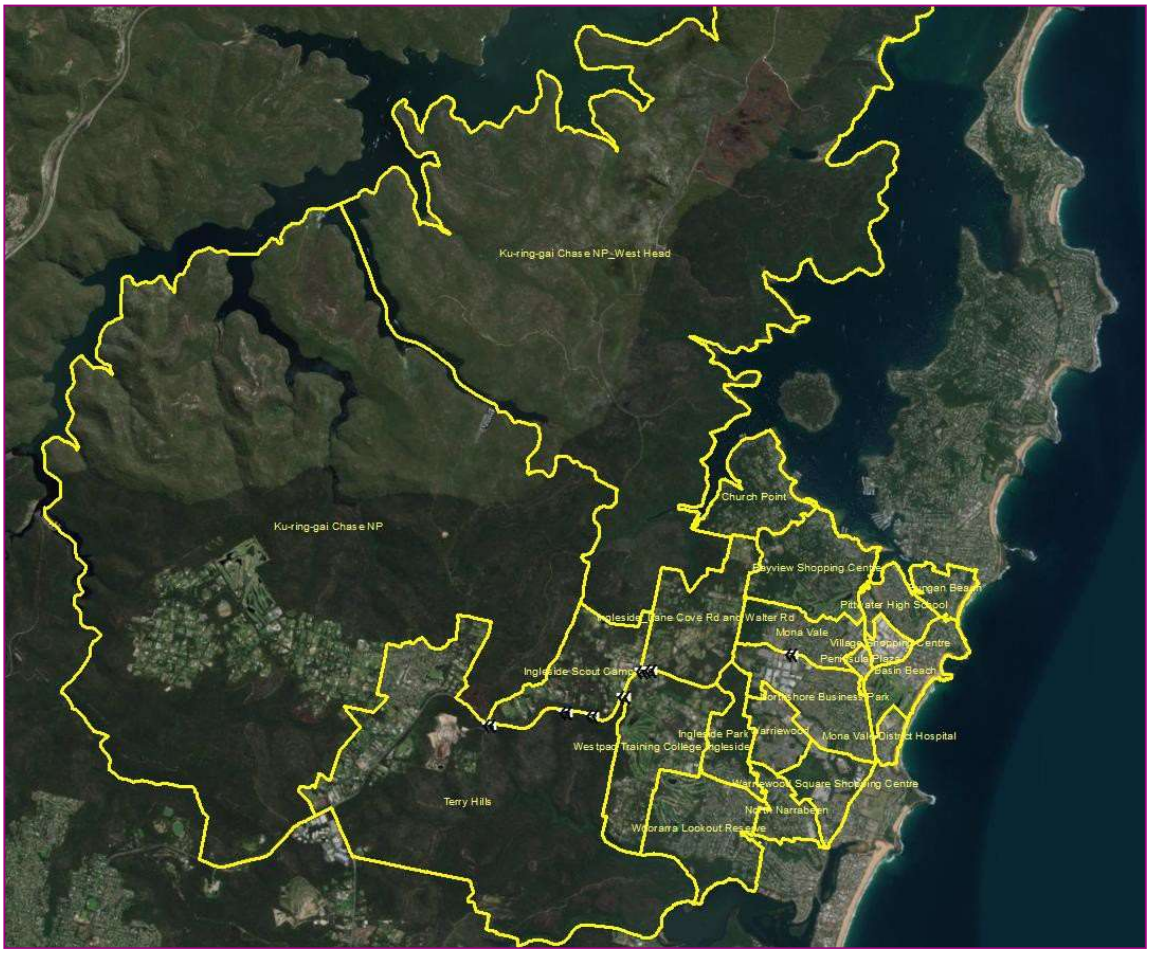



**Figure 2: ABS Travel Zone evacuation population catchment *(source: ABS, 2019)***

The Ingleside Precinct growth area illustrated in Figure 1 spreads across four ABS Travel Zones, namely:

- Ingleside Scout Camp;
- Ingleside Lane Cove Rd and Walter Rd;
- Westpac Training College Ingleside; and
- Ingleside Park.

The remaining Travel Zones outlined in Figure 2 were all considered as potential areas from which a portion of the population might evacuate during a bushfire in Ku-ring-gai Chase or Garigal National Parks (NP).

Suburbs north of Newport, towards Palm Beach, were not considered as 'at risk' in the event of a bushfire in the abovementioned National Parks, given separation offered by Pittwater, thus the population residing in these Travel Zones is **not** considered.

Residents of suburbs to the west of Ku-ring-gai Chase NP and Terrey Hills were considered to favour evacuation westwards, away from the National Parks and Ingleside Precinct, in the event of a bushfire. As such, they would not impact the Precinct's ability to evacuate as they would not use the same part of the road network, thus they were not considered.

## 2.3 Road network

Despite much of the Northern Beaches population catchment being considered as potentially evacuating during a bushfire, the modelled road network covers only the key intersections local to the Precinct, the performance of which would directly impact the Precinct's ability to evacuate. The road network considered in this study is illustrated in Figure 3.

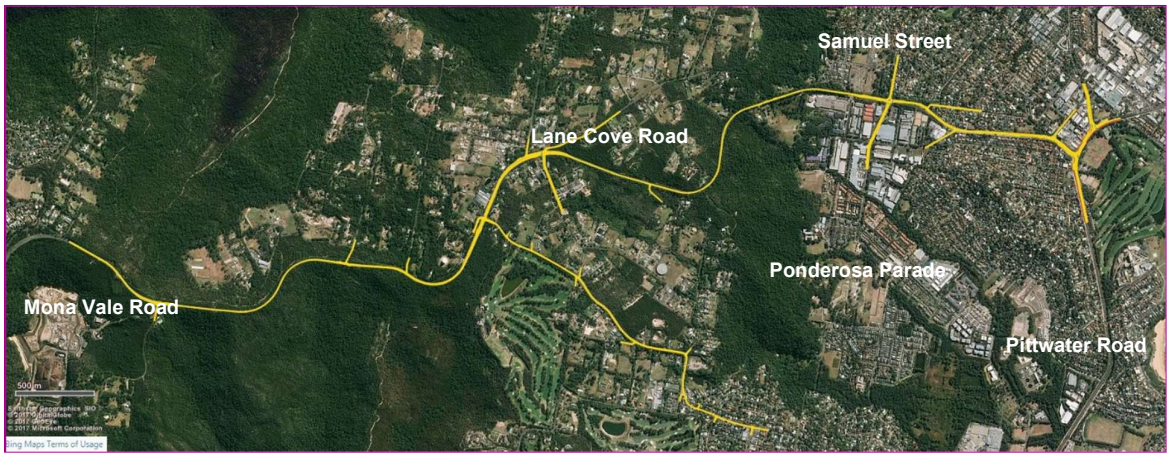



**Figure 3: Traffic model study area**

The model study area covers Mona Vale Road between, and inclusive of, intersections with Kimbriki Road and Pittwater Road. The Pittwater Road intersection with Barrenjoey Road is also included, as is a length of Powderworks Road to a point just south of Kalang Road.

All priority and signalised side arms along Mona Vale Road are included, though those along Powderworks Road are primarily included for illustrative purposes only, given traffic counts were only obtained for Powderworks Road intersections with Mona Vale Road and Kalang Road.

# 3.0 Existing conditions

## 3.1 Demographics

The Ingleside Precinct growth area forms part of the Ingleside State Suburb, within the boundaries of the Pittwater Statistical Area 3 (SA3), Northern Beaches LGA (Figure 4).

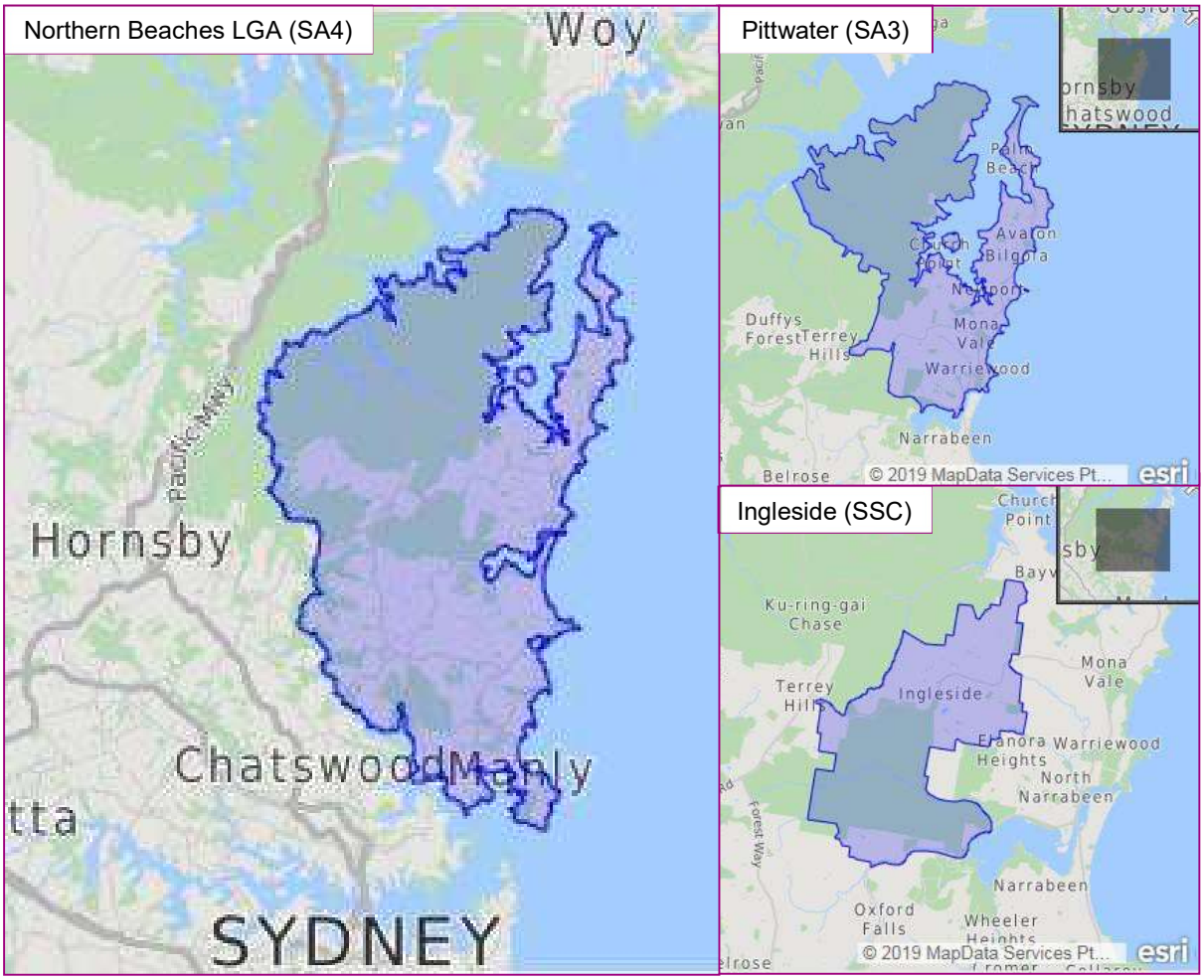



**Figure 4: Ingleside statistical boundaries *(source: ABS, 2019)***

Key 2016 census statistics for the study area are provided in Table 1.

**Table 1: 2016 census statistics**

| Area | Population | Avg. people per dwelling | Under 15 years | Over 65 years |
|---|---|---|---|---|
| **Ingleside** | 974 | 3.1 | 161 | 171 |
| **Pittwater** | 60,438 | 2.8 | 11,751 | 12,018 |
| **Northern Beaches LGA** | 252,878 | 2.7 | 49,849 | 42,465 |

In 2016, Ingleside had a population of 974 which accounts for approximately 1.6% of the total population of Pittwater (SA3). The average number of people per dwelling is slightly higher in Ingleside than for Pittwater and the Northern Beaches LGA, at 3.1 per dwelling compared to 2.8 per dwelling in Pittwater and 2.7 per dwelling in the Northern Beaches LGA.

Proportions of potentially vulnerable residents in Pittwater is slightly higher than the New South Wales average, with 19.4% of the Pittwater population aged under 15 years compared to a state average of 18.5%, and 19.9% aged over 65 compared with a state average of 16.2%.

## 3.2 Motor vehicle ownership

2016 census population data has been used to identify the Estimated Resident Population (ERP) and number of Occupied Private Dwellings (OPD) in 2019 and 2023, the two traffic assessment years considered in this study, for all the Travel Zones (TZ) illustrated in Figure 2.

2016, 2021 and 2026 census data values of ERP and OPD are presented in Table 2 below.

**Table 2: 2016 census ERP and OPD data - 2016, 2021 and 2026**

| TZ code | TZ name | ERP 2016 | ERP 2021 | ERP 2026 | OPD 2016 | OPD 2021 | OPD 2026 |
|---|---|---|---|---|---|---|---|
| 2009 | Church Point | 1,837 | 1,843 | 1,843 | 675 | 677 | 677 |
| 2010 | Bayview Shopping Centre | 2,764 | 2,797 | 2,827 | 1,155 | 1,165 | 1,170 |
| 2011 | Ingleside_Lane Cove Rd and Walter Rd | 342 | 344 | 1,112 | 116 | 116 | 441 |
| 2012 | Ingleside Scout Camp | 242 | 243 | 918 | 84 | 84 | 384 |
| 2013 | Westpac Training College Ingleside | 538 | 541 | 1,029 | 182 | 182 | 385 |
| 2014 | Ingleside Park | 786 | 796 | 807 | 261 | 264 | 267 |
| 2015 | Woorarra Lookout Reserve | 3,431 | 3,465 | 3,549 | 1,139 | 1,152 | 1,187 |
| 2027 | Mona Vale | 3,416 | 3,558 | 3,648 | 1,292 | 1,356 | 1,396 |
| 2028 | Village Shopping Centre | 155 | 162 | 165 | 72 | 75 | 77 |
| 2029 | Peninsula Plaza | 469 | 475 | 485 | 215 | 218 | 224 |
| 2030 | Basin Beach | 3,222 | 3,392 | 3,552 | 1,303 | 1,375 | 1,433 |
| 2031 | Northshore Business Park | 4,210 | 5,639 | 6,365 | 1,486 | 2,096 | 2,406 |
| 2032 | Warriewood | 2,881 | 3,252 | 3,580 | 1,027 | 1,184 | 1,321 |
| 2170 | Ku-ring-gai Chase NP | 928 | 928 | 929 | 307 | 307 | 307 |
| 2171 | Terry Hills | 2,777 | 2,787 | 2,805 | 885 | 887 | 891 |
| 2007 | Ku-ring-gai Chase NP_West Head | 355 | 362 | 365 | 155 | 159 | 160 |
| 2026 | Pittwater High School | 2,062 | 2,065 | 2,069 | 733 | 734 | 736 |
| 2023 | Bungan Beach | 1,283 | 1,290 | 1,292 | 421 | 424 | 425 |

2016 census data reports the Northern Beaches LGA private motor vehicle ownership rates as **0.66 vehicles per person** (10% higher than Sydney average) and **1.75 vehicles per dwelling** (6% higher than Sydney average). Applying these rates to ERP and OPD determines two similar values for the total number of vehicles in each Travel Zone, which were averaged to remove bias.

Once 2016, 2021 and 2026 estimated motor vehicle ownership was known, linear interpolation was used to identify respective 2019 and 2023 vehicle ownership which is presented in Table 3.

**Table 3: 2019 and 2023 number of vehicles per Travel Zone**

| TZ code | TZ name | Number of vehicles | |
|---|---|---|---|
| | | **2019** | 2023 |
| **2009** | Church Point | 1,200 | 1,202 |
| **2010** | Bayview Shopping Centre | 1,937 | 1,950 |
| **2011** | Ingleside_Lane Cove Rd and Walter Rd | 215 | 431 |
| **2012** | Ingleside Scout Camp | 154 | 348 |
| **2013** | Westpac Training College Ingleside | 338 | 474 |
| **2014** | Ingleside Park | 492 | 496 |
| **2015** | Woorarra Lookout Reserve | 2,145 | 2,177 |
| **2027** | Mona Vale | 2,322 | 2,389 |
| **2028** | Village Shopping Centre | 117 | 120 |
| **2029** | Peninsula Plaza | 346 | 351 |
| **2030** | Basin Beach | 2,277 | 2,366 |
| **2031** | Northshore Business Park | 3,296 | 3,904 |
| **2032** | Warriewood | 2,007 | 2,203 |
| **2170** | Ku-ring-gai Chase NP | 575 | 575 |
| **2171** | Terry Hills | 1,695 | 1,701 |
| **2007** | Ku-ring-gai Chase NP_West Head | 257 | 260 |
| **2026** | Pittwater High School | 1,325 | 1,327 |
| **2023** | Bungan Beach | 796 | 798 |
| | **Total** | **21,495** | **23,072** |

Across the Travel Zones considered as potentially containing residents who would evacuate onto the road network identified in Section 2.3 in the event of a bushfire, there are an estimated 21,495 vehicles in 2019 and 23,072 by 2023.

## 3.3 Journey to work mode

2016 ABS data has been analysed to understand existing mode share patterns for trips to and from the Pittwater SA3 in comparison to Greater Sydney. Findings are presented in Table 4.

**Table 4: 2016 travel to work census responses**

| Travel to work method | Pittwater SA3 | Greater Sydney |
|---|---|---|
| People who travelled to work by public transport | 9.2% | 22.8% |
| People who travelled to work by car as driver or passenger | 67.5% | 59.8% |

Table 4 demonstrates that the study area has a higher reliance upon private vehicles than Greater Sydney, which corresponds with car ownership rates presented in Section 3.2.

## 3.4 Historical traffic growth

A Roads and Maritime permanent count site (ID 57024) located on Mona Vale Road, just west of Powderworks Road, has been used to determine historical traffic trends over the past five years. Combined east and westbound Annual Average Daily Traffic (AADT) volumes are presented in Table 5.

**Table 5: Mona Vale Road AADT counts**

| Station | Location | 2013 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| 57024 | Mona Vale Road west of Powderworks Road | 29,302 | 27,491 | 31,217 | 28,992 | 31,375 | 25,176 |

*Note: no data was recorded in 2014. Data recorded in 2013, 2015 and 2019 is based on select months only, with data unavailable for the full year.*

Table 5 demonstrates that there is no clear growth trend in traffic volumes along Mona Vale Road over the past few years, with AADT in 2013 representing the second highest average over the past six recorded years. The highest AADT was recorded in 2018 at 31,375 vehicles per day, with the following 2019 value reducing by over 6,000 to 25,176; it is acknowledged however that 2019 values are an average of January and February only.

## 3.5 Seasonal traffic variability

Given the study area's proximity to the coastline and numerous summer resorts and facilities, a review was undertaken to identify seasonal traffic variability in the study area. Data from the Roads and Maritime permanent count site used in Section 3.3 was analysed, with total monthly traffic volumes recorded as illustrated in Figure 5.

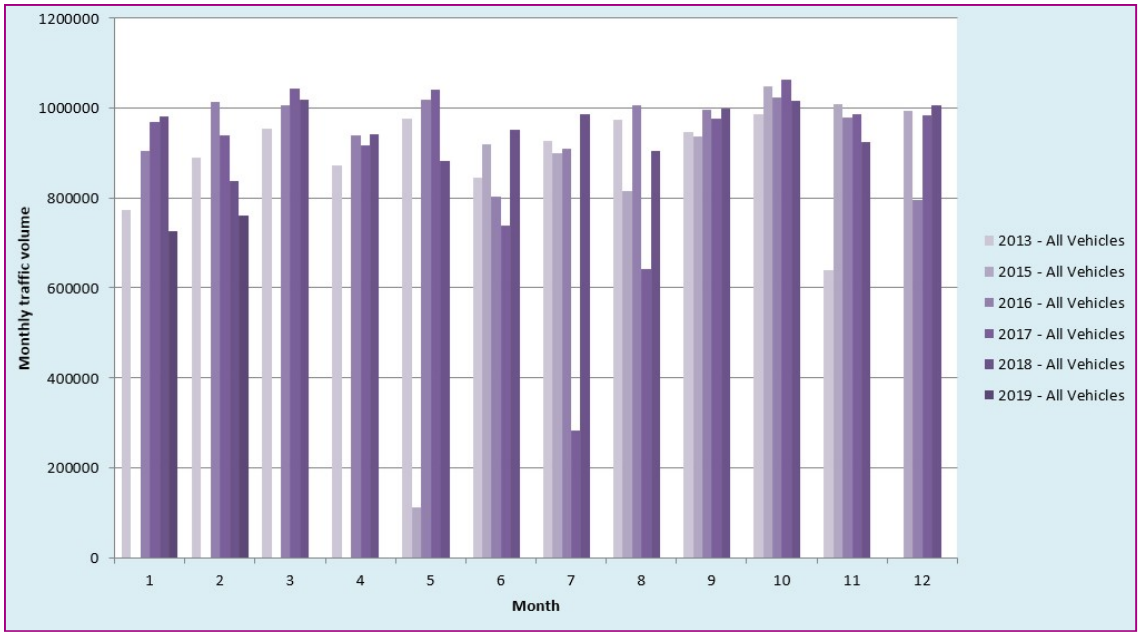



**Figure 5: Monthly traffic volumes at Mona Vale Road permanent count ID 57024**

Accounting for anomalies and miscounts, Figure 5 demonstrates a trend of reduced traffic volumes during winter months and higher volumes during summer months. This pattern is particularly prominent when assessing midday weekend data for the entirety of 2018, in which November – January generally experience higher traffic volumes than other months, as illustrated in Figure 6.

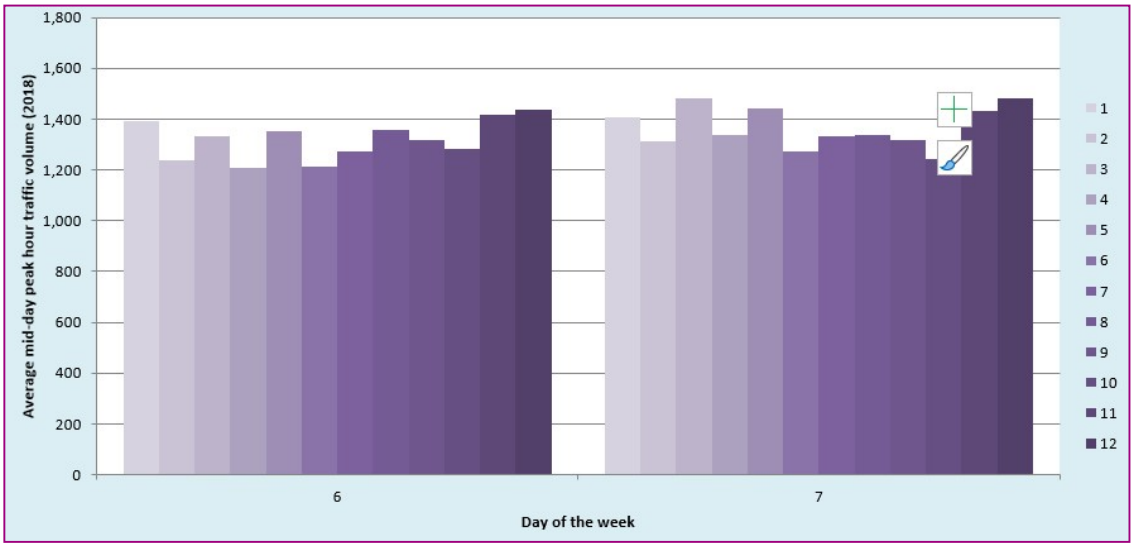



**Figure 6: 2018 12:00 - 13:00 weekend traffic volumes per month at Mona Vale Road permanent count ID 57024**

A more detailed assessment was undertaken using SCATS Detector counts at the critical intersection of Mona Vale Road / Pittwater Road (TCS 587) to validate the permanent counter findings.

Data from three Sundays in December 2018 (omitting public holidays) was compared with data from all Sundays in May 2019 to determine percentage differences and the scale of seasonal variability in the study area. May was selected as it represents the month in which observed traffic counts used in the study were obtained (Section 4.1), with December chosen as it represents the month in which the maximum average traffic volumes were recorded (Figure 6). Only data for the hours 12:00 – 14:00 were assessed, as this represents the model study period (Section 4.2.3).

Percentage differences in the average of 12:00 – 14:00 volumes from May 2018 and December 2019 are provided in Table 6.

**Table 6: Seasonal traffic growth at TCS 587**

| Pittwater Road (south) | | | Pittwater Road (north) | | | Mona vale Road (west) | | | Total |
|---|---|---|---|---|---|---|---|---|---|
| Through | Left | Total | Through | Right | Total | Left | Right | Total | |
| 0.2% | 25.4% | 3.3% | 6.6% | 25.8% | 11.2% | 32.7% | 12.1% | 26.4% | **10.5%** |

Table 6 demonstrates an increase in traffic volumes in December 2019 was recorded for all movements at TCS 587 when compared to May 2018. Some movements recorded much higher increases than others, with the Mona Vale Road approach recording an average of 26.4% increase, whereas the Pittwater Road (south) approach average increase is only 3.3%. The average overall intersection traffic growth was 10.5%.

## 3.6 B-Double routes

Mona Vale Road is the main east-west heavy vehicle route in northern Sydney. It connects Macquarie Park and Warriewood and is the most direct heavy vehicle route for accessing Warriewood and Mona Vale from Western and South West Sydney.

Figure 7 shows designated B-Double routes connecting to Mona Vale. Mona Vale Road is designated a B-Double route for trucks up to 26m in length, with connections to other B-Double routes including Forrest Way and Pittwater Road (also for trucks up to 26m in length), as well as Barrenjoey Road (for trucks up to 19m in length).

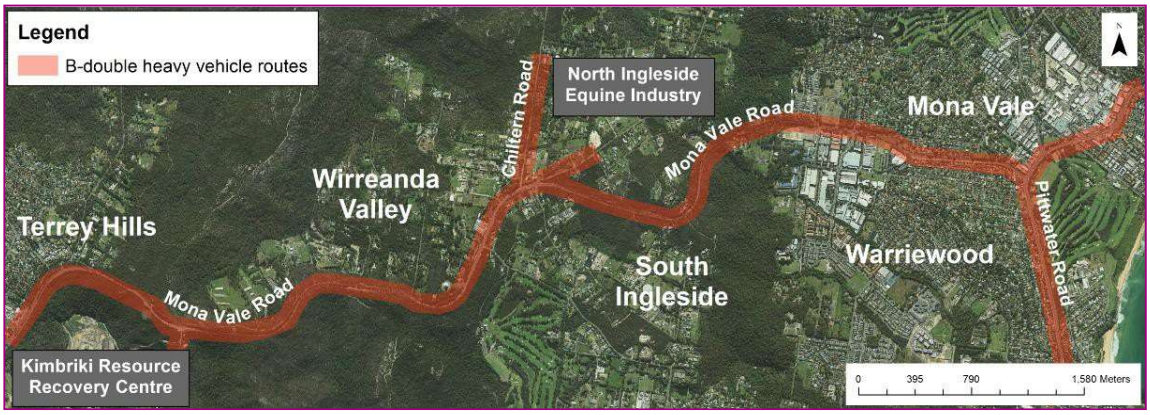



**Figure 7: B-Double routes**[3]

## 3.7 Public transport

Table 4 demonstrates that public transport use in the study area is well below the Greater Sydney average, with less than half the proportion of residents in Pittwater travelling to work by public transport than in Greater Sydney.

There is no rail connectivity in the vicinity, with northern lines following the Pacific Highway alignment between Chatswood and Hornsby to the west.

There are multiple bus services that provide connectivity within the local area, and also those which connect to key commuter routes such as Sydney CBD; these are listed in Table 7.

**Table 7: Bus connectivity and routes**

| **Local routes within Pittwater SA3** | | | |
|---|---|---|---|
| **155** | Bayview Garden Village to Narrabeen | **156** | McCarrs Creek to Mona Vale |
| **182** | Mona Vale to Narrabeen | **191** | Avalon Beach to Taylors Point |
| **192** | Avalon Beach to Stokes Point | | |
| **Commuter routes to and from Pittwater SA3** | | | |
| **B1** | Mona Vale to City Wynyard | **E60** | Mona Vale to Chatswood |
| **E83** | North Narrabeen to City Wynyard | **E88** | North Avalon Beach to City Wynyard |
| **E89** | Avalon Beach to City Wynyard | **L90** | Palm Beach to City Wynyard |
| **151** | Mona Vale to City QVB | **185** | Mona Vale to Warringah Mall |
| **188** | Mona Vale to City Wynyard | **196** | Mona Vale to Gordon |
| **197** | Mona Vale to Macquarie University | **199** | Palm Beach to Manly |

Most commuter bus routes access the area via Pittwater Road, with only the 196 and 197 services travelling the section of Mona Vale Road between Terrey Hills and Pittwater.

## 3.8 Road hierarchy

State roads managed by Roads and Maritime in the study area are Mona Vale Road, Pittwater Road, Barrenjoey Road and McCarrs Creek Road. All other roads in the study area are Regional or Local roads managed and financed by Council.

# 4.0 Base model (2019)

A traffic model of the study area was developed to assess traffic performance during the given evacuation conditions. Modelling requires the development of a Base model which reflects current year (2019) conditions, against which evacuation scenarios can be compared and assessed. The Base model represents existing conditions through calibration and validation to observed traffic data.

The approach taken in developing the Base model is set out below.

## 4.1 Existing traffic conditions

To inform and ensure appropriate model coding, traffic surveys were commissioned and undertaken by Matrix Traffic and Transport Data (Matrix) for a weekday PM and Sunday afternoon peak period, on Sunday 19th May 2019 and Tuesday 21st May 2019. These two periods were chosen following assessment and PSC discussion and agreement as to the worst-case time of day for an evacuation to occur. This is discussed further in Section 4.2.3.

Surveys undertaken are set out below.

### 4.1.1 Corridor description

Mona Vale Road is an important arterial road connector for north-eastern Sydney. The 20km route connects Pittwater Road at Mona Vale in the north east, to the Pacific Highway at Pymble. It is classified by Roads and Maritime as a Class 4 Urban Road, and an important State Road.

The number of lanes along the corridor varies as shown in Table 8[3].

**Table 8: Number of lanes along Mona Vale Road**

| Section | Number of lanes |
|---|---|
| McCarrs Creek Road – Kimbriki Road | 3 lanes (1 lane eastbound, 2 lanes westbound) |
| Kimbriki Road – Tumburra Street | 2 lanes (1 lane in each direction) |
| Tumburra Street – Powderworks Road / Baha'i Temple Way | 3 lanes (2 lanes eastbound, 1 lane westbound) |
| Powderworks Road / Baha'i Temple Way – Lane Cove Road / Manor Road | 4 lanes (2 in each direction) |
| Lane Cove Road / Manor Road – Foley Street | 2 lanes (1 in each direction) |
| Foley Street – Pittwater Road | 4 lanes (2 in each direction) |

Mona Vale Road is frequently used by Heavy Good Vehicles (HGVs) and is the main east-west connector in northern Sydney for HGVs. As a designated B-Double route it can accommodate large HGVs. Key connecting B-Double routes include Pittwater Road, Barrenjoey Road, Forest Way and the Pacific Highway.

[3] Mona Vale Road Upgrade West Traffic and Transport Assessment, AECOM, January 2017

### 4.1.2 Traffic volumes

Classified intersection turn count data was recorded for 15 sites (Table 9) during weekday PM (15:00 – 22:00) and Sunday afternoon (11:00 – 16:00) peak periods.

**Table 9: Intersection count and queue length survey locations**

| Site ID | Intersection | Counts | Queue |
|---|---|---|---|
| 1 | Mona Vale Road / Kimbriki Road | X | X |
| 2 | Mona Vale Road / Tumburra Street | X | X |
| 3 | Mona Vale Road / Addison Road | X | X |
| 4 | Mona Vale Road / Powderworks Road | X | X |
| 5 | Mona Vale Road / Chiltern Road | X | X |
| 6 | Mona Vale Road / Manor Road / Lane Cove Road | X | X |
| 7 | Mona Vale Road / Ponderosa Parade / Samuel Street | X | X |
| 8 | Mona Vale Road / McCarrs Creek Road | X | |
| 9 | Mona Vale Road / Pittwater Road | X | X |
| 10 | Pittwater Road / Barrenjoey Road | X | X |
| 11 | Powderworks Road / Garden Street | X | |
| 12 | Mona Vale Road / Emma Street | X | |
| 13 | Mona Vale Road / Foley Street | X | X |
| 14 | Mona Vale Road / Bungan Street | X | X |
| 15 | Powderworks Road / Kalang Road | X | |

Counts were classified as Lights and Heavies and undertaken using video surveys.

### 4.1.3 SCATS signal data

Roads and Maritime supplied SCATS Intersection (traffic signal) and Subsystem data (from the LX file) and SCATS History data in 15-minute intervals on 06 June 2019, for the days on which traffic surveys were undertaken. This data was used in addition to SCATS signal phasing plans and Timeline data to derive phase sequence, average phase splits, phase frequency and offsets for the peak hours under assessment.

Overall, the SCATS data and LX files provided a comprehensive snapshot of how the traffic signals operate at each site and if and how they are coordinated.

### 4.1.4 Travel times

Travel times were taken along the Mona Vale Road corridor between the intersections with McCarrs Creek Road and Pittwater Road. The route was divided into 11 intermediary sections (Table 10), with data collected for the entire survey period identified in Section 4.1.1.

Travel times were recorded manually via the floating vehicle survey method in which the survey company repeatedly travelled the entirety of the route in both directions.

**Table 10: Travel time survey segments**

| Site ID | Survey segment |
|---|---|
| | **Mona Vale Road – Eastbound** |
| **START** | Mona Vale Road / McCarrs Creek Road |
| **1** | Mona Vale Road / Kimbriki Road |
| **2** | Mona Vale Road / Tumburra Street |
| **3** | Mona Vale Road / Addison Road |
| **4** | Mona Vale Road / Powderworks Road |
| **5** | Mona Vale Road / Chiltern Road |
| **6** | Mona Vale Road / Manor Road / Lane Cove Road |
| **7** | Mona Vale Road / Ponderosa Parade / Samuel Street |
| **8** | Mona Vale Road / Emma Street |
| **9** | Mona Vale Road / Foley Street |
| **10** | Mona Vale Road / Bungan Street |
| **END** | Mona Vale Road / Pittwater Road |
| | **Mona Vale Road - Westbound** |
| **START** | Mona Vale Road / Pittwater Road |
| **10** | Mona Vale Road / Bungan Street |
| **9** | Mona Vale Road / Foley Street |
| **8** | Mona Vale Road / Emma Street |
| **7** | Mona Vale Road / Ponderosa Parade / Samuel Street |
| **6** | Mona Vale Road / Manor Road / Lane Cove Road |
| **5** | Mona Vale Road / Chiltern Road |
| **4** | Mona Vale Road / Powderworks Road |
| **3** | Mona Vale Road / Addison Road |
| **2** | Mona Vale Road / Tumburra Street |
| **1** | Mona Vale Road / Kimbriki Road |
| **END** | Mona Vale Road / McCarrs Creek Road |

25 runs were undertaken in each direction on Sunday 19th August (11:00 – 16:00), with 30 undertaken on Tuesday 21st August (15:00 – 22:00).

