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Final Report: Hydrogeology

Moree Special Activation Precinct

for Department of Planning, Industry and Environment

February 2021

J1774.3R-rev1

C. M. Jewell & Associates Pty Ltd

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1.0 INTRODUCTION

1.1 Background

The New South Wales (NSW) Government has identified dedicated areas throughout regional NSW to bring together planning and investment to stimulate economic growth across a range of industries such as freight and logistics, advanced manufacturing, renewable energy, agribusiness and tourism. These dedicated areas are recognised as Special Activation Precincts (SAPs).

The NSW Government announced the investigation of a SAP at Moree on 3 December 2019. The purpose of the SAP is to investigate opportunities to unlock the economic potential of the region by leveraging Moree's location in the middle of one of the most productive agricultural regions in Australia, its proximity to the Inland Rail, and its strategic connections to inter- and intra-state, national and global markets. The SAP will guide development to support and enable future business growth and diversification in Moree.

1.2 Investigation area and surroundings

Moree is located on the lands of the Gamilaroi (also known as Kamilaroi) people, the second largest Aboriginal nation on the eastern coast of Australia. The descendants of the Gamilaroi Nation continue to live on their land in Moree, with 21.6 percent of the Moree Plains local government area (LGA) population identifying as Aboriginal and/or Torres Strait Islander.

The natural assets of Moree and the surrounding area have made it one of the most productive agricultural regions in Australia. Natural benefits brought by fertile soils, a favourable climate, and the availability of both surface water and groundwater has supported both large-scale broadacre cropping and pastoral production in the region. The region relies on a reliable water supply of both groundwater (from an alluvial aquifer) and surface water to support community and agribusiness. Fertile plains are drained by the Namoi and Gwydir Rivers and their tributaries, including the Mehi and Peel Rivers.

The Moree SAP investigation area encompasses an area of approximately 5,800 hectares (ha) and lies just south of the Moree township and Gwydir Highway. The SAP investigation area spans both sides of the Newell Highway and the Inland Rail corridor (Narrabri to North Star section). There are a number of creek tributaries which traverse the investigation area. The primary waterway is Halls Creek, which crosses the SAP investigation area midway in an east-west direction, south of the Moree Regional Airport.

The Moree SAP investigation area and key features are shown on Figure 1.1.

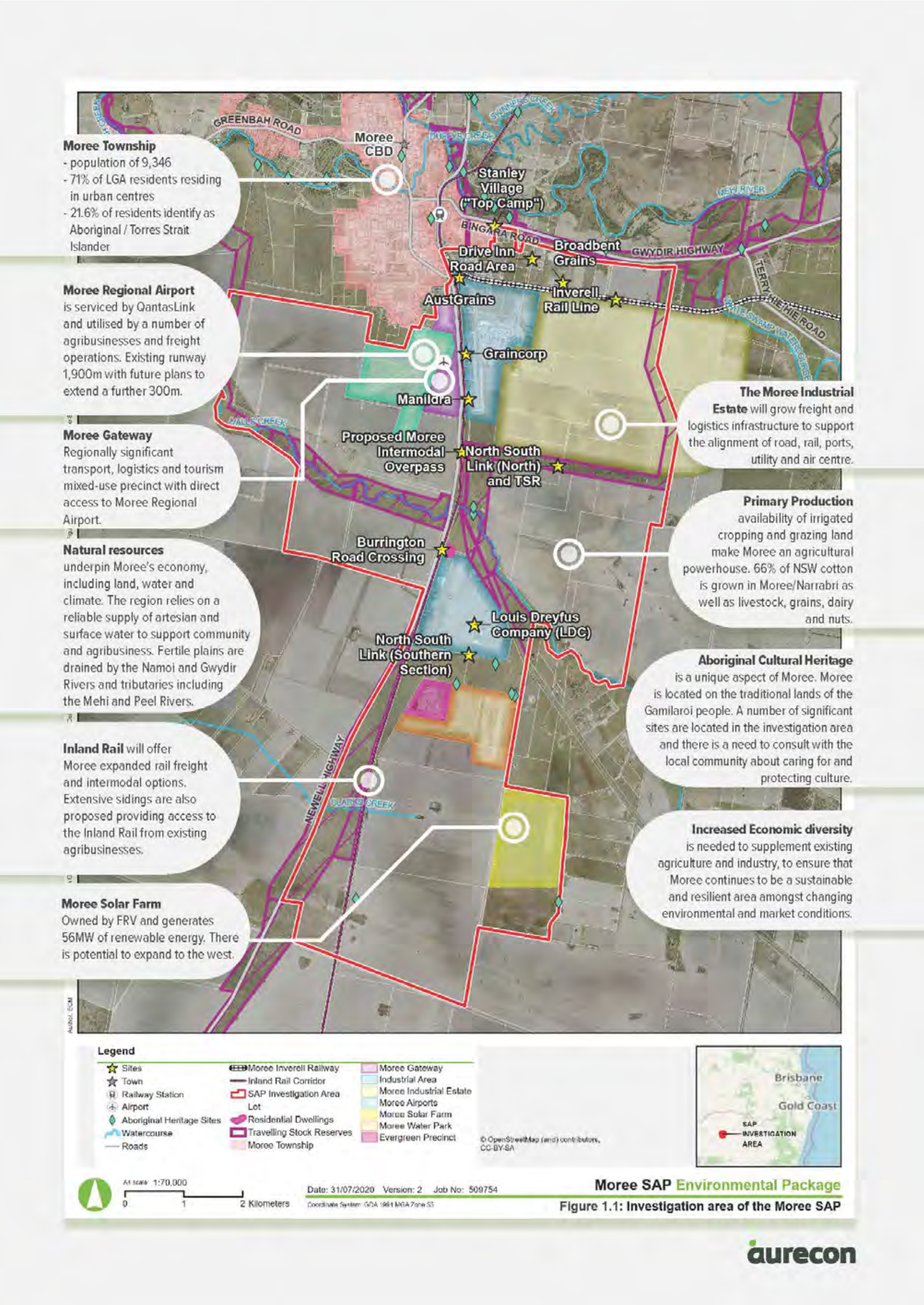


Figure 1.1 Investigation area of the Moree SAP

1.3 Purpose of this report

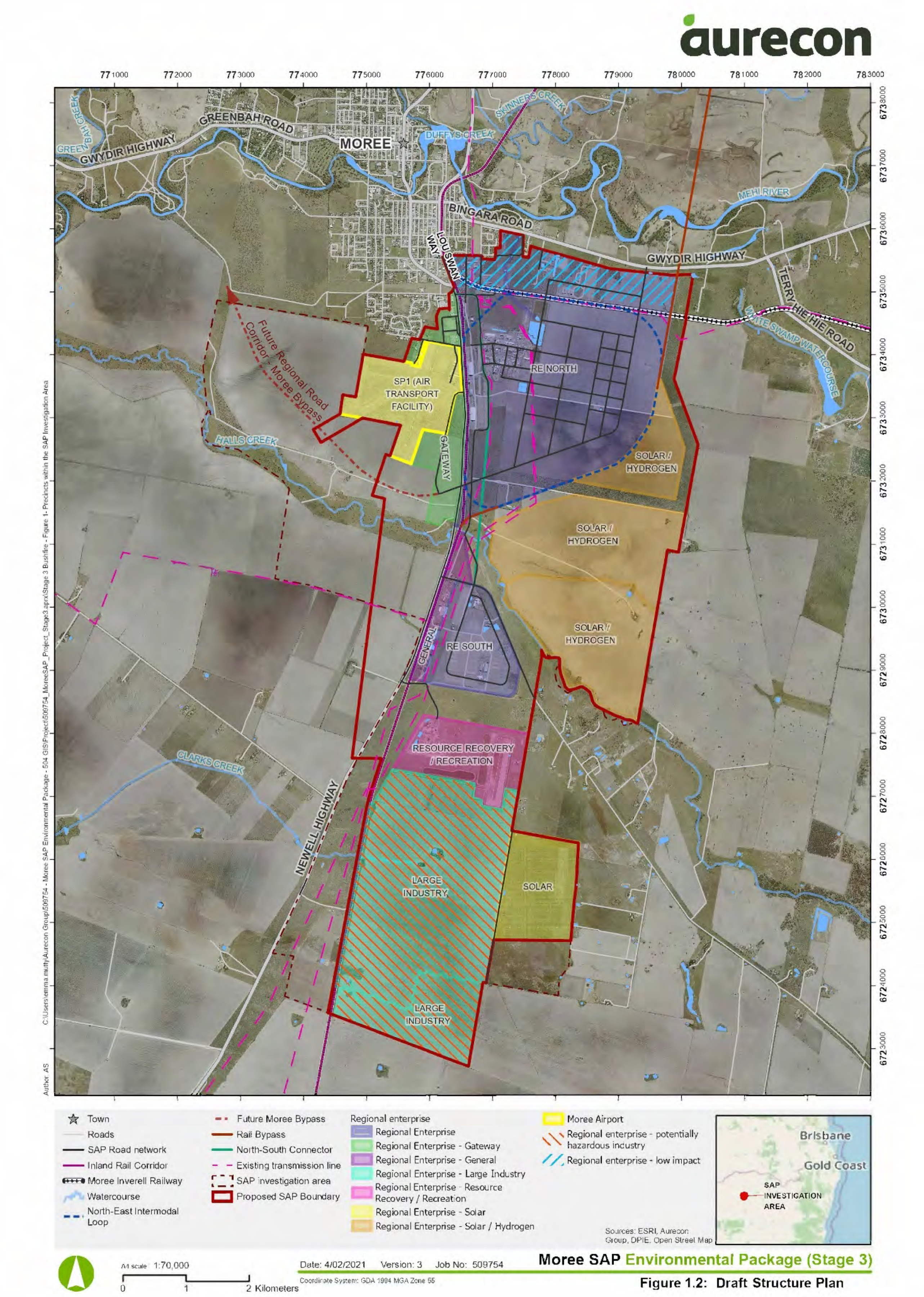
Aurecon has been commissioned by the NSW Department of Planning, Industry and Environment (DPIE) to prepare a suite of environmental technical studies to support the Moree SAP Structure Plan, including:

- Biodiversity
- Bush fire
- Aboriginal and non-Aboriginal cultural heritage
- Soils, geology and contamination
- Hydrogeology
- Air, odour and noise

Aurecon has engaged C.M. Jewell & Associates Pty Ltd (CMJA) to prepare this report summarising hydrogeological conditions within and around the proposed SAP investigation area and outlining the constraints to the SAP development posed by limited groundwater availability.

1.4 Draft Structure Plan

A draft Structure Plan for the Moree SAP is shown on Figure 1.2. The proposed SAP boundary for the draft Structure Plan has been developed through an enquiry by design process identifying the possible location of certain types of industries within precincts.



Note: Precincts identified as Regional Enterprise on Figure 1.2 correspond to General Enterprise in the Structure Plan Report

Figure 1.2 Draft structure plan

1.5 Report structure and methodology

Section 2 of this report describes the hydrogeological baseline analysis carried out for the project. Its purpose is to clearly define the physical hydrogeological framework, as it is understood at the present time. There are some data gaps, and these are highlighted.

Section 3 provides an overview of the regulatory framework that governs the extraction of groundwater from the aquifer systems described in Section 2, within NSW. This framework was developed to allow for equitable sharing between water users and between human beneficial use and the environment, at a rate that is sustainable over the long term.

Section 4 uses the material provided in sections 2 and 3, together with analytical modelling of a hypothetical borefield, to assess both the quantity of water that could be physically available, and the quantity that would be permissible to extract under the current regulatory regime.

Section 5 briefly describes some aspects of the preferred structure plan that emerged from the design process, together with the water demand associated with that plan as assessed by WSP Australia Pty Limited. It then assesses the viability of the water requirement of the structure plan against the water availability estimated in earlier sections of this report. It also discusses aquifer vulnerability to contamination, in the context of the structure plan, and the measures that might be taken to mitigate the risk of contamination.

Section 6 identifies apparent constraints and opportunities.

Section 7 summarises the conclusions drawn previously in the report and makes appropriate recommendations.

2.0 HYDROGEOLOGICAL BASELINE ANALYSIS AND KEY CONSIDERATIONS

This section sets out a hydrogeological baseline analysis focussing on the key hydrogeological considerations of relevance to the proposed SAP. The analysis was undertaken to assess groundwater availability and hydrogeological characteristics within and around the SAP investigation area, including groundwater flow, quality and availability, and the ability to be able to use groundwater as a resource for the draft Structure Plan.

2.1 Hydrogeological setting

The area around Moree, and the Gwydir catchment more generally, are underlain by three major geological sequences, each of which hosts groundwater resources. These are, from the top down:

- A sequence of generally unconsolidated Cenozoic-age sediments laid down by the Gwydir River, its tributaries and prior streams, or as slopewash deposits. The alluvial sediments are composed of interbedded clays, silts, sands and gravels. Individual units generally have limited lateral continuity but broader vertical stratification into zones of predominantly coarse or predominantly fine materials is apparent. The coarser zones (sands and gravels) form aquifers that host significant groundwater resources, including the Lower Gwydir Alluvial Aquifer (LGAA), whilst the finer zones function as aquitards, partially separating the aquifer units. The uppermost, unconfined, aquifers show varying degrees of connectivity with surface watercourses. The LGAA is described in more detail in Section 2.2.

- The Mesozoic-age (predominantly Jurassic and Cretaceous) Great Artesian Basin (GAB), composed of a thick sequence of clastic sedimentary rocks. The GAB hosts regional-scale confined aquifers that extend across three Australian States. The GAB system is described in detail in Section 2.3.

- The Upper Palaeozoic rocks of the Gunnedah Basin and, further north, the Bowen Basin, bounded to the east by the New England Fold Belt and to the west by the Lachlan Fold Belt. These rocks are heavily folded and faulted. They host coal, coal-seam gas and, in the Bowen Basin, conventional petroleum resources. They also host some groundwater, principally in fractured-rock aquifers. In this area the Gunnedah Basin occurs at substantial depth (>1,000 m), beneath potentially much more productive groundwater sources and it has not been addressed in detail in this report.

Figure 2.1 and Figure 2.2 show the groundwater sources and geology in the Gwydir region, respectively.

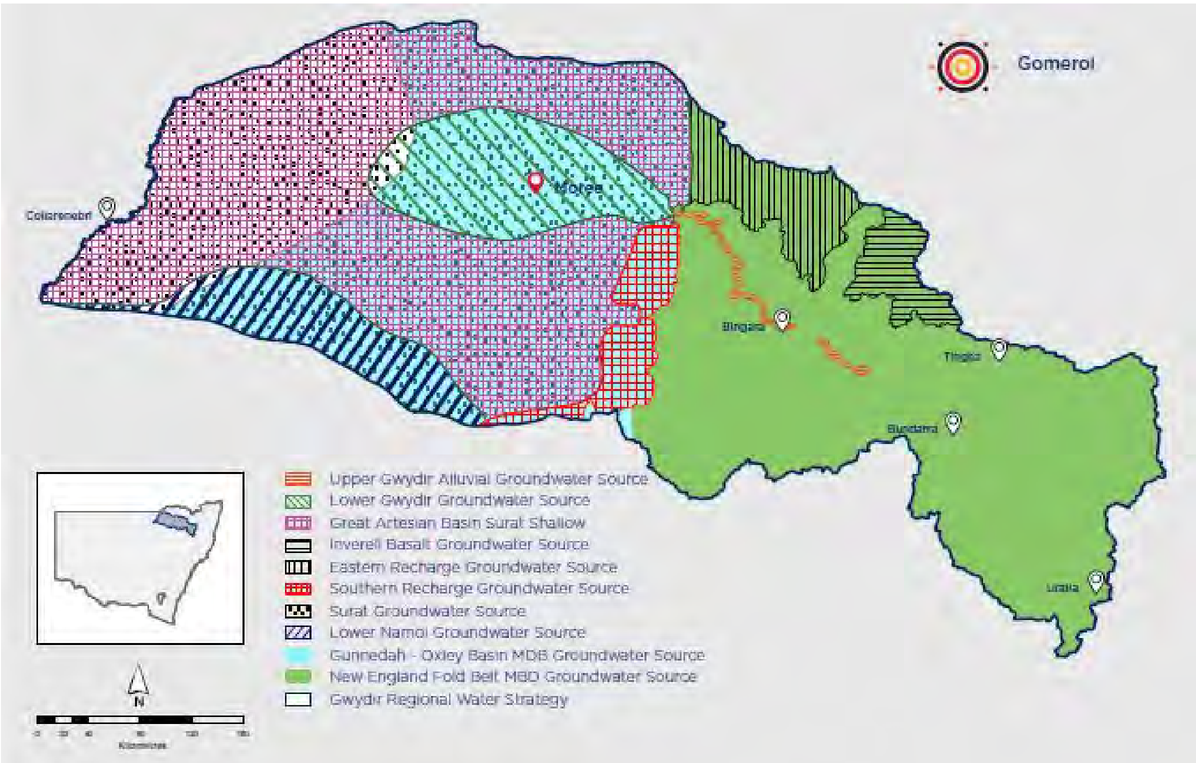


Figure 2.1: Map of the groundwater sources in the Gwydir region (Source: NSW Department of Industry 2018)