### 4.1.5 Queue lengths

Queue length data was collected for all approach lanes for the 11 intersections marked in Table 9. Queue lengths recorded for the full survey period, per traffic signal cycle, as the number of stationary vehicles the moment the controlling traffic signal turns green.

### 4.1.6 Congestion locations

Traffic surveys and site understanding identified that the primary congestion location on a 'typical' Sunday afternoon in May is to the east of the study area, at Mona Vale Road and Barrenjoey Road intersections with Pittwater Road.


**Figure 8: Congestion locations**

Figure 8 illustrates the direction of queuing in the network on a 'typical' Sunday, with heavy eastbound right turn volumes from Mona Vale Road (W) competing with the conflicting Pittwater Road (N) westbound right turn movement.

Given competing requirements for signal green time, localised queuing forms on Mona Vale Road though does not extend beyond Foley Street to the west.

Queuing is also present on the Pittwater Road (N) approach to Mona Vale Road which blocks through to Barrenjoey Road, causing localised queuing at the Pittwater Road / Barrenjoey Road intersection. This queuing is a product of the performance at Pittwater Road / Mona Vale Road; however most vehicles are able to clear the signals within one signal cycle.

## 4.2 Model assumptions

This section documents the approach adopted in developing the Base model.

### 4.2.1 Methodology

A Base model is a model that provides a reasonable representation of traffic conditions currently observed on street, which is suitable for analysing the network performance and acting as a benchmark against which future year and option test scenarios can be tested. The model developer must gather enough knowledge of current network conditions to ensure the Base model is a fair representation of current conditions.

Following data collection, the Base model network is coded to scale using background mapping and drawings. All network features such as signal heads, public transport stops and posted speed limits are layered onto the model network, before model inputs gathered during data collection are entered. For this assessment, these inputs constitute classified intersection turning counts (derived through traffic surveys of peak periods) and signal timings (derived through SCATS History data provided by

Roads and Maritime). The process of entering verifiable data into the traffic model to represent current conditions is called model calibration.

The final task is model validation, which is the process of comparing model outputs against independently gathered data that is not used as an input. For this scheme, travel times recorded along Mona Vale Road were used to validate the model. On the basis that satisfactory calibration and validation has been achieved, this would then suggest that the model can produce reasonable predictions for the future year testing.

### 4.2.2 Modelling platform

Traffic micro-simulation modelling has been undertaken in VISSIM 11.00-08, allowing for the development of a Base (existing case) model, against which evacuation scenario models can be compared.

The software generates and assigns vehicles to the model network using different 'seed' values to replicate the variation in traffic conditions that are typically experienced on a day to day basis. Each seed value will stochastically input vehicles into the network across the modelled time period, and assign individual behaviours based on distributions, such as desired speed.

For this analysis five seed values were used to ensure model stability and to obtain results representative of typical network operating conditions. The following random seed properties were adopted:

Starting seed: 42

Seed increment: 1

### 4.2.3 Time period

The assessment aims to robustly test the road network's ability to accommodate evacuation traffic by modelling the time during the week that would have the greatest impact on road network operation.

Assessment of traffic counts, recorded by a Roads and Maritime permanent count site (ID: 57024) located on Mona Vale Road just west of Powderworks Road, identifies weekday Tuesday AM and PM peaks as containing the highest 'typical' east and westbound traffic volumes. Bushfire evacuation traffic demand is however atypical in nature and so existing traffic counts do **not** form a reliable basis upon which to identify the assessment time period.

During an evacuation, 'typical' trips are unlikely to enter the road network as they otherwise would, and it is expected that there would be a significant increase in local population traffic joining the road network to evacuate. As such, and in order to test a worst-case scenario, the assessment time period necessitates a period during which a large proportion of the local population would be at home.

Balancing the requirements for high home occupancy and busy roads upon which the local population would be required to evacuate, a model time period of **Sunday Midday** was identified. This ensures that many of the local population are not working, whilst reflecting a time of day during which 'typical' traffic volumes are high.

It was also determined that evacuation of such a catchment would likely take a considerable amount of time, and so a two-hour model peak period was assessed, with a one-hour warm-up and 30-minute cool down period. These periods are summarised below, and were agreed at a Project Steering Committee (PSC) workshop with stakeholders on 10 May 2019:

Warm up: 11:00 – 12:00

**Peak hour 1: 12:00 – 13:00**

**Peak hour 2: 13:00 – 14:00**

Cool down: 14:00 – 14:30

This two-hour period was identified through use of the Roads and Maritime permanent counter observations illustrated in Figure 9.

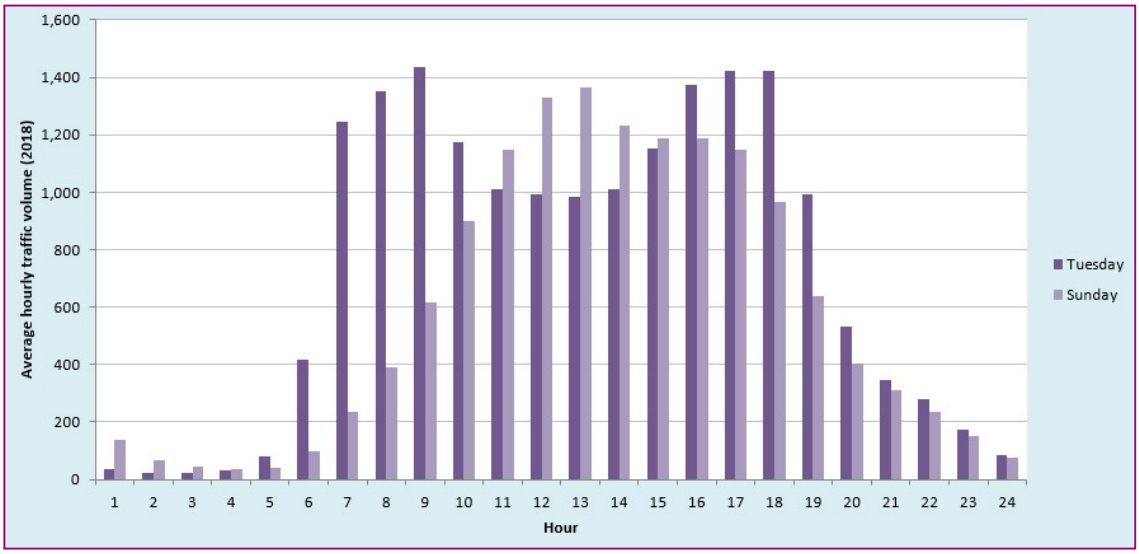



**Figure 9: Average bidirectional hourly traffic volumes | Tuesdays and Sundays in 2018 | Roads and Maritime permanent counter**

Discussion on identification of the appropriate time period and respective traffic demand determination is discussed further in Section 7.2.

### 4.2.4 Assignment type

Traffic was assigned to the network using the dynamic assignment procedure in VISSIM. The models dynamically assign vehicles to various paths, as informed by the assignment procedure based on a principle of 'generalised cost'. As a result of the network structure, most Origin/Destination (OD) pairs only have one route, and so there is very limited route choice available in the model.

Models are converged using an iterative process whereby VISSIM updates the 'cost' of each route at the start of each model run, through experience of previous runs undertaken. As the costs change between successive runs, so too do the traffic volumes assigned to each route. Given route choice is limited in this assessment, traffic volumes were fixed at 50% of the total and run to meet convergence criteria. These criteria were for travel time on paths to demonstrate a maximum of 15% variation between two successive runs on 95% of paths.

### 4.2.5 Vehicle type

Observed intersection turning counts classified vehicles into Lights and Heavies. Default vehicle types for Car, HGV and Bus have been applied accordingly, with no adjustment made to dimensions and driving behaviour parameters.

### 4.2.6 Traffic zones / input

Agreement on the model study area was reached with stakeholders at the PSC workshop held 10 May 2019, such that it comprises Mona Vale Road between and inclusive of Kimbriki Road (to the west) and Pittwater Road (to the east). It extends north along Pittwater Road to include the intersection with Barrenjoey Road, and south along Powderworks Road to the intersection with Kalang Road.

The network extents and zoning system is illustrated in Figure 10.

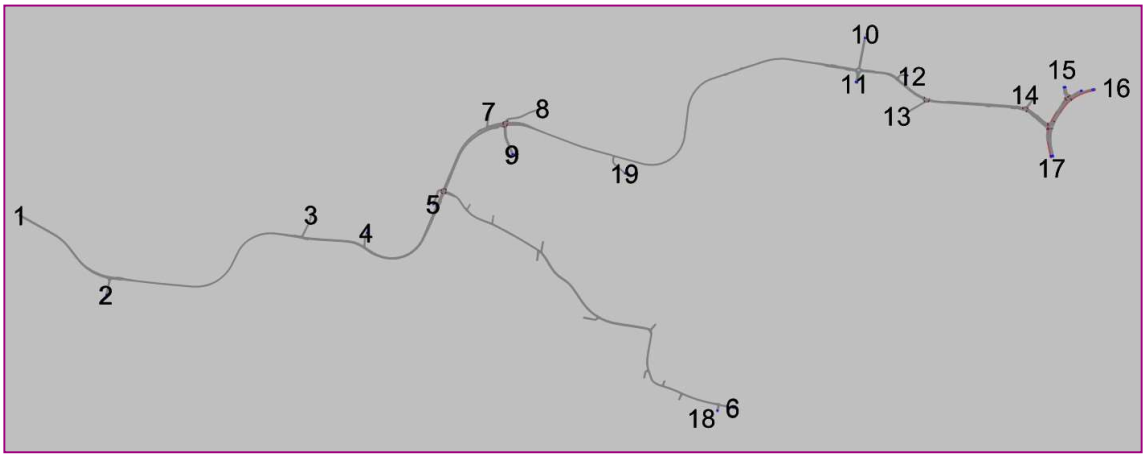



**Figure 10: Model extents and zoning system**

### 4.2.7 Road type

VISSIM's default Urban (motorized) driver and link behaviour type has been applied to all road links within the network, with no adjustment made to parameters.

### 4.2.8 Speed profiles

Posted speed limits in the model vary from 50km/h to 70km/h and thus desired speed decisions use the default profiles associated with these speeds.

At key locations where vehicle speeds are expected to be less than the posted speed limit due to geometry (i.e. horizontal curvature), a reduced speed area has been located with a speed which is considered appropriate for the particular turning movement, to replicate the speed vehicles travel through these corners. All reduced speed areas in the network use 20km/h for Cars and 12km/h for HGVs and buses.

Speed profiles for the distributions used are provided in Table 11.

**Table 11: Speed distributions**

| Speed | Lower bound | Upper bound |
|---|---|---|
| **12km/h** | 12 | **15** |
| **20km/h** | 20 | **25** |
| **40km/h** | 40 | **45** |
| **50km/h** | 48 | **58** |
| **60km/h** | 58 | **68** |
| **70km/h** | **68** | **78** |

### 4.2.9 School zones

There are no school zones within the modelled network.

### 4.2.10 Traffic signals

The following process was adopted in deriving the signal phase times used in the VISSIM model:

1. The phase sequence during each peak period is informed by the SCATS phasing plan and site observations.
2. The phase times during the peak hour were calculated using the SCATS History data, and then freely adjusted for model purposes ensuring green times remained within 10% of observed data.

3. Phasing was coded as Fixed Time, and so phase lengths were adjusted for phase frequency. For example, if a phase appeared in 50% of cycles then its average phase length is taken as 50% of the average shown on SCATS History data.
4. The average modelled cycle time varies between time periods at intersections, and also between intersections. Single cycle times for the full model period were adopted, though these are different between intersections, ranging from 64 seconds at the Mona Vale Road / Powderworks Road intersection to 150 seconds at Mona Vale Road / Pittwater Road. Phase lengths were set to ensure the sum of all, including intergreen times, equals this cycle time.
5. Signal amber and red times were based on the intergreen times informed by SCATS data.
6. Pedestrian protection has been coded where applicable, as informed by SCATS data.
7. Diamond variable phase use was determined using SCATS Timeline information, with the most prevalent variable phase adopted.

A review of SCATS data indicated that, in general, main traffic phases were called every cycle. Where demand dependent stages were recorded as being called infrequently during the peak hours, they have been omitted from sequencing.

The SCATS data does not show if filter movements are permitted. Site visits were undertaken to confirm where filter movements are allowed, and these were coded into the model accordingly.

Signals have been coded as Fixed Time within VISSIM's VAP facility.

#### 4.2.11 Public transport

Bus routeing through the network was advised by online information available at the TfNSW website. This information was used to determine routes, stops and frequency.

A number of bus routes pass through the study area: some between Mona Vale Road (west) and Barrenjoey Road (north), or zones 1 and 16 from Figure 10, some north and southbound along Pittwater Road, and one entering the network at Foley Street and departing northbound along Barrenjoey Road. A list of bus routes coded in the network is provided in Table 12.

**Table 12: Modelled bus routes**

| Route number | Route description (between) |
|---|---|
| **151** | Pittwater Road (south) and Barrenjoey Road (north) |
| **185** | Foley Street and Barrenjoey Road (north) |
| **188** | Pittwater Road (south) and Barrenjoey Road (north) |
| **196** | Mona Vale Road (west) and Barrenjoey Road (north) |
| **197** | Mona Vale Road (west) and Barrenjoey Road (north) |
| **B1** | Pittwater Road (south) and Barrenjoey Road (north) |
| **L90** | Pittwater Road (south) and Barrenjoey Road (north) |

#### 4.2.12 Demand assumptions / adjustment

Intersection turning counts were processed via Excel spreadsheet to identify 30-minute matrices for each individual intersection within the study area, broken down into Lights and Heavies. Processing allowed for flow discrepancies between intersections to be identified prior to matrix estimation to ensure no inaccuracies were present.

These intersection turning counts were then entered into a skeleton LinSig (v3) model network using the *Edit Junction Turning Counts* function, with LinSig's Matrix Estimation tool then used to generate matrices using total *In* and *Out* zone totals.

Matrices were developed for each 30-minute period for Light and Heavy vehicle types, thus 14 in total for the two-hour Sunday period.

Warm up (11:00 – 12:00) volumes were coded as 95% of the respective peak hour volume between 12:00 – 13:00, for example the 11:00 – 11:30 matrix was derived as 95% of the 12:00 – 12:30 matrix. Cool down matrices were calculated similarly, as 90% of the final peak half-hour matrix, thus 14:00 – 14:30 volumes are derived as 90% of 13:30 – 14:00.

### 4.2.13 Pedestrians and cycles

Cyclists are not coded or represented within the model, given the relatively small volume and limited impact to general traffic.

Pedestrian volumes at crossings of the intersections identified in Table 9 were recorded for the full survey period. These volumes were coded as 'Vehicle' Inputs on pedestrian links in the network, with Priority Rules used as a mechanism to ensure vehicles give way to pedestrians when the two run concurrently at intersections across the network.

Pedestrian volumes were found to be relatively low across the study area, with the highest hourly directional pedestrian volume being 49 pedestrians making the westbound crossing across Pittwater Road (south) at its intersection with Mona Vale Road. Aside from this intersection, the Pittwater Road / Barrenjoey Road intersection is the only other that has single directional hourly pedestrian volumes greater than 15 pedestrians.

### 4.2.14 Traffic profile

The process for identifying traffic demand profiles is set out Section 4.2.12. Total model demand for the seven 30-minute modelled periods across the Sunday peak is set out in Table 13 below.

**Table 13: Demand profiles**

| Time period | Lights | Heavies | Total (veh) | Heavy (%) |
|---|---|---|---|---|
| 11:00 – 11:30 | 3460 | 49 | 3509 | 1.4% |
| 11:30 – 12:00 | 3303 | 28 | 3331 | 0.8% |
| 12:00 – 12:30 | 3642 | 52 | 3694 | 1.4% |
| 12:30 – 13:00 | 3477 | 29 | 3506 | 0.8% |
| 13:00 – 13:30 | 3660 | 44 | 3704 | 1.2% |
| 13:30 – 14:00 | 3301 | 43 | 3344 | 1.3% |
| 14:00 – 14:30 | 2761 | 39 | 2800 | 1.0% |

Heavy vehicle proportions are low in the network, ranging from 0.8 – 1.4%, given the modelled peak period is Sunday 12:00 – 14:00, a time during which freight traffic on the road network is not heavy.

### 4.2.15 Behaviour parameters

Default driver behaviour in VISSIM was adopted with no modifications. All road links and drivers use Urban (motorized) behaviour, whilst pedestrian crossings use Footpath (no interaction).

### 4.2.16 General assumptions

Model coding is representative of generally accepted best practice and no bespoke model coding has been required to achieve abnormal operation.

### 4.2.17 Calibration and validation targets

**Intersection turn counts**

The GEH statistic was adopted as the main indicator of "goodness of fit", that is the extent to which modelled traffic flows match the corresponding observed counts. The GEH statistic is an "intuitive" and "empirical engineering" measure, which is defined as:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

*Where M is the hourly traffic volume from the traffic model and C is the observed traffic count.*

In terms of model calibration, the various GEH values provide an indication of goodness of fit of the Base VISSIM model against the observed data:

| | |
|---|---|
| *GEH < 5* | *Flows considered a good fit* |
| *5 < GEH < 10* | *Flows may require further investigation* |
| *10 > GEH* | *Flows not considered a good fit* |

*Table 11.1* of *Roads and Maritime Traffic Modelling Guidelines* identifies network-wide criteria for the GEH parameter, as outlined below:

- *GEH < 5 Minimum 85 per cent of observations to be within tolerance limits*
- *Turn or link flows with GEH > 10 require explanation in reporting*

Aside from the GEH statistic, *Table 11.2* of *Roads and Maritime Traffic Modelling Guidelines* identifies core area criteria for the link or turn counts within the model, as outlined below:

- *Flows < 99 – to be within 10 vehicles of observed value*
- *Flows 100 to 999 – to be within 10 per cent of observed value*
- *Flows 1000 to 1999 – to be within 100 vehicles of observed value*
- *100 per cent of observations to be within tolerance limits*

Adherence to these calibration targets is discussed in Section .

**Signal timings**

Signal timings have been calibrated to criteria set out in *Table 11.3* of *Roads and Maritime Traffic Modelling Guidelines*, as outlined below:

- *Average modelled cycle time for each one-hour period to be within 10 per cent of observed average cycle time for same one-hour period*
- *Total of green time over each one-hour period to be within 10 per cent of observed equivalent for each phase (since this has a direct impact upon hourly stop line capacity)*

Adherence to these calibration targets is discussed in Section 4.4.2.

**Travel times**

Models were initially developed to meet travel time validation criteria as set out in *Table 11.5* of *Roads and Maritime Traffic Modelling Guidelines*, listed below:

- *Average modelled journey time to be within 15 per cent or one minute (whichever is greater) of average observed journey time for full length of route. Each route should be cumulatively graphed by section as shown above*
- *Average modelled journey times to be within 15 per cent of average observed journey time for individual sections*

Adherence to these validation targets is discussed in Section 4.4.2.

## 4.3 Model stability

Microsimulation models use Random Seed values to produce a small level of variability (stochasticity) within each simulation to reflect the range of behaviours that are exhibited in the real world. The range of behaviours capture the variability in release times of vehicles onto the network, the individual driving style allocated to a particular vehicle as well as the total demand loaded onto the network.

Model stability was assessed using the process set out in *Section 11.8* of R*oads and Maritime Traffic Modelling Guidelines*, with Vehicle Hours Travelled (VHT) used as the network metric for assessing performance. VHT for the five random seeds used in modelling for the AM peak is illustrated in Figure 11.

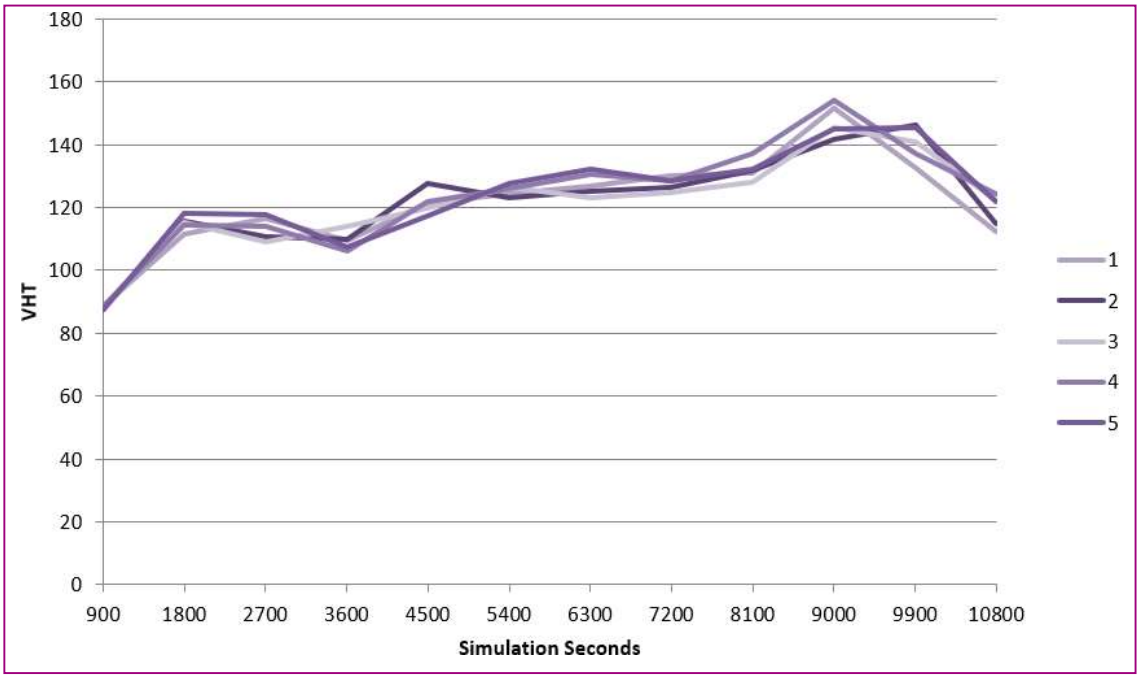



**Figure 11: Vehicle Hours Travelled (VHT) for five random seeds**

Figure 11 demonstrates that VHT is very consistent across the entire model period for each of the five random seeds assessed, suggesting the model is suitably stable to form the basis for assessment.

## 4.4 Model calibration and validation

Model calibration is the process of entering verifiable data into the traffic model to represent current conditions. Model validation is the process of comparing model outputs against independently gathered data that is not used as an input.

This section demonstrates adherence of the Ingleside VISSIM model to *Roads and Maritime Traffic Modelling Guideline* calibration and validation criteria set out in Section 4.2.17.

### 4.4.1 Intersection turn counts

Turn count calibration was assessed at all intersections listed in Table 9.

Table 14 demonstrates GEH criteria adherence for all movements in the model network, with full details provided in Appendix A

**Table 14: GEH Summary (network wide)**

| **12:00 – 13:00** | |
|---|---|
| GEH <5 | 95 |
| GEH >5 | 0 |
| 13:00 – 14:00 | |
| GEH <5 | 95 |
| GEH >5 | 0 |

Table 14 shows all turning movements across the two peak hours return GEH values below 5, with only a single movement during the two-hour peak period recording a GEH value of over 3. This demonstrates good flow calibration to observed turn counts in the model.

Correspondence to core area criteria set out in Section 4.2.17 is provided in Table 15 below.

**Table 15: RMS criteria correspondence**

| Category | Criteria | 12:00 – 13:00 | | 13:00 – 14:00 | |
|---|---|---|---|---|---|
| | | Pass | Fail | Pass | Fail |
| <99 | ± 10 | 47 | 1 | 47 | 1 |
| 100 to 999 | ± 10% | 36 | 1 | 36 | 1 |
| 1000 to 1999 | ± 100 | 10 | 0 | 10 | 0 |
| **Total** | | **93** | **2** | **93** | **2** |

Of the movements that failed criteria set out in Table 15, the largest discrepancy between observed and modelled flow was 26 vehicles, with the corresponding movement GEH value 1.7. Two of the fails relate to the Pittwater Road (north) left turn to Barrenjoey Road, for which modelled values are 14 and 19 vehicles lower than observed. The two other fails are for the Bungan Street left turn onto Mona Vale Road, with the modelled value in the first hour exceeding observations by 14 vehicles and falling short of the observed count by 26 vehicles in the second hour.

These discrepancies are all considered small in relation to total turn volumes travelling through the network, and are unlikely to notably impact intersection or network performance, thus turn count calibration is considered satisfactory.

### 4.4.2 Signal timings

The process for deriving observed signal timings for use in modelling is set out in Section 4.2.10, with calibration assessment performed at the six signalised intersections in the study area, namely:

- TCS 3617: Mona Vale Road / Powderworks Road
- TCS 3618: Mona Vale Road / Lane Cove Road / Manor Road
- TCS 3945: Mona Vale Road / Foley Street
- TCS 2552: Mona Vale Road / Bungan Street
- TCS 587: Mona Vale Road / Pittwater Road
- TCS 1049: Pittwater Road / Barrenjoey Road

Signal timings were coded using VISSIM's VAP function, with 15-minute fixed time periods allowing for a degree of traffic signal variation across the peak period. Timing splits for each 15-minute period was coded to reflect observed signal timings, as informed by SCATS History data provided for the survey date; this ensures traffic signals in the Base model vary as they did on site during the survey date, in response to traffic demand.

All 15-minute time periods have been coded to reflect observations and remain within the Roads and Maritime criteria set out in Section 4.2.17, with the two-hour average observed and modelled signal green times provided in Table 16.

**Table 16: Signal green time calibration (12:00 – 14:00 average per cycle)**

| Intersection | Phase | Signal Group | Observed | Modelled | % Diff |
|---|---|---|---|---|---|
| **Mona Vale Road / Powderworks Road** | **A** | **1** | **42 s** | **42 s** | 0% |
| | **A** | **2** | **42 s** | **42 s** | 0% |
| | **E** | **3** | **17 s** | **17 s** | 0% |
| TCS 3617 | **A,E** | **4** | **66 s** | **66 s** | 0% |
| | **D** | **5** | **5 s** | **5 s** | 0% |

| | | | | | |
|---|---|---|---|---|---|
| | **D** | **6** | **5 s** | **5 s** | 0% |
| | **D,E** | **8** | **29 s** | **29 s** | 0% |
| | **D,E** | **9** | **29 s** | **29 s** | 0% |
| **Mona Vale Road / Lane Cove Road / Manor Road** | **A** | **1** | **53 s** | **54 s** | 2% |
| | **A** | **2** | **53 s** | **54 s** | 2% |
| | **E** | **3** | **5 s** | **5 s** | 0% |
| TCS 3618 | **E** | **4** | **5 s** | **5 s** | 0% |
| | **D** | **5** | **11 s** | **11 s** | 1% |
| | **D** | **6** | **11 s** | **11 s** | 1% |
| | **D** | **7** | **11 s** | **11 s** | 1% |
| | **D** | **8** | **11 s** | **11 s** | 1% |
| **Mona Vale Road / Foley Street** | **A** | **1** | **100 s** | **100 s** | 1% |
| | **A,B** | **2** | **112 s** | **111 s** | 1% |
| | **A,B** | **3** | **112 s** | **111 s** | 1% |
| TCS 3945 | **B,C** | **4** | **21 s** | **21 s** | 1% |
| | **A** | **5** | **100 s** | **100 s** | 1% |
| | **C** | **6** | **9 s** | **9 s** | 3% |
| **Mona Vale Road / Bungan Street** | **A** | **1** | **82 s** | **84 s** | 2% |
| | **C** | **2** | **20 s** | **20 s** | 1% |
| | **A,B** | **3** | **93 s** | **94 s** | 2% |
| TCS 2552 | **A,B** | **4** | **93 s** | **94 s** | 2% |
| | **B,C** | **5** | **31 s** | **31 s** | 0% |
| | **C** | **6** | **84 s** | **84 s** | 1% |
| **Mona Vale Road / Pittwater Road** | **A** | **1** | **79 s** | **79 s** | 0% |
| | **A,B,D** | **2** | **118 s** | **117 s** | 1% |
| | **B,D** | **3** | **24 s** | **24 s** | 0% |
| TCS 587 | **C** | **4** | **18 s** | **18 s** | 0% |
| | **A,C** | **5** | **98 s** | **98 s** | 0% |
| | **B,C,D** | **6** | **57 s** | **57 s** | 0% |
| **Barrenjoey Road / Pittwater Road** | **A** | **1** | **89 s** | **91 s** | 3% |
| | **A** | **2** | **89 s** | **91 s** | 3% |
| | **C** | **3** | **23 s** | **23 s** | 0% |
| TCS 1049 | **A,C** | **4** | **118 s** | **118 s** | 0% |
| | C | 5 | 23 s | 23 s | 0% |

All signal groups calibrate well to observed timings, with minor differences reflecting adjustments made in modelling to improve turn count calibration and validation to travel times.

### 4.4.3 Travel times

Travel times along the Mona Vale Road were observed on the same day that the intersection turn counts were taken. Travel times were recorded for the full survey period (11:00 – 16:00); however only those taken during the model period of 12:00 – 14:00 have been considered in determining average observed travel times against which model performance is compared.

Model travel time adherence to validation criteria set out in Section 4.2.17 is provided in Figure 12 to Figure 15 below.

**Eastbound**

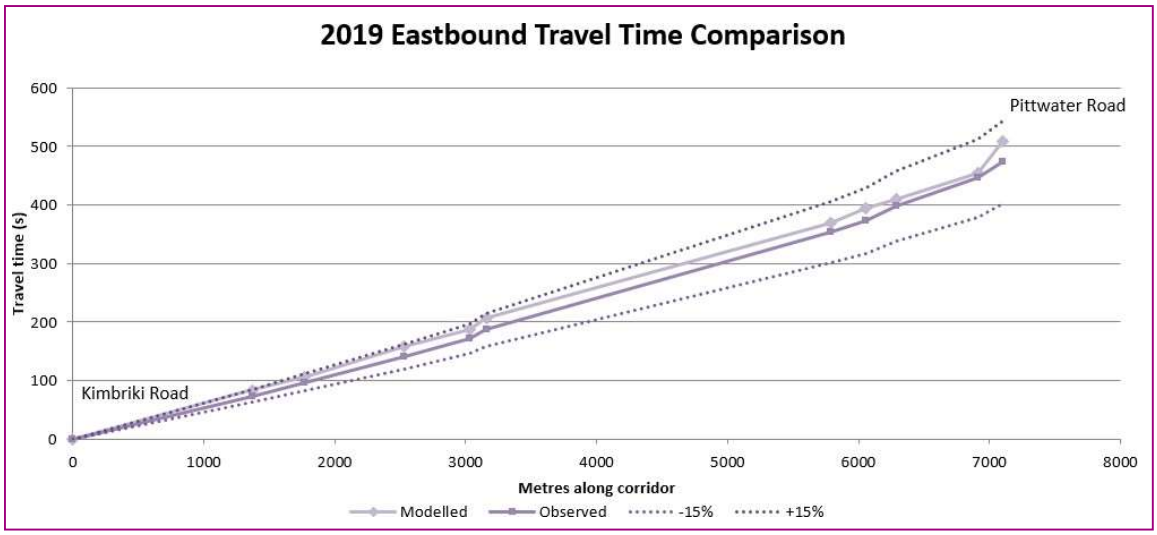



**Figure 12: Eastbound travel time comparison | 12:00 - 13:00**

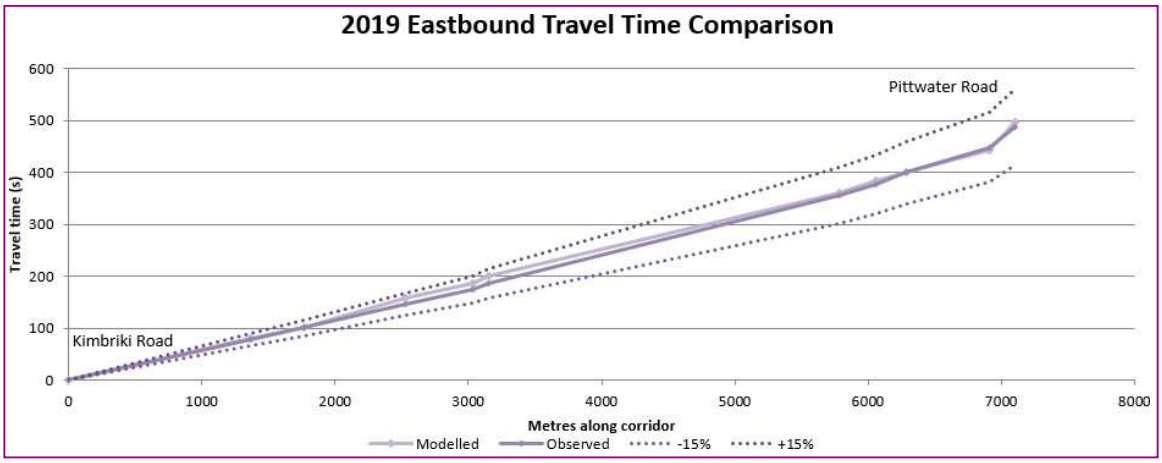



**Figure 13: Eastbound travel time comparison | 13:00 - 14:00**

Figure 12 and Figure 13 demonstrate good validation of observed and modelled travel times, with cumulative travel time plots demonstrating very similar gradients. The cumulative corridor 12:00 – 13:00 modelled travel time is 34 seconds higher than observed (7% difference), with the 13:00 – 14:00 difference being only 9 seconds (2%).

### Westbound

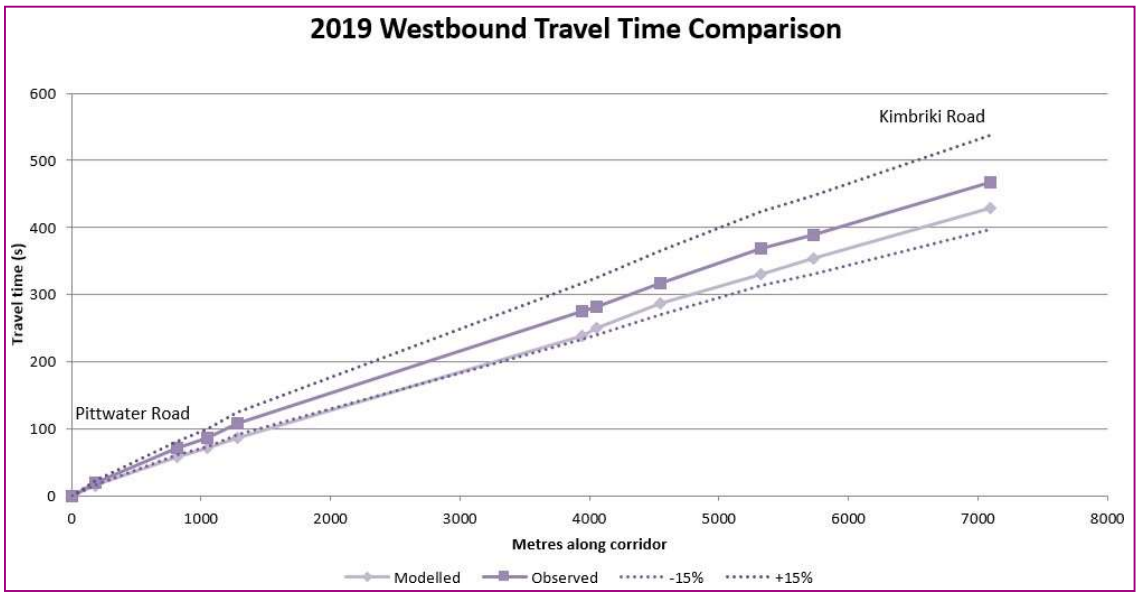



**Figure 14: Westbound travel time comparison | 12:00 - 13:00**

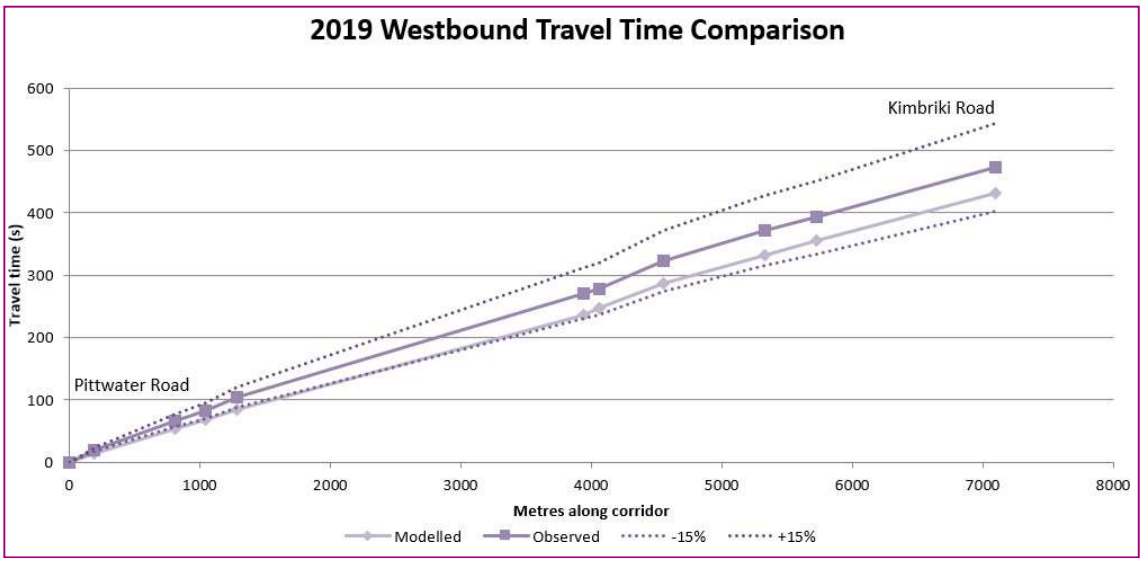



**Figure 15: Westbound travel time comparison | 13:00 - 14:00**

Figure 14 and Figure 15 demonstrate that modelled westbound travel time validation to observed times is good, with both peak hour travel times falling within the 15% criteria. Modelled travel times are slightly lower than observed for the two peak hours, with 12:00 – 13:00 travel time 39 seconds faster than that observed (8% difference) and 13:00 – 14:00 travel time 43 seconds (9%) faster than that observed over the entire 7 km length of the Mona Vale Road study corridor.

## 4.5 Model limitations

The following limitations with the traffic model are identified:

- The project is driven by land use planning for the Ingleside Precinct and the modelled road network therefore covers the surrounding locality and primary roads used by the Precinct. Intersections outside of the study area may be adversely impacted during an evacuation, as will local roads, however these impacts are not assessed as part of this exercise.

This approach conservatively assumes that there will be no traffic withheld at local road intersections, and that all traffic from remoter residential premises will be able to access the assessed road network without hindrance.

- Without the use of SCATSIM, traffic signal coding in VISSIM cannot reflect dynamic signal timings per cycle driven by detectors and maintain intersection offsets. 15-minute Fixed Time operation was adopted such that a degree of variability could be reflected. This gives the model engineer increased control over traffic signals.
- Given large observed cycle time variations between intersections, offsets are not maintained throughout the model period.
- Vehicle Types 'Car' and 'HGV' are used which reflect traffic data recorded for the study; more detailed driver compositions, including, for example, MGV, motorcycles or bicycles are not reflected.
- Modelling is not sophisticated enough to reflect individual premises' evacuation protocols, with the broader population catchment assumed as using the average household car ownership rates. As such, evacuation traffic in evacuation assessment is all comprised of 'Cars'. There are no special considerations made for individual properties or premises that may use alternative vehicles, such as buses, to evacuate.

  Despite this and given that the evacuation traffic demand is informed by population census data, the approach is considered robust. To use an example, a nursing home may evacuate 30 residents on a single bus. The approach adopted would assume these 30 residents use the average car occupancy rate per person (0.66 for the Northern Beaches) and so 20 cars would be assumed as accessing the road network for evacuation. 20 cars would have a greater impact on traffic than a single bus.
- The impact of smoke on driver behaviour is not considered or factored into assessment.
- A key limitation of the study is that evacuation during a bushfire is highly dependent upon human behaviour. The study draws upon behavioural surveys, anecdotal evidence and first-hand discussions with stakeholders in the area; however, it is acknowledged that there may be a notable variance between what people say they will do, and what they actually do or are able to do.
- The impact of climate change is not accounted for in bushfire modelling.
- 'Fire arrival', or the duration of the evacuation window, has been defined as certain fire conditions are prevalent in the Ingleside Precinct; however, it is acknowledged that this duration would be different for premises across the study area and that in reality, a staged evacuation may be more likely in which residents of certain suburbs are required to evacuate before others.
- Whilst the gridded ignition approach removes bias, it is that an approach balancing this with a strategic assessment of fire history and fire input, that is what happens during singular ignitions, may nuance the conservative approach of landscape fire.
- NSW RFS have specific models which have not been used for the purpose of this study.

  Bushfire modelling assumes no suppression occurs, that is no intervention by emergency services to influence the rate of fire progression.
- No bushfire modelling has been undertaken to test preventative measures which could be put in place to mitigate risk.

# 5.0 Bushfire evacuation considerations

## 5.1 Objective

In order to explore the ability for the existing community of Ingleside to evacuate the area in a bushfire emergency, the primary objective of bushfire modelling is to understand a worst-case evacuation window, under certain conditions. That is, to identify the relevant time during which evacuation would be required to occur, between bushfire ignition and the point at which a fire front may arrive at Ingleside.

## 5.2 Background

Bushfire has previously impacted on the suburb of Ingleside, as well as surrounding suburbs. In January 1994, Ingleside was overrun by the Cottage Point fire which started in Ku-ring-gai Chase National Park and transitioned across the landscape in a south-easterly direction, before impacting upon the suburb of Ingleside, causing more than $12 million in damage (in 1994 dollar-value).

No life was lost in Ingleside, however the Cottage Point fire formed part of the 1995 Coronial Inquiry into the 1994 NSW bushfires and was highlighted by the Coroner. Witness testimonial to the inquiry raised concern in relation to the potential future development of the suburb of Ingleside and its bushfire risk. The Coroner at that time noted concerns in relation to the existing road network (which has not substantially changed since 1994) and the ability for residents to evacuate in a bushfire emergency.

Following the release of the Draft Ingleside Structure Plan by the former Department of Planning and Environment (now Department of Planning, Industry and Environment) in 2017, community consultation highlighted ongoing concerns regarding the area's bushfire hazard. Following consultation, the Department commissioned a land use planning-based bushfire risk assessment[4] to analyse the risk profile of Ingleside, in consideration of the Draft Structure Plan. The Bushfire Risk Assessment determined that:

> *'Overall and having regard to the 'inappropriate' development benchmarks prescribed by state-level policy in Planning for Bush Fire Protection (PBP 2018), the scale and complexity of the competing, compounding and cascading risks to life and property indicated by the Draft Structure Plan, supported by the evidence based presented by this risk assessment, determines that currently available mitigation measures are unable to reduce the risk profile created by the Draft Structure Plan to a level which is universally acceptable to DPE, NSW RFS or Northern Beaches Council.'*

The recommendations of the bushfire risk assessment further identified the need for the forward planning pathway for Ingleside to be clearly identified, including addressing the existing risk profile to strengthen community resilience.

This traffic assessment is undertaken in concordance with the above recommendations, filling a gap in the current evidence base in relation to the performance of the road network during bushfire emergency.

One of the key challenges in considering the level of performance is the behavioural aspects of people. Whilst the NSW RFS clearly communicates each year the importance of household survival plans, many residents across NSW's bushfire prone areas do not maintain such a plan or they adopt a 'wait and see' approach.

Increasing reliance on emergency warnings also means communities defer their own responsibility in deciding what action to take and when to leave, instead placing this onus on emergency services. In many instances, residents who receive an emergency warning hesitate to act, instead opting to verify the information with third party sources such as neighbours or social media.

[4] Bushfire Risk Assessment for the Ingleside Planned Precinct, Meridian Urban, 2018

In some situations, emergency warnings simply may not be received in time – this could be due to prevailing fire conditions on the day which result in Catastrophic impacts and disruptions to systems, failure of telecommunications networks, dynamic fire behaviour or loss of power.

Further challenges with assessing the performance of road networks in a bushfire emergency could relate to the decisions which may be made from an emergency management perspective on any given day, pursuant to unfolding situations, resources, weather conditions, spot fire propagation, smoke, tree or debris across roads, traffic accidents, and so on.

It is not possible to test every potential scenario that may prevail on any given day.

The bushfire modelling prepared as part of this traffic assessment is for the express purpose of understanding the potential worst-case evacuation window for Ingleside, from the time of ignition to arrival of the fire front at Ingleside, under a range of conditions. Thus, the modelling remains for a very specific purpose, in support of land use planning and engineering considerations, and cannot be used, interpreted or applied for any other purpose.

## 5.3 Fire Danger Rating system and associated policy

At a national level, a Fire Danger Rating system is in place which translates forecast fire weather into more easily communicable and understood Fire Danger Ratings. There is a total of six Fire Danger Rating categories (Figure 16), each with associated messaging pertaining to what community members should do (Figure 17).

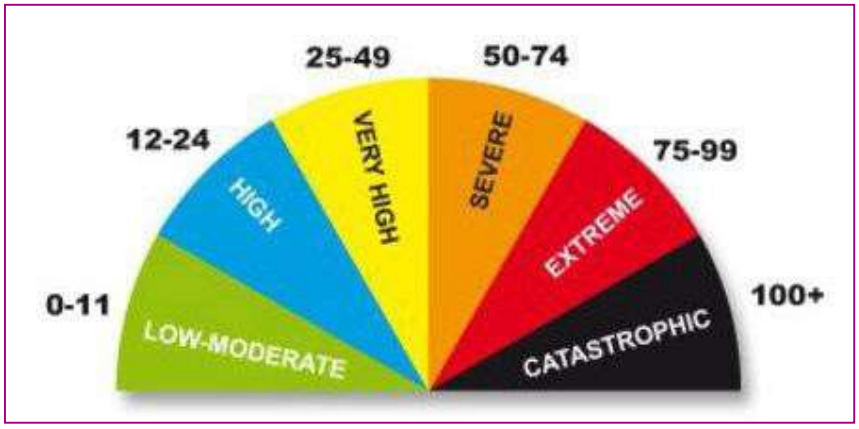



**Figure 16 - Fire Danger Ratings and corresponding FFDI values (Source: ABC News)**


**Figure 17 - Fire Danger Rating messaging for community action**

A new national Fire Danger Rating system, simplified in nature, is currently being prepared and is intended to be released soon. However, for the purposes of this study, the current arrangements are considered.

The Fire Danger Rating and fire weather circumstances are both used to prepare agencies and communities for *upcoming* fire danger. These do not play a role in an emergency.

In NSW, there are three levels of Bushfire Alerts which are issued when an ignition occurs. These are presented in Figure 18.


**Figure 18 - NSW Bushfire Alert levels (Source: NSW RFS)**

Where there is a risk from bushfire, the NSW RFS uses Bushfire Alerts to provide information to affected communities using radio, television, and the internet. However, NSW RFS also notes that fires can threaten suddenly and encourages communities not to rely on a single source for emergency information, and the importance of being prepared and ready to act.

An *Emergency Warning* is the highest level of bushfire alert. The alert will give information about the severity of the fire, its location and what individuals should do.

Bushfire Alerts are not always given in the order illustrated in Figure 18.

A fire may be at *Watch and Act* or *Emergency Warning* first. Some fires start and spread so quickly that there is no time for any warning at all. NSW RFS encourages individuals to be prepared to put bushfire survival plans into action with little or no warning, and to use Bushfire Alerts in bushfire survival plans as triggers to leave early or prepare to stay and defend where appropriate.

The NSW RFS maintains its own, internal processes which dictate which type of Bushfire Alert is issued and when.

The NSW RFS 'Fires Near Me' app is a reliable and accurate source of bushfire activity and alerts across the state.

## 5.4 Emergency management legislation and regulation

NSW RFS, along with other emergency management agencies in NSW, are required to carry out and abide by a range of statutory emergency management activities to plan for prevention, preparation, response and recovery (PPRR).

The responsibilities of the NSW RFS are set out under the Rural Fires Act 1997 (Act). This legislation sets out the many and varied PPRR activities required of the NSW RFS which includes (but is not limited to) the convening of bushfire management committees, the preparation of bushfire management (mitigation) plans and the designation of neighbourhood safe places.

Part 4 of the Act sets out the agencies' responsibilities in relation to bushfire prevention. This includes the NSW RFS duty to prevent bushfires, to plan for and undertake bushfire hazard reduction, declaration of general and local bushfire danger periods, declaration provisions for total fire bans (known as TOBANS), land use planning provisions and development controls provisions, vegetation clearing, and so on.

The regional offices are involved across a range of prevention and preparation responsibilities, including risk assessments, evacuation planning including liaison and coordination, and working alongside NSW Policy and the local emergency management committee (LEMC) at Council.

It is critical to note this work, which must be considered in parallel to the purposes of this study, is in support of a land use planning activity which considers emergency management, rather than an emergency management activity in itself. Despite this, all findings of this work will be provided to the regional office of the NSW RFS and the Council LEMC.

## 5.5 The process of evacuation

How evacuations are planned, managed and executed requires diligent consideration. These processes are all the more complex when involving large communities, in emergency situations.

### 1.1.1 Policy

Following the 2009 Victorian Bushfires Royal Commission (Commission), national policy regarding messaging around bushfire evacuations has changed. Prior to February 2009, the core message was 'stay or go' however, the Commission found this message to be too simple, and does not readily communicate the fact that attempting to evacuate when it is too late places life at risk. That message has now been changed to 'leave early, or stay and defend a well-prepared property'. This does not apply in Catastrophic fire danger contexts, where leaving early is the only option to ensure survival.

Unfortunately, there are circumstances in which it becomes too late to leave and that is usually because the passage to safety has been overrun by fire.

In Catastrophic situations, when systems fail, communities may not receive emergency alerts for a variety of reasons – the telecommunications networks may be damaged or lost, electricity is lost, or the fire situation may be so dynamic that systems are not keeping pace. In a world with a changing climate, it is entirely necessary to contemplate situations which may be considered incomprehensible under blue sky conditions.

### 1.1.2 AIDR evacuation handbook

Where evacuation warnings are issued, human nature intervenes. As such, it is necessary to contemplate human behaviour as part of the evacuation planning process, which reflects the reality of how communities and individuals generally react in emergency evacuation situations.

The Australian Institute of Disaster Risk Reduction (AIDR) in 2017 released Handbook 4 – Evacuation Planning, as part of its Handbook Series. This handbook incorporates guidelines and considerations for developing community evacuation plans underpinned by an all-hazards approach. It uses the nationally recognised five stages of the evacuation process as a framework for planning an evacuation. The purpose of the handbook is to guide pre-event community evacuation planning, which will in turn maximise the efficiency and effectiveness of evacuation processes.

The handbook identifies five stages of the evacuation process as follows:

1. Decision to evacuate
2. Warning
3. Withdrawal
4. Shelter
5. Return.

After a fire is reported and fire services respond, the behaviour of the bushfire is assessed. Over time, and perhaps quickly depending upon the day's fire weather and localised weather, topography and fuel load conditions, authorities may decide to issue a warning which may require evacuation action. That action may either be:

- self-determined by the individual based on the nature of information available, potentially framed by previous experience, or
- advice to evacuation may be issued by fire authorities once a decision by authorities is reached and communicated (either via door knocking, by mobile app, online, over the radio or television or other means).

In either case, stages one and two of the evacuation process will take some time.

One of the matters not addressed by the AIDR handbook is the interface of the evacuation process with human behaviour and decision-making processes, which become strained in an emergency. Work undertaken by Steve Opper of the NSW State Emergency Service (SES) in relation to flood evacuation modelling offers some insight into this aspect of evacuation.

Opper (2004 and 2014) identifies that individuals will generally seek to fact-check information or get second opinions to confirm the veracity of the information. Human processing of important information in an emergency can become illogical or irrational, as people become confused or panicked.

Individuals will seek to confirm evacuation warning information with neighbours, consult social media, online news websites, mobile phone apps or other sources. All of this occurs *before* a decision is made to evacuate. Opper's work refers to this period as the 'Warning Acceptance Factor' within the SES flood evacuation model.

Once the decision is made, people will take time, whether it be 5 minutes or 1 hour, to collect personal items, load them and their family into vehicles and leave their property. Opper refers to this stage as the 'Warning Lag Factor'.

Evidence from a Bushfire Cooperative Research Centre (BCRC) mail survey of households affected by the 2009 Victorian Bushfires indicates a variation in evacuation departure times (Figure 19[5]), with most of those who decided to evacuate doing so within 2 hours of the fire arrival time, and 20% attempting to leave *after* the fire had arrived.

| Departure Time before the fire arrived | Percentage of those who left during the bushfire |
|---|---|
| More than 8 hrs | 11.8% |
| 4 hrs – 8 hrs | 7.4% |
| 2 hrs – 4 hrs | 12.7% |
| 1 hr – 2 hrs | 14.8% |
| 20 min – 1 hr | 17.4% |
| 10 min – 20 min | 8.8% |
| Less than 10 min | 7.2% |
| Left when the fire had already arrived | 19.9% |

**Figure 1 - Evacuation departure data for the 2009 Victorian Bushfires**

Once individuals have moved onto the road network to evacuate, limitations of the road network to handle the capacity of surge vehicle volumes will be felt. Opper refers to this period as the 'Travel Time'. The road network may be impacted by vehicle accidents, fallen trees, fallen power lines or other non-typical conditions caused by the bushfire. This may extend the period in which some vehicles are on the road network.

In some cases, those evacuating may not be able to utilise the road network to evacuate if it has become compromised and too dangerous. In these cases, residents would need to take shelter in-situ. Neighbourhood safer places could be an option in this regard.

One of the stages of the AIDR handbook focuses on evacuation shelters and planning their location and the facilities available. The first policy for evacuation in NSW is to encourage persons to travel to the homes of family or friends in the first instance. Ideally, people will pre-plan for this, however this is not always the case. Many evacuees will evacuate without a destination in mind; their priority will simply be to get to safety. Evacuees on a part of the road network that is not exposed to or flanked by a hazard, thus not at risk, is an acceptable outcome.

In this case, it is likely any evacuation centres opened would be south of Ingleside on the Northern Beaches, rather than to the west or north (towards Palm Beach). To this end, it is reasonable to expect most traffic evacuation from or through Ingleside will evacuate to the east and/or south.

The AIDR handbook focuses primarily on the preparation of evacuation plans, and as such it is reasonable that it does not consider the traffic or human behaviour interface. However, both issues are considered as part of this study.

[5] Mowbray Road Precinct Strategic Review, SMEC, November 2011

## 5.6 The context of human behaviour

Evacuation processes in bushfire emergencies tend to be complex, as result of both the nature of bushfire intensity and its interactions with the landscape and settlements, as well as its interface with human behaviour which can be unpredictable in times of emergency.

In 2018 a seminal piece of research was released by Dr Josh Whittaker and Dr Mel Taylor[6] on behalf of the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC). This work was conducted for the NSW RFS.

January and February 2017 saw several destructive bushfires in NSW, some of which occurred during Catastrophic fire weather conditions.

These fires damaged and destroyed a range of assets including houses, outbuildings, community halls, livestock, machinery, fences and other agricultural assets. Fortunately, no human lives were lost.

The NSW RFS commissioned the BNHCRC to undertake research into community preparedness and responses to bushfires in NSW in 2017, using the following themes:

- Information and warnings
- Planning and preparedness measures.

This work included several key insights which are relevant for consideration as part of this study. These include:

- Most people interviewed do not intended to leave before there is a fire on days of Catastrophic fire danger. Those who intend to leave will wait until there is a fire, and others intend to stay and defend.
- 12% of those interviewed left for a place of safety when they received a Catastrophic fire danger warning (this almost matches the proportion of evacuees who left more than 8 hours in advance of fire arrival during the 2009 Victoria bushfires).
- Only 12% of interviewees stated they would leave early upon receiving a Catastrophic fire danger warning next season. 24% said they would wait and see if a fire started before leaving, 27% said they would prepare to stay and defend and the final 24% said they would wait for a fire to decide what action to take.
- The analysis of interviewees determined that some people underestimate the risks to life and property if fire danger is not Catastrophic.

Seemingly, the reality of human behaviour when considering or confronted with a bushfire emergency remains largely counter to fire agency policy and community messaging, regarding what actions individuals should be taking relative to circumstance.

This presents a conundrum of sorts from a planning perspective, on whether strategic planning decisions should be made based on emergency management policy, or the reality of human behaviour derived from research. The answer likely lies in between.

## 5.7 Life loss data from Australian bushfire events

One of the unfortunate aspects of considering emergency evacuation processes is historical life loss data in Australia, as a result of bushfire events. The reason this is necessary is because of the extent of life loss which has historically occurred as a result of evacuation activities.

In 2012, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in conjunction with the former Bushfire Corporative Research Centre undertook a comprehensive study into matters of both life and house loss, utilising over 110 years (1901-2011) of data across 260 bushfire events

[6] Community Preparedness and Responses to the 2017 New South Wales Bushfires, Whittaker and Taylor, February 2018

(Blanchi et al. 2012[8]). Over this period, a total of 825 known civilian and firefighter fatalities have occurred[7]. More have occurred since this period.

Important findings of this research are as follows:

- It is evident that fire weather and proximity to forest are very strong contextual drivers for defining the potential for fatalities to occur.
- 85% of fatalities occurred within 100 metres of bushland.
- 50% of all recorded facilities have occurred on days exceeding Forest Fire Danger Index (FFDI) 100. Most fatalities occur as a result of infrequent but high magnitude events.
- Late evacuation is the most common activity persons were engaged in at time of death (30.3%) followed by sheltering inside a structure (24.8%) and defending a property outside (22.4%).
- For those instances where enough data is available with respect to fatalities occurring during the act of evacuation, most were trapped on roads by either fallen trees or become bogged, the remainder having run off the road due to poor visibility as a result of smoke conditions.
- In terms of location of fatal exposure, 50% occurred out in the open (including persons found outside structures and outside vehicles) and 28% occurred inside structures. In events where FFDI exceeded 100, fatalities within structures represented over 75% of life loss;
- The percentage of fatalities within structures appears to be increasing over time, mostly attributed to the 2009 Victorian Bushfires where 118 of the 173 fatalities occurred inside a structure.
- During the 2009 Victorian Bushfires, findings demonstrate that most of those persons who lost their lives ‘could not respond appropriately to the risk the bushfire presented’ on that day.
- Increasing percentages of fatalities occurring within structures in later fires (1965-2011) were persons aged 65 and over, as well as those with physical and / or mental disability.
- Most fatalities occur between the hours of 3pm and 9pm, when FFDI is at its peak (3pm) and when summer cool-change winds occur. 90% of fatalities occur immediately after afternoon wind changes.
- 41.9% of fatalities which occurred from 1965 to 2011 ‘were aware of the fire with enough time to save their lives, had a fire plan and were following intended actions which were ineffective’, with 21.8% who also had enough time to save their lives but either had no fire plan or that plan was not followed (including persons who were ‘waiting to see’).

  10.9% were unaware of a fire and only realised when it was too late, and a further 10.7% were either children or adults following the instructions of another person. 6.1% were either physically or mentally incapable of implementing an effective survival strategy.

Having regard to this data, it is clear to see the complex relationships between fire danger, human behaviour and evacuation processes, hence the importance of this particular study to assist in supporting risk-informed land use planning decision making.

[7] Life and house loss database description and analysis, Blanchi et al., December 2012

# 6.0 Bushfire modelling

## 6.1 Methodology: determining a potential evacuation window

The purpose of the bushfire modelling component of this traffic assessment is to understand a potential worst-case evacuation window, that is the duration from time of ignition to fire front arrival at Ingleside. The reason for this is to guide performance of traffic models assessing possible bushfire behaviour.

During the 1994 Cottage Point fire, ignition occurred several days prior to its impact on Ingleside and surrounding suburbs. However, fire weather is highly dynamic, as a rule. In most bushfire events, warnings will escalate from *Advice* to *Watch and Act*, or sometimes straight to *Emergency Warning*. These are also known as Bushfire Alerts, and emergency services routinely communicate that residents should never wait for a warning before deciding to take action or evacuate, as some fires spread so quickly there may not be time for a warning (NSW RFS, 2019).

This being the case, it is necessary to consider how long residents may have to safely evacuate, as opposed to how long it may take. In order to determine this window, or period of time, the evacuation window begins from the time of a potential ignition to the time of fire front arrival at Ingleside (which could be expedited by the coalescence of spot fires within the Precinct), which for the purposes of this traffic assessment is taken to signal the end of the evacuation window.

Spot fires occur where embers, thrown out by bushfire ahead of the fire front, start isolated fires which build in intensity to eventually be drawn back toward the advancing fire front. This phenomenon often results in perceptions of multiple fire fronts coming from multiple directions. This phenomenon is an important consideration in evacuation.

Critical to formulating an understanding of a worst-case evacuation window, there are two central aspects:

- fire weather conditions; and
- location of ignition.

Both aspects are highly variable. Fire weather conditions change remarkably across hours and minutes throughout the day. Likewise, the location of an ignition point cannot be foreseen, however some locations can have a higher likelihood, for example: along bushland-flanked and remote roads, camping sites, access tracks and trails.

In these locations, accidental ignitions can be more likely (for example from discarded cigarette butts or unattended campfires), as can deliberate ignition (arson activity where persons may be concealed from view but able to make a swift escape). Natural ignitions (for example from lightning strike) are more random in nature, though recent pilot studies are beginning to better understand potential lightning strike activity across regions which may correlate to increased understanding of natural ignition likelihood.

One the basis of the above, it is necessary to undertake a series of scenario-based bushfire models in order to understand the variability of bushfire behaviour across different instances of fire weather and ignition location.

### 6.1.1 Scenario-based assessment

It is not possible to model every possible fire circumstance or scenario which may prevail on any given day. To this end, an approach which reflects a range of potential scenarios, across different fire weather circumstances, and different ignition locations across the wider region was adopted.

**Fire weather circumstances**

A range of different fire weather scenarios are required to reflect the scale and diversity of fire behaviour and intensity that may occur, subject to different hourly and daily FFDI values. FFDI was developed by McArthur[8] in 1967 and forms the basis of bushfire intensity modelling in Australia. It is an

[8] Fire behaviour in eucalypt forests, A.G. McArthur, 1967

estimate of fire danger based on a combination of meteorological variables (dryness, rainfall and evaporation, wind speed, temperature and humidity). The index of 100 was set to coincide with weather conditions during the Victorian 1939 'Black Friday' fires[10].

It is commonly identified by Australian fire services that opportunity for direct fire suppression becomes compromised at FFDI 50. Likewise, it is around FFDI 50 where house loss trends escalate in Australian bushfires[9].

The 1994 Cottage Point fire which impacted upon Ingleside and surrounding communities appeared to occur on a day where the FFDI was at approximately 62-64, as recorded at the Richmond weather station on 8 January 1994. However, anecdotal evidence provided by the NSW RFS indicates that local fire weather at Ingleside may have been more extreme.

Irrespective, the first fire weather scenario adopted for the purposes of the bushfire modelling component of this study is **FFDI 64**, to correspond with the fire weather recorded on 8 January 1994. This fire weather scenario represents quite regular fire weather patterns for this part of Greater Sydney, on an annual basis, under which somewhat remarkable damage and loss was sustained in 1994.

At the other end of the scale, FFDI 100 represents the upper extent of the FFDI scale beyond which conditions are considered to be 'Catastrophic'. The highest recorded FFDI on record at the Terrey Hills weather station was 116 which occurred on 26 November 2015. Land use planning and building regulation for bushfire hazard in this area of NSW requires planning and building responses to encompass an FFDI of 100.

At this stage, climate change is not factored in to mapping or fire behaviour intensity approaches. On this basis, whilst it is acknowledged that FFDI 100 represents the planning and building design parameter, a climate-adjusted scenario for the purposes of this study is adopted at 116, which is the highest FFDI on record for the region. This represents a somewhat rudimentary approach to the inclusion of climate change factors, however in the absence of further evidence or information, the PSC agreed this to be a satisfactory approach.

Thus, **FFDI 116** represents the second fire weather scenario adopted for the purposes of the bushfire modelling component of this study.

Between FFDI 64 and FFDI 116, a further fire weather scenario was sought. In conjunction with the FFDI is the national Fire Danger Rating system. This currently includes six categories of fire danger, upon which public messaging is communicated in relation to the expected level of fire danger and the fire services' expectation of the actions that communities and individuals are expected the take. The Fire Danger Rating system is currently being reviewed with a view to being replaced soon, however for the purposes of this study, the current Fire Danger Rating systems is used.

FFDI 64 equates to a Fire Danger Rating of 'Severe' which includes the FFDI values from 50 to 74. FFDI 116 equates to a Fire Danger Rating of 'Catastrophic' which accounts for FFDI values of 100 and higher. 'Extreme' Fire Danger includes the FFDI values from 75 to 99.

The FFDI 116 fire weather scenario accounts for a very high bushfire intensity scenario which is accompanied by specific messaging to the community in relation to the need to leave early. Thus, it is ideal to test a fire weather scenario with a lower FFDI, and one that attracts a different community message under the Fire Danger Rating system to that associated with an FFDI 64 or FFDI 116 scenario.

Thus, a FFDI within the 'Extreme' Fire Danger Rating range, but toward the lower end of the range was identified as appropriate. This was chosen because community perception of fire danger is likely to be different at this range when compared to the other two scenarios, and public messaging regarding leaving early and evacuation in accordance with the national Fire Danger Rating system is also different.

[9] Queensland Bushfire Risk Planning Project, Leonard and Blanchi, 2012

Thus, **FFDI 77** was selected for this purpose as the third fire weather scenario adopted for the purpose of the bushfire modelling component of this study.

### Ignition locations

Historical ignition data was initially used to derive an ignition location methodology across Ku-ring-gai Chase National Park and Garigal National Park. This methodology noted that most ignitions are either naturally occurring, or accidental or deliberate and thus relying on human intervention.

Available research into accidental ignition and arson activity note the strong relationship between accessibility and concealment. That is, the ability for human access – either via remote roads, along trails or at camping sites – and in cases of arson, the ability to conceal one's actions and make an immediate departure from the area. To this end, roads, trails, campsites and places of human interest within the National Parks is of key interest.

This is also predicated on ignitions occurring within the national parks and not within Ingleside or surrounding communities. This is recognised; however, such ignitions may take longer to reach maximum rate of spread due to a level of fuel fragmentation and are more likely to be reported in a shorter period of time due to the proximity to residences.

As per the bushfire risk assessment[10] completed in 2018, fire runs from Ku-ring-gai Chase National Park in particular, running south-easterly towards Ingleside, represent the key fire runs during higher FFDI events. As such, it is these runs which remain the focus of the bushfire modelling component of this study.

Upon discussion of this methodology with NSW RFS, an alternative ignition methodology was collectively identified. One of the shortcomings of basing ignition location on lightning strike, along roads, trails and publicly accessible locations is unconscious bias, and an inherent higher level of assumption in relation to ignition location and likelihood.

To overcome this, a 'gridded ignition' approach has been adopted. This approach requires the bushfire modelling software to ignite fires across a grid, which is overlaid on a determined geography. In this case, the relevant geography extends west across the entirety of Ku-ring-gai Chase and Garigal National Parks to the Pacific Motorway.

Across this area, a 1km$^2$ mapping grid is overlayed, surrounding the existing settlement of Ingleside. An ignition point, for the purposes of bushfire behaviour modelling, is located within each grid square, which in this case equates to 31 random ignition points. The location of these ignition points is illustrated in Figure 20.

[10] Bushfire Risk Assessment for the Ingleside Planned Precinct, Meridian Urban, 2018

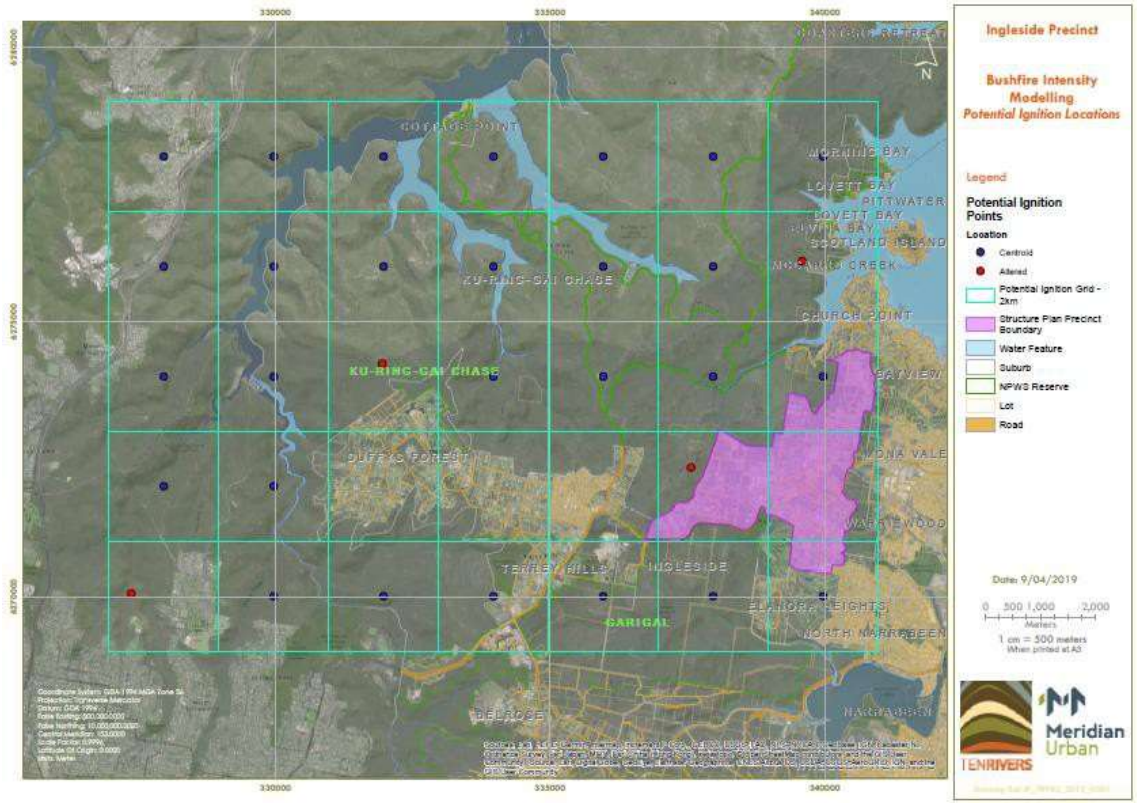



**Figure 20 - Gridded ignition point locations**

This approach effectively removes the potential for unconscious bias, by maintaining a structured yet random approach to ignition location and likelihood. All ignition points are 'lit' within the model at the same time, in order to measure time from ignition to arrival of fire front and coalescence of spot fires to a point where safe evacuation likely becomes compromised.