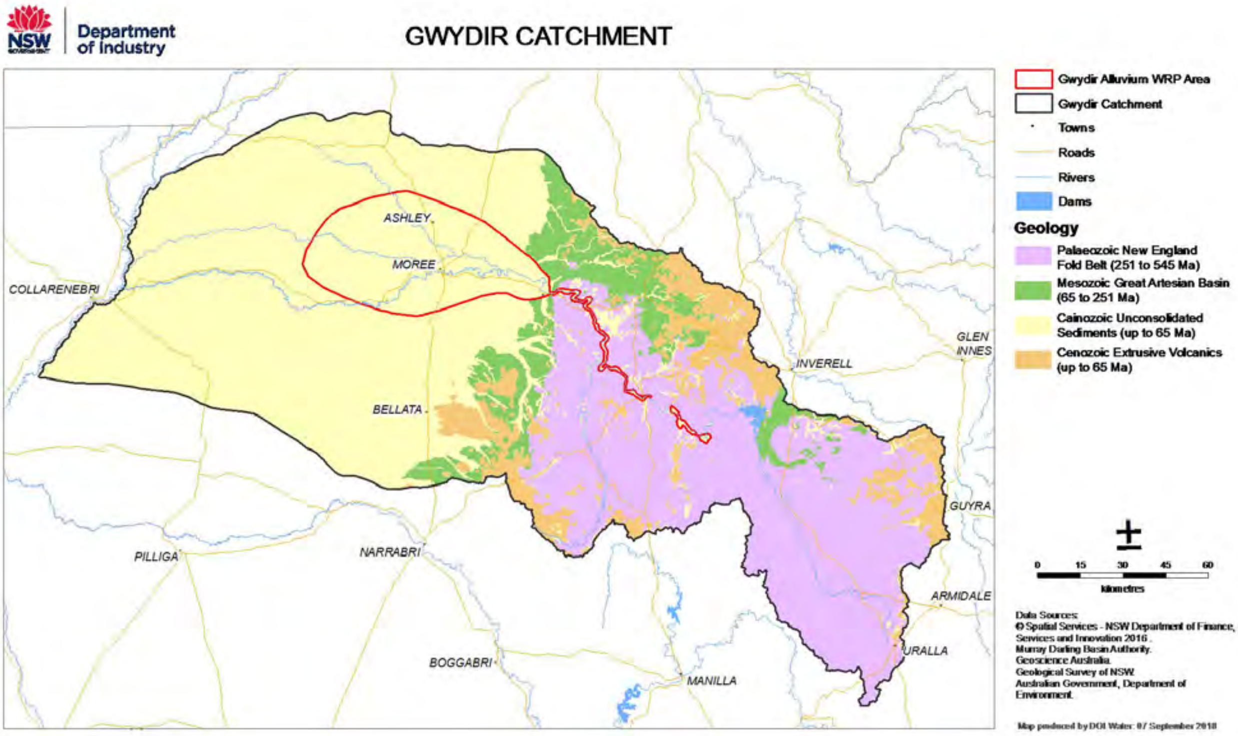


Figure 2.2: Gwydir catchment geology map (Source: NSW Department of Industry 2018)

2.2 The Lower Gwydir Alluvial Aquifer

The Gwydir River catchment, as shown on Figure 2.2 has an area of approximately 26,600 km² and is one of the sub-catchments of the Murray-Darling drainage basin (the Murray-Darling Basin – MDB). It contributes approximately 2.4 percent of the total MDB area. The LGAA, also shown on Figures 2.1 and 2.2, is composed of a sequence of generally unconsolidated Cenozoic-age sediments laid down by the Gwydir River, its tributaries and prior streams, or as slopewash deposits. The alluvial sediments include interbedded clays, silts, sands and gravels. The sediments were predominantly deposited within a braided river system that included high-energy channels separated by lower-energy braid bars. In such a system the channel form is constantly changing, so individual sediment units generally have limited lateral continuity, but broader vertical stratification into zones of predominantly coarse or predominantly fine materials is apparent. Units tend to be truncated both laterally and vertically by subsequent erosion due to channel movement.

The coarser sediment zones (sands and gravels) form aquifers that host significant groundwater resources, whilst the finer zones function as aquitards, partially separating the aquifer units. The uppermost, unconfined, aquifers show varying degrees of connectivity with surface watercourses.

Information on the Lower Gwydir Groundwater Source provided in this section has been sourced from the NSW Department of Industry 2018, Gwydir Alluvium Water Resource Plan – Groundwater Resource Description unless otherwise stated.

2.2.1 Hydrostratigraphy

The Lower Gwydir alluvial sediments are divided into two hydrostratigraphic units:

- A shallow unconfined aquifer extending to approximately 10 to 40 m depth, referred to as the *Narrabri Formation*. The sediments in this unit are polymictic and often poorly sorted, and include rock fragments as well as reworked material from older deposits. They are predominantly brown and yellow in colour. These sediments are Pleistocene in age (Martin 1980, 2014).

- A deeper confined/semi-confined aquifer extending from approximately 40 to 80 m depth, referred to as the *Gunnedah Formation*. These sediments are generally well sorted and contain thick units of quartzose sand and gravel separated by discrete silt and clay horizons. They are uniformly grey in colour. These sediments are late Miocene-Pliocene in age (Martin 1980, 2014).

The shallower Narrabri Formation is sometimes separated from the deeper Gunnedah Formation by a relatively low-permeability clay-dominant horizon of variable thickness. This unit is vertically and laterally variable in both lithology and thickness, and does not form a continuous horizon or aquitard layer that defines a distinct boundary between the Narrabri and Gunnedah formations.

Maximum thickness of the alluvial sediments increases from 20 m in the upstream area to about 60 m near Moree and 75-80 m in the west (Bilge 2002). Bores in the deeper aquifers are capable of yielding up to 100 litres per second, however the majority of bores produce supplies in the range of 10-40 litres per second (Barrett 2009).

The Department of Water and Energy (Barrett, 2009) assessed lithological logs within Lower Gwydir Alluvium to interpret the hydrostratigraphy of this aquifer system along four cross sections, shown in Figure 2.3. The geological sections used are provided in Appendix B. The interpreted hydrostratigraphy at these cross section locations is shown in figures 2.4, 2.5, 2.6 and 2.7.

Figure 2.8 shows a generalised hydrogeological conceptual model (HCM) of the layered groundwater system of the Gwydir Alluvium. The HCM illustrates how, when there is a vertical hydraulic gradient, the water level elevation measured in bores in an area can vary depending on the depth of the screened interval of the bore. The presence of a vertical gradient implies resistance to vertical flow and is usually associated with anisotropic hydraulic conductivity often, though not necessarily, associated with discrete aquitard units.