Based on the fire weather circumstances and ignition location methodologies set out above, a total of

**93 discrete bushfire behaviour scenarios** were undertaken.

### 6.1.2 Phoenix Rapid Fire

In order to test the 93 bushfire scenarios identified, a bushfire behaviour modelling platform known as 'Phoenix Rapid Fire' was utilised. Phoenix Rapid Fire (Phoenix) is a research tool developed by Dr Kevin Tolhurst and Dr Derek Chong of the University of Melbourne. It has been used by fire agencies for both incident prediction and as a key tool for bushfire risk assessment and strategic bushfire management planning. Phoenix is more commonly used as a fireground prediction model but has been proven to have a high level of accuracy in retrospectively modelling the fire spread of specific events, such as the Kilmore fire during the 2009 Victoria fires.

Phoenix simulates bushfires across various fire weather conditions and across different vegetation communities, or fuel loads. Phoenix simulation outputs may not reflect *actual* fire spread. There are several input layers and sub-models within Phoenix, each of which must be validated. The model is also sensitive to minor differences or shifts in weather, fuel accumulation and other factors.

The 93 bushfire modelling scenarios were input into Phoenix, with assessment detailed in separate modelling report included in **Appendix B,** which includes the range of additional data inputs used as well as key observations.

When considering this reporting and its observations, the bushfire modelling prepared as part of this study is for the express purpose of understanding the potential worst-case evacuation window for Ingleside, from the time of ignition to arrival of the fire front at Ingleside, under certain conditions.

Thus, the modelling remains for a very specific purpose, in support of land use planning and engineering considerations, and cannot be used, interpreted or applied for any other purpose.

The report provided in Appendix B, prepared by Ten Rivers, identifies several key observations, including:

- Fire behaviour modelled at FFDI 64, +3 hours from ignition:
    - Mona Vale Road would likely be impacted by fire, to the west of McCarrs Creek Road, before this moment in time
    - There is no direct impact on Ingleside, though the fire front is approaching Wirreanda Valley
    - +4 hrs from ignition, larger scale conflagration impacting on Ingleside
- Fire behaviour modelled at FFDI 77, +3 hours from ignition:
    - Mona Vale Road is likely to be impacted by fire at Kimbriki Road – this seems likely around 2 hours 30 minutes from ignition, noting fire front arrival at the western edge of Ingleside has not occurred at this point
    - Spot fire ignitions within Ingleside have started
- Fire behaviour modelled at FFDI 116:
    - At +2 hours from ignition, fire is present within the Ingleside precinct
    - At +3 hours from ignition, Mona Vale Road would be impacted by fire at several locations along its length and larger scale file conflagration is impacting on Ingleside

An illustration representing modelled bushfire conditions at FFDI 77 3 hours after fire ignition is provided in Figure 21.

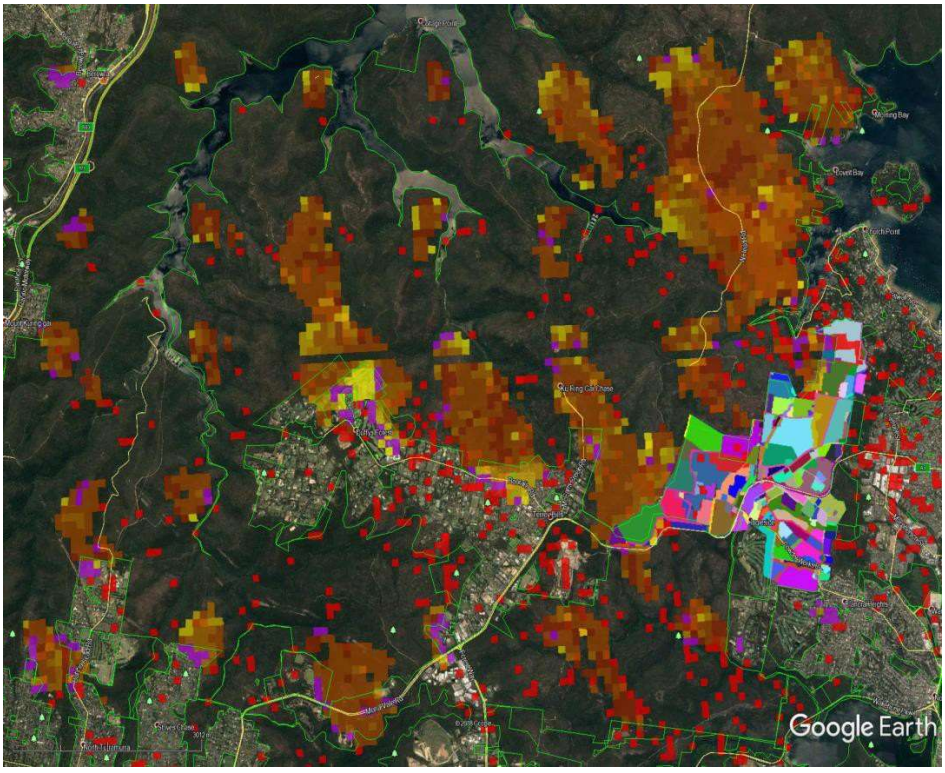



**Figure 21 - Extract of bushfire behaviour simulation at 3 hours post-ignition for FFDI 77**

From a strategic perspective, it is critical to note the closer ignition points to Ingleside through this modelling process will impact on Ingleside or surrounds more quickly than those which are further away. However, the purpose of this exercise is to determine the potential worst-case evacuation window. Singling these closer points out introduces bias into the process and on this basis, they remain part of the broader gridded ignition group.

The indicative worst-case time to impact is **approximately 2 hours 30 minutes** for immediate ignition locations, though smoke and ember attack is likely to be significant in advance of this.

Across different fire weather scenarios, the determined evacuation window varies from 2 hours 30 minutes to 4 hours. This does not include the effect of smoke on the ability to evacuate, noting reduced visibility from considerable smoke impact may lead to early road closures.

Mona Vale Road to the west of Ingleside is likely to be impacted by fire between 2 hours 30 minutes and 3 hours from ignition in each fire weather scenario. At FFDI 77, Mona Vale Road is likely to be directly impacted in several locations by conflagration moving out of Ku-ring-gai Chase National Park. This is not only relevant to consider in terms of impact on the ability for the residents of Ingleside to evacuate, but also the residents of Terrey Hills and Duffys Forest to the west.

This particular aspect of likely impact on Mona Vale Road is commonly known by local emergency services, and emergency management arrangements are in place to manage Mona Vale Road in case of an emergency.

Some ignition points to the west of Duffys Forest, even under FFDI 116 conditions, do not appear to lead to an impact on Ingleside. This is largely due to the fact there are too many points of interruption to fuels, noting also the Phoenix simulations do not account for any suppression activity (i.e. firefighting). It is likely that suppression activity by land management agencies and fire services will be ongoing.

## 6.2 Identifying the evacuation window

The assessment provided in Appendix B was presented to the PSC for consideration. In advance of this, a separate discussion was held directly with NSW RFS on the technical nature of the modelling performed. Based upon the exclusive purpose or nature of the modelling, NSW RFS was satisfied with the technical componentry, inputs and processes undertaken.

The PSC requested a detailed identification of the relevant evacuation window. In order to determine this, there were several component elements for consideration, one of the key issues being which fire weather scenario of the three (FFDI 64, 77 or 116) should be considered for the purposes of understanding a worst-case evacuation window.

Whilst FFDI 116 is a worst-case fire weather scenario, it may *not* represent a worst-case scenario from a traffic perspective.

Whilst only 12% of people are likely to act on fire agency advice to leave early (understood from the 2017 BNHCRC research[7] as well as the departure data from the 2009 Victorian Bushfires[6]), it must be considered that this proportion of persons who leave early may *not* decide to do so under a lesser Fire Danger Rating. That is to say, more people may remain home in an FFDI of 77 than FFDI 116, meaning more people would need to evacuate during the evacuation window under FFDI fire weather conditions.

In addition, the evacuation of Ingleside cannot be considered in isolation; other surrounding suburbs will also likely be evacuating from the same event, including potentially Terrey Hills, Duffys Forrest, Bayview and Elanora Heights. Not only will these residents be potentially accessing the same road network around the same time, but their ability to evacuate must also be considered as part of the future of Ingleside. That is to say, the ability for surrounding suburbs to evacuate should be maintained, and not worsened, by any development activity undertaken in Ingleside.

Taking these matters into consideration, adoption of the FFDI 77 scenario upon which to analyse the worst-case evacuation window was selected, noting the potentially higher number of vehicles on, and accessing, the road network in the event of an evacuation.

**On the basis of FFDI 77, a worst-case evacuation window of between 2 hours and 20 minutes and 2 hours 40 minutes is identified.**

One of the challenges in identifying the window, is its closure, or the point at which the modelling indicates that safe evacuation may no longer be feasible; this is a complex issue.

In the case of impact upon North Ingleside, spot fires have coalesced into larger fires as the main fire front impact is immanent between the period of 2 hours 20 minutes and 2 hours 40 minutes. These conjoined spot fires have a flame height of more than 1 metre and is spotting in and around key road networks. Mona Vale Road to the west is also compromised. The extent of smoke is unknown at this stage. On this basis, the above window is considered the point at which safe evacuation of Ingleside is compromised.

## 6.3 Assumptions

The bushfire behaviour modelling to inform this work assumes a conflagration event, with multiple ignitions in the area. This approach removes the potential for unconscious bias, by relying upon a gridded ignition approach which assists in establishing time to fire arrival under worst case conditions.

The approach also assumes a worst-case scenario situation. This is important in testing the capacity of the road network to function in emergency, in a situation likely to see more residents at home during the event than at work or at school, and with weekend ‘beach’ traffic traversing Mona Vale Road. This scenario does not reflect catastrophic fire weather conditions as the worst case scenario, as in those situations residents will be urged to leave by authorities, well ahead of any ignition. To this end, the fire weather scenario utilised at FFDI 77 is of a level which can give rise to extreme bushfire behaviour, with the possibility of a higher number of residents choosing to remain at home.

## 6.4 Exclusions

The bushfire behaviour modelling cannot be used or interpreted for any other purposes than to inform a traffic study to support strategic land use planning. It is not intended to support emergency management decisions or protocols.

# 7.0 Evacuation assessment

This section details the assessment undertaken of various bushfire evacuation scenarios.

The report acknowledges that bushfire behaviour is highly variable and dependent upon multiple factors which are difficult to foresee. From ignition location and time of day, to prevailing weather conditions and fire fuel load, factors associated with bushfire progression are unique to individual events, rendering testing of all possible outcomes impossible.

This assessment uses a wealth of observed input data, research, behavioural surveys and industry expertise to test a unique set of conditions that are considered representative of how an event may unfold in the study area, though does not constitute a prediction, nor claim to be wholly encompassing of the potential outcomes of any future bushfire event in the region.

## 7.1 Evacuation scenarios

4 traffic evacuation scenarios have been assessed to provide an indication of prevailing traffic conditions under the bushfire scenarios considered in the study area. Scenarios tested are listed below:

- Reference Case (2023)
- Scenario 1 (2023)
- Scenario 2 (2019)
- Scenario 3 (2023)
- Scenario 4 (2023)

Components of Scenarios 3 and 4 were informed by preceding scenario findings; as such, details of these components are discussed further in the respective ‘Description’ sections below, following findings of preceding scenarios.

## 7.2 Traffic demand

Section 4.1.2 details the observed intersection turn count surveys that were undertaken to inform existing (Base) case conditions and model development; these turn counts represent traffic conditions ‘typical’ of a Sunday afternoon.

This section discusses how *evacuation* traffic demand was derived, through use of existing intersection turn counts, census data and behavioural research.

For the purpose of this study, evacuation traffic demand has been considered as two key components: background traffic and evacuation traffic.

**Background traffic** refers to traffic coincidentally on the road network at the time of a bushfire event. Observed intersection turn count surveys form the starting point for determining this component, with adjustments made temporally to the demand to reflect how driver behaviour would change in the event of a bushfire event.

**Evacuation traffic** refers to vehicles that would otherwise not be on the road network at the time of a bushfire event. This represents residents and visitors to the area who use their private vehicle to depart from the area in response to the risk posed by a bushfire.

Further detail on the derivation of these components of demand are provided in Section 7.2.2 and

7.2.3 below. Directional routeing of these two components is discussed in 7.2.4.

### 7.2.1 Traffic profile

Section 4.2.3 discusses the rationale for adopting a Sunday Midday as the assessment period, that being the necessity to balance the requirements for high home occupancy and busy roads which the local population would use to evacuate.

Section 6.1 details the distinct purpose of the bushfire assessment in this study as being identification of the time period within which an evacuation would be required to take place, measured from fire ignition to a time at which ember spotting is expected to occur in the Ingleside Precinct (termed 'fire arrival').

From a traffic perspective, a fire arrival time of **13:00** would represent the worst-case time given this coincides with peak 'typical' traffic conditions on the road network. The approach adopted was therefore to use this fire arrival time as a reference from which the fire ignition time could be identified.

Adopting a **2 hour 30 minute** evacuation window, informed by bushfire assessment discussed in Section 6.2, the fire ignition time is taken as **10:30**. Alignment of temporal fire progression and model simulation periods is presented in Table 17.

**Table 17: Fire progression during modelled time periods**

| Time of day | Model period | Model state | Fire and road network conditions |
|---|---|---|---|
| **10:30** | N/A | Model begins at 11:00 | Fire ignition occurs |
| **11:00 – 12:00** | 'Warm up' | Traffic begins to enter the model and queuing develops<br>Unsuitable for performance assessment | Early fire development occurs from gridded ignition points and progresses per bushfire assessment<br>First residents begin to evacuate |
| **12:00 – 13:00** | **Peak hour 1** | Model traffic demand is fully populated<br>Outputs suitable for assessment | Fire continues to develop and progress, with first signs of ember spotting reaching the Ingleside Precinct by 13:00<br>Increased residential evacuation |
| | | | Roads in the study area are impacted by fire, rendering them unusable for evacuation |
| **13:00 – 14:00** | **Peak hour 2** | | Fire has arrived at the Ingleside Precinct and many other built up suburbs in the study area, and continues to develop and progress |
| | | | Further residential evacuation post-fire arrival |
| | | | Roads in the study area are impacted by fire, rendering them unusable for evacuation |
| **14:00 – 14:30** | **Cool down** | Replicates the final half hour of Peak hour 2 to allow vehicles already in the network to complete their trips<br>Unsuitable for performance assessment | Fire continues to develop and covers a large area of bushland and built up suburbs in the study area<br>Roads in the study area are impacted by fire, rendering them unusable for evacuation<br>No further residential evacuation |

The traffic model simulation begins after fire ignition, as traffic conditions at the moment of ignition would be considered 'typical' and do not require assessment. The 'warm up' period is used to populate the traffic model with vehicles prior to the periods which are to be assessed, those being Peak hours 1 and 2. As such, the 'warm up' period is a necessary model function but is **not** representative of road network conditions and is not used for assessment. It does however include components of traffic demand responding to the bushfire, in order to ensure conditions at the start of Peak hour 1 are representative.

### 7.2.2 Background traffic demand derivation

Background traffic refers to traffic coincidentally on the road network at the time of a bushfire event. Observed intersection turn counts were used as a basis for deriving this traffic component; however, adjustments were made to reflect how motorists would change their travel patterns in response to a developing bushfire event.

This section sets out the approach taken to adjust observed intersection turn count data to derive the evacuating background traffic component. Warm up and cool down matrices were simply derived as factors of the resultant final peak hour matrices, and so discussion initially focuses on derivation of peak hour 1 & 2 traffic demand, before finishing with a brief description of how warm up and cool down matrices were determined.

**Peak hour (1 & 2) traffic demand**

Several steps were taken to adjust the observed intersection turn counts to reflect how 'typical' driver behaviour would change in the event of a bushfire.

| Step | Description |
|---|---|
| **1** | Apply seasonal uplift |
| **2** | Bring forward Peak hour 2 (after the fire arrives) inbound trips to peak hour 1 |
| **3** | Remove trips by residents who will not return home |
| **4** | Reroute trips from 30-minutes before fire arrival onwards |
| **5** | Commuter traffic reduced |
| **6** | Remove trips from inside the study area destined for outside of the study area |

These steps are detailed further below:

**1. Apply seasonal uplift**

Section 3.5 details how traffic volumes in the study area vary over the course of the year, with comparisons of the traffic survey month (May) and the month in which traffic counts were the highest (December) provided in Table 6.

In order to test worst-case traffic conditions, an uplift was applied to observed May 2019 intersection turn counts such that they reflected higher volumes measured during the month of December.

The Pittwater Road movement percentages presented in Table 6 for left, through and right turn movements respectively were applied directly to those movements. These are movements from zones 16 and 17, illustrated in Figure 10.

Movements from all other zones along the corridor were factored by the weighted average of the Mona Vale Road seasonal uplift, again provided in Table 6.

The total resultant percentage increase in network traffic demand for the two-hour peak periods is

**18%**.

**2. Bring forward Peak hour 2 (after the fire arrives) inbound trips to peak hour 1**

This was the first step taken to adjust traffic due to behavioural response of motorists to the bushfire event.

The Mona Vale Road corridor, illustrated in Figure 3, forms a link from which many local destinations are accessible along its length. Many of the zones (Figure 10) along its length connect directly to residential properties or suburbs, which can be considered as trip origins and destinations. Only the connection to Pittwater Road would be considered as a point at which traffic would connect to another commuter route, without necessarily intending to complete their trip in the immediate future.

The rationale behind this step is that motorists who would have 'typically' been making an inbound trip, that is travelling to any of the trip destinations accessible from Mona Vale Road, would not continue to do so in Peak hour 2, after the fire has arrived.

Rather than removing these trips from the assessment, they were conservatively brought forward and applied to Peak hour 1 instead. This represents an assumed behavioural change that motorists and residents in the area will travel to their intended destination one hour sooner and before the fire arrives.

This amendment was made for all trips to zones 2 – 14 and 18, given trips to zones 1 and 15 – 17 are considered to be more of a commuter nature. These latter trips remain unchanged as part of Step 2.

### 3. Remove trips by residents who will not return home

Research carried out by Whittaker and Taylor[11] surveyed driver motivations for re-entering potentially at-risk areas during a bushfire. Of the 95 respondents, 71% suggested that if they were not at home when they found out that a bushfire was threatening, they would attempt to return. Analysis of respondents' comments suggests that the main reason people would return would be to defend property, to assist or rescue other household members and to protect pets and animals.

This in turn suggests 29% of residents will not return home in the event of a bushfire.

Given the rationale that Mona Vale Road forms a link to many local destinations such as homes and residential suburbs, the assessment assumes that 29% of inbound trips to zones 2 – 14 and 18 (Figure 10) would not occur, as this percentage represents those who would not return home upon learning of a bushfire.

Trips to these zones were therefore reduced by **29%**.

### 4. Reroute trips from 30-minutes before fire arrival onwards

This step has no impact on trips occurring before 12:30, that is before half-way through Peak hour 1 and up to the moment 30 minutes before fire arrival at 13:00.

Motorists making inbound trips to zones 2 – 14 and 18, those being local destinations such as homes and residential suburbs, are assumed as altering their intended trip purpose once fire arrival is imminent.

The behavioural assumption here is that motorists who are travelling home to defend property, to assist or rescue other household members or to protect pets and animals would continue to do so until such a point that fire arrival was imminent, and they were no longer able to access their property. This behaviour would either be through choice, enforced by fire impacting roads making such a trip impossible, or through emergency services preventing access to at-risk properties and suburbs.

All inbound trips therefore intending to complete their trip from 12:30 onwards were rerouted to continue along state roads to depart the area.

Traffic arriving from Mona Vale Road west (zone 1, Figure 10) travelling to zones 2 – 14 and 18 were rerouted to leave the area via Pittwater Road, with 80% turning right to travel south and 20% turning left to travel north.

Traffic arriving from Pittwater Road (north and south) and Barrenjoey Road, travelling to zones 1 – 14 and 18, were rerouted to continue along the Pittwater Road / Barrenjoey Road corridor in their direction of travel.

### 5. Commuter traffic reduced

Trips between Mona Vale Road west, Pittwater Road and Barrenjoey Road are considered to be commuter trips in nature, that is motorists using these corridors as part of a longer trip beginning and ending outside of the study area.

Given these trips do not originate from or not destined for locations within the study area, it is assumed motorists making these trips would reroute or cancel their trip in the event of a bushfire. This assumption is made as these trips do not have the same motivations to enter a potentially at-risk area as local residents would, such as to defend property or assist other household members, and therefore would be more willing and likely to avoid entering the area.

[11] Community Preparedness and Responses to the 2017 New South Wales Bushfires, Whittaker and Taylor, February 2018

All trips between Mona Vale Road west (zone 1), Pittwater Road (zones 15 and 17) and Barrenjoey Road (zone 16) were therefore reduced to **10%**.

**6. Remove trips from inside the study area destined for outside of the study area**

On a 'typical' Sunday afternoon, there are many trips *from* local destinations such as homes and residential suburbs (zones 2 – 14 and 18, Figure 10) *to* areas outside of the study area (zones 1 and 15 – 17). Whatever the reason for these trips, the assumption made in this assessment is that they would no longer be made in the event of a bushfire, as residents instead respond to the impending risk of the bushfire.

On this basis, trips from residential areas (zones 2 – 14 and 18) to wider destinations (zones 1 and 15 – 17) were removed from the background traffic component, as their trip purpose would change to evacuation and therefore be considered as evacuation traffic (Section 7.2.3).

**'Warm up' traffic demand**

This was calculated as a factor of Peak hour 1 traffic demand, after the seasonal uplift was applied but before any subsequent behavioural amendments were made. This approach was adopted as it was assumed warm up traffic would not be fully aware of and responsive to a bushfire event, given it proceeds only 30 minutes after fire ignition; as such, 'typical' background traffic conditions would prevail until 12:00.

The factor applied to Peak hour 1 traffic was **0.95**, to ensure warm up traffic was capable in populating the network sufficiently, whilst not exceeding Peak hour volumes.

**'Cool down' traffic demand**

'Cool down' traffic demand replicates the final 30 minutes of Peak hour 2, after all adjustments discussed in this section are made.

The 'cool down' period is a model requirement to enable all vehicles still in the network from Peak hour 2 to complete their trip, though no further residents will evacuate during this period and no assessment of network performance of this period will be performed.

### 7.2.3 Evacuation traffic demand derivation

Evacuation traffic refers to vehicles that would otherwise not be on the road network at the time of a bushfire event. This represents residents and visitors to the area who use their private vehicle to depart from the area in response to the risk posed by a bushfire.

This section details how evacuation traffic demand was estimated, through use of census data to determine the population catchment and car ownership, and behavioural research to inform adjustments made to driver behaviour in the event of a bushfire.

Evacuation traffic demand has been informed by assumptions on a range of aspects and comprises two key parts: residential population and visitors to the area, i.e. those who will be in the area during a bushfire event who do not live there and so are not considered in census data.

The derivation of these components is summarised and detailed below.

| # | Residential population |
|---|---|
| **1** | Study area residential yield |
| **2** | Vehicle ownership rate |
| **3** | Vehicle trips generated from study area Travel Zones |
| **4** | Model study area access points from Travel Zones |
| **5** | Dwelling occupancy |
| **6** | Evacuation profile departure times |
| **7** | Proportion of residents who stay and defend |
| **8** | Private vehicle usage during evacuation |

| # | Visitors |
|---|---|
| **9** | Summer trip purpose visitor yield |
| **10** | Visitor evacuation scale factors |

These steps are detailed further below:

**Residential population**

**1. Study area residential yield**

A relatively large study area was identified from which the population would potentially evacuate in the event of a bushfire in the adjoining National Parks. This study area is segregated into Travel Zones as illustrated in Figure 2, and includes suburbs surrounding the Ingleside Precinct from which residents may evacuate.

Travel Zones further afield, such as those north of Bungan Beach or south of Warriewood, were not considered for varying reasons; primarily that population from these Travel Zones would evacuate southwards via Pittwater Road (and so not enter the model study area illustrated in Figure 3), or would not be impacted by the fire and so not evacuate at all.

Only Travel Zones from which traffic would potentially evacuate onto the same roads as the Ingleside Precinct were considered.

Table 2 presents 2016 census population data and forecasts for each of the Travel Zones illustrated in Figure 3.

**2. Vehicle ownership rate**

Section 3.2 discusses how the 2016 census population data was used to determine the anticipated number of vehicles present across Travel Zones in the study area. Applying the Northern Beaches LGA private motor vehicle ownership rate of **0.66 vehicles per person** to population figures allowed determination of respective 2019 and 2023 vehicle ownership figures, which are presented in Table 3.

Across the Travel Zones considered as potentially containing residents who would evacuate onto the road network in the event of a bushfire, there are an estimated 21,495 vehicles in 2019 and 23,072 by 2023.

**3. Vehicle trips generated from study area Travel Zones**

Not all vehicles in each of the Travel Zones illustrated in Figure 2 would use the model study area (Figure 3) to evacuate in the event of a bushfire, given the availability of alternative routes.

Following a PSC workshop on 10 May 2019, feedback was obtained from multiple participants representing NSW RFS, Council and the Department as to the likely percentages of residents in each Travel Zone that would use the model study area as their primary evacuation route.

Each Travel Zone was assessed individually to ascertain the location of properties and proximity and accessibility to roads, to determine the percentage of the population in each that would use the model study area; these percentages and the resultant number of vehicle trips generated from each Travel Zone are presented in Table 18.

**Table 18: 2023 vehicle trips generated from study area Travel Zones using the model study area**

| TZ code | TZ name | Total 2023 vehicles in study area | Percentage evacuating via model study area |
|---|---|---|---|
| **2009** | Church Point | 1,202 | 37.5% |
| **2010** | Bayview Shopping Centre | 1,950 | 40% |
| **2011** | Ingleside_Lane Cove Rd and Walter Rd | 431 | 100% |
| **2012** | Ingleside Scout Camp | 348 | 100% |

| | | | |
|---|---|---|---|
| **2013** | Westpac Training College Ingleside | 474 | 60% |
| **2014** | Ingleside Park | 496 | 50% |
| **2015** | Woorarra Lookout Reserve | 2,177 | 20% |
| **2027** | Mona Vale | 2,389 | 80% |
| **2028** | Village Shopping Centre | 120 | 50% |
| **TZ code** | **TZ name** | **Total 2023 vehicles in study area** | Percentage evacuating via model study area |
| **2029** | Peninsula Plaza | 351 | 50% |
| **2030** | Basin Beach | 2,366 | 50% |
| **2031** | Northshore Business Park | 3,904 | 30% |
| **2032** | Warriewood | 2,203 | 20% |
| **2170** | Ku-ring-gai Chase NP | 575 | 0%[12] |
| **2171** | Terry Hills | 1,701 | 5%[12] |
| **2007** | Ku-ring-gai Chase NP_West Head | 260 | 10% |
| **2026** | Pittwater High School | 1,327 | 50% |
| **2023** | Bungan Beach | 798 | 20% |
| | **Total** | **23,072** | **38.4%** |

Following assessment of accessibility and appeal of the model study area to the residents of the Travel Zones illustrated in Figure 2, **38.4%** of the population are considered to form the catchment which would use the model study area in the event of an evacuation, before further considerations discussed below are accounted for.

The remaining 61.6% of vehicles are considered as evacuating via alternative routes which do not enter the model study area.

## 4. Model study area access points from Travel Zones

The percentages identified in Table 18 represent the overall proportion of the respective travel zone that accesses the model study area for evacuation in the event of a bushfire. In many cases, trips from Travel Zones can access the model study area at multiple locations.

The locations at which trips generated by each Travel Zone access the model study area and respective proportions across these locations are presented in Table 19. The percentages provided are the constituent parts of those presented in Table 18; as such, they may not necessarily total 100%.

[12] Figure presented is for the Reference Case scenario; see Section 7.2.5 for remaining scenario values discussion.

**Table 19: Model study area access from Travel Zones**

| TZ code | TZ name | Model study area access point | Percentage evacuating |
|---|---|---|---|
| 2009 | Church Point | Samuel Street | 37.5% |
| 2010 | Bayview Shopping Centre | Lane Cove Road | 15% |
| | | Samuel Street | 25% |
| 2011 | Ingleside_Lane Cove Rd and Walter Rd | Chiltern Road | 25% |
| | | Lane Cove Road | 75% |
| 2012 | Ingleside Scout Camp | Tumburra Street Addison Road | 15% |
| | | Baha'i access road | 15% |
| | | Chiltern Road | 15% |
| | | | 55% |
| 2013 | Westpac Training College Ingleside | Powderworks Road | 30% |
| | | Manor Road | 30% |
| 2014 | Ingleside Park | Powderworks Road | 30% |
| | | Manor Road | 20% |

| TZ code | TZ name | Model study area access point | Percentage evacuating |
|---|---|---|---|
| 2015 | Woorarra Lookout Reserve | Kalang Road | 20% |
| 2027 | Mona Vale | Samuel Street Emma Street | 25% |
| | | Pittwater Road (N) | 25% |
| | | | 30% |
| 2028 | Village Shopping Centre | Pittwater Road (N) | 12.5% |
| | | Barrenjoey Road (N) | 37.5% |
| 2029 | Peninsula Plaza | Bungan Street | 15% |
| | | Pittwater Road (N) | 35% |
| 2030 | Basin Beach | Barrenjoey Road (N) | 50% |
| 2031 | Northshore Business Park | Ponderosa Parade | 30% |
| 2032 | Warriewood | Ponderosa Parade | 20% |
| 2170 | Ku-ring-gai Chase NP | - | - |
| 2171 | Terry Hills | Kimbriki Road | 5% |
| 2007 | Ku-ring-gai Chase NP_West Head | Chiltern Road | 10% |
| 2026 | Pittwater High School | Pittwater Road (N) | 15% |
| | | Barrenjoey Road | 35% |
| 2023 | Bungan Beach | Barrenjoey Road | 20% |

Table 19 demonstrates that some Travel Zones only have one primary access to the model study area of Mona Vale Road, from which a certain percentage of all trips generated by the Travel Zone will access the network. Other Travel Zones, such as Ingleside Scout Camp, contain multiple side road accesses to Mona Vale Road via which traffic could potentially access the model study area.

Some of the model study area access points do not pass through the Travel Zone from which trips are accessing it. An example is the Church Point Travel Zone, from which trips are assigned to the Samuel Street model study area access point. Whilst Samuel Street does not extend northwards to the Church Point Travel Zone, the expectation is that trips generated by this Travel Zone will use the internal road network to ultimately access the model study area via Samuel Street, hence the rationale behind their inclusion. This same logic is adopted elsewhere across the study area.

There are instances in which the percentage evacuating in Table 19 represent Travel Zones which have alternative routes to depart the study area. An example is Warriewood: 20% of trips generated by this Travel Zone are assumed as heading northwards to Ponderosa Parade to leave the area, with the remaining 80% assumed as using the local road network to head southwards. Given this remaining 80% would not enter the model study area, they are not considered in this assessment.

It is noted that the remainder of the Terrey Hills Travel Zone traffic and also the Duffys Forest Travel Zone traffic are assumed as being able to evacuate via McCarrs Creek Road to Mona Vale Road westbound, and so do **not** enter the model network study area (Figure 3) in the Reference Case scenario.

## 5. Dwelling occupancy

The assessment assesses worst-case road network conditions in the event of a bushfire. 2016 ABS data suggests the number of unoccupied private dwellings in the study area is approximately 10%. As such, it has been conservatively assumed that **95%** of residents of study area Travel Zones will be at home during the bushfire event and thus be required to evacuate.

This ensures a high number of trips are generated by the Travel Zones in the study area, and thus poorer road network conditions are assessed.

## 6. Evacuation profile departure times

Critical to performance of the road network is the time period over which residents can evacuate, in other words the amount of warning they have before the fire arrives.

If residents are given warning that the risk of a bushfire event is high, they may depart their premises in advance of any risk to life or property; this in turn would reduce the number of residents evacuating closer to the time of fire arrival.

On the other hand, if a bushfire event occurs suddenly with no warning, it is likely a larger proportion of the population would be required to evacuate over a shorter period, thus putting increased pressure on the road network to accommodate the evacuating traffic demand.

Given this study assesses worst-case traffic conditions, a ‘sudden ignition’ approach was adopted. This assumes that residents have no warning of an impending bushfire event, before sudden fire ignition occurs which poses a risk to life and property.

The response of residents was informed by bushfire modelling detailed in Section 6.0 and the 2009 Victorian Bushfires Royal Commission (Commission), which investigated, amongst other aspects, departure times of residents before the bushfire arrived.

These findings are provided in Figure 19, which demonstrate that the population evacuation rate increases as fire arrival gets closer. Only 11.8% of those who left their property during a bushfire did so more than 8 hours before arrival, with 33.4% doing so in the one-hour before arrival. The Commission also found that 19.9% only left *after* the fire had arrived.

The 2009 Victorian bushfires occurred during extreme weather conditions, with many residents informed of the potential risk of a bushfire event in advance of it occurring. This meant that whilst many residents still only departed one-hour before the fire arrived, there was a notable proportion who left well in advance, thus easing the burden on the road network the hour before the fire arrived.

Given this study assumes no warning is given, all residents who would evacuate would have to do so after fire ignition. The purpose of bushfire modelling detailed in Section 6.0 was to identify the evacuation window, that is the period from fire ignition to fire arrival at the Ingleside Precinct. This window becomes the period during which all those who are evacuating would have to do so.

Section 6.2 identifies the evacuation window as being 2 hours 20 minutes to 2 hours 40 minutes. This window was averaged to **2 hours 30 minutes** to inform the evacuation traffic profile adopted in traffic assessment.

Profiling of evacuating traffic demand was informed by the Commission to determine behavioural responses, with the profile broken down into the four components detailed in Table 20:

**Table 20: Evacuation profile**

| Time before fire arrival | Commission departures | Model period | Model departures |
|---|---|---|---|
| 02:00 – 02:30 hours | 3.2%[13] | N/A | N/A |
| 01:30 – 02:00 hours | 7.4%[14] | Warm up | 0% |
| 01:00 – 01:30 hours | 7.4%[14] | Warm up | 28.8% |
| 00:00 – 01:00 hours | 33.4% | Peak hour 1 | 70.8% |
| After arrival | 19.9% | Peak hour 2 | 29.2% |

All evacuation traffic demand identified through steps in this section is assumed as evacuating across the two model peak hours, those being the hour before the fire arrives and the hour after.

The percentage split across these two hours was informed by the Commission, as a ratio between the percentage of those who left 00:00 – 02:00 hours before the 2009 Victoria fire (7.4 + 7.4 + 33.4 = **48.2%**) and those who left after the fire (**19.9%**).

No evacuating traffic (0%) was assumed as departing 01:30 – 02:00 hours before fire arrival, this being the period 30 minutes – 1 hour after fire ignition. This represents a period during which the fire has started to develop, but in which residents remain unaware of its existence or the imminent risk posed.

Despite all evacuation traffic demand being assigned to model Peak hours 1 and 2, a further amount (28.8%) was added to the final 30 minutes of the warm up period, representing 01:00 – 01:30 hours before fire arrival. This amount was added to ensure the model road network contained an element of congestion before Peak hour 1, representing the first residents to evacuate onto the road network.

This was added solely for the reason of ensuring robust assessment of congested conditions during the Peak hours as the warm up period is a model feature that will not form part of the assessed outputs.

## 7. Proportion of residents who stay and defend

Another aspect considered relating to the interface between traffic modelling and human behaviour included the implications of the 'leave early, or stay and defend a well-prepared property' policy discussed in Section 5.5. Whilst the policy position attached to the national Fire Danger Rating system advocates for individuals to leave early in Catastrophic conditions, and recommends it in extreme conditions, the proportion of persons who defy this is a reality that requires contemplation.

Whilst there is a level of merit in planning for what communities should be doing, in this case there is strong evidence that suggests that despite repeated and clear messaging, the reality of community action is very different from that which fire agencies would like. Thus, it is incumbent upon this process to recognise that.

As discussed in Section 5.6, Whittaker and Taylor[12] documents research undertaken into protective responses to a bushfire event, that being the proportion who would attempt to stay and defend their property in the event of a bushfire as opposed to departing.

[13]Taken as 25% of the percentage of the 12.7% who left 2 - 4 hours before the 2009 Victoria fire arrived
[14] Taken as 50% of the percentage of the 14.8% who left 1 – 2 hours before the 2009 Victoria fire arrived

The study found that of survey respondents who were threatened or impacted by bushfire in 2017, **46.7%** stayed or returned to defend their property, although some were not impacted and 6.5% began defending and then left.

A separate survey asked what respondents would do if a Catastrophic Fire Danger warning was issued next summer, with **27%** indicating they would get ready to stay and defend.

To ensure conservative assessment of road network conditions, a stay and defend percentage of **20%** was adopted for this assessment.

### 8. Private vehicle usage during evacuation

The study assumes **all** private vehicles owned by residents who would depart would be used in the event of an evacuation, with no scaling applied to reflect the fact that some residents may leave one or more cars at their property in the event of an evacuation.

## Visitors

Aside from residents of the study area, it is acknowledged that there would potentially be visitors to the area who would be required to evacuate in the event of a bushfire, and therefore use of census population data alone does not suffice in identifying the full potential evacuation yield.

Determination of the number of visitors in an area at any given time is difficult, given the lack of studies investigating the topic. NBC were consulted to identify anticipated visitor numbers for the area; however no meaningful data allowing quantification exists.

Given the location of the study area and a primary purpose of Mona Vale Road being to serve popular destinations such as Palm Beach, the peninsular and surrounding beaches, particularly during the summer month this study is considering (Section 4.2.3), an approach was developed which indicatively reflects the number of visitors to the area for 'summer trip purposes'. This approach is detailed below.

### 9. Summer trip purpose visitor yield

The number of 'summer trip purpose' visitors in the area, those being visitors in the area primarily because of warmer weather and the proximity of the time of year to a variety of religious holiday and non-school term time, was determined through comparison of winter and summer month traffic volumes along Mona Vale Road.

The Roads and Maritime permanent counter discussed in Section 3.5 was used to identify seasonal variability, and determined higher traffic volumes in summer months than winter months (Figure 5).

Data from this same permanent counter was used to compare eastbound and westbound traffic volumes along Mona Vale Road for all Sundays in 2018.

The method adopted for identifying the number of 'summer trip purpose' visitors in the area was to first obtain average Sunday eastbound (towards the coast) traffic volumes for winder and summer months, for the time period 08:00 – 14:00.

The average traffic volume for winter months (June – August) was subtracted from the average traffic volume for summer months (November – January) for the duration of 08:00 – 14:00. The working assumption determining this duration was that a majority of those visiting the trip attractors in the area would remain in the area for the duration of the day, that is that a vehicle travelling towards the beach in the morning would not have left the beach before the bushfire emergency began. As such, they would still be in the area and be required to evacuate.

The cumulative eastbound traffic difference between the winter and summer months for this duration was identified **1,511 vehicles**, suggesting there are approximately **250 more vehicle trips per hour** in the eastbound direction along Mona Vale Road in summer months than there are in winter months.

## 10. Visitor evacuation scale factors

The total number of summer trip purpose visitors to the area was scaled to reflect the proportions estimated as evacuating during the two assessment peak hours (12:00 – 14:00) and the route they take.

Firstly, it was assumed that the same proportion of visitors would evacuate during the two assessment hours as identified in *6. Evacuation profile departure times*, earlier in this Section. This equated to a total percentage of 48.2% in Peak hour 1 and 19.9% in Peak hour 2.

Secondly, it was assumed that most of these visitors would depart the area via Pittwater Road, that being the primary road furthest away from likely fire locations inland. **20%** of summer trip purpose visitors to the area were assumed as departing via Mona Vale Road.

Having applied this routing, a total of 206 visitor trips were assumed as originating from Barrenjoey Road (north) and evacuating via Mona Vale Road (westbound), with 823 visitor trips travelling from Barrenjoey Road (north) to Pittwater Road (south).

### 7.2.4 Evacuation traffic demand routeing

Discussion in Section 7.2.3 identifies how the number of vehicles set to evacuate in the event of a bushfire is determined, and the roads these vehicles will use to enter the model study area illustrated in Figure 3. This section sets out how vehicles are routed, that is which direction they will go, upon reaching the model study area.

Observed traffic count data is not a reliable indicator of where motorists evacuating the area in the event of a bushfire would go; this behaviour is atypical as motorists respond to specific events and unique traffic conditions.

The below discussion covers **Reference Case** conditions, in which all roads remain open for access. Section 7.2.5 discusses modifications to these assumptions for other scenarios tested.

There are two key elements to traffic routeing in this study:

- Which direction along Mona Vale Road traffic will go, upon reaching it via a side road
- Where traffic travelling along Mona Vale Road will ultimately leave the study area

The first of these components was determined through proximity to model network extents, with traffic on side arms located towards the west of the model study area primarily exiting westbound, and vice versa for traffic located towards the east of the model study area.

One example is Tumburra Street, located towards the west of the Mona Vale Road study area. From this side arm, it was assumed 90% would turn right to leave the area westwards and 10% would turn left to travel east. Conversely, traffic using the Foley Street approach to Mona Vale Road primarily turns right to travel eastwards, with only 10% turning left to leave the area westwards.

A graded scale between the two model network extents was applied.

Once traffic from side streets had accessed Mona Vale Road, the assumption made is that they would continue to its extents in both directions, those being exiting via Mona Vale Road westwards, or travelling eastwards to Pittwater Road and then heading southbound. Of trips originating from Barrenjoey Road and Pittwater Road (north), 15% were assumed as turning right to evacuate via Mona Vale Road westwards, with the remaining 85% continuing southbound along Pittwater Road to evacuate.

No traffic, once on Mona Vale Road, evacuate the area via any other side roads such as Powderworks Road. This is an assumption that is reconsidered in other scenarios tested and discussed in Section 7.2.5.

### 7.2.5 Scenario modifications

Given the nature of this study and the scenarios tested, modifications are required to the model traffic demand from the Reference Case, in which all routes are open; an example is a key assumption of Scenario 1 being that Mona Vale Road (west) is impacted by fire and thus closed to traffic, requiring all traffic to instead head eastwards.

Sections 7.2.2 and 7.2.3 identify the broad assumptions which form the basis for traffic demand in the Reference Case scenario, that being a scenario in which all routes are available for evacuation and motorists are permitted to evacuate without bushfire interference or human intervention.

These assumptions are then modified for specific scenarios, as discussed below:

**Scenario 1**

Section 7.4 below identifies the key features of Scenario 1, being the initial scenario in which findings of bushfire assessment and input from key stakeholders and emergency services were considered.

The key measures implemented in Scenario 1 impacting on traffic demand are:

- Mona Vale Road west of McCarrs Creek Road closed in both directions

This measure impacts evacuation traffic demand routeing discussed in Section 7.2.4, requiring **all** traffic to instead evacuate eastwards via Pittwater Road. As a result, the graded scale approach from east to west is not applied to scenario testing.

Whilst no evacuation traffic *originates* from Mona Vale Road (west) in the Reference Case, bushfire assessment has determined that Mona Vale Road will be impacted towards the west of the study area. To ensure robust assessment, this study assumes the impact is located west of the Mona Vale Road intersection with McCarrs Creek Road.

The implication of this assumption is that all Terrey Hills and Duffys Forest Travel Zone traffic is unable to evacuate via McCarrs Creek Road and Mona Vale Road westwards, as assumed in the Reference Case. As such, traffic generated by these Travel Zones enters the road network at Mona Vale Road (west) in Scenario 1 and is routed to evacuate via Pittwater Road (south).

This same measure impacts background traffic demand, with all traffic that heads westwards in the Reference Case required to instead route eastwards to Pittwater Road.

- Powderworks Road northbound closed at Wilga Street

This measure was advised by emergency services during consultation, as a means of limiting the traffic heading northwards, towards the bushfire. A closure is applied in the northbound direction on Powderworks Road at Wilga Street, with traffic originating south of this point instead assumed as evacuating southwards and not entering the model network study area.

**Scenario 3**

Section 7.5 identifies the key features of Scenario 3, being a scenario which builds on the findings of Scenario 1 and incorporates more detailed emergency services input as to how traffic would be managed in the event of a bushfire.

The key measures implemented in Scenario 3 impacting on traffic demand are:

**Background 12:00 – 12:30**:- no change with Scenario 1, given emergency services wouldn't have started responding yet. Evacuating traffic using local roads isn't valid here, as this is a background comment.

**Background 12:30 – 13:00**:- traffic from Pittwater (S) doesn't turn left but goes north instead. Vice Versa for Pittwater (N) and Barrenjoey, which heads south instead. Local re-routeing in response to Table 22, with side arms in the middle of the network typically making their way to Powderworks Road (S), as opposed to making longer through movements. Side arms to the south in the middle closed, traffic going southwards instead (e.g. Manor Rd & Ponderosa)). Samuel St all TH to Ponderosa.

**Background 13:00** – onwards: nothing besides Pittwater north-south.

**Evacuation 12:00 – 12:30**:- Same as Scenario 1 matrix for same time, though with key adjustments: Traffic routed to depart via additional side arms (Powderworks, Ponderosa & Foley) as opposed to just Pittwater (south); Kalang Rd right turn in Sc 1 was very high as it was all traffic previously going northwards to Powderworks that was being blocked at Wilga; this was reduced down to only 25%, as being a more reasonable estimate of vehicles south of Wilga that would actually right turn from Kalang; Pittwater (N) and Barrenjoey (N) traffic routed southwards along Pittwater; none along MVR.

All the above is true for the Evacuation warm-up 11:30 – 12:00 with relation to Sc 1.

**Evac 12:30 – 13:00**:- routeing changes made per Table 22 and Background traffic. Samuel St (N) traffic rerouted such that 20% removed (goes north/east), remaining 80% goes either TH or left. Same for Emma. Traffic from south doesn't enter after 12:30 (forced southwards). 50% of Chiltern traffic assumed northwards & removed from matrix – same for Lane Cove (N). Same issue with Pittwater (N) and Barrenjoey (N).

- Traffic evacuates via Pittwater Road and local roads
- Further road closures enforced to better manage evacuation (Table 22)

### 7.2.6 Resultant traffic demands

**Table 21: 2023 vehicle trips generated from study area Travel Zones using the model study area**

| TZ code | TZ name | Total 2023 vehicles in study area | Percentage evacuating via model study area | Resultant 2023 model vehicle trips |
|---|---|---|---|---|
| 2009 | Church Point | 1,202 | 37.5% | 233 |
| 2010 | Bayview Shopping Centre | 1,950 | 40% | 404 |
| 2011 | Ingleside_Lane Cove Rd and Walter Rd | 431 | 100% | 223 |
| 2012 | Ingleside Scout Camp | 348 | 100% | 180 |
| 2013 | Westpac Training College Ingleside | 474 | 60%[12] | 148 |
| 2014 | Ingleside Park | 496 | 50%[12] | 128 |
| 2015 | Woorarra Lookout Reserve | 2,177 | 20%[12] | 225 |
| 2027 | Mona Vale | 2,389 | 80% | 989 |
| 2028 | Village Shopping Centre | 120 | 50% | 31 |
| 2029 | Peninsula Plaza | 351 | 50% | 91 |
| 2030 | Basin Beach | 2,366 | 50% | 612 |
| 2031 | Northshore Business Park | 3,904 | 30% | 606 |
| 2032 | Warriewood | 2,203 | 20% | 228 |
| 2170 | Ku-ring-gai Chase NP | 575 | 0%[12] | 0 |
| 2171 | Terry Hills | 1,701 | 5%[15] | 44 |
| 2007 | Ku-ring-gai Chase NP_West Head | 260 | 10% | 13 |
| 2026 | Pittwater High School | 1,327 | 50% | 343 |
| 2023 | Bungan Beach | 798 | 20% | 83 |
| | **Total** | **23,072** | **38.4%** | **4,581** |

[15] Figure presented is for the Reference Case scenario; see Section 7.2.5 for remaining scenario values discussion.

## 7.3 Reference Case (2023)

### Key features

- **Evacuation traffic demand**
- **Amended traffic signal timings**
- **2023 road layout: Mona Vale Road East upgrade included**

### Network Details

#### 7.3.1 Description

This scenario represents the anticipated traffic conditions of the road network during a bushfire evacuation in the event that all roads are open and accessible for evacuation. This means the bushfire has **not** impacted any roads such that vehicles cannot use them, nor have any road closures been enforced by emergency services.

This case is so named as it forms a reference against which further scenarios can be compared, and differs from the Base in that traffic demand has changed to reflect residents' response to the bushfire; that is whereas traffic conditions in the Base are 'typical' of a Sunday afternoon, traffic conditions in the Reference Case are those considered representative of bushfire evacuation (refer to Section 7.2 for further details).

Traffic signals were modified from the Base to reflect SCATS response to changing traffic conditions; however, no special signal plans or exceptional operation were implemented.

An assessment year of 2023 was adopted to incorporate planned road infrastructure upgrades along the Mona Vale Road corridor, specifically the Mona Vale Road East upgrade between Manor Road, Ingleside to Foley Street, Mona Vale for which completion is expected in 2022[16].

These works involve the upgrade of 3.2 kilometres of Mona Vale Road from two lanes to four lanes and replacing the existing roundabout at the intersection of Ponderosa Parade and Samuel Street with traffic lights and signalised pedestrian crossings on all legs. These upgrades are incorporated in the 2023 Reference Case.

An associated planned upgrade of Mona Vale Road West, between McCarrs Creek Road, Terrey Hills and Powderworks Road, Ingleside, has **not** been considered.

## 7.4 Scenario 1 (2023)

### Key features

- **Evacuation traffic demand**
- **Amended traffic signal timings**
- **2023 road layout: Mona Vale Road East upgrade included**
- **Mona Vale Road west of McCarrs Creek Road closed in both directions**
- **Powderworks Road northbound closed at Wilga Street**
- **All traffic evacuates via Pittwater Road**

### Network Details

[16] https://www.rms.nsw.gov.au/projects/mona-vale-road/mvreast/index.html

### 7.4.1 Description

This scenario draws upon findings of the bushfire assessment (Section 6.0) and discussion with emergency services to represent and assess informed potential traffic conditions during a bushfire evacuation. Components of this scenario were presented and agreed at a PSC workshop 10 May 2019, as detailed in Appendix C.

Noted below are differences from the Reference Case.

Bushfire assessment identified severance of Mona Vale Road may occur under the assessed conditions, which impacts traffic through the inability for road users to access certain parts of the network. Consideration was given as to how severance would most negatively impact the road corridor under assessment, with the decision taken to assume Mona Vale Road was affected and thus closed at a point between McCarrs Creek Road and Forest Way.

This prevents residents from evacuating westbound along Mona Vale Road, thus all vehicles would be forced to route eastbound towards Mona Vale. The specific location was chosen to ensure all Terrey Hills and Duffys Forest residents would also be required to evacuate eastbound, as a closure east of McCarrs Creek Road would allow these residents to leave the area westbound and via Forest Way.

The concept of assuming closure of an entire direction to evacuating traffic was adopted to ensure assessment considers worst-case traffic conditions, as it conservatively routes all traffic evacuating from the area eastbound, resulting in poorer road network performance. Retaining access east and westbound along Mona Vale Road would offer more evacuation possibilities to residents and result in generally better road network performance.

Limited emergency service response was also reflected through the forced closure of Powderworks Road northbound at Wilga Street, done to reflect emergency responders' likely requirement to prevent vehicles travelling towards high risk areas, which significantly limits northbound traffic along Powderworks Road.

Traffic signals were modified from the Reference Case to reflect SCATS response to changing traffic conditions; however no special signal plans or exceptional operation were implemented.

## 7.5 Scenario 3 (2023)

## Key features

- **Evacuation traffic demand**
- **Amended traffic signal timings**
- **2023 road layout: Mona Vale Road East upgrade included**
- **Mona Vale Road west of McCarrs Creek Road closed in both directions**
- **Powderworks Road northbound closed at Wilga Street**
- **Traffic evacuates via Pittwater Road and local roads**
- **Further road closures enforced to better manage evacuation (Table 22)**

## Network Details

### 7.5.1 Description

Scenario 1 findings were presented at a PSC workshop 20 August 2019, with agreement made that Scenario 3 incorporate emergency service response to Scenario 1 performance.

A follow up workshop was held with emergency service representatives from NSW RFS, NSW Police, TMC and Council at which the traffic performance of Scenario 1 was presented, and emergency services' feedback sought to identify their likely actions to mitigate poor traffic performance and accelerate evacuation.

Measures implemented focused on two key areas: the first was reconsideration of evacuating residents' chosen evacuation routes discussed in Section 7.2.4. The second was the implementation of road closures by emergency services in response to prevailing Scenario 1 traffic conditions, in order to clear traffic from high risk areas as quickly as possible.

Full discussion of possible actions that would be taken in response to Scenario 1 traffic performance can be found in workshop minutes provided in Appendix C, with key implications to the traffic assessment summarised in Table 22.

Whilst some of the closures noted are at intersections outside of the model network, they are important to note as they impact on traffic arriving into the model network at downstream model inputs. The below therefore note closures to be implemented at intersections in the broader study area, with subsequent discussion on how this impacts traffic arriving into the model network.

**Table 22: Emergency services Scenario 3 road closures**

| Intersection | Closure description | Model traffic impact |
|---|---|---|
| **Mona Vale Road / Pittwater Road** | No entry left or right towards Mona Vale Road westbound | Traffic rerouted through along Pittwater Road |
| **Mona Vale Road / Ponderosa Parade / Samuel Street** | No access westbound to Mona Vale Road | Traffic originating north of Mona Vale Road routed through or left<br>Traffic originating south of Mona Vale Road routed southwards |
| **Mona Vale Road / Chiltern Road** | No access northbound to Chiltern Road<br>No access eastbound to Mona Vale Road | Right out only from Chiltern Road onto Mona Vale Road, to direct traffic southbound to Powderworks Road |
| **Mona Vale Road / Lane Cove Road / Manor Road** | No access northbound to Lane Cove Road<br>No access eastbound to Mona Vale Road<br>No access northbound from Manor Road to Mona Vale Road | Right out only from Lane Cove Road onto Mona Vale Road, to direct people southbound to Powderworks Road<br>Westbound traffic routed to Powderworks Road<br>Traffic originating south of Mona Vale Road routed southwards |
| **Mona Vale Road / Powderworks Road** | No access northbound from Powderworks Road to Mona Vale Road<br>No westbound access to Mona Vale Road | Westbound traffic routed to Powderworks Road.<br>Traffic originating south of Mona Vale Road routed southwards |
| **Mona Vale Road with Tumburra Street and Addison Road** | No access westbound to Mona Vale Road | Left out only, to direct traffic southbound to Powderworks Road |
| **Mona Vale Road / Kimbriki Road** | No access eastbound to Mona Vale Road | Left out of Kimbriki Road only<br>All Terrey Hills and Duffys Forest traffic routed south/westbound along Mona Vale Road |
| **Cabbage Tree Road / Minkara Road** | No access westbound to Cicada Glen Road | 50% of traffic arriving at Chiltern Road is assumed as having been affected by this closure and routed eastwards, with the remaining 50% still accessing Mona Vale Road via Chiltern Road to evacuate via Powderworks Road |

| | | |
|---|---|---|
| **McCarrs Creek Road north of Terrey Hills** | No access north/eastbound to McCarrs Creek Road | All Terrey Hills and Duffys Forest traffic routed south/westbound along Mona Vale Road |
| **McCarrs Creek Road at Church Point** | No access to McCarrs Creek Road westbound | N/A |
| **Minkara Road / Narla Road** | No access northbound | N/A |
| **Garden Street / Jacksons Road** | No entry northbound towards Powderworks Road | N/A |

These road closures were implemented in the model through a combination of traffic flow matrix adjustments and physical closures.

## 7.6 Scenario 4 (2023)

### Key features

- **Evacuation traffic demand + development to south of Mona Vale Road only**
- **Emergency service support to traffic management**
- **Amended traffic signal timings**
- **2023 road layout: Mona Vale Road East upgrade included**
- **Mona Vale Road west of McCarrs Creek Road closed in both directions**
- **Powderworks Road northbound closed at Wilga Street**
- **Traffic evacuates via Pittwater Road and local roads**
- **Further road closures enforced to better manage evacuation (Table 22)**
- **Iterative test of development trips to determine anticipated number of dwellings**

### Network Details

Scenario 4 took on board the outcomes and measures applied from Scenario 3 and considered the opportunities for additional development in the area. In considering accessibility to / from Mona Vale Road, and the impact of any pre-existing evacuation concerns, it was agreed that in this case, only the area to the south of Mona Vale Road should include development. From this location development traffic was afforded better opportunities for evacuation without having a further detrimental impact on Mona Vale Road.

The incremental testing of additional traffic from the potential residential development to the south of Mona Vale Road was undertaken to identify the network's capacity to accommodate vehicles from a combination of existing and new residents evacuating in the event of a bushfire. It assumed all residents in the new development would add to those evacuating via Powderworks Road southbound and avoid the use of Mona Vale Road which would be closed.

The assessment determined that the addition of 800 – 1,000 new residential dwellings, of the same average density as the existing Northern Beaches LGA, may be built, whilst satisfying the following criteria:

- In the event of an evacuation, vehicles from these dwellings, which are evacuating southwards along Powderworks Road towards Pittwater Road, would not generate queuing that extends back towards and reach Mona Vale Road.
- Additional queuing generated in the southbound direction along Powderworks Road would

not negatively impact residents evacuating via Powderworks Road from Mona Vale Road.

- All residents who intend to evacuate would be able to access the road network and commence their evacuation before the fire arrived.

This assessment focused solely on the ability of residents to evacuate from a bushfire whilst meeting the above criteria, and makes no comment on other constraints or considerations. Development of any dwellings would be subject to the full and proper planning process, led by the Department of Planning, Industry and Environment.

# 8.0 Strategic Observations and Insights

## 8.1 Scenarios 1 and 2

***Evacuation of current population under modelled conditions fails***

Having regard to the outputs of Scenarios 1 and 2 and noting the application of bushfire modelling represents a potential worst case scenario, the performance of the road network in these scenarios is such that vehicles may remain queued in traffic, awaiting signal changes at key intersections whilst evacuating east and south-east.

In both scenarios, the ability to clear the road network of vehicles prior to possible fire arrival is challenged. This results in those vehicles being unable to evacuate prior to the arrival of the modelled fire.

This is noting these scenarios relate to the catchment area which includes the existing community of Ingleside as well as the surrounding locations, including Terrey Hills and Duffys Forest, which may evacuate east and add further traffic onto the road network. This approach was adopted for the purposes of considering a worst-case, but possible, traffic situation in a time of emergency evacuation.

The limitation on evacuation capability largely relates to the limited number of evacuation routes options, being mainly Mona Vale Road and Powderworks Road.

Scenarios 1 and 2 rely solely on the performance of the road network without any emergency services intervention at all to assist evacuation. Therefore, it is evident that the design and capacity of the road network as assumed, designed and modelled under these scenarios in themselves may not be sufficient to support the complete evacuation of the Ingleside precinct.

In order to address this issue, Scenario 3 traffic modelling was undertaken to establish the evacuation ability in a situation involving emergency services intervention.

## 8.2 Scenario 3

***Evacuation of current population is possible, but requires emergency services intervention to facilitate the evacuation process***

Scenario 3 responds to the findings of Scenarios 1 and 2 and introduces ‘likely actions’ of emergency services during an evacuation emergency. This relates to the traffic management and intersection control measures set out at Table 22 of this report.

Having regard to the 2023 road network, the outcomes of Scenario 3 demonstrate the intervention of emergency services, in evacuation traffic management, results in the ability for the road network, particularly Mona Vale Road and Powderworks Road and lower-order roads, to be clear of vehicles prior to the time of estimated fire arrival.

Based on the traffic modelling, it is reasonable to contend that existing residents would be able to evacuate to safety in a bushfire emergency under this scenario, should the modelled bushfire event (with limited warning time) eventuate.

Again, it must be noted this study relates only to a limited series of modelled events, noting a vast range of situations could prevail on any given day and the content of this report cannot be relied upon to inform the decision making of individuals in informing their bushfire survival plans. This study is undertaken for the express purposes of informing land use planning, and nothing further.

As this scenario relates to the current population only, compliance with Planning for Bush Fire Protection 2019 is not required as no development is proposed. Rather, its focus on mitigation of the existing situation, should certain extreme events occur. This results in the need for further examination of operational evacuation planning by the responsible combat agency(ies) to support evacuation of the current population.

## 8.3 Scenario 4

***Evacuation of current population and some development uplift is possible, but requires emergency services intervention to facilitate the evacuation process***

Scenario 4 contemplates the 2023 road network condition (Mona Vale Road upgraded) and the 'likely actions' of emergency services to consider the potential for 'development uplift' in Ingleside.

As described in Section 7.6, the iterative traffic modelling assessment has indicated that there is potential for a level of development uplift comprising between 800 and 1,000 new dwellings where an on-site emergency services role in managing the road network during an evacuation procedure is in place. The most appropriate location for new development, based solely on the result of traffic modelling, is south of Mona Vale Road and east of Powderworks Road, however no other hazard or risk, planning, environmental or servicing considerations have been applied, as such there are additional considerations requiring contemplation.

This principally relates to mitigation and risk transfer, and satisfaction of the strategic planning principles set out at Part 4 of the 2019 Planning for Bush Fire Protection statutory guideline.

### 8.3.1 Compliance with Planning for Bush Fire Protection 2019 for Scenario 4

Planning for Bush Fire Protection 2019 (PBP 2019) incorporates a series of strategic planning principles and provisions for consideration. Those principles which are relevant in this context include:

- 'providing adequate infrastructure associated with emergency evacuation and firefighting operations'.

PBP 2019 also provides a range of identifiers of inappropriate development and these were discussed at length in the 2018 Bushfire Risk Assessment for the Ingleside Planned Precinct. Those indicators relevant to this study include:

- 'the development is likely to be difficult to evacuate during a bushfire due to its siting in the landscape, access limitations, fire history and / or size and scale;
- the development will adversely effect other bushfire protection strategies or place existing development at increased risk'.

Having regard to Table 4.2.1 of PBP 2019 and the access and egress assessment considerations associated with the conduct of a Bush Fire Strategic Study, it requires that a 'study of the existing and proposed road networks both within and external to the masterplan area or site layout' is undertaken, with specific regard to the following:

- 'the capacity for the proposed road network to deal with evacuating residents and responding emergency services, based on the existing and proposed community profile;
- the location of key access routes and direction of travel; and
- the potential for development to be isolated in the event of bush fire'.

Additionally, PBP 2019 also provides assessment considerations on the future impact of new development on emergency services. These include a consideration of increase in demand for emergency services responding to a bush fire event.

# 9.0 Conclusions and Recommendations

In relation to the first principle identified above, Scenario 4 does not introduce any additional road network connections or intersection changes. Ingleside is generally constrained by surrounding bushland which comprises national parks, bushland sanctuaries or reserves. The topography of the area is a further consideration. Combined, these constraints make it challenging to consider new road corridors. The 2023 scenario (Scenario 1) which is the reference case for Scenarios 3 and 4, incorporates the eastern upgrade to Mona Vale Road.

Having regard to the provision of adequate infrastructure associated with emergency evacuation, the study has relied upon the existing / committed upgrades to the established road network which, for Scenarios 1-3 is elementary. This becomes more complex in relation to Scenario 4 which investigated the potential for development uplift in the absence of an associated uplift to road network infrastructure to support increased development. This scenario is, instead, considered on the basis of emergency services intervention.

If for any reason, insufficient emergency resources were available to implement the 'likely actions' identified above, it may be feasible that additional development may affect the evacuation ability of existing residents.

In terms of the indicators of potentially inappropriate development, it is noted the Ingleside Precinct:

- is constrained by surrounding vegetation and topography;
- is constrained by its ability to be serviced by new road infrastructure due to surrounding vegetation and topography, as well as existing development; and
- has a history of fire activity which has led to property loss.

The identification of evacuation processes in certain circumstances which trigger actions by emergency services in response to existing risk is acceptable pursuant to Scenario 3, and is a suitable mitigation arrangement in response to a potential existing risk.

However, in the case of Scenario 4, and the consideration of additional development in a situation which relies upon emergency services intervention rather than a planning / built environment / infrastructure-based solution to resolve future risk, requires further contemplation.

From a land use planning perspective, Scenario 4 does not include any associated uplift to road infrastructure to support further development. As such, the land use planning and infrastructure process, pursuant to this scenario, cannot effectively mitigate the risk and instead, proposes a transfer to emergency management in order to support development potential.

This may be considered to place added burden on emergency services however ultimately, this would need to be decided by emergency services agencies, and involving the Local Emergency Management Committee.

DPIE, in partnership with NSW Rural Fire Service, will need to determine whether Scenario 4 satisfies the strategic planning principles and strategic planning assessment considerations of PBP 2019, specifically those identified above, in the manner intended by PBP 2019.

A further element for consideration is the potential for additional development in the Ingleside Precinct, pursuant to Scenario 4, to absorb the redundancy of the road network system in the event of an emergency evacuation which may inadvertently limit further development elsewhere in the catchment (beyond the bounds of the Ingleside Precinct). The cumulative impact of development in other locations which may rely on evacuation through Ingleside may, over time, further compound the ability of the network to function in an emergency.

## 9.1 Recommendations

On the basis of the above, the following recommendations are identified:

1. The Department of Planning, Industry and Environment together with NSW Rural Fire Service should consider the nature of risk transfer posed by Scenario 4 to emergency services, to determine whether this scenario satisfies the Part 4 provisions of the Planning for Bush Fire Protection 2019 statutory guideline, in the manner the provisions are intended.
2. The 'likely actions' of emergency services used to inform Scenarios 3 and 4 of this study (intersection and traffic management in an emergency) should be incorporated into the suite of emergency and bushfire management plans for the area, if not already included.