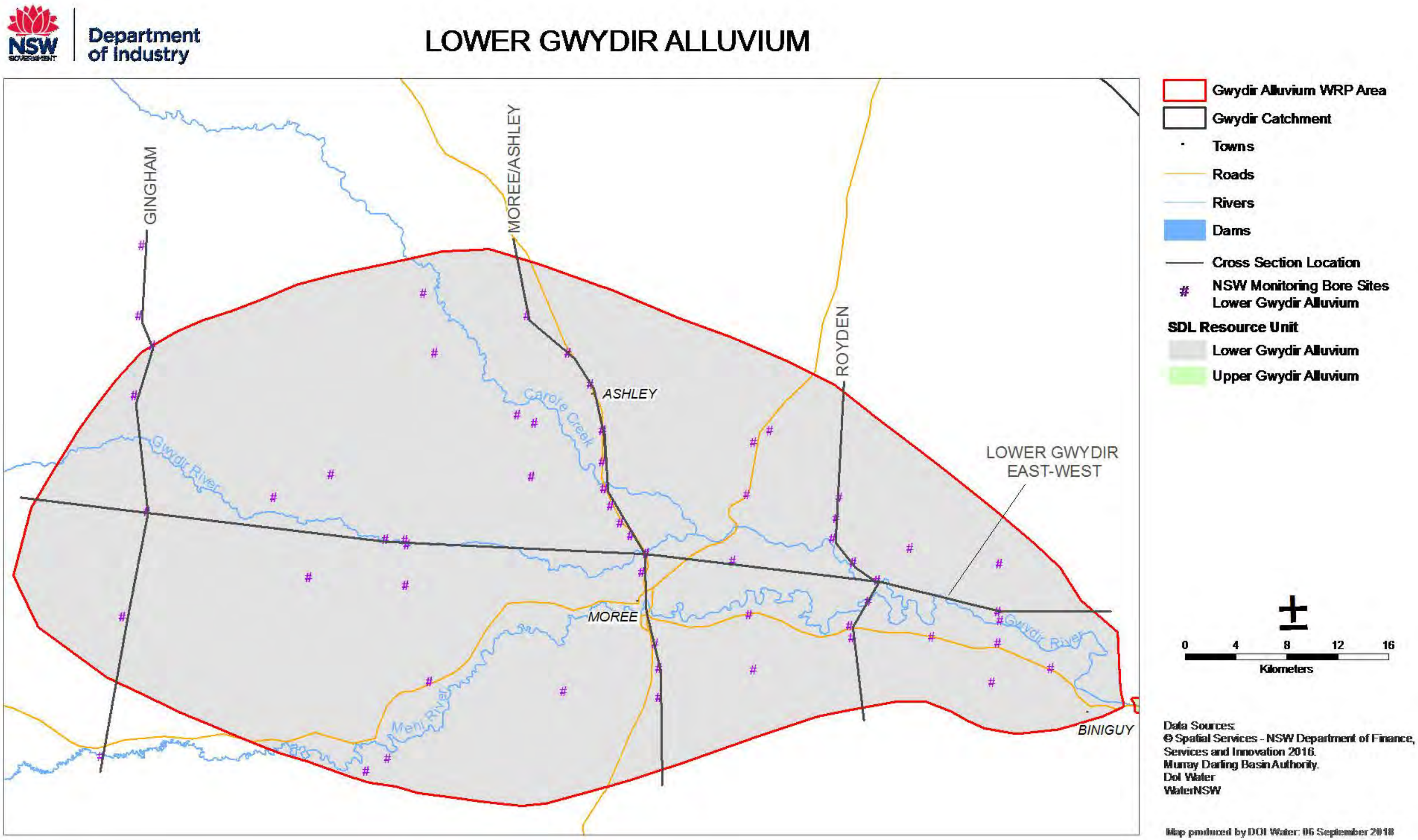


Figure 2.3: Lower Gwydir Alluvium cross section location map (Source: NSW Department of Industry, 2018)

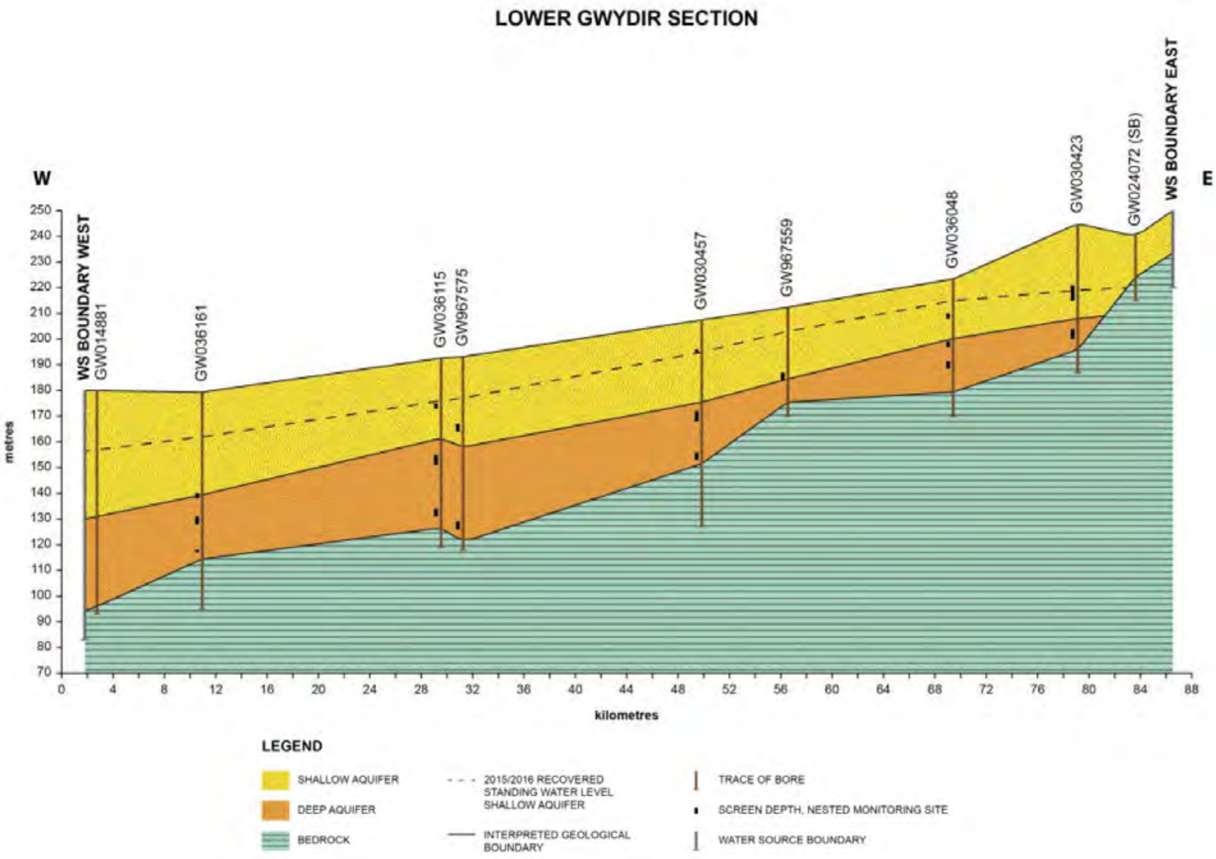


Figure 2.4: East - west long section (vertical axis in mAHD). Note the boundary between the deep and shallow aquifers is approximate (Source: NSW Department of Industry, 2018)

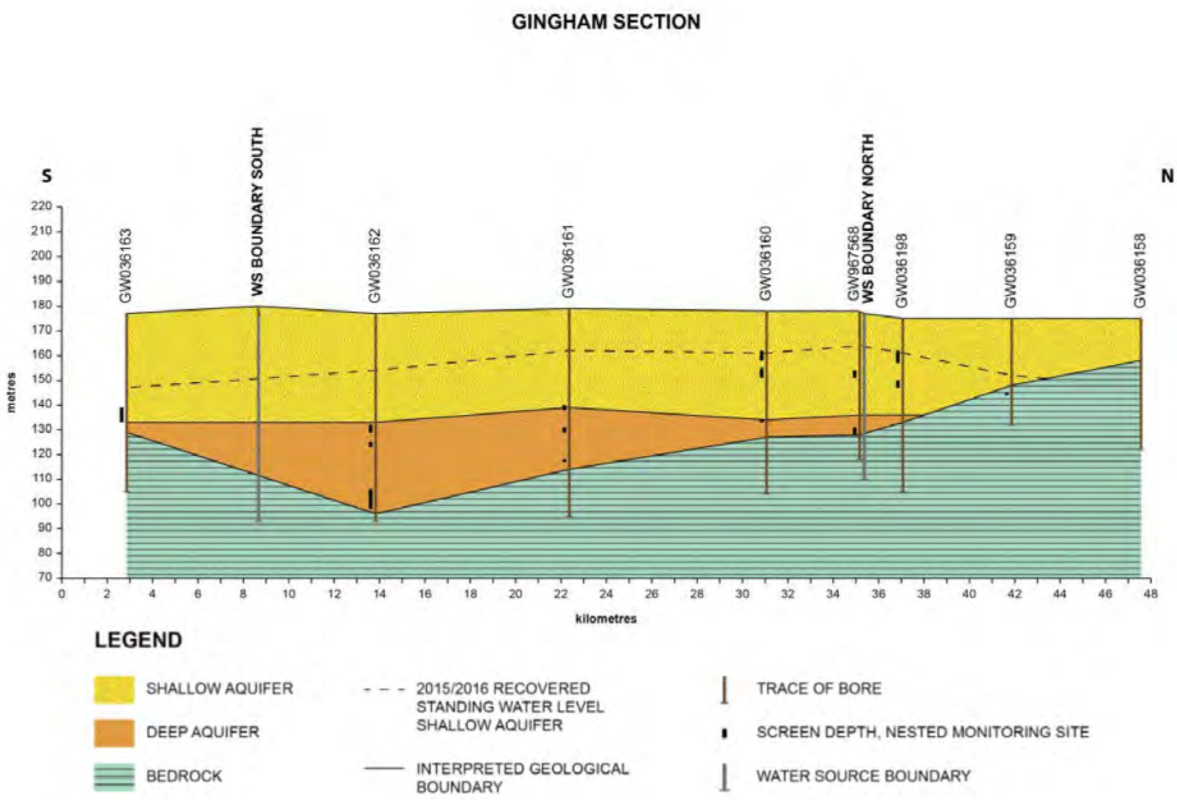


Figure 2.5: Gingham cross section (vertical axis in mAHD). Note the boundary between the deep and shallow aquifers is approximate (Source: NSW Department of Industry, 2018)