# Appendix A

## Intersection turn count calibration

**From 12:00 to 13:00**

| MONA VALE ROAD | | | | 12:00 – 13:00 | | | | |
|---|---|---|---|---|---|---|---|---|
| Intersection | Approach | Name | Mov | Obs. Flow | Model | GEH | Criteria Check | Within Tolerance* |
| Mona Vale Road / Kimbriki Road | East | Mona Vale Rd (E ) | LT | 42 | 44 | 0.3 | <99 | TRUE |
| | | | TH | 1,170 | 1191 | 0.6 | 1000 to 1999 | TRUE |
| | South | Kimbriki Rd (S) | LT | 82 | 82 | 0.0 | <99 | TRUE |
| | | | RT | 48 | 45 | 0.4 | <99 | TRUE |
| | West | Mona Vale Rd (W) | TH | 1,255 | 1262 | 0.2 | 1000 to 1999 | TRUE |
| | | | RT | 71 | 71 | 0.0 | <99 | TRUE |
| Mona Vale Road / Tumburra St | North | Tumburra St (N) | LT | 31 | 29 | 0.4 | <99 | TRUE |
| | | | RT | 29 | 29 | 0.0 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 1,198 | 1207 | 0.3 | 1000 to 1999 | TRUE |
| | | | RT | 9 | 5 | 1.5 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 24 | 24 | 0.0 | <99 | TRUE |
| | | | TH | 1,268 | 1284 | 0.4 | 1000 to 1999 | TRUE |
| Mona Vale Road / Addison Rd | North | Addison Rd (N) | LT | 2 | 0 | 2.0 | <99 | TRUE |
| | | | RT | 0 | 0 | 0.0 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 1,236 | 1216 | 0.6 | 1000 to 1999 | TRUE |
| | | | RT | 0 | 0 | 0.0 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 1 | 1 | 0.0 | <99 | TRUE |
| | | | TH | 1,364 | 1313 | 1.4 | 1000 to 1999 | TRUE |
| Mona Vale Road / Powderworks Rd | North | Mona Vale Rd (N) | LT | 33 | 34 | 0.2 | <99 | TRUE |
| | | | TH | 828 | 778 | 1.8 | 100 to 999 | TRUE |
| | | | RT | 1 | 0 | 1.4 | <99 | TRUE |
| | East | Powderworks Rd (E ) | LT | 413 | 412 | 0.0 | 100 to 999 | TRUE |
| | | | TH | 3 | 3 | 0.0 | <99 | TRUE |
| | | | RT | 46 | 43 | 0.4 | <99 | TRUE |
| | South | Mona Vale Rd (S) | LT | 9 | 9 | 0.0 | <99 | TRUE |
| | | | TH | 958 | 921 | 1.2 | 100 to 999 | TRUE |
| | | | RT | 398 | 385 | 0.7 | 100 to 999 | TRUE |
| | West | Powderworks Rd (W) | LT | 8 | 5 | 1.2 | <99 | TRUE |
| | | | TH | 7 | 8 | 0.4 | <99 | TRUE |
| | | | RT | 23 | 23 | 0.0 | <99 | TRUE |
| Mona Vale Road / Chiltern Rd | North | Chiltern Rd (N) | LT | 12 | 9 | 0.9 | <99 | TRUE |
| | | | RT | 51 | 50 | 0.1 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 780 | 774 | 0.2 | 100 to 999 | TRUE |
| | | | RT | 14 | 12 | 0.6 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 30 | 31 | 0.2 | <99 | TRUE |
| | | | TH | 978 | 950 | 0.9 | 100 to 999 | TRUE |
| Mona Vale Road / Lane Cove Rd / Manor Rd | North | Lane Cove Rd (N) | LT | 3 | 2 | 0.6 | <99 | TRUE |
| | | | TH | 32 | 31 | 0.2 | <99 | TRUE |
| | | | RT | 133 | 126 | 0.6 | 100 to 999 | TRUE |
| | East | Mona Vale Rd (E ) | LT | 30 | 28 | 0.4 | <99 | TRUE |
| | | | TH | 642 | 647 | 0.2 | 100 to 999 | TRUE |
| | | | RT | 3 | 1 | 1.4 | <99 | TRUE |
| | South | Manor Rd (S) | LT | 12 | 12 | 0.0 | <99 | TRUE |
| | | | TH | 35 | 35 | 0.0 | <99 | TRUE |
| | | | RT | 27 | 27 | 0.0 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 110 | 116 | 0.6 | 100 to 999 | TRUE |
| | | | TH | 796 | 831 | 1.2 | 100 to 999 | TRUE |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | RT | 9 | 9 | 0.0 | <99 | TRUE |
| Mona Vale Road / Samuel St / Ponderosa Pde | North | Samuel St (N) | LT | 23 | 24 | 0.2 | <99 | TRUE |
| | | | TH | 136 | 137 | 0.1 | 100 to 999 | TRUE |
| | | | RT | 41 | 42 | 0.2 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | LT | 110 | 109 | 0.1 | 100 to 999 | TRUE |
| | | | TH | 491 | 497 | 0.3 | 100 to 999 | TRUE |
| | | | RT | 36 | 34 | 0.3 | <99 | TRUE |
| | South | Ponderosa Pde (S) | LT | 143 | 142 | 0.1 | 100 to 999 | TRUE |
| | | | TH | 152 | 152 | 0.0 | 100 to 999 | TRUE |
| | | | RT | 142 | 143 | 0.1 | 100 to 999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 51 | 51 | 0.0 | <99 | TRUE |
| | | | TH | 642 | 654 | 0.5 | 100 to 999 | TRUE |
| | | | RT | 123 | 123 | 0.0 | 100 to 999 | TRUE |
| Mona Vale Road / Emma St | North | Emma St (N) | LT | 31 | 30 | 0.2 | <99 | TRUE |
| | | | RT | 63 | 64 | 0.1 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 585 | 573 | 0.5 | 100 to 999 | TRUE |
| | | | RT | 23 | 22 | 0.2 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 81 | 83 | 0.2 | <99 | TRUE |
| | | | TH | 710 | 741 | 1.2 | 100 to 999 | TRUE |
| Mona Vale Road / Foley St | East | Mona Vale Rd (E ) | LT | 169 | 176 | 0.5 | 100 to 999 | TRUE |
| | | | TH | 562 | 562 | 0.0 | 100 to 999 | TRUE |
| | South | Foley St (S) | LT | 32 | 28 | 0.7 | <99 | TRUE |
| | | | RT | 96 | 98 | 0.2 | <99 | TRUE |
| | West | Mona Vale Rd (W) | TH | 716 | 733 | 0.6 | 100 to 999 | TRUE |
| | | | RT | 42 | 38 | 0.6 | <99 | TRUE |
| Mona Vale Road / Bungan St | North | Bungan St (N) | LT | 118 | 132 | 1.3 | 100 to 999 | FALSE |
| | | | RT | 176 | 174 | 0.2 | 100 to 999 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 571 | 575 | 0.2 | 100 to 999 | TRUE |
| | | | RT | 134 | 133 | 0.1 | 100 to 999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 195 | 190 | 0.4 | 100 to 999 | TRUE |
| | | | TH | 640 | 641 | 0.0 | 100 to 999 | TRUE |
| Mona Vale Road / Pittwater Rd | North | Pittwater Rd (N) | TH | 1,274 | 1276 | 0.1 | 1000 to 1999 | TRUE |
| | | | RT | 502 | 506 | 0.2 | 100 to 999 | TRUE |
| | South | Pittwater Rd (S) | LT | 211 | 207 | 0.3 | 100 to 999 | TRUE |
| | | | TH | 1,539 | 1537 | 0.1 | 1000 to 1999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 567 | 560 | 0.3 | 100 to 999 | TRUE |
| | | | RT | 210 | 212 | 0.1 | 100 to 999 | TRUE |
| Pittwater Rd / Barranjoey Rd | North | Barranjoey Rd (N) | TH | 1,515 | 1525 | 0.3 | 1000 to 1999 | TRUE |
| | South | Pittwater Rd (S) | LT | 284 | 298 | 0.8 | 100 to 999 | TRUE |
| | | | TH | 1,806 | 1800 | 0.1 | 1000 to 1999 | TRUE |
| | West | Pittwater Rd (W) | LT | 45 | 30 | 2.4 | <99 | FALSE |
| | | | RT | 261 | 250 | 0.7 | 100 to 999 | TRUE |
| Powderworks Rd / Kalang Rd | East | Powderworks Rd (E ) | LT | 82 | 86 | 0.4 | <99 | TRUE |
| | | | TH | 368 | 391 | 1.2 | 100 to 999 | TRUE |
| | South | Kalang Rd (S) | LT | 68 | 66 | 0.2 | <99 | TRUE |
| | | | RT | 78 | 78 | 0.0 | <99 | TRUE |
| | West | Powderworks Rd (W) | TH | 350 | 344 | 0.3 | 100 to 999 | TRUE |
| | | | RT | 80 | 75 | 0.6 | <99 | TRUE |

**From 13:00 to 14:00**

| MONA VALE ROAD | | | | | | 1300 - 1400 | | |
|---|---|---|---|---|---|---|---|---|
| Intersection | Approach | Name | Mov | Obs. Flow | Model | GEH | Criteria Check | Within Tolerance* |
| Mona Vale Road / Kimbriki Road | East | Mona Vale Rd (E ) | LT | 42 | 38 | 0.6 | <99 | TRUE |
| | | | TH | 1,048 | 1073 | 0.8 | 1000 to 1999 | TRUE |
| | South | Kimbriki Rd (S) | LT | 67 | 67 | 0.0 | <99 | TRUE |
| | | | RT | 36 | 36 | 0.0 | <99 | TRUE |
| | West | Mona Vale Rd (W) | TH | 1,416 | 1417 | 0.0 | 1000 to 1999 | TRUE |
| | | | RT | 76 | 76 | 0.0 | <99 | TRUE |
| Mona Vale Road / Tumburra St | North | Tumburra St (N) | LT | 25 | 24 | 0.2 | <99 | TRUE |
| | | | RT | 21 | 21 | 0.0 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 1,073 | 1084 | 0.3 | 1000 to 1999 | TRUE |
| | | | RT | 14 | 9 | 1.5 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 22 | 22 | 0.0 | <99 | TRUE |
| | | | TH | 1,429 | 1431 | 0.1 | 1000 to 1999 | TRUE |
| Mona Vale Road / Addison Rd | North | Addison Rd (N) | LT | 2 | 0 | 2.0 | <99 | TRUE |
| | | | RT | 0 | 1 | 1.4 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 1,099 | 1084 | 0.5 | 1000 to 1999 | TRUE |
| | | | RT | 0 | 0 | 0.0 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 1 | 1 | 0.0 | <99 | TRUE |
| | | | TH | 1,406 | 1454 | 1.3 | 1000 to 1999 | TRUE |
| Mona Vale Road / Powderworks Rd | North | Mona Vale Rd (N) | LT | 20 | 15 | 1.2 | <99 | TRUE |
| | | | TH | 739 | 722 | 0.6 | 100 to 999 | TRUE |
| | | | RT | 3 | 1 | 1.4 | <99 | TRUE |
| | East | Powderworks Rd (E ) | LT | 355 | 350 | 0.3 | 100 to 999 | TRUE |
| | | | TH | 2 | 2 | 0.0 | <99 | TRUE |
| | | | RT | 26 | 24 | 0.4 | <99 | TRUE |
| | South | Mona Vale Rd (S) | LT | 5 | 5 | 0.0 | <99 | TRUE |
| | | | TH | 1,013 | 980 | 1.0 | 1000 to 1999 | TRUE |
| | | | RT | 458 | 467 | 0.4 | 100 to 999 | TRUE |
| | West | Powderworks Rd (W) | LT | 2 | 0 | 2.0 | <99 | TRUE |
| | | | TH | 6 | 6 | 0.0 | <99 | TRUE |
| | | | RT | 12 | 12 | 0.0 | <99 | TRUE |
| Mona Vale Road / Chiltern Rd | North | Chiltern Rd (N) | LT | 9 | 6 | 1.1 | <99 | TRUE |
| | | | RT | 52 | 52 | 0.0 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 709 | 693 | 0.6 | 100 to 999 | TRUE |
| | | | RT | 8 | 9 | 0.3 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 28 | 25 | 0.6 | <99 | TRUE |
| | | | TH | 1,015 | 978 | 1.2 | 1000 to 1999 | TRUE |
| Mona Vale Road / Lane Cove Rd / Manor Rd | North | Lane Cove Rd (N) | LT | 2 | 0 | 2.0 | <99 | TRUE |
| | | | TH | 37 | 38 | 0.2 | <99 | TRUE |
| | | | RT | 89 | 85 | 0.4 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | LT | 21 | 20 | 0.2 | <99 | TRUE |
| | | | TH | 640 | 604 | 1.4 | 100 to 999 | TRUE |
| | | | RT | 5 | 3 | 1.0 | <99 | TRUE |
| | South | Manor Rd (S) | LT | 12 | 13 | 0.3 | <99 | TRUE |
| | | | TH | 35 | 35 | 0.0 | <99 | TRUE |
| | | | RT | 22 | 20 | 0.4 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 147 | 144 | 0.2 | 100 to 999 | TRUE |
| | | | TH | 838 | 834 | 0.1 | 100 to 999 | TRUE |

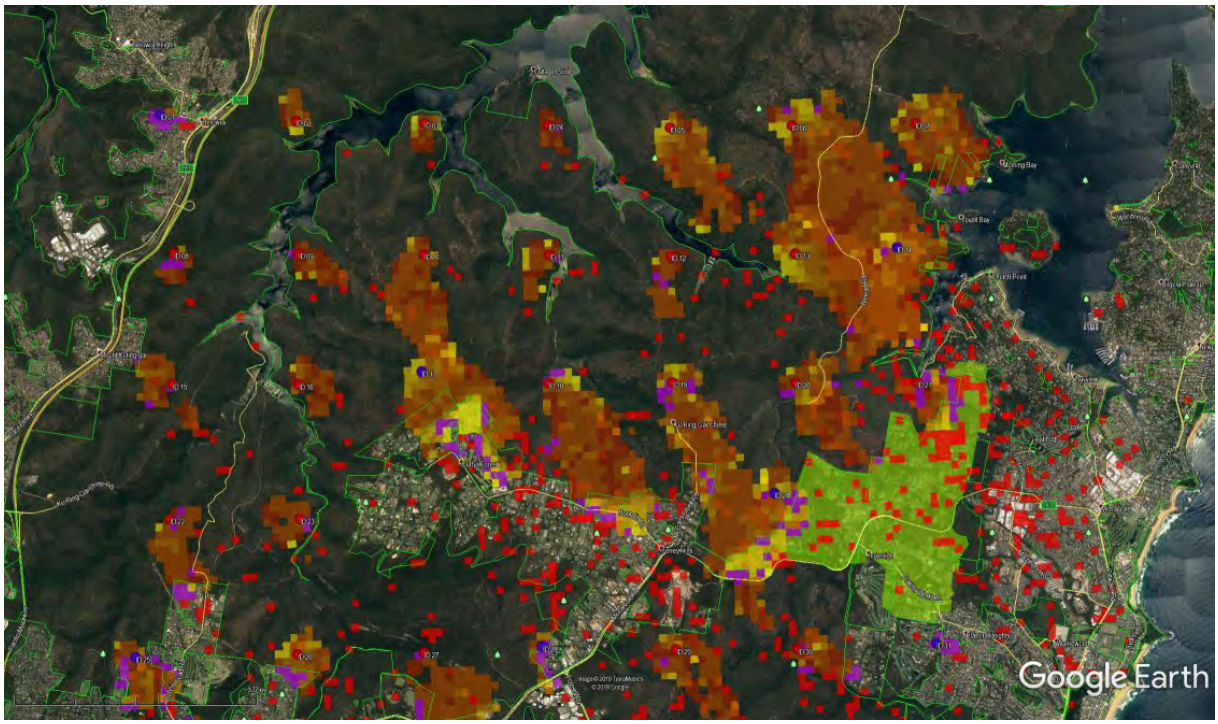
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | RT | 7 | 7 | 0.0 | <99 | TRUE |
| Mona Vale Road / Samuel St / Ponderosa Pde | North | Samuel St (N) | LT | 32 | 33 | 0.2 | <99 | TRUE |
| | | | TH | 133 | 133 | 0.0 | 100 to 999 | TRUE |
| | | | RT | 48 | 46 | 0.3 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | LT | 121 | 121 | 0.0 | 100 to 999 | TRUE |
| | | | TH | 481 | 462 | 0.9 | 100 to 999 | TRUE |
| | | | RT | 35 | 34 | 0.2 | <99 | TRUE |
| | South | Ponderosa Pde (S) | LT | 114 | 113 | 0.1 | 100 to 999 | TRUE |
| | | | TH | 116 | 116 | 0.0 | 100 to 999 | TRUE |
| | | | RT | 128 | 126 | 0.2 | 100 to 999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 59 | 61 | 0.3 | <99 | TRUE |
| | | | TH | 622 | 665 | 1.7 | 100 to 999 | TRUE |
| | | | RT | 154 | 159 | 0.4 | 100 to 999 | TRUE |
| Mona Vale Road / Emma St | North | Emma St (N) | LT | 21 | 22 | 0.2 | <99 | TRUE |
| | | | RT | 52 | 47 | 0.7 | <99 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 563 | 569 | 0.3 | 100 to 999 | TRUE |
| | | | RT | 17 | 19 | 0.5 | <99 | TRUE |
| | West | Mona Vale Rd (W) | LT | 89 | 84 | 0.5 | <99 | TRUE |
| | | | TH | 695 | 738 | 1.6 | 100 to 999 | TRUE |
| Mona Vale Road / Foley St | East | Mona Vale Rd (E ) | LT | 116 | 124 | 0.7 | 100 to 999 | TRUE |
| | | | TH | 558 | 569 | 0.5 | 100 to 999 | TRUE |
| | South | Foley St (S) | LT | 20 | 19 | 0.2 | <99 | TRUE |
| | | | RT | 64 | 68 | 0.5 | <99 | TRUE |
| | West | Mona Vale Rd (W) | TH | 722 | 734 | 0.4 | 100 to 999 | TRUE |
| | | | RT | 24 | 25 | 0.2 | <99 | TRUE |
| Mona Vale Road / Bungan St | North | Bungan St (N) | LT | 251 | 225 | 1.7 | 100 to 999 | FALSE |
| | | | RT | 132 | 129 | 0.3 | 100 to 999 | TRUE |
| | East | Mona Vale Rd (E ) | TH | 555 | 564 | 0.4 | 100 to 999 | TRUE |
| | | | RT | 127 | 129 | 0.2 | 100 to 999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 171 | 177 | 0.5 | 100 to 999 | TRUE |
| | | | TH | 619 | 631 | 0.5 | 100 to 999 | TRUE |
| Mona Vale Road / Pittwater Rd | North | Pittwater Rd (N) | TH | 1,324 | 1301 | 0.6 | 1000 to 1999 | TRUE |
| | | | RT | 500 | 494 | 0.3 | 100 to 999 | TRUE |
| | South | Pittwater Rd (S) | LT | 194 | 193 | 0.1 | 100 to 999 | TRUE |
| | | | TH | 1,433 | 1442 | 0.2 | 1000 to 1999 | TRUE |
| | West | Mona Vale Rd (W) | LT | 582 | 592 | 0.4 | 100 to 999 | TRUE |
| | | | RT | 263 | 267 | 0.2 | 100 to 999 | TRUE |
| Pittwater Rd / Barranjoey Rd | North | Barranjoey Rd (N) | TH | 1,587 | 1591 | 0.1 | 1000 to 1999 | TRUE |
| | South | Pittwater Rd (S) | LT | 349 | 350 | 0.1 | 100 to 999 | TRUE |
| | | | TH | 1,666 | 1683 | 0.4 | 1000 to 1999 | TRUE |
| | West | Pittwater Rd (W) | LT | 42 | 27 | 2.6 | <99 | FALSE |
| | | | RT | 237 | 225 | 0.8 | 100 to 999 | TRUE |
| Powderworks Rd / Kalang Rd | East | Powderworks Rd (E ) | LT | 87 | 89 | 0.2 | <99 | TRUE |
| | | | TH | 316 | 317 | 0.1 | 100 to 999 | TRUE |
| | South | Kalang Rd (S) | LT | 68 | 64 | 0.5 | <99 | TRUE |
| | | | RT | 94 | 95 | 0.1 | <99 | TRUE |
| | West | Powderworks Rd (W) | TH | 438 | 411 | 1.3 | 100 to 999 | TRUE |
| | | | RT | 80 | 79 | 0.1 | <99 | TRUE |

# Appendix B

## Bushfire Assessment

# Ingleside Settlement

## Bushfire Behaviour Modelling




Contribution to traffic modelling study — Meridian Urban

**Document Tracking**

| Article | Specific Detail |
|---|---|
| **Project Name** | Bushfire Behaviour Modelling: Contribution to traffic modelling study |
| **Project Number** | TR982 |
| **Project Manager** | Cuong Tran<br>07 3248 8731<br>L4 / 52 Merivale Street, South Brisbane QLD 4101 |
| **Prepared by** | Cuong Tran and Diana Virkki |
| **Reviewers** | Nicole Nesvadba |
| **Approved by** | Derek Osborn |
| **Status** | Draft, for comment |
| **Version & Date** | Version 1<br>30 May 2019 |

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*Disclaimer*



Data sources: Bureau of Meteorology, Eco Logical P/L, AECOM, NSW RFS, and Weather Underground

# Executive Summary

Ten Rivers was requested to undertake bushfire behaviour modelling and the subsequent impact from ignitions on the Ingleside settlement, along the Northern Beaches in NSW. We used inputs developed from a previous report for Ingleside and developed bushfire behaviour models under three scenarios:

1. Fire Danger Index 64 – Fire Danger Rating of Severe; like those experienced during the bushfire event on 8 Jan. 1994 in the National Park
2. Fire Danger Index 77 – Fire Danger Rating of Extreme
3. Fire Danger Index 117 – Fire Danger Rating of Catastrophic

Additional model inputs included weather data, fuel load accumulation data and terrain data. A gridded approach for ignition was developed and in total, 31 ignition locations were identified adjacent to the settlement. Phoenix RapidFire was used to simulate ignitions at all locations under all three scenarios, with outputs in ESRI ArcGIS and Google Earth Pro formats for visual display of the outputs.

Under each scenario, there is a window between two and three hours following ignition where the main road networks remain open and relatively unaffected from bushfire. After three hours, Mona Vale Road is subject to bushfire impacts and likely to be close to movement to / from Ingleside. Even though outside of the study area, to the north, West Head Road is breached under all fire danger scenarios, and in some circumstances, breached soon after ignition. We recommend a focus to increase bushfire mitigation efforts along this road in collaboration with the relevant state agency (Roads & Maritime Services and National Parks & Wildlife Service). Furthermore, across all fire danger scenarios, the area north of the Ingleside settlement is subject to significant fire behaviour and should be the focus of complementary hazard reduction efforts in the lead up to the fire season. Finally, the vegetation immediately adjacent to Ingleside, from Wirreanda Creek (on Ingleside's west perimeter) to the adjacent parallel fire-trail (Duckholes Trail) should also be a focus for hazard reduction. Working with the NPWS for collaborative management of this corridor will have significant reduction in bushfire hazard across Ingleside.

The use of Phoenix in this instance provides an improved understanding of the movement of potential bushfires across this landscape. It is worth noting that in these simulations, all ignition points occurred at the same time, an event unlikely to occur and therefore provides a 'worse case' scenario for bushfire development and growth.

# Methodology

## Phoenix RapidFire

Following initial studies on potential bushfire impacts, Ten Rivers was requested to undertake bushfire behaviour modelling using Phoenix RapidFire to assist in determining timeframes for impact to Ingleside and associated road infrastructure network. Phoenix RapidFire, was developed by Tolhurst *et al.* (2008) and requires a number of inputs related to geography, vegetation ecosystems and potential fuel load and weather. Ignitions can be simulated for single and multiple ignition points. Outputs include numerous metrics on the fire-front (height, depth), rate of spread, ember and spotting development.

The inputs for this assessment have been based on information provided by Eco Logical (2018). This includes GIS data generated and provided to the NSW Department of Planning and Environment by Eco Logical (2018). Inputs such as slope, terrain, vegetation ecosystems and accepted maximum fuel load (in t/ha), derived from vegetation types, is particularly important in this exercise.

Daily weather streams for the closest automatic weather stations (AWS) at Terrey Hills were acquired from two sources, the Bureau of Meteorology and the online resource Weather Underground. From these sources, we obtained the weather streams for historically relevant bushfire events (such as 8 January 1994) and replicate weather conditions experienced at the time.

Further, it was requested that the bushfire modelling outputs would focus on three scenarios, at Forest Fire Danger Indexes of:

- 64 (Fire Danger Rating of 'Severe'),
- 77 (Fire Danger Rating of 'Extreme'), and
- 116 (Fire Danger Rating of 'Catastrophic').
  The 8 January 1994 bushfire in this location had a FFDI of 62

## Ignition Points / Locations

Following an iterative approach completed with AECOM and Meridian Urban, rather than specific locations / number of ignitions, it was determined that a gridded ignition pattern was to be employed, and placed at the centroid of 1 km$^2$ grids surrounding the settlement. A further review of these grids was undertaken; whereby some grids were moved or removed as existing assets / development were already in place. A total of 31 ignition points were included in this study, and shown in Figure 1.

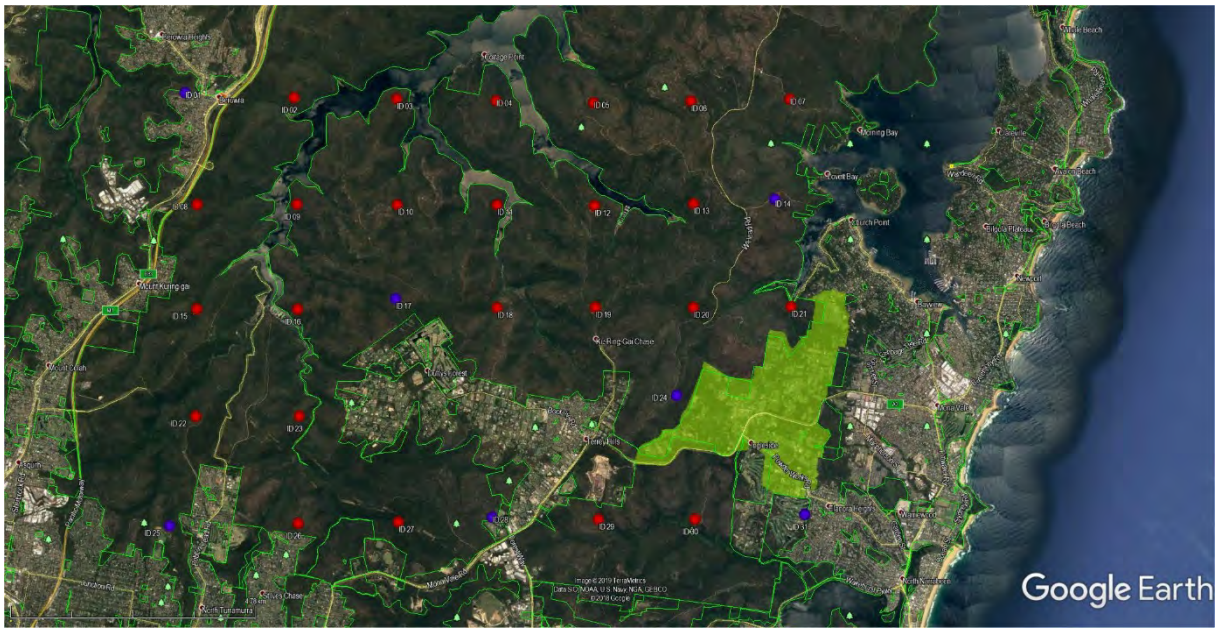


*Figure 1: Potential ignition points across the Ingleside settlement. Red points indicate no change to ignition location, blue points indicate realignment of ignition location.*

# Outputs

## FFDI 64

The following climate variables (averages) were used to generate this Fire Danger Index are outlined in Table 1.

*Table 1: Weather and fuel conditions for fire simulation scenario 1, FFDI 64*

| | | | |
|---|---|---|---|
| Temperature (°C) | 36.1 | Drought Factor | 10 |
| Relative Humidity (%) | 12 | Curing Rate (%) | 100 |
| Wind Speed (k/hr) | 25.5 | Wind Direction (°) | 247.5 – 315<br>WSW – NW |

These conditions were generated from the 8 January 1994 bushfire event in Ku-Ring-Gai Chase National Park.

The following figures will outline the progression of fire from simultaneous ignition of all points under the specified weather conditions. Figure 2 below provides an indication of the main points of interest in this study. Each figure shows:

- Ingleside settlement in yellow hashing to the east,
- M1 Pacific Motorway marking the western extent
- Mona Vale Road, the main road which intersects Ingleside (from a west - east direction)
- Forest Way, southwest of Ingleside, a main junction off Mona Vale Road
- Powderworks Road, at Ingleside, a main junction off Mona Vale Road. Both junctions lead traffic south of Ingleside (towards Sydney), and
- McCarrs Creek Road, north-east of Ingleside and leads to Bayview on the coast
- West Head Road, which junction off McCarrs Creek Road leads further north through Ku-Ring-Gai Chase National Park

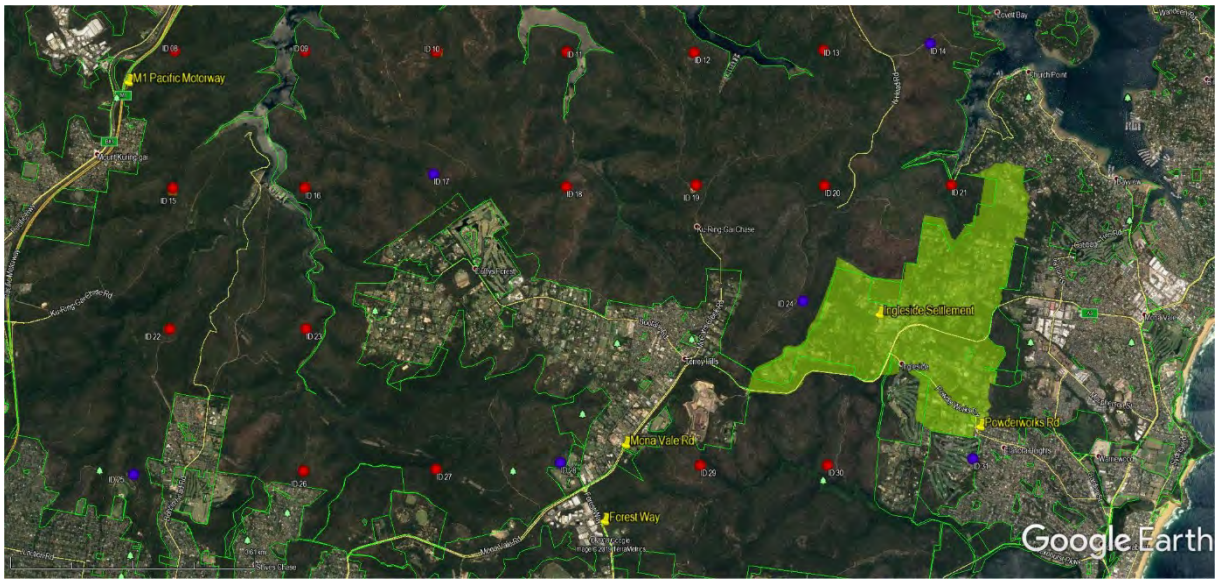


*Figure 2: Main points of interest in this bushfire modelling review.*

Fire behaviour one-hour post-ignition is indicated on Figure 3.

One-Hour Post Ignition

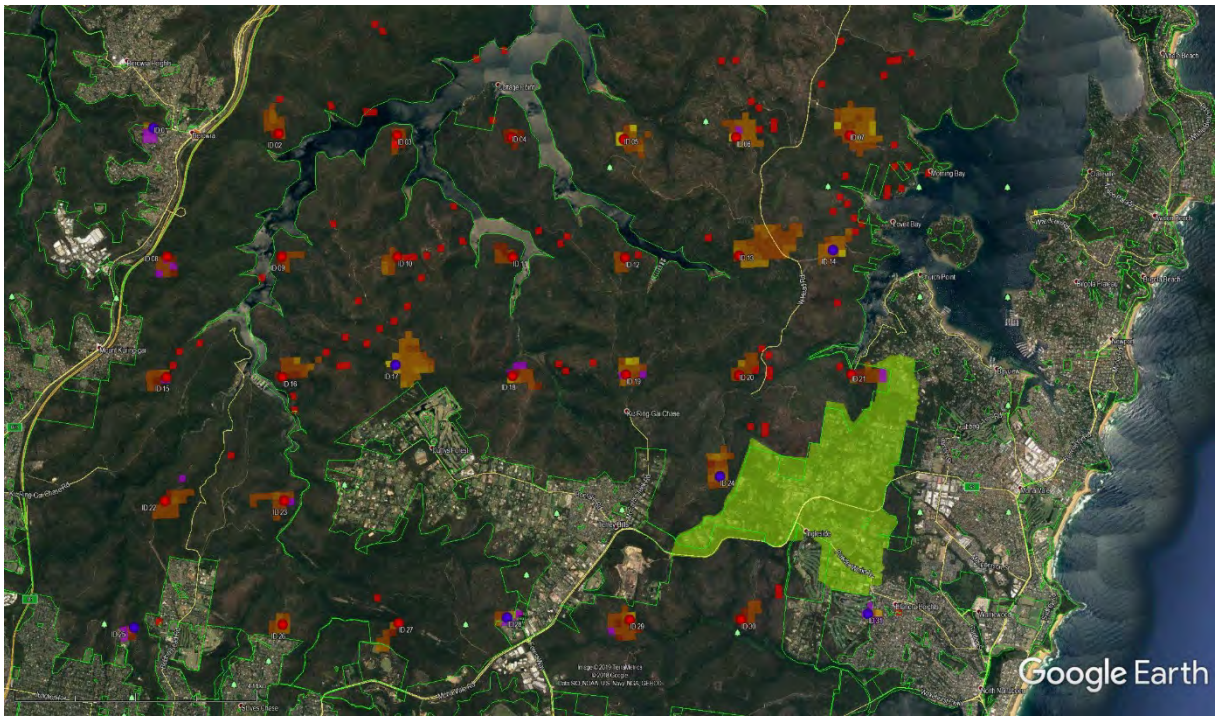


*Figure 3: Potential fire behaviour following one hour from ignition.*

Key Outcomes:

- Immediate vegetation adjacent to western boundary of settlement experiencing high fire behaviour (flame height, intensity, potential rate of spread)
- Spotting behaviour from ignitions points west of Terrey Hills (mainly from WSW/SW winds)
- No spotting behaviour into the settlement
- Main roads unaffected, though breaches McCarrs Creek Road in the north

## Two-Hours Post Ignition

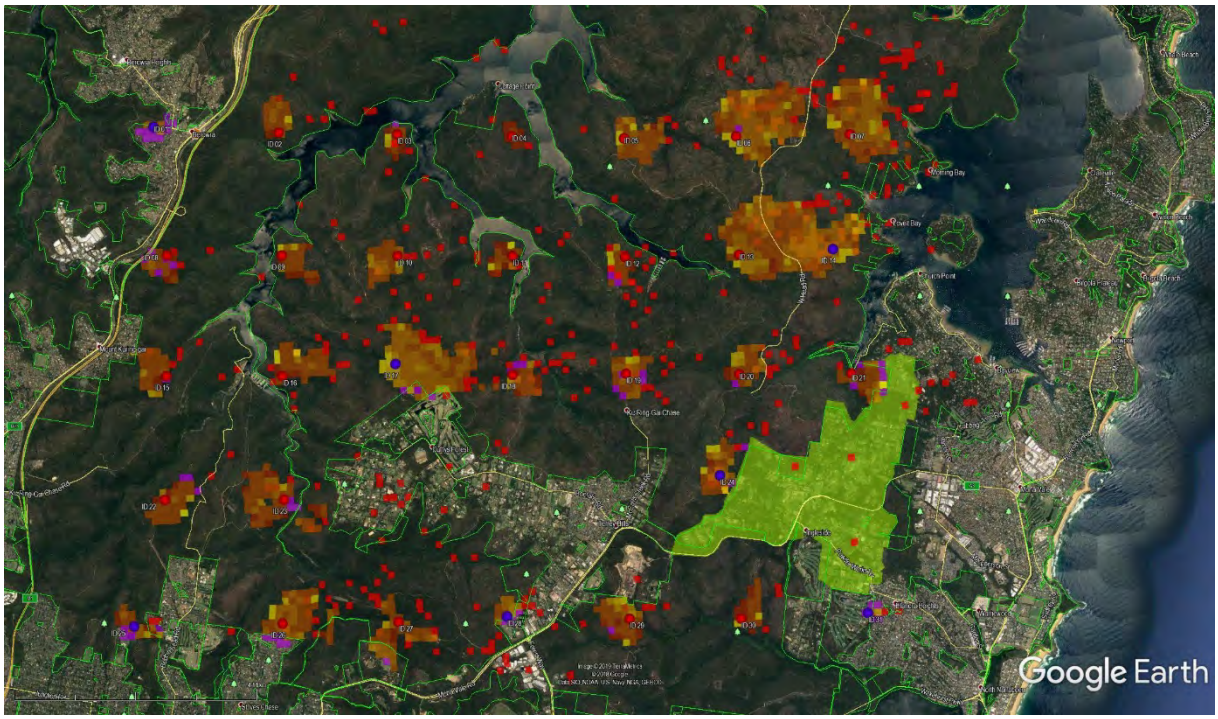


*Figure 4: Potential fire behaviour two-hours from ignition.*

Key Outcomes

- Initial spotting behaviour into the settlement; direct flame contact is experienced on western settlement boundary but self-extinguishes
- Spot fires approaching Mona Vale Road, breaches West Head Road to the north, Powderworks Road unaffected
- Terrey Hills not directly impacted

## Three-Hours Post Ignition

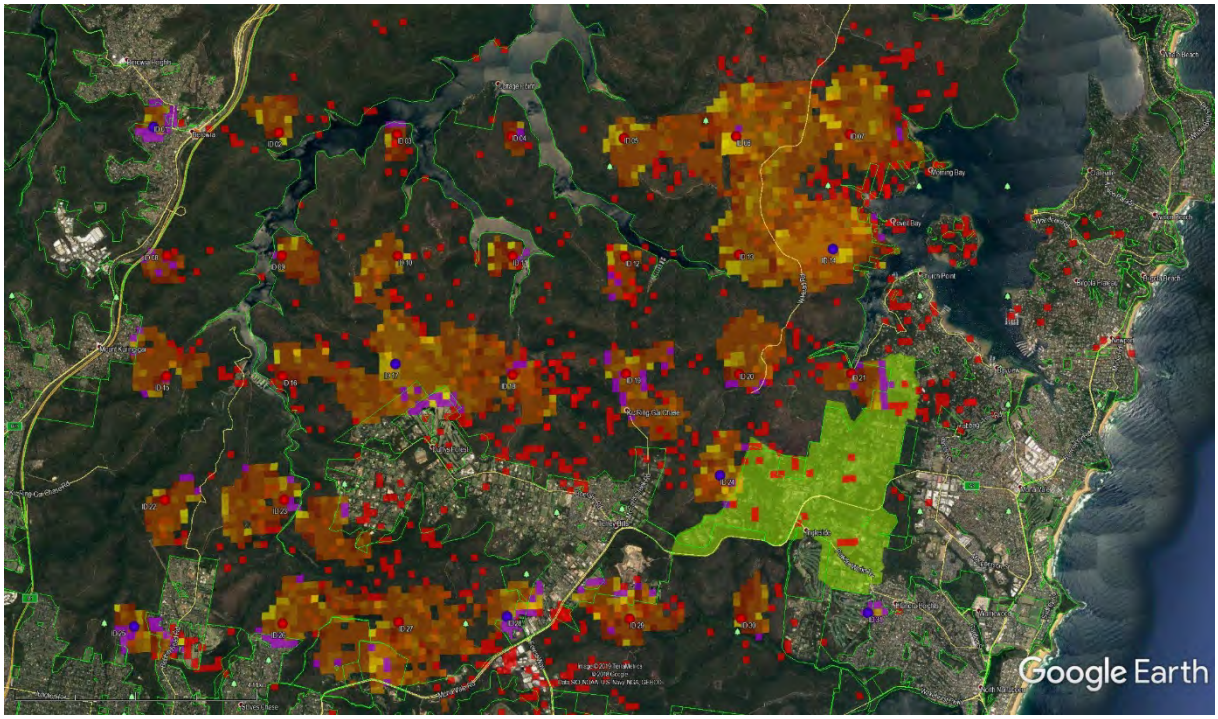


*Figure 5: Potential fire behaviour three-hours from ignition.*

## Key Outcomes

- Fire moves into Ingleside and Terrey Hills via direct flame contact and spotting behaviour. Fires joining into head-fire north of settlement; significant fire behaviour in this location
- Mona Vale Road south of Forest Way junction is breached
- Spotting behaviour into settlement will start impacting on Powderworks Road

## Four-Hours Post Ignition

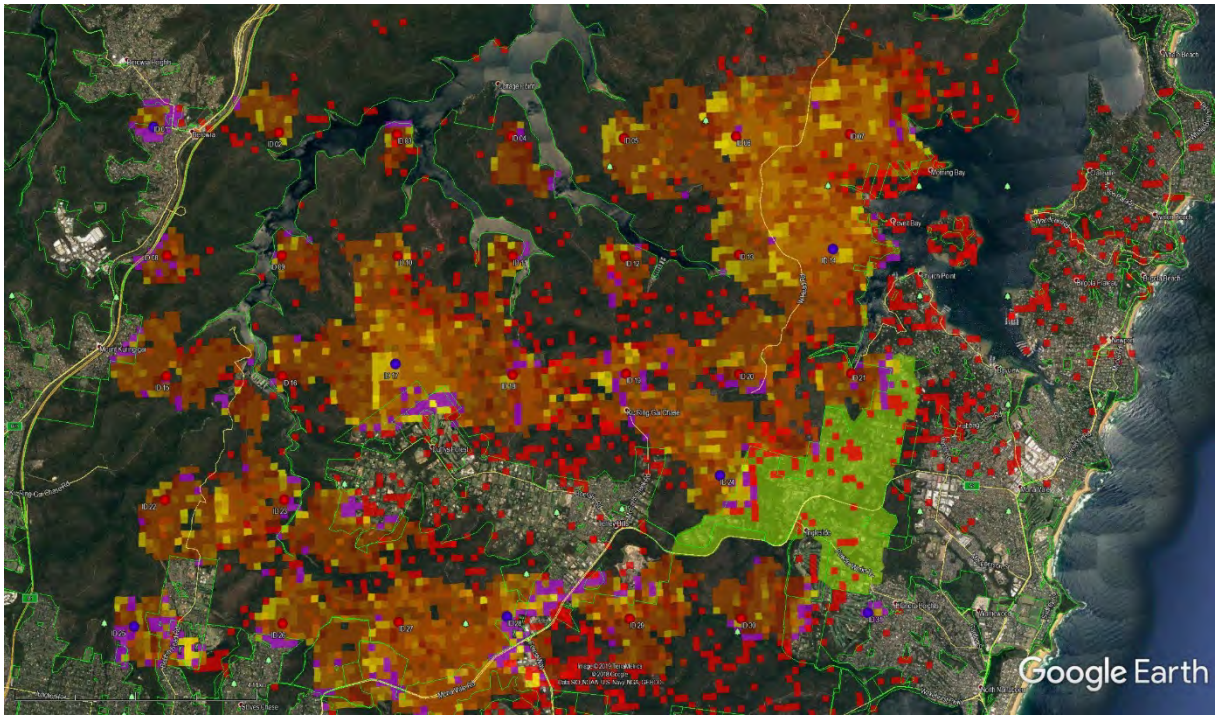


*Figure 6: Potential fire behaviour four-hours from ignition.*

## Key Outcomes

- Western perimeter of settlement with fire impact, both direct and from spotting
- Entirety of the southern section of Mona Vale Rd and Forest Way breached by fire development
- Powderworks Road though impacted by spotting, remains relatively unaffected, but strong development in the Monash Country Club golf course location
- Area north of settlement now developed into significant bushfire

## Five-Hours Post Ignition

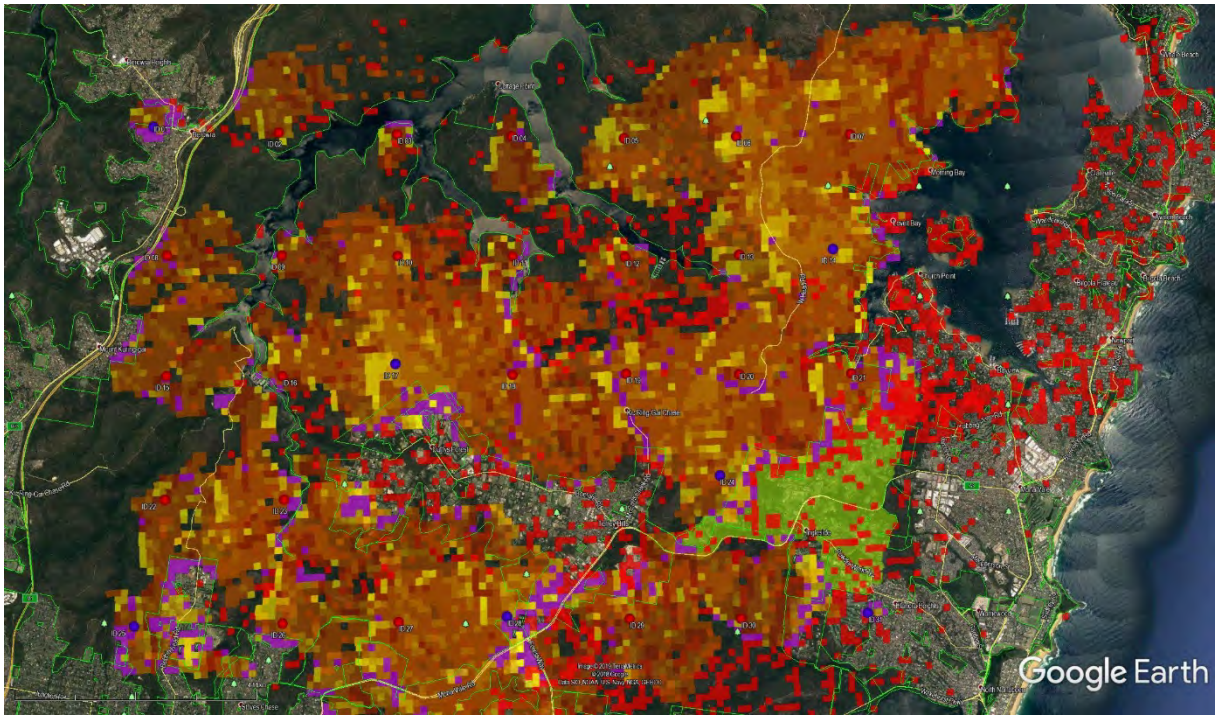


*Figure 7: Potential fire behaviour five-hours from ignition.*

## Key Outcomes

- Bushfire has overwhelmed all major arterial road networks
- Significant impacts to all built environment, major encroachment into Ingleside

## FFDI 77

The following climate variables (averages) were used to generate this Fire Danger Index are outlined in Table 2.

*Table 2: Weather and fuel conditions for fire simulation scenario 2, FFDI 77*

| | | | |
|---|---|---|---|
| Temperature (°C) | 39.9 | Drought Factor | 10 |
| Relative Humidity (%) | 13 | Curing Rate (%) | 100 |
| Wind Speed (k/hr) | 33.9 | Wind Direction (°) | 292.5 – 337.5<br>WSW – WNW |

The following figures outline the predicted fire behaviour and potential impact at one hour intervals across the study area under the conditions outlined in Table 2.

### One-Hour Post Ignition

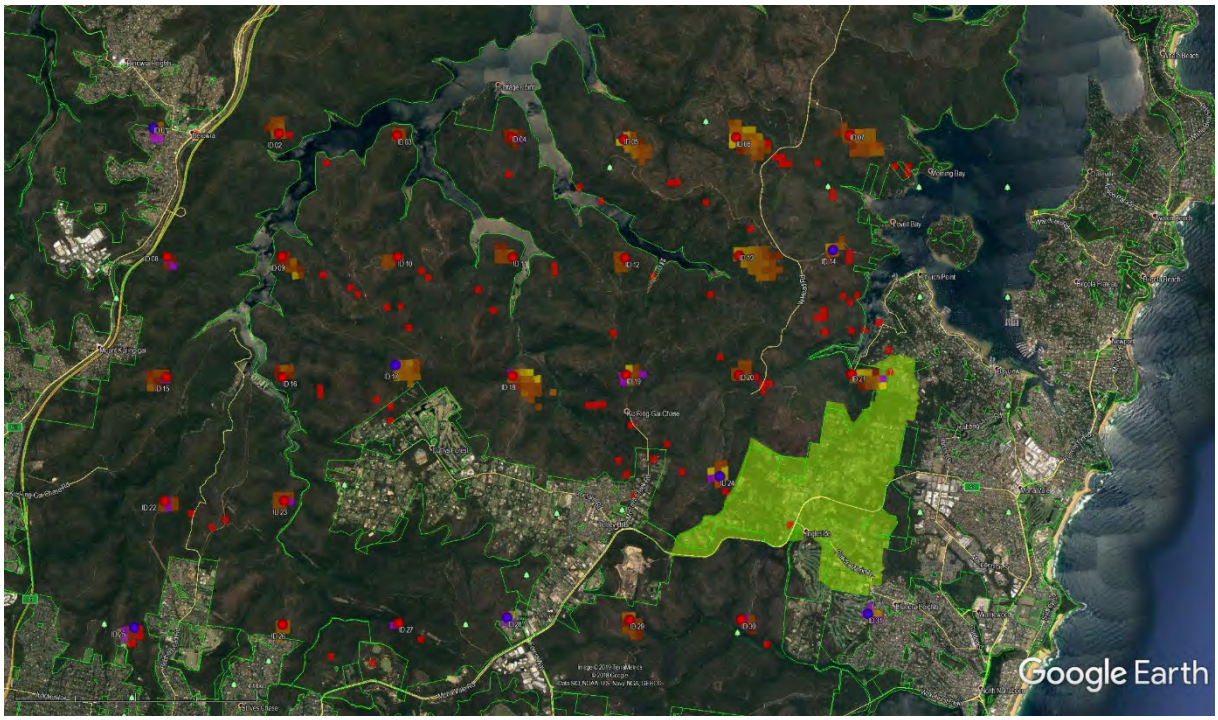


*Figure 8: Potential fire behaviour one-hour from ignition at FFDI 77.*

Key Outcomes

- Main arterial roads remain open and not affected, West Head Road to the north starting to be impacted
- Spotting behaviour in western ignition locations is quite pronounced
- Fire has impacted on settlement in the north, though flames less and 1 m in height

## Two-Hours Post Ignition

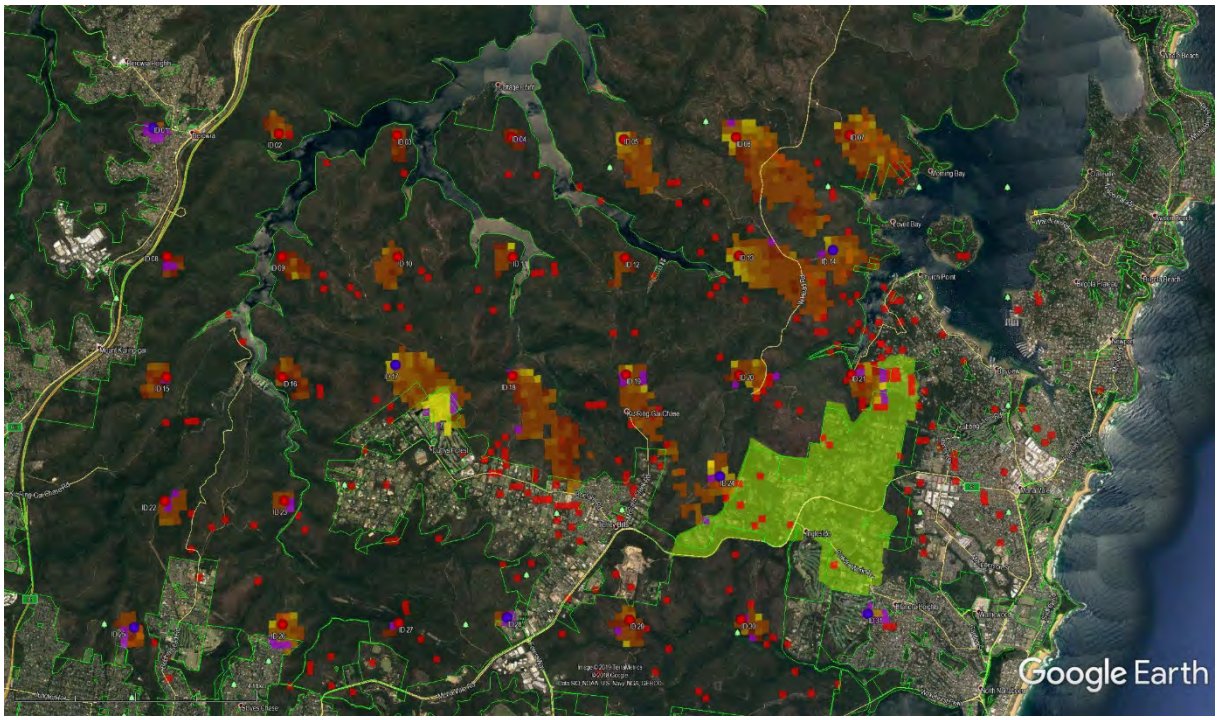


*Figure 9: Potential fire behaviour two-hours from ignition.*

Key Outcomes

- Main arterial roads remain open and unaffected. West Head Road has been breached
- Spotting behaviour more pronounced, impacting on Ingleside and Terrey Hills, fires in the north exhibiting accelerated rates of spread

## Three-Hours Post Ignition

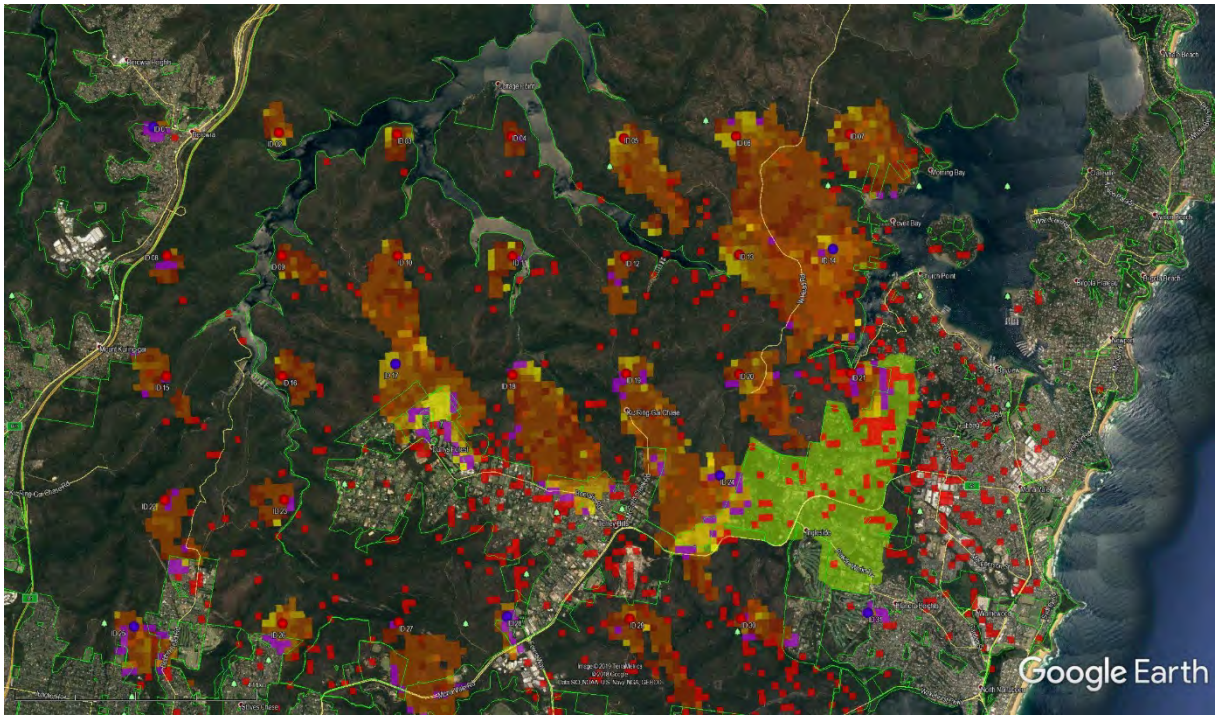


*Figure 10: Potential fire behaviour three-hours from ignition.*

## Key Outcomes

- Significant fire behaviour north of Ingleside, direct and spotting into northern areas of settlement. Northern perimeters of Terrey Hills impacted by bushfire
- Mona Vale Road, south of Forest Way junction has been breached. Mona Vale Road between Resource Recovery Centre and southern section of settlement also breached. Powderworks Road remains open

## Four-Hours Post Ignition

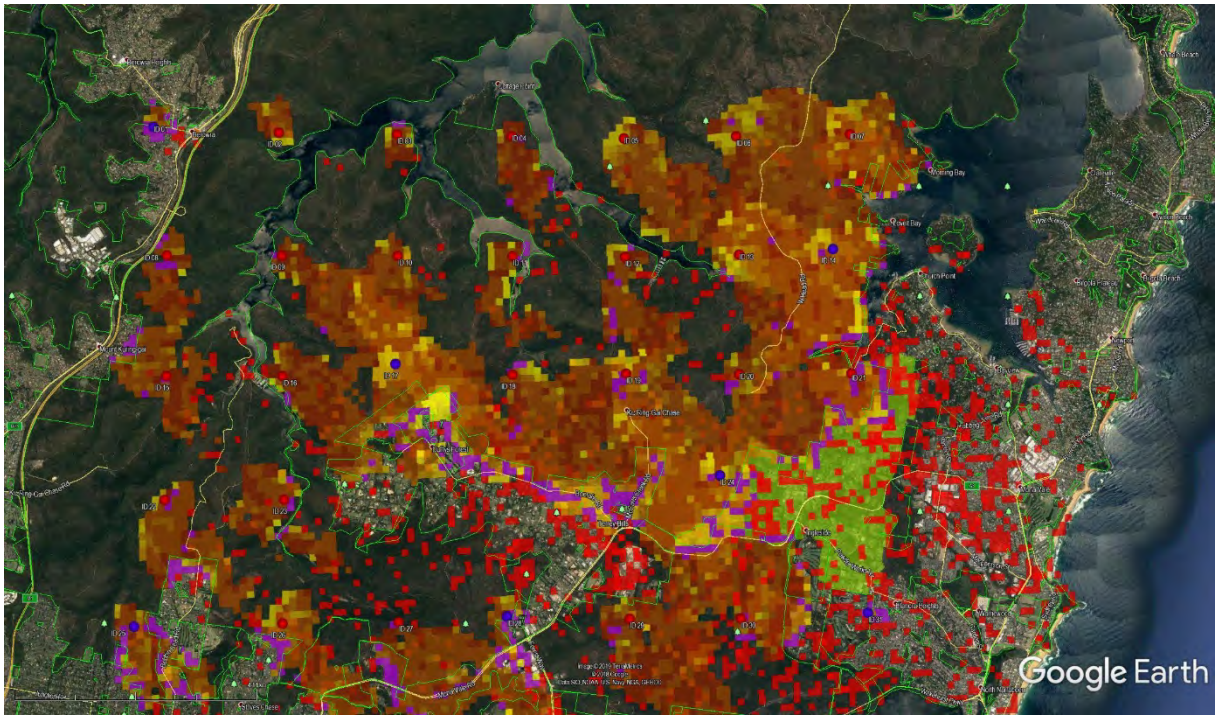


*Figure 11: Potential fire behaviour four-hours from ignition.*

### Key Outcomes

- Significant bushfire impacts across Ingleside and Terrey Hills settlements, this includes well developed spot fires
- All main roads impacted by the bushfire, Powderworks Road will now be closed due to bushfire impact

## Five-Hours Post Ignition

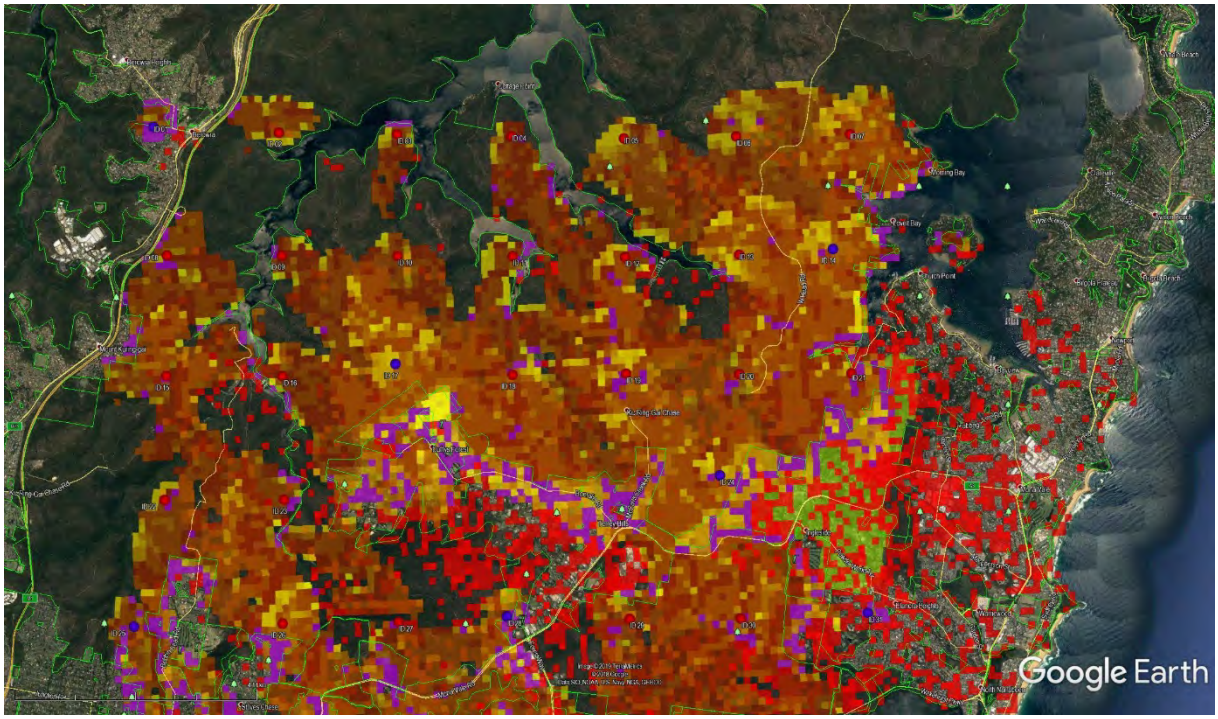


*Figure 12: Potential fire behaviour five-hours from ignition.*

## Key Outcomes

- Major conflagration with fires reaching beach on coastline
- All of Terrey Hills and Ingleside and surrounding areas consumed by bushfire

## FFDI 117

The following climate variables (averages) were used to generate this Fire Danger Index are outlined below in Table 3.

*Table 3: Weather and fuel conditions for fire simulation scenario 3, FFDI 117*

| | | | |
|---|---|---|---|
| Temperature (°C) | 37.2 | Drought Factor | 10 |
| Relative Humidity (%) | 8.3 | Curing Rate (%) | 100 |
| Wind Speed (k/hr) | 40.8 | Wind Direction (°) | 270.0 – 315.0<br>W – NW |

The following figures show the potential fire behaviour and impacts on the study area; under the conditions outlined in Table 3 with all ignition points with simultaneous ignition. It is noted that there is a significant increase in wind speed and narrowing of wind direction. Relative humidity remains very low.

## One-Hour Post Ignition

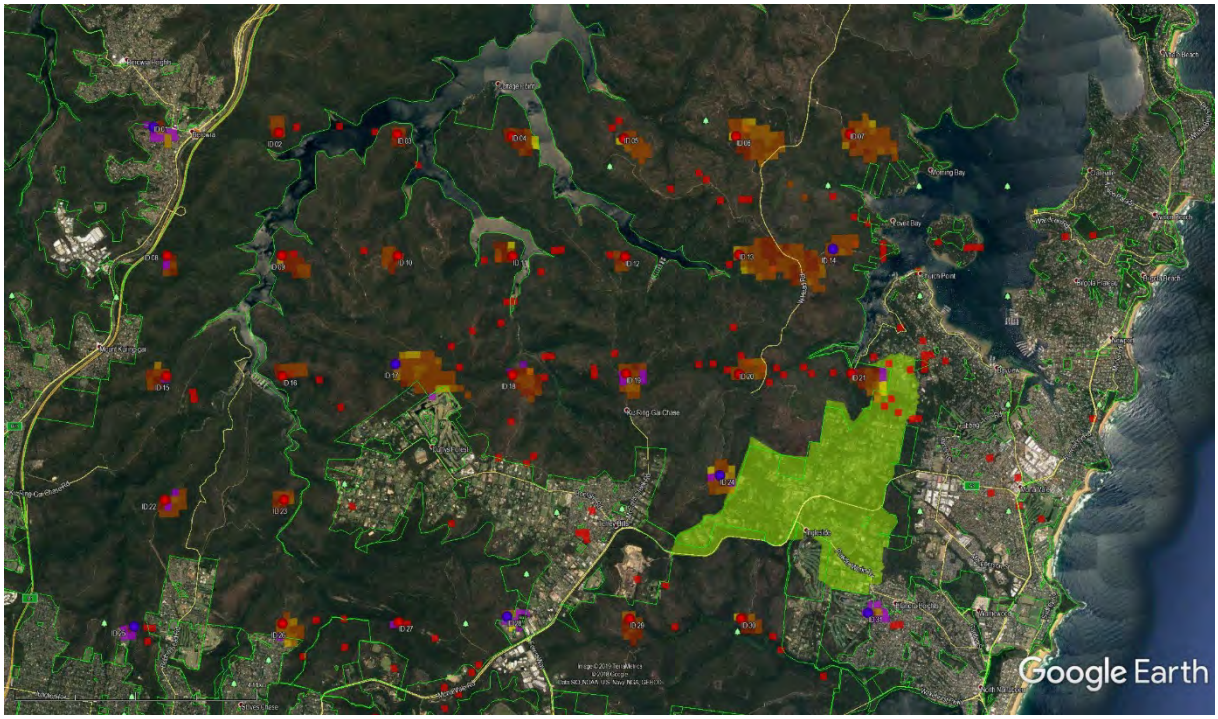


*Figure 13: Potential fire behaviour one-hour from ignition at FFDI 117.*

### Key Outcomes

- Higher wind speeds results in spotting behaviour for all ignition points; with resultant impact into Ingleside and southern (open) sections of Mona Vale Road
- Fires in northern locations moving quickly, West Head Road already breached
- All other arterials remain open

## Two-Hours Post Ignition

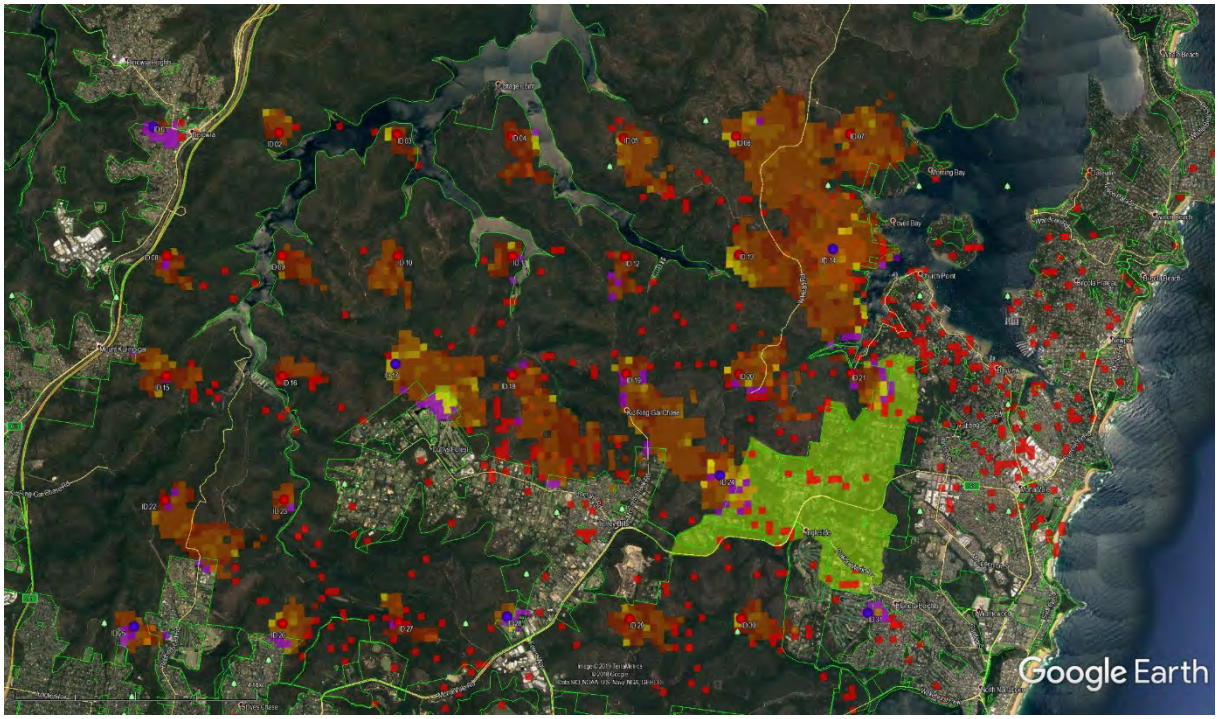


*Figure 14: Potential fire behaviour two-hours from ignition.*

## Key Outcomes

- Area north of Ingleside has developed into a fast-moving bushfire, spotting to the coast
- Direct flame and spot fires inside of Ingleside
- Main arterial roads remain unaffected and open

## Three-Hours Post Ignition

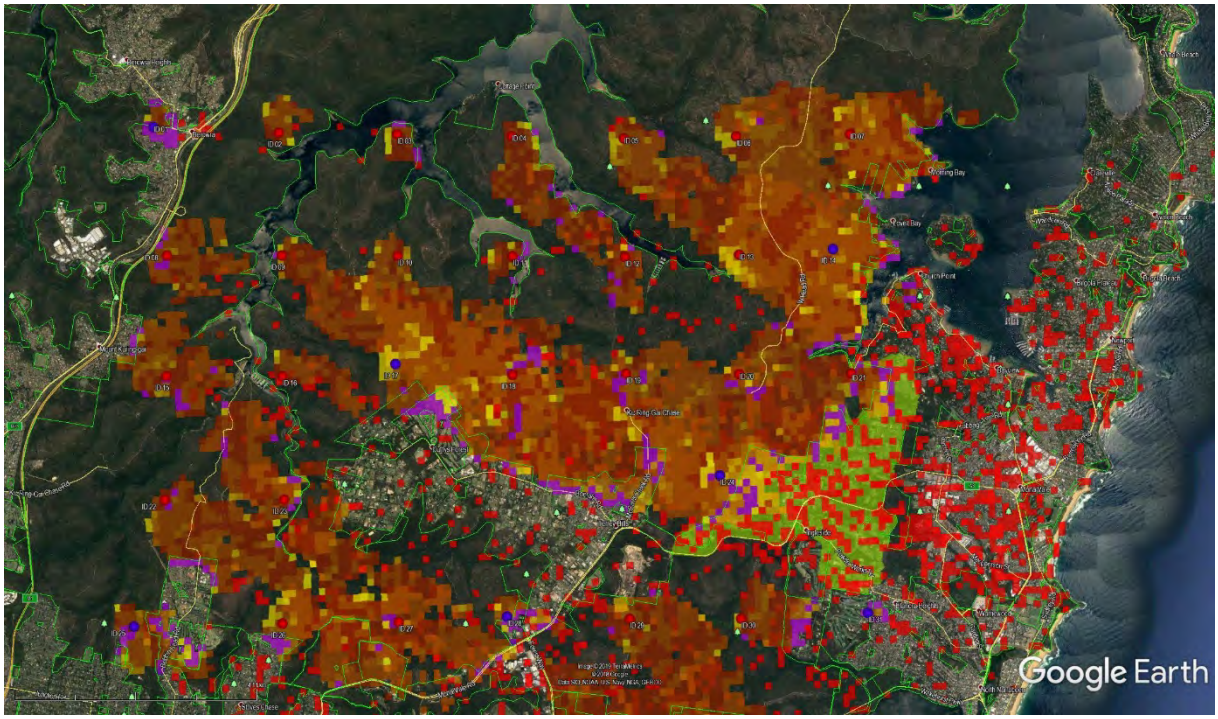


*Figure 15: Potential fire behaviour three-hours from ignition.*

## Key Outcomes

- Major encroachment of bushfire into Ingleside
- Mona Vale Road, south of Forest Way is breached. Forest Way is also breached
- Powderworks Road will be under significant ember development and most likely will be closed to traffic movement
- Terrey Hills experiencing minor impact due to speed of fire moving through the National Park

### Four-Hours Post Ignition

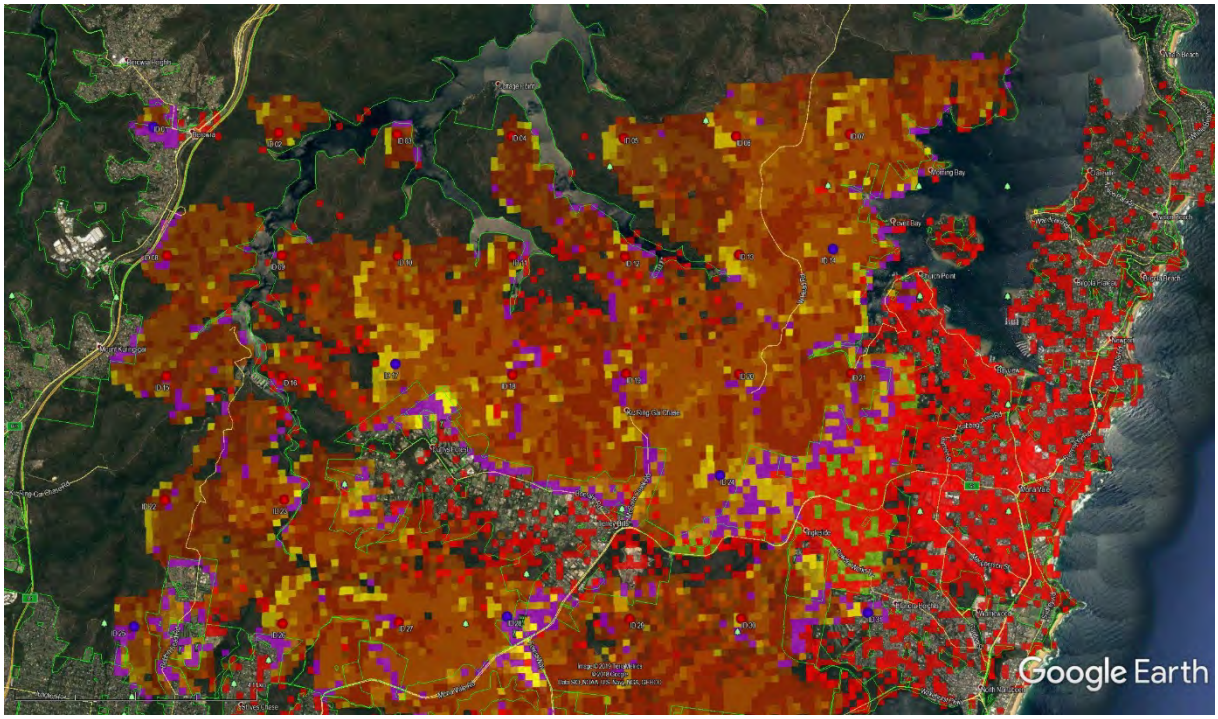


*Figure 16: Potential fire behaviour four-hours from ignition.*

Key Outcomes

- Significant bushfire affected all locations in the Northern Beaches
- All roads remain impacted directly by bushfire activity

## Key Observations

- Under all scenarios, there is a crucial period between two and three hours post ignition where the main roads transition from no impact to being overwhelmed / breached
- Proactive management of West Head Road to the north of Ingleside is highly recommended - this will provide additional time and reduce impact areas of Ingleside north
- Vegetation management in the immediate corridor between the western perimeter of the Ingleside settlement (along Wirreanda Creek) and the fire-trail (Duckholes Trail) in Ku-Ring-Gai Chase National Park, is **highly recommended**. The vegetation complex has high potential fuel load, and as such, the behaviour modelling indicates a significant increase in fire behaviour under all scenarios.