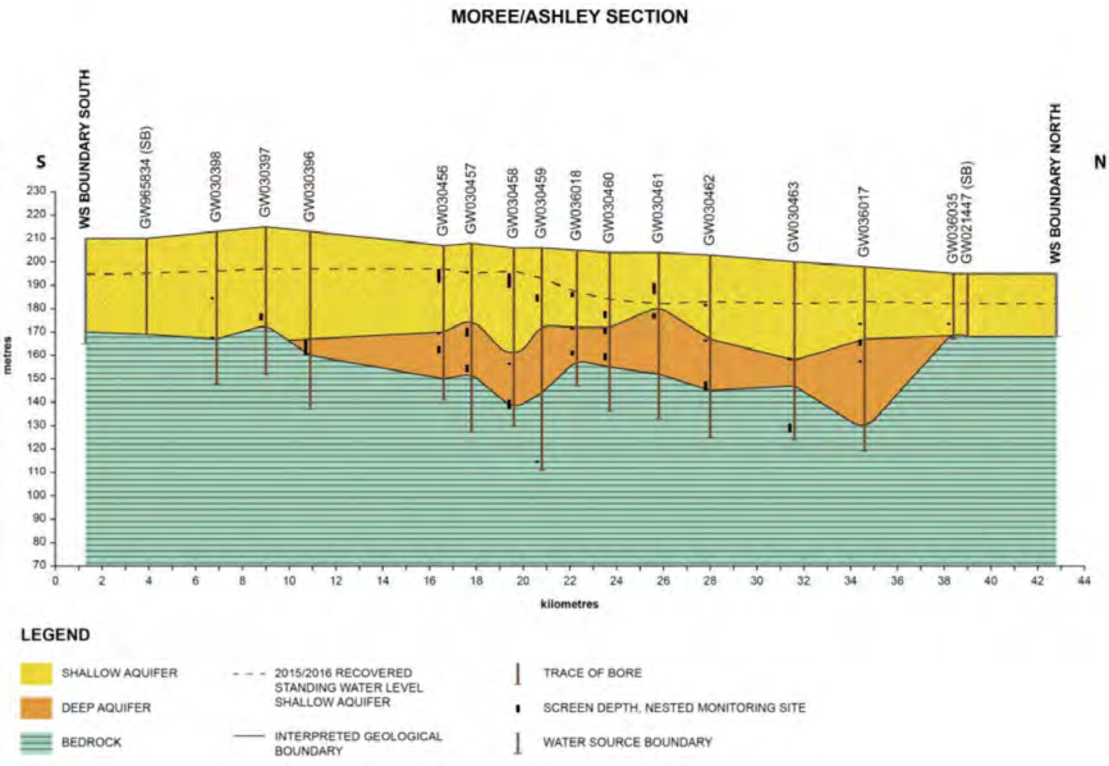


Figure 2.6: Moree/Ashley cross section (vertical axis in mAHD). Note the boundary between the deep and shallow aquifers is interpreted based on limited information (Source: NSW Department of Industry, 2018)

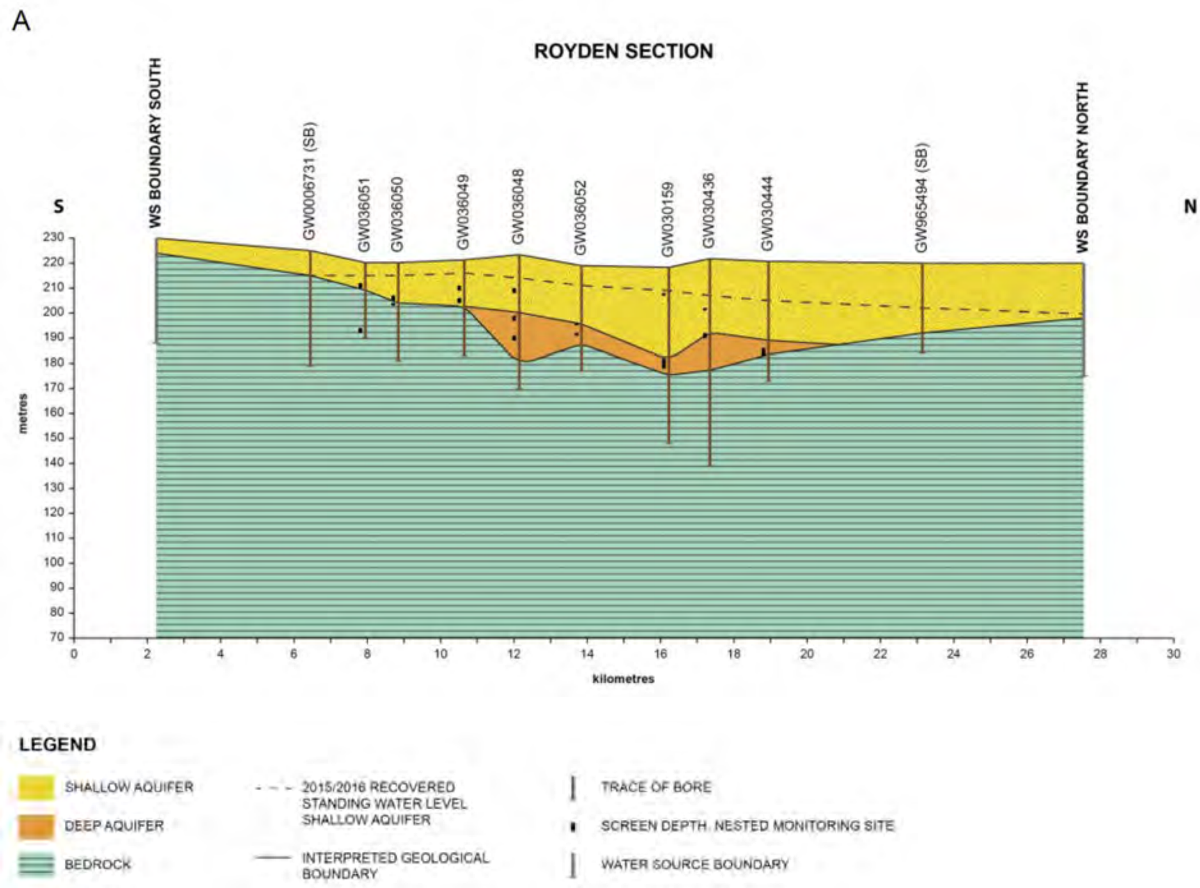
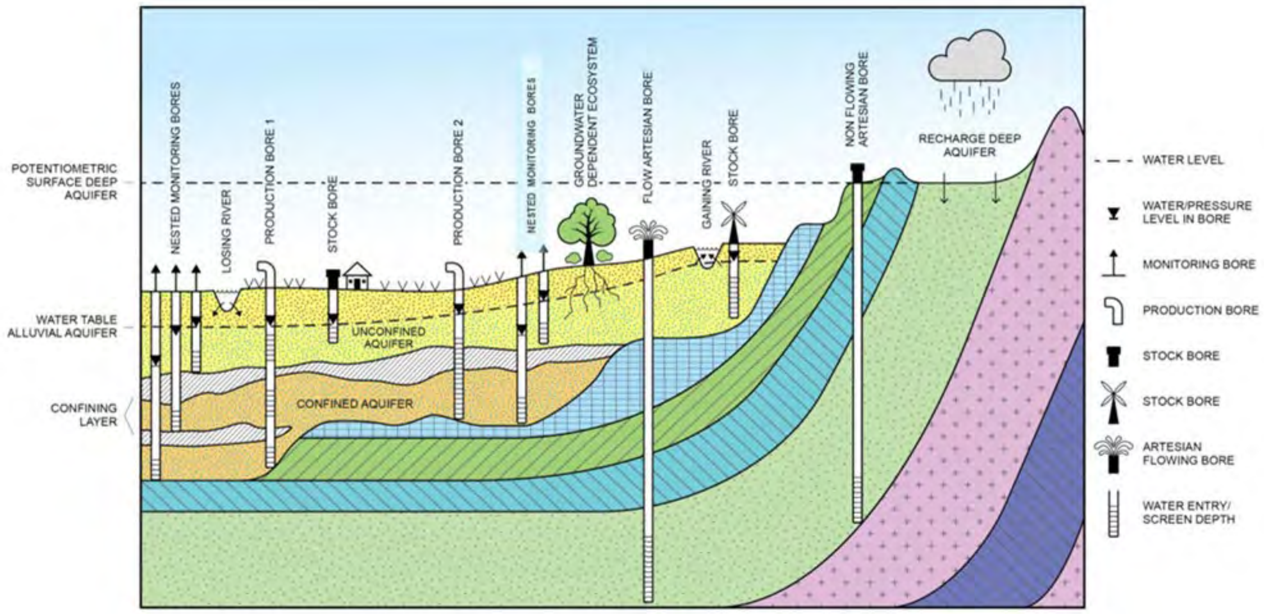


Figure 2.7: Royden cross section (vertical axis in mAHD). Note the boundary between the deep and shallow aquifers is interpreted based on limited information (Source: NSW Department of Industry, 2018)



At a conceptual level, the unconfined aquifer represents the Narrabri Formation, the confined aquifer represents the Gunnedah Formation, and the deep aquifer represents the Pilliga Sandstone (at a time in the past when it was a flowing artesian aquifer)

Figure 2.8: Hydrogeological conceptual model of a groundwater system similar to that at Moree

2.2.2 Nature and distribution of aquifers within the Lower Gwydir Alluvial Aquifer system

The coarser aquifer units are thicker and more laterally extensive in the eastern-central portion of the system, where they contain coarse, but often polymictic and poorly sorted, gravels and sands (Narrabri formation) and fine to medium well-sorted quartz gravels and sands (Gunnedah formation). In the downstream areas, towards Bullarah, both formations become more irregular in occurrence and grade into finer grained sediments.

However, as shown on Figure 2.6 above, the Gunnedah Formation thins to the south, and pinches out altogether about 5 km south of Moree. Thus, the most productive aquifer is not present beneath most of the SAP area.

This is further discussed in Section 2.2.5 below.

2.2.3 Groundwater flow system characterisation

Groundwater levels

Topography is the most important driving force for regional groundwater flow in groundwater systems. Flow occurs because there is a hydraulic gradient as hydraulic head decreases from a high-elevation recharge area (high hydraulic head) to a low elevation discharge area (low hydraulic head).

In this alluvial groundwater system, the direction of groundwater flow is influenced by both the regional hydraulic gradient and local effects such as pumping and interaction with surface water bodies. However, it is dominated by the regional gradient. Contours of groundwater elevation head in the Lower Gwydir Alluvium, illustrated in Figure 2.9 (drawn for 2010), show that the regional groundwater flow direction is generally consistent with the topography, flowing from east to west. Groundwater elevation heads range from 224 mAHD in the east, flowing towards 150 mAHD in the west. This change in elevation head occurs over a distance of approximately 90 km, therefore, the regional horizontal hydraulic gradient across the Lower Gwydir Alluvium is approximately 0.0008m/m. As the ground surface slopes fairly uniformly from 228 m AHD in the east to 172 m in the west, the water table in the Narrabri Formation at the northern end of the SAP investigation area is typically about 15 m below ground level, with a seasonal fluctuation of about 2 m. As shown on Figure 2.19, over the intervening 10 years the groundwater level has risen about 2 m, then fallen again to the similar levels at Moree, and lower levels further north, so that Figure 2.9 is reasonably representative of current conditions.

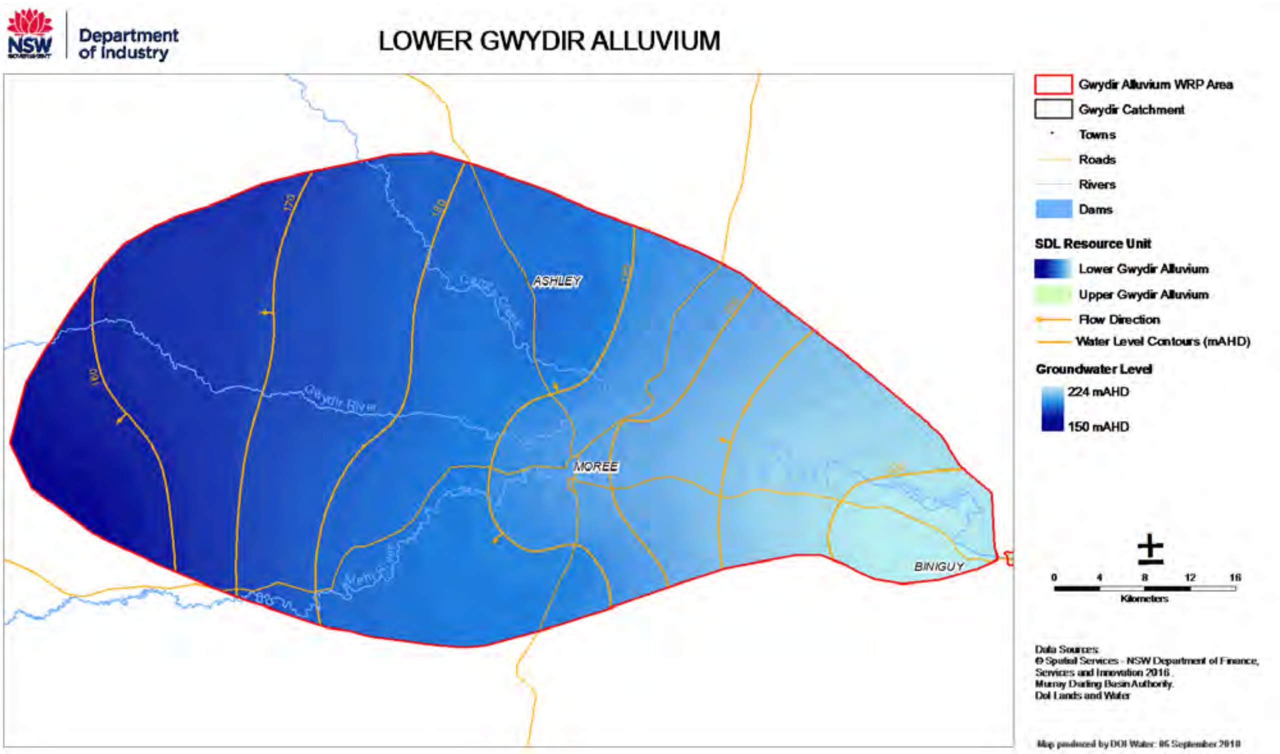


Figure 2.9: Groundwater elevation contours and flow directions in the Gunnedah Formation (deep aquifer)

Hydraulic Characteristics

Information on hydraulic parameters is available in the numerical model for the LGAA system. However, it has not been possible to access this model. By comparison with other alluvial aquifers in western NSW with similar stratigraphy and reported bore yields, hydraulic conductivity up to 10 to 15 metres per day (m/d) would be expected in the Narrabri Formation, and within the range 20 to 50 m/d in the Gunnedah Formation. According to CSIRO and SKM (2010), the specific yield of the unconfined Narrabri Formation aquifer ranges from 0.05 to 0.35, with an average of 0.20.

Recharge and Surface-Groundwater Connectivity

The recharge mechanisms in the Lower Gwydir Alluvium are direct infiltration from rainfall and flooding, leakage from surface water bodies and irrigation. The dominant recharge mechanism is stream leakage. The Lower Gwydir numerical model provides the groundwater balance for this aquifer system as summarised in Table 1.

The CSIRO (2007) surface–groundwater connectivity map (Figure 2.10) shows the nature of interactions between the major rivers of the Gwydir River catchment and surrounding areas. This mapping shows that nearly all river reaches in the Lower Gwydir area are losing, with reaches of the Gwydir River and Gingham Channel near Moree in the 'high losing' category. There is a single gaining reach of the Gwydir River at the eastern edge of the Narrabri Formation. The 'high losing' category rivers are characterised by high hydraulic conductivity zones ranging from 5 to 50 m/d CSIRO (2007). Gaining reaches are restricted to the Upper Gwydir region and were classified as 'gaining', with most reach falling in the 'low gaining' category.