Proactive management adjacent to Ingleside will provide additional benefits to the settlement, reducing direct flame contact and ember development

- Mona Vale Road, south of the Forest Way junction is a critical pinch-point for vehicle movement. The area west of Mona Vale Road between the St Ives Showground and the Terrey Hills area deserves additional consideration for hazard reduction
- Powderworks Road serves as an important road – under most circumstances, this road is relatively unaffected by bushfire

## References

Eco Logical Australia. 2018. Bushfire Intensity Modelling of the Ingleside Precinct. Prepared for Department of Planning & Environment, 31 pp.

Tolhurst, K., Shields, B. and Chong, D. 2008. *Australian Journal of Emergency Management* **23** (4). Phoenix: Development and Application of a Bushfire Risk Management Tool

# Appendix C

## Workshop minutes

# Minutes

**Meeting name**
Bushfire and Traffic Modelling Workshop

**Meeting date**
10th May 2019

**Location**
AECOM, L21 420 George Street, Sydney NSW

**AECOM project number**
60602885

**Subject**
Ingleside Bushfire Study

**Time**
9:30 am – 1:00 pm

**Project name**
Ingleside Bushfire Study

**Prepared by**
Buddhini Wagasooriya

**Attendees**
Ian Bignell (IB) DPE
David Boverman (DB) RFS
Michele Cooper (MC) NBC
Liza Cordoba (LC) NBC
Philip Devon (PD) NBC
Ben Fallowfield (BF) NBC
Nika Fomin (NF) RFS
Laura Gannon (LG) Meridian
Louise Kerr (LK) NBC
Steve McCormack (SM) NSW Police
Gina Metcalfe (GM) DPE
Ben Midgley (BM) AECOM
Bruno Monteleone (BMo) TfNSW
Chris Munro (CM) NBC
Robert Platt (RP) NBC
Andrew Popoff (AP) RMS
Jacalyn Salter (JS) NBC
Lew Short (LS) NBC consultant
Buddhini Wagasooriya (BW) AECOM
Rex Wightley (RW) DPE

**Apologies**
Todd Dickinson
Jorde Frangopoles
Mark Hawkins
Matty Mathivanar
Andy McGregor
Andrew Pigott
Clinton Rose
Craig Geddes (CG)

## Key Actions and Decisions:

| Ref | Action | Responsible | Due by |
|---|---|---|---|
| 01 | Engage National Parks and Wildlife Service as project stakeholder moving forward | IB | - |
| 02 | Consideration of southerly wind change's impact on bushfire spread | LG | 17-05-2019 |
| 03 | 2019 assessment year to replace 2023 in Reference Case modelling | BM | - |
| 04 | Extend model extents along Powderworks Road to include Kalang Road | BM + BW | - |
| 05 | Potential review of four-hour evacuation profile, should Ten Rivers revise down the evacuation window from 3 hours for FFDI 77 | BM + LG | - |
| 06 | Review, update and circulate the TZ evacuation assumptions to select attendees for feedback | BM | 17-05-2019 |
| 07 | Apply uplift to observed traffic counts to reflect seasonal traffic flow variations | BM | - |

## Discussion:

| | |
|---|---|
| **Opening**<br><br>Introductions and Agenda Outline | **GM** introduced herself which was followed by around-the-room introductions by all attendees.<br><br>**GM** ran through the Agenda for the Workshop.GM noted that this study is an emerging area of work and DPE is seeking thorough understanding and agreement to assumptions before proceeding to ensure that the final report is reliable.<br><br>**LS** suggested George Shepherd and Craig Geddes (NSW RFS) as key stakeholders for future involvement. IB noted CG was unavailable today but had provided advice in advance. DB will consult CG post-workshop. |

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| **Safety Moment** | **BM** presented a Bushfire Survival Plan video from the NSW Rural Fire Service website.<br><br>*https://www.rfs.nsw.gov.au/plan-and-prepare/bush-fire-survival-plan* |
| **Study Mission Statement**<br><br>Background and Objectives | **GM** summarised the project history, introducing the prior Draft Structure Plan that was exhibited in December 2016 and subsequent Bushfire Risk Assessment.<br><br>**GM** clarified the driver for the study was primarily an engineering exercise to support land use planning; the study is not being led by a requirement to inform bushfire management or emergency response.<br><br>**LS** suggested that initial findings of the study should be considered in advance of the 2019/20 bushfire season, or at least the raw outputs communicated in advance of formal reporting. The room noted the suggestion, with communication considerations to be made following the study, noting the primary driver for this study is the land use planning exercise and not to inform or advise emergency protocol.<br><br>**DB** requested clarity over the scenarios to be tested and assumptions made in each, to avoid a public perception that scenarios were 'reverse engineered' in response to initial findings. **GM** and **BM** agreed that key assumptions needed to locked down up front where possible to ensure that the final report is reliable and not subjective but explained the rationale, being that certain test measures may become redundant after the first scenario is run, and so retaining flexibility to scope each scenario only once the preceding one is undertaken remains the preference.<br><br>**GM** introduced the 'Workshop decision points' that the project team intended to gain resolution on from attendees. This initiated various discussions which are covered under points later in these Minutes.<br><br>**CM** suggested a potentially important project stakeholder is the National Parks and Wildlife Service. **IB** to reach out and seek engagement. |
| **Bushfire Modelling**<br><br>Methodology and Key findings | **LG** ran through the summary of the Ten Rivers modelling carried out to date (to be formalised in a report soon):<br><br>• 93 scenarios have been modelled using Phoenix RapidFire, spread across three Forest Fire Danger Index (FFDI) categories:<br>– 64 (Cottage Point fire 1994 – affected Ingleside)<br>– 77<br>– 116 (highest recorded in Sydney)<br>• 31 gridded ignition points lit simultaneously to account for likelihood and spotting, removing bias.<br>• FFDIs tested had many commonalities in that ignitions closest to the Ingleside precinct affect the impact time, with those in Ku-Ring-Gai Chase National Park much more likely to impact populated areas than those in Garigal National Park.<br>• All FFDIs suggest Mona Vale Road to the west of Terrey Hills would be impacted at some stage.<br>• Fire impact time on Ingleside from the time of ignition is expected to range between 2 – 4 hours, depending upon the FFDI.<br><br>**LS** stated that normally fire bans get put in place at FFDI 45, and that these smaller scale fires are more common and likely to occur, so recommended there may be a need to consider modelling this at some point. There would also be less warning under these conditions, thus residents would be less prepared to evacuate in a timely manner.<br><br>In response, **LG** and **RW** reiterated the desire to test worst-case conditions, and that the main purpose of the bushfire modelling is to determine impact times for traffic modelling. Higher FFDIs result in lower impact times and thus represent a worst case scenario, except in Catastrophic fire weather conditions where early warning is provided. **LG** stated the purpose of this work is to consider evacuation windows and not house loss at lower FFDIs. **BM** suggested this consideration has been made in selecting which FFDI impact time will be used for traffic modelling, discussed below.<br><br>**DB** raised comments made by Craig Geddes (CG, NSW RFS) regarding consideration of a southerly change in the afternoon which would change the direction of fire spread. **LG** to discuss with Ten Rivers and advise. |

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| **Traffic Modelling**<br><br>Desktop research findings and suggested modelling methodology<br><br>*Reference Case model assumptions* | **BM** reiterated the primary purpose of the workshop was to seek agreement on model inputs and assumptions. With that in mind, the recommended approach was put forward as outlined in the sections below, with feedback provided by attendees.<br><br>**BM** gave reasons in support of modelling a 2023 future year as the Reference Case for land use planning purposes; that being the fact that construction has already started on the Mona Vale Road (MVR) East Upgrade and so modelling should reflect how the road network will behave in its final state. MVR East cannot be upgraded any sooner, despite any findings of modelling.<br><br>**LS, BF** and **DB** all voiced opinions that the current year (2019) and existing road layout should be assessed, with DB confirming this as a suggestion from **CG** too.**GM** indicated that given the secondary purpose of the study is to increase bushfire resilience for existing communities DPE would support stakeholders' request for a 2019 reference case.<br><br>**RW** stated the potential implications of adopting a 2019 assessment year is that local roads may be identified as deficient, prompting a need for investment.<br><br>It was agreed that a 2019 assessment year and existing road layout would be adopted for the Reference Case, with any potential future year assessment undertaken as part of scenario testing.<br><br>**BM** reiterated the suggestion that traffic signal operation remain in place, with no intention to revert to flashing amber signals / blackout / manual operation. **SM** and **BMo** supported this, though **BMo** commented that there would be certain limitations / restrictions with regards to how signal phasing and timing may be optimised during an evacuation. Signal operation may be supplemented by emergency service restrictions / closures to limit access into the study area.<br><br>**BMo** made the recommendation that emergency evacuation plans during the construction of Mona Vale Road East Upgrade should be implemented.<br><br>**BM** suggested AECOM run proposed phasing modifications during Reference Case and scenario testing by TMC and RMS for comment during testing.<br><br>The remaining assumptions around the model were agreed upon:<br><br>• 2-hour peak period: one hour before fire arrives and one hour after<br>• No interim / construction phasing assessment carried out |
| *Project study area* | **BM** presented the model network extents along Mona Vale Road from Kimbriki Road in the west to Pittwater Road to the east. RW reiterated that this study area had already extended in response to RMS feedback.<br><br>**RP + LS** raised questions of evacuation via Cabbage Tree Road, parallel and to the north of Mona Vale Road. Cabbage Tree Road is a fairly heavily used parallel road and is more likely that the northern suburbs (especially early evacuees) will use this to head east towards Pittwater Road and then south along Pittwater Road.<br><br>**BM** explained that the road network study area was identified to test the local road network in the immediate vicinity of Ingleside. In doing so, demand from many surrounding suburbs / Travel Zones (TZ) is considered and accounted for, though only when it reaches the modelled network being assessed.<br><br>**BM** suggested that the larger the study area, the more time and labour intensive the modelling exercise becomes and so a compromise must be made in limiting the study area to achieve the desired outcomes in an manner which meets project timeframe requirements (noting that DPE currently has the study delivery date communicated on their website as being 'mid-2019').<br><br>**LC** and **JS** expressed concern that Powderworks Road was not being modelled far enough south, and that the roundabout with Kalang Road is often a pinch point in the local road network that local residents are well aware of.<br><br>Following discussion, it was agreed to extend the model to include this intersection. |

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| *Evacuation protocol and rates* | **BM** ran through the possible ignition scenarios and the rationale behind choosing the *sudden ignition* profile as the worst-case. This is so because under more extreme fire conditions (e.g. FFDI 116) it is likely residents will have greater advance warning and so a longer evacuation window within which to leave Ingleside. Under lower FFDI, prior warning is reduced and thus evacuation windows are shorter, resulting in a higher proportion of residents surging onto the road network at once.<br><br>**BM** outlined how the resultant four-hour evacuation window profile was identified (using 2009 Victoria bushfire data), though noted this will potentially come under review once Ten Rivers refine their advice.<br><br>FFDI 77 is therefore chosen as the scenario informing the traffic model window.<br><br>**BM** identified the assumed 'stay and defend' proportion of 20% assumed in the profile.<br><br>**LG** mentioned that this was contrary to likely to directions from emergency authorities but based on predicted behaviour derived from the Whittaker & Taylor research paper (February, 2018) which states 27% will stay and defend, based on survey findings. For the purpose of this study, this was reduced to 20% for conservativeness. BM confirmed that multiple sources identify higher 'stay and defend' proportions, and so 20% is considered conservative in estimating a higher volume of traffic attempting to evacuate in assessing the road network's capacity.<br><br>**BF** and **LG** discussed the potential to refine this assessment further to consider demographics and land holding sizes when identifying the proportion of residents with livestock likely to 'stay and defend'. **BM** suggested that whilst this could be done, simply ensuring the assessment undercuts the lowest estimates of 'stay to defend' proportions will ensure the assessment is robust and conservative; 20% is considered as such.<br><br>**SM** mentioned we could investigate whether data is available for more recent ACT bushfires, conditions for which are likely to be more applicable to NSW than Victoria. **BM** and **LG** don't believe data is available but will investigate and if available assess any impact on already agreed assumptions before starting modelling. |
| *Suburbs being evacuated and evacuation routing* | **BM** ran through the process of identifying traffic demand of the local population who would likely evacuate during the evacuation window. This involves two key tasks:<br><br>a) Identifying suburbs (TZ) which are likely to contain residents who would use the model study area as part of their evacuation route;<br><br>b) Identify which roads into the proposed model study area these residents will use.<br><br>**BM** worked through an on-screen example of this process, which uses Excel to draw upon raw 2016 BTS census data to derive the number of trips each TZ is likely to generate.<br><br>**LG** mentioned that FFDI value will not have a direct impact on traffic – in fact, a higher FFDI will more likely mean people would evacuate sooner and therefore in the model period this would result in lower overall traffic demand. Trip generation identified in the spreadsheet model is independent of bushfire modelling, which has the sole purpose of identifying the evacuation window within which the identified trips will evacuate.<br><br>**LS and others** suggested that the TZ image presented, which identified all TZs from which a proportion of the population had been assumed as potentially evacuating via the proposed model study area, appears to overestimate the number of evacuees and will require review.<br><br>**LS** suggested the way by which warning messages were delivered should drive evacuation behaviour, with **SM** confirming warnings do **not** go to residents via postcode. Should they be sent out via towers, it is difficult to ascertain exactly the radius of the population which will receive the warnings.<br><br>**BM** suggested that not all residents from each TZ were assumed as evacuating, though the assumptions will be reviewed downwards nonetheless, following discussion with **LG** with regards to how bushfire modelling may advise which TZ are likely to be affected and how this may influence evacuation behaviour.<br><br>Proposed evacuation proportions and routing will be circulated by **BM** through DPE to a select group of attendees for their feedback and input.<br><br>**AP** asked whether contraflow is often used as an emergency evacuation measure in these situations. **SM** |

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| | confirmed that preventing / limiting access into an area of high risk is protocol, though residents would still be allowed to pass to 'stay and defend' should they choose.<br><br>**BM** suggested that as a result, 10% of background traffic would be considered as continuing to use the road network, to reflect these trips additional to evacuating residents.<br><br>**BMo** mentioned that the method used often depends on various issues, e.g. if it is considered safe to do so. And that in this instance we would expect it to be dependent on traffic signals, physical measures etc. |
| *Date and time of day to be modelled and demand estimation* | **BM** ran through the process followed to arrive at choosing midday Sunday as the assessment time, including discussion around the four types of traffic identified:<br><br>a) Background<br>b) Population<br>c) Employment<br>d) Visitor / tourist<br><br>Primary data sources were identified as the RMS Permanent Count site, BTS census data and JTW data.<br><br>**SM** and **PD** raised the point that weekday peaks are typically much busier than weekend peaks. **BM** suggested traffic conditions during an evacuation were atypical, and the additional number of residents who would be at home to evacuate on a Sunday, teamed with the additional number of visitors in the area, would outweigh weekday demand and therefore Sunday remains the proposed day to model.<br><br>**SM** raised the question about what would happen if for instance on a Thursday afternoon – when people are heading home during a fire to pick up kids, necessities etc and then can't get back on to the network.<br><br>**BM** mentioned that modelling assumed that there are barriers stopping people from coming into the area, although a small proportion (10%) would be allowed 'in' to the study area, representing residents who may wish to get home to stay and defend.<br><br>**LS** suggested its worthwhile looking into a series of years to see how seasonal variations affect traffic volumes, and then try applying these sensitivities to survey volumes obtained for modelling. **BM** agreed that this could be achieved using the RMS permanent count site information. |
| *Evacuation scenarios* | **BM** explained that in addition to the Reference Case there will also be three scenarios testing various cases.<br><br>Scenario 1 inclusions currently decided upon were explained; this being what the project team consider to be the most realistic evacuation scenario as informed by bushfire modelling and desktop research. Upon reviewing the findings of this scenario, further tests would then be identified.<br><br>**BMo** stated that it will not be possible to do real-time changes to traffic lights in an evacuation scenario outside of what is currently coded in SCATS.<br><br>Scenario 1's components were agreed upon by attendees.<br><br>**BM** explained that following initial modelling, there are many tests / actions that could be built in to the next scenario. The components of each scenario will be discussed and agreed upon prior to assessment. |
| *Workshop decision points* | After the decision to adopt 2019 volumes for Reference Case, it was confirmed that these volumes would also be used for Scenario 1. 2023 would then be used on a separate Scenario, as a sensitivity test on the model.<br><br>**BM** ran through the decision points set out at the onset of the workshop and then confirmed the decisions reached by its conclusion. |

| Decision Point | Decision |
|---|---|
| Fire Warning = Sudden ignition | Agreed |
| Proportion staying to defend = 20% | Agreed |

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| Confirm Emergency Services can physically restrain traffic from certain areas | Yes – we can consider closures as an option |
| Evacuation routing + suburbs | Data will be circulated to select attendees for comment |
| Study Area | Extended on Powderworks Road |
| Time of model | Agreed |
| Measures used to assess performance | Deferred |
| Scenario 1 components | OK |

**GM** thanked participants for their contribution and advised that DPE would reconvene this group or a subset of agency representatives to consider the results.

# Minutes

**Meeting name**
Mid-model Workshop

**Meeting date**
20 August 2019

**Location**
AECOM, L21 420 George Street, Sydney NSW

**AECOM project number**
60602885

**Subject**
Ingleside Bushfire Study

**Time**
9:30 am – 12:30 pm

**Project name**
Ingleside Bushfire Study

**Prepared by**
Ben Midgley

**Attendees**
Ian Bignell (IB) DPIE
David Boverman (DB) RFS
Steve Chapple (SC) NPWS
Michele Cooper (MC) NBC
Liza Cordoba (LC) NBC
Philip Devon (PD) NBC
Todd Dickinson (TD) NBC
Nika Fomin (NF) RFS
Laura Gannon (LG) Meridian
Amanda Harvey (AH) DPIE
Gloria Hill (GH) DPIE
Steve Lawlor (SL) - NBC
Andy McGregor (AM) AECOM
Brendan Metcalfe (BMe) DPIE
Gina Metcalfe (GM) DPIE
Ben Midgley (BM) AECOM
Yolande Miller (YM) DPIE
Tom Molski (TM) TfNSW
Kristen Montgomery (KM) NBC
Chris Munro (CM) NBC
Andrew Pigott (APi) NBC
Andrew Popoff (AP) RMS
Craig Sawyer (CS) NBC
Adonna See (AS) NBC
Lew Short (LS) NBC consultant
Buddhini Wagasooriya (BW) AECOM
Rex Wightley (RW) DPIE

**Apologies**
Nick Armstrong (NA) DPIE
Craig Geddes (CG)
Louise Kerr (LK) NBC
Steve McCormack (SM) NSW Police
Bruno Monteleone (BMo) TfNSW
George Sheppard (GS) RFS

## Key Actions and Decisions:

| Ref | Action | Responsible | Due by |
|---|---|---|---|
| 01 | Scenario 3 to form an 'Emergency Management' scenario, in which emergency management response to traffic evacuation is considered. | AECOM | TBC (depends on Ref 02) |
| 02 | DPIE (RW & GH) to organise a meeting between key Emergency Management stakeholders to inform the specifics of Scenario 3. | DPIE (RW & GH) | 04/09/19 – 13/09/19 |
| 03 | KM to circulate calendar invite for Northern Beaches LEMC Meeting. | KM | Done. |
| 04 | Finalise Scenario 2 (2019 scenarios). | AECOM | Done. |
| 05 | BM and LG to begin preparing Reporting structure template for internal project team discussion and agreement. | BM & LG | 30/08/19 |
| 06 | BM to provide DPIE with revised programme estimate. | BM | Done. |

## Discussion:

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|---|---|
| **Opening**<br><br>Introductions and Agenda Outline | **GM** introduced herself which was followed by around-the-room introductions by all attendees.<br><br>**GM** ran through the Agenda for the Workshop and the key objectives, which were to recap bushfire analysis undertaken, present findings of traffic modelling to date, take on board feedback on the methodology and findings of analysis undertaken to date and identify the direction moving forward with respect to further scenario testing.<br><br>It was acknowledged that NBC have requested 2019 year assessment and that this will be undertaken; however was not ready for presentation at this workshop. |

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| **Safety Moment** | **LG** highlighted that the Bush Fire Danger Period had commenced at a further nine areas across the state's north from 17 August (highlighting that we're still in winter), and strongly encouraged all attendees to be aware of and use the NSW RFS Fires Near Me app or website; the example of an ongoing fire at Long Nose Point in Ku-Ring-Gai Chase NP was used to demonstrate the tool's effectiveness.<br><br>*https://www.rfs.nsw.gov.au/fire-information/fires-near-me* |
| **Bushfire report update**<br><br>Methodology and Key findings | **LG** ran through the summary of the Ten Rivers modelling carried out to date (to be formalised in a report soon), noting its core purpose as being to advise an evacuation window between fire ignition and fire arrival at the Ingleside Precinct for traffic modelling:<br>• 93 scenarios have been modelled using Phoenix RapidFire, spread across three Forest Fire Danger Index (FFDI) categories:<br>– 64 (Cottage Point fire 1994 – affected Ingleside)<br>– 77 (mid-point: selected for this study)<br>– 116 (highest recorded in Sydney)<br>• 31 gridded ignition points lit simultaneously to account for likelihood and spotting, removing value judgement or bias. This supersedes the prior approach of selecting ignition points based on perceived likelihood, e.g. near paths and trails, or in proximity to roads.<br>• Ignitions closest to the Ingleside Precinct have a greater and sooner impact than those further away.<br>• FFDI 77 was chosen as a means of reflecting conditions in which residents are not as aware of or prepared for a bushfire or evacuation, given its lower perceived risk than higher FFDI. This would in turn result in more vehicles accessing the road network in the event of a bushfire, given fewer residents would have relocated in advance, thus allowing for traffic modelling of conservative, 'worst-case' conditions.<br>– This was discussed and agreed at the previous workshop (10 May 2019).<br>– **LS** noted that under FFDI 77, RFS will issue an order to remain in place and not evacuate. The project team acknowledged this and accept that traffic modelling is therefore still very conservative in the number of vehicles accessing the road network in the short evacuation window assumed. A lower FFDI would result in a longer evacuation window (fewer vehicles per hour on the road network).<br><br>**RFS** noted that under the top two risk categories, the local population is advised to relocate early, with advising to "stay and defend" not an option under national policy.<br><br>**LG** discussed how the model estimates a bushfire would develop over time from ignition, as follows:<br>• Two hours post-ignition: West Head Road is affected. Spotting occurs in built-up areas within the study area, including the Ingleside Precinct.<br>• Three hours post-ignition: Significant fire front has reached the north of Ingleside Precinct. Terrey Hills perimeters impacted. Mona Vale Road is impacted in several locations east of Ingleside, primarily east of Forest Way and in between McCarrs Creek Road and Powderworks Road. Powderworks Road remains largely unaffected by the fire front, though bushfire modelling does not advise on the impact of smoke or radiant heat.<br>• The evacuation window is therefore estimated at 2h20 – 2h40 for north Ingleside, noting that many variable inputs inform this assumption. This information has informed traffic modelling and a 2h30 evacuation window for the entire study area has been assumed for the traffic analysis.<br><br>**LG** noted that the 1994 Cottage Point fire started the day before it reached populated areas, but that the evacuation alert went out only shortly before the fire arrived.<br><br>**LG** noted that the RFS FBAN has reviewed the bushfire modelling methodology and is satisfied.<br><br>**DB** noted the need to be cautious and flexible in response to assessing bushfire outputs, which are based on |

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| | defined inputs that are highly variable. **DB** noted there are millions of scenarios possible, from high consequence / low likelihood to low consequence / high likelihood. In response, **BM** reiterated that bushfire assessment was used as a *guide* to steer the traffic modelling methodology, and as such findings would not be adopted verbatim for use but used to inform and advise a conservative, robust traffic modelling approach. |
| **Evacuation model key features & evacuation traffic demand determination** | **BM** reiterated key elements of the traffic study methodology, beginning with the 2019 Base (existing case) model. This summary confirmed a 2019 Base year was adopted, reflecting traffic survey data collected on Sunday 19th May 2019. **BM** reiterated the previously agreed assumption that a Sunday Midday is assumed as reflecting the most robust assessment period, as it forms a period during which there will be many residents at home whilst also being a time during which the local road network is busy with 'background' traffic. These assumptions were discussed and agreed at the previous workshop (10 May 2019). |
| *Reference Case model* | **BM** ran through the purpose of a Reference Case model, that being a model in which the evacuation traffic demand (discussed later) is modelled but in which no other road closures or intervention measures are applied. This Reference Case allows for direct comparison of measures implemented in Scenario testing, to isolate and identify the impacts of said Scenarios.<br><br>The Reference Case model was developed for a 2023 future year, that being the year the Mona Vale Road East Upgrade is expected to be complete. The Mona Vale Road West Upgrade was not coded. Traffic signals were optimised, within reason, to improve traffic performance in response to demand; the signals ran the same phase sequence as existing, with phase splits only modified. No road closures or Ingleside Precinct development uplift was assumed. |
| *Background traffic demand* | **BM** ran through the core assumptions adopted in identifying traffic demand for the evacuation scenarios. Traffic demand was considered as constituting two components: background traffic and evacuation traffic. The key steps involved in identifying background traffic were as follows:<br><br>1. Begin with observed 2019 traffic volumes<br>2. Apply a seasonal uplift (to convert observed winter counts to higher summer counts)<br>3. Bring forward hour 2 (after the fire arrives) inbound / homebound trips to hour 1 (before the fire arrives)<br>4. Remove residents who won't attempt to return home (informed by surveys)<br>5. Once only 30 minutes away from fire arrival, assume inbound / homebound trips reconsider their destination and continue 'through' to the end of the network along the Mona Vale Road mainline<br>6. Outbound / leaving home trips are removed as they are replaced by 'evacuation traffic' discussed below<br>7. End to end 'through' traffic along Mona Vale Road reduced to 10% to reflect the fact that those using this corridor for a wider regional trip would no longer do so with a bushfire in the area<br><br>**BM** stated that any quantified adjustments or modifications to traffic demands were determined through use of available data / surveys / studies, and further detail could be provided to any attendees who wish to scrutinise inputs further. |
| *Evacuation traffic demand* | Evacuation traffic demand was discussed in the same manner:<br><br>1. 2016 census data informs travel zone populations (catchment population ~35,000)<br>• 2021 and 2026 Estimated Resident Populations used to estimate 2023 population<br>2. 95% of all residents are at home<br>3. 20% stay and defend<br>4. Of those evacuating: hour before the fire arrives: 48.2% \| hour after the fire arrives: 19.9%<br>5. Percentage of population evacuating towards Mona Vale Road agreed through consultation<br>6. Direction they take upon reaching Mona Vale Road is graded east to west |

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| *Scenario 1* | • Eastbound Mona Vale Road approach to Pittwater Road split 80% right (SB) and 20% left (NB)<br>• All evacuating traffic goes to either Mona Vale Road (WB), Pittwater Road (SB) or Barrenjoey Road (NB) – no traffic evacuates to 'internal' locations.<br>7. Hour 1 evacuation demand: 3,600 vehicles. Hour 2 evacuation demand: 1,500 vehicles.<br><br>**BM** reiterated that whilst not all steps were presented at the workshop, these slides demonstrate the depth in thought and research that has informed this critical component of the traffic model. It was also reiterated that the adjustments and modifications applied were deliberately conservative to maximise the number of vehicles evacuating during the model period, thus resulting in 'worst-case' traffic performance.<br><br>In response, **TM** suggested a power outage and non-functioning traffic signals would represent an even case. **BM** and **RW** suggested this approach were not adopted on the basis that prior agreement was reached (10 May 2019) on the methodology and that NSW Police had stated there may not be resources to manually operate signalised intersections, therefore how this would operate is difficult to predict. **DB** noted that police response would be similar between 2019 and 2023 scenarios.<br><br>**PD** queried the number of cars per household assumed as evacuating. **BM** responsed that conservatively, all cars (using 2016 census data to derive the average number of cars per person in the Northern Beaches LGA) were assumed as being used, to model the maximum possible impact on the road network.<br><br>**BM** presented the key components of Scenario 1, those being:<br>• Optimised traffic signals (within confines of current TCS plan);<br>• Mona Vale Road closed in both directions between Forest Way and McCarrs Creek Road;<br>• Evacuation traffic from Duffys Forest and Terrey Hills included;<br>• Powderworks Road closed northbound at Wilga Street, southbound remains open to assist evacuation.<br><br>The VISSIM traffic model was then run on-screen, with **BM** providing a running commentary of performance, with highlights as follows:<br>• 10:30am fire ignites. First response and evacuation begin 11:00am.<br>• Congestion builds from the Mona Vale Road / Pittwater Road intersection, given the majority of evacuating traffic heads eastwards following closure of Mona Vale Road between McCarrs Creek Road and Forest Way.<br>• By 12:00, queuing is relatively short as the bulk of evacuating traffic is yet to access the road network. By the time the fire arrives (13:00), eastbound queuing originating at the Mona Vale Road / Pittwater Road intersection extends through the Powderworks Road intersection.<br>• By 14:00 (one hour after the fire arrives), queuing has still not cleared given capacity restrictions / merge for Mona Vale Road (west) right turners to Pittwater Road (south). |
| *Scenario 1 group discussion* | As the model was running on screen, several questions were asked:<br><br>**APi**: can we direct more traffic form the west to evacuate down Powderworks Road? **BM** responded yes, and that this would likely form part of the next scenario.<br><br>**PD**: raised registered vehicle rates for Terrey Hills and questioned the volumes coded in the model, i.e. has a cap been applied to limit evacuating traffic to vehicle ownership? **BM** suggested that the volume coded as evacuating from Terrey Hills in the model period was similar to / just less than the total number of registered vehicles, which is a conservative assumption to test a worst-case scenario, and that 2016 population and average car ownership per person rates for the Northern Beaches LGA were used to determine the cap.<br><br>**GM**: can we output the number of vehicles that wanted to get out but did not reach their destination (i.e. unreleased vehicles)? **BM** responded yes, and that an objective of this workshop and subsequent discussions was to determine which evaluation criteria the PSC would like to see reported upon. |

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| | **RW** raised the comment that NSW Police could theoretically route vehicles wherever they like in the event of an emergency evacuation, and so any rerouting via Powderworks Road would be possible and would be discussed prior to informing Scenario 3 components.<br><br>**DB** reiterated the statement that scenarios to be tested need to be reasonable and test the uncertainty around variables. Caution was urged in the use of findings of the traffic model, in that prevailing 'real life' bushfire conditions may be different to those modelled and assessed. **BM** and **RW** concurred, acknowledging that traffic and bushfire modelling is to be used as a guide, but that quantitative outputs of the scenarios we're testing would not necessarily form the most appropriate measure of how capable the road network is in accommodating a bushfire evacuation. **LS** supporting **DB's** position. State the problem and means to mitigate it, broadly.<br><br>**DB** confirmed that RFS would never confirm or deny whether what has been tested in reasonable or not but are happy to be engaged in discussions.<br><br>**TD** commented that emergency management of traffic evacuation would likely reduce congestion and queuing and endorsed the use of qualitative outputs and findings as opposed to quantitative. **DB** concurred that we are using a quantitative study to paint a qualitative picture.<br><br>The use of Neighbourhood Safer Places (NSP) was discussed by the group, with a conclusion being made that no evacuation order would recommend residents to access their NSP; evacuation or stay and defend would instead be instructed, depending upon the prevailing conditions. NSP is a plan C, not plan A.<br><br>**BM** responded to a query that 80% of vehicles evacuating eastwards would turn right from Mona Vale Road to Pittwater Road (south), with the remaining 20% evacuating north.<br><br>**BM** noted that side arms in the model have a limited length, with queues beyond this being captured as 'latent demand' or 'unreleased vehicles'. The group agreed that quantifying these values for the time the fire arrives was important.<br><br>**TD** advised that confidence levels may be considered as a means of communicating findings. **TD** advised that sensitivity analysis could be undertaken on the critical issues that limit evacuation.<br><br>**DB** commented that not enough time is set aside to discuss the context and relevancy of the study, and that RFS would not take a position on quantitative outputs, though accepts acceptance criteria need establishing.<br><br>The question was put to the group: what is acceptable? Queuing not backing to Ingleside reserve? Not having traffic queueing in a bushfire prone area?<br><br>Discussion was held around the potential for physical upgrades, for example removal of the raised median segregating the Mona Vale Road right turn to Pittwater Road (south) from the Pittwater Road (north) through movement to Pittwater Road (south); the room concurred that physical improvements need to be cost-benefit analysed, in that they'd be put in place for a once in X years event at the potential expense of daily traffic movements in the interim.<br><br>It was discussed and agreed that Scenario 3 should reflect emergency management protocol enacted in the event of a bushfire. DPIE (RW & GH) to organise a meeting with emergency management stakeholders to determine requirements for scenario.<br><br>Potential requirement for a further scenario to test residential dwelling uplift in the Ingleside Precinct, should Scenario 3 determine there is capacity available.<br><br>It was noted that the project team is obliged to complete the study by the end of the year (communicated online on DPIE website). |