A comparison of stream gauge and groundwater level information in and around the Gwydir River in the eastern portion of the Lower Gwydir Alluvium is provided at Figure 2.10, which shows that groundwater levels are lower than river water levels. Due to the high hydraulic conductivity of the riverbed material in these river reaches, there would be significant leakage from the river into the underlying groundwater system.

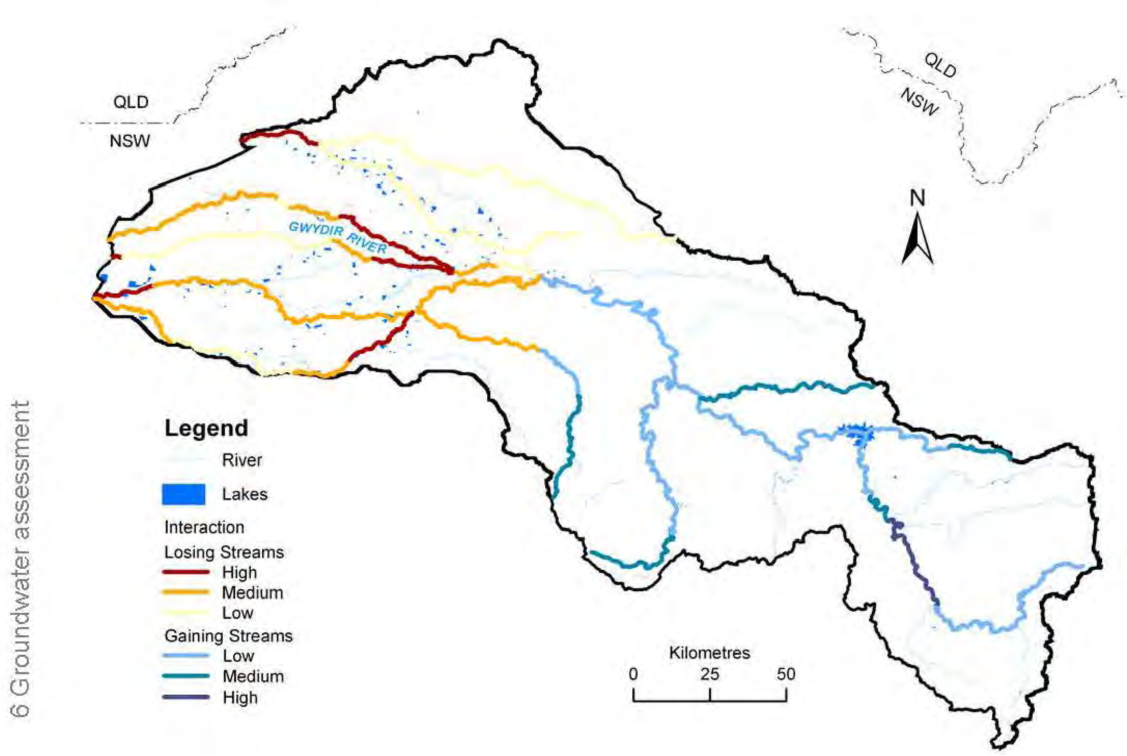


Figure 2.10: Surface-groundwater connectivity map for Gwydir and surrounding regions (CSIRO, 2007)

TABLE 1 Modelled average annual recharge		
	Simulated recharge over the last 5 years	Simulated recharge over the modelled 111-year period under the 2004/2005 groundwater resource development scenario*
	(GL/year)	(GL/year)
Rainfall	16.2 (34%)	15.0 (29%)
Irrigation	5.2 (11%)	6.5 (13%)
River system (net)	20.5 (43%)	22.0 (43%)
Lateral flow	5.4 (11%)	7.7 (15%)
Total	**47.30 (100%)**	**51.2 (100%)**

*Source: CSIRO and SKM (2010)

Storage relative to recharge

The ratio of storage to recharge for the Lower Gwydir Alluvium system was determined as 296 by CSIRO and SKM (2010). This was taken to indicate that there is a low risk of the productive base of the aquifer being jeopardised by factors such as climate change and the short-term extraction in excess of recharge. In the long-term of course, it is necessary to keep the combined usage and environmental requirement in equilibrium with recharge.

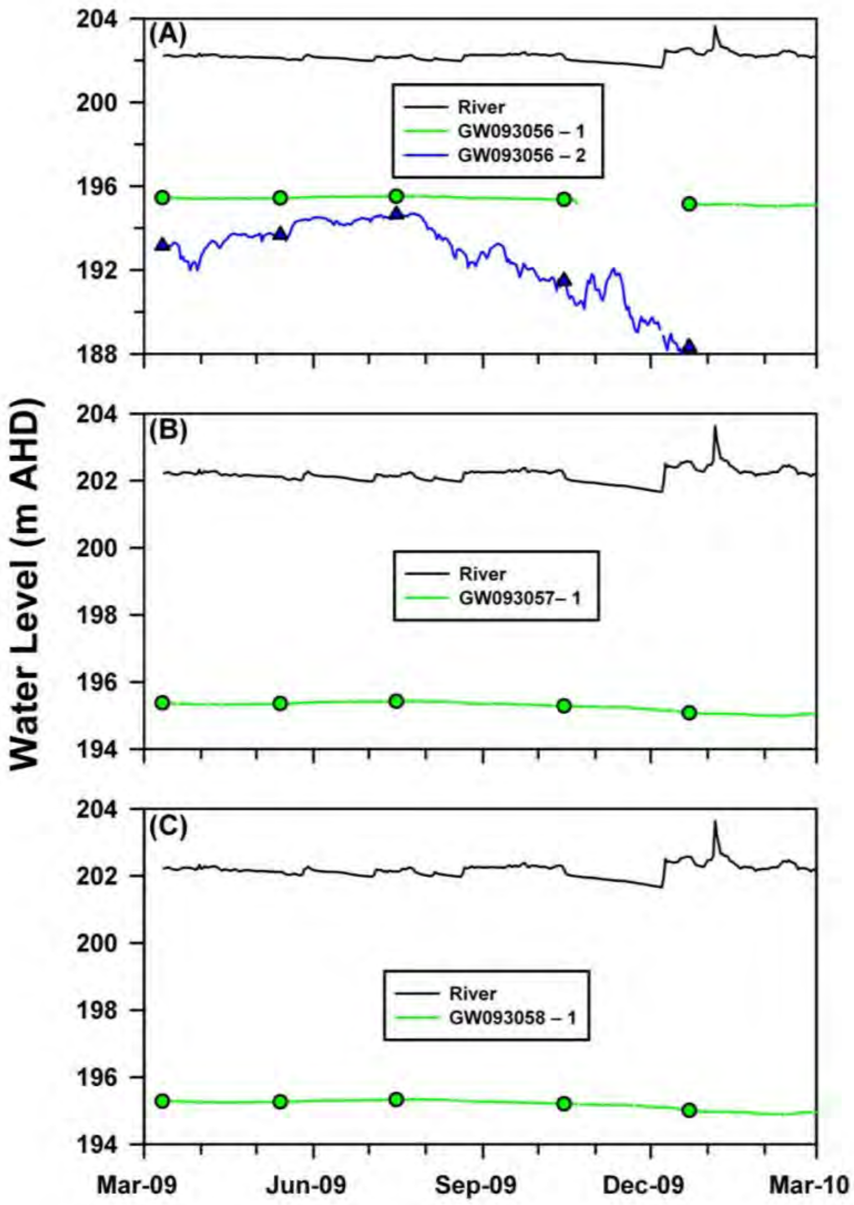


Figure 2.11: Temporal variations in river stage and hydraulic head in surrounding piezometers at Yarraman Bridge in the vicinity of Moree (Lamontagne et al., 2011)

2.2.4 Groundwater quality

Previous investigations (Green et al 2011) have assessed the variation in shallow groundwater quality across the entire Gwydir catchment, including both the upper and lower Gwydir alluvial aquifers and the fractured rocks (including Tertiary-age volcanic rocks) of the upper catchment.

As shown on Figure 2.12, groundwater quality is classified as either 'fresh' or 'moderate' across large areas of the catchment. It is predominantly 'fresh' or high quality in the alluvial sediments of the Moree area and in the fractured rocks of the upper catchment. Figure 2.12 also provides potential application or use of the groundwater based on the water quality category. Being in the 'fresh' band (0-500 TDS mg/L), water within the Moree SAP area is suitable for irrigation, stock and domestic use, as well as municipal supply.

Water quality monitoring undertaken in the Lower Gwydir Alluvium between 2009-2010 (Parsons Brinckerhoff, 2011) also indicated that groundwater in the Gunnedah Formation is typically fresh (electrical conductivity <750 µS/cm) and was therefore deemed to be suitable for a wide range of beneficial uses, such as drinking water supply, food irrigation and stock water supply.

Groundwater in the Narrabri Formation was reported as fresh to brackish (electrical conductivity <1,500 µS/cm), with a general trend of increasing salinity from east to west. Based on this, the water quality in the eastern portion of the Lower Gwydir Alluvium was deemed suitable for drinking water supply, food irrigation and stock water supply, whereas the water quality in the western portion of the Lower Gwydir Alluvium is unsuitable for drinking water supply.

Groundwater in the LGAA has a low sodium adsorption ration (SAR), i.e. the ratio of sodium to divalent cations is low; it is suitable for irrigation onto reactive soils and is widely used for that purpose in the area around Moree.

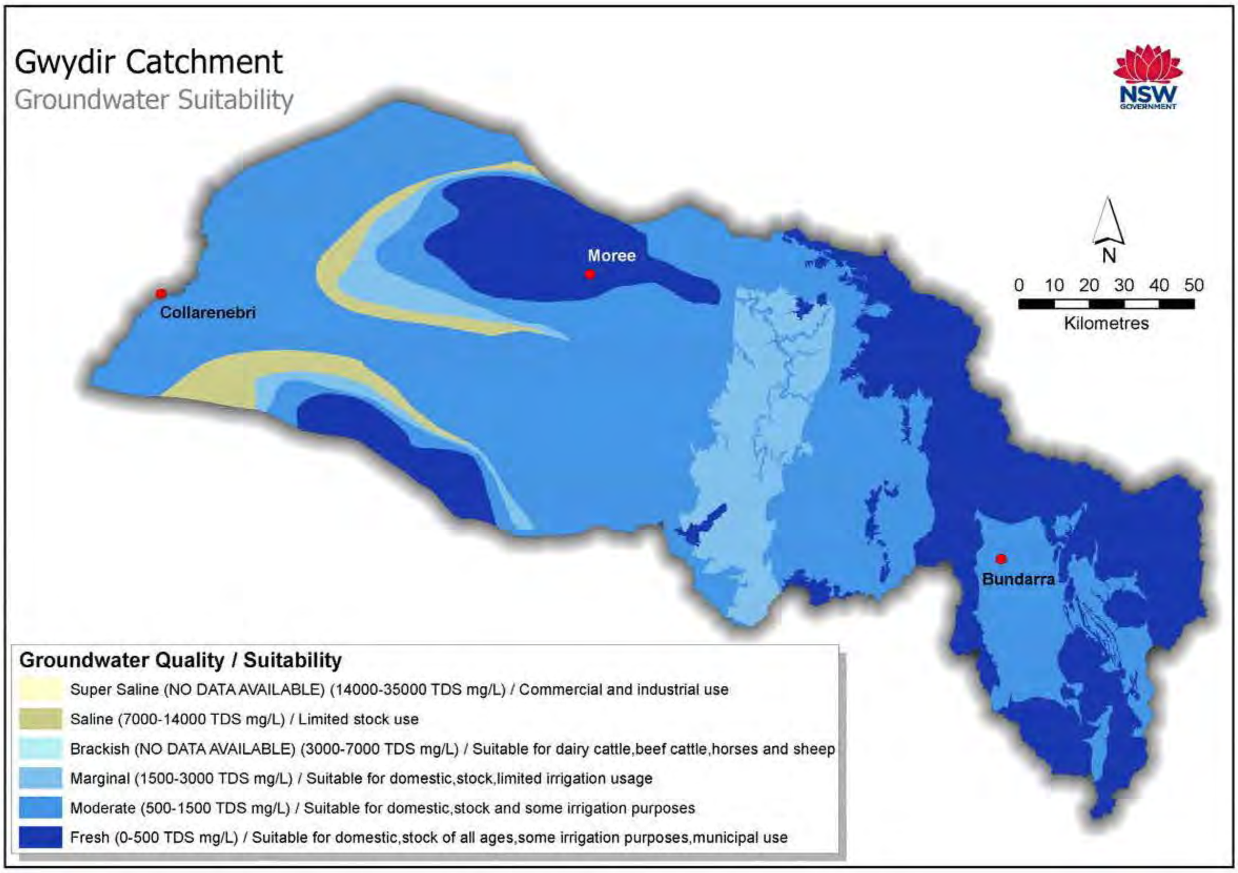


Figure 2.12: Groundwater quality and suitability in the Gwydir catchment (after Green et al. 2011)

2.2.5 Groundwater use

Groundwater is taken throughout the Lower Gwydir Alluvium for purposes such as irrigation, industrial use, stock, local water utilities and domestic supply.

There are approximately 1,500 registered bores within the Lower Gwydir Alluvium. The majority of these bores are irrigation, stock/domestic and water supply bores. The towns of Pallamallawa and Moree extract groundwater as their main local water utility supply. Bores constructed in the deeper, more productive aquifer system (Gunnedah Formation) can yield up to 1,000 ML/year. However, most production and water supply bores produce approximately 500 ML/year.

Within the SAP investigation area there are currently 52 registered bores completed in the Lower Gwydir Alluvium, of which 9 are monitoring bores. Thirteen of the bores have Aquifer Access Licences, with a share component totalling 334 ML/yr.

An overview of annual groundwater extraction between 1993-2016 is illustrated in Figure 2.13 and groundwater extraction details recorded between 2006-2019 (since the commencement of the Water Sharing Plan) is provided in Table 2. The variation of the usage of groundwater illustrated in Figure 2.13 and Table 2 is closely linked to climatic influences and availability of surface water.

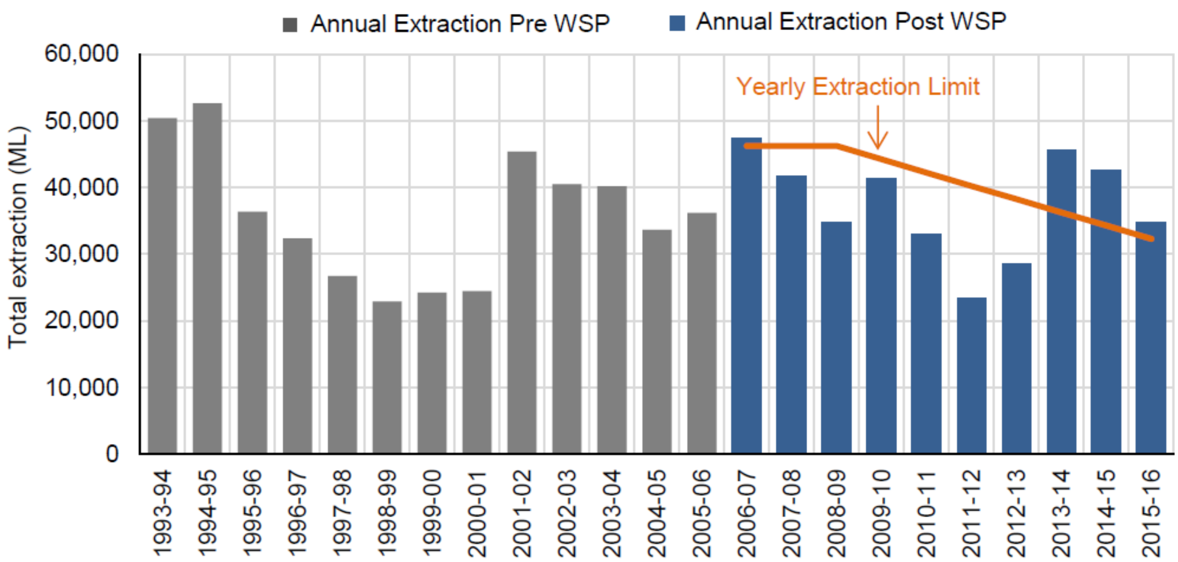


Figure 2.13: **Annual groundwater extraction from the Lower Gwydir Alluvium (1993-2016)**

TABLE 2
Annual groundwater extraction from the Lower Gwydir Alluvium (2006-2019)

Year	Annual Groundwater Extraction (ML)
2006-07	34,705.2
2007-08	41,744.7
2008-09	34,851
2009-10	41,345.8
2010-11	32,932
2011-12	23,487.7
2012-13	28,634
2013-14	45,684.8
2014-15	42,630.6
2015-16	34,837.8
2016-17	23,062.2
2017-18	35,571
2018-19	36,816.7
2019-20	28,303
Average	**34,615**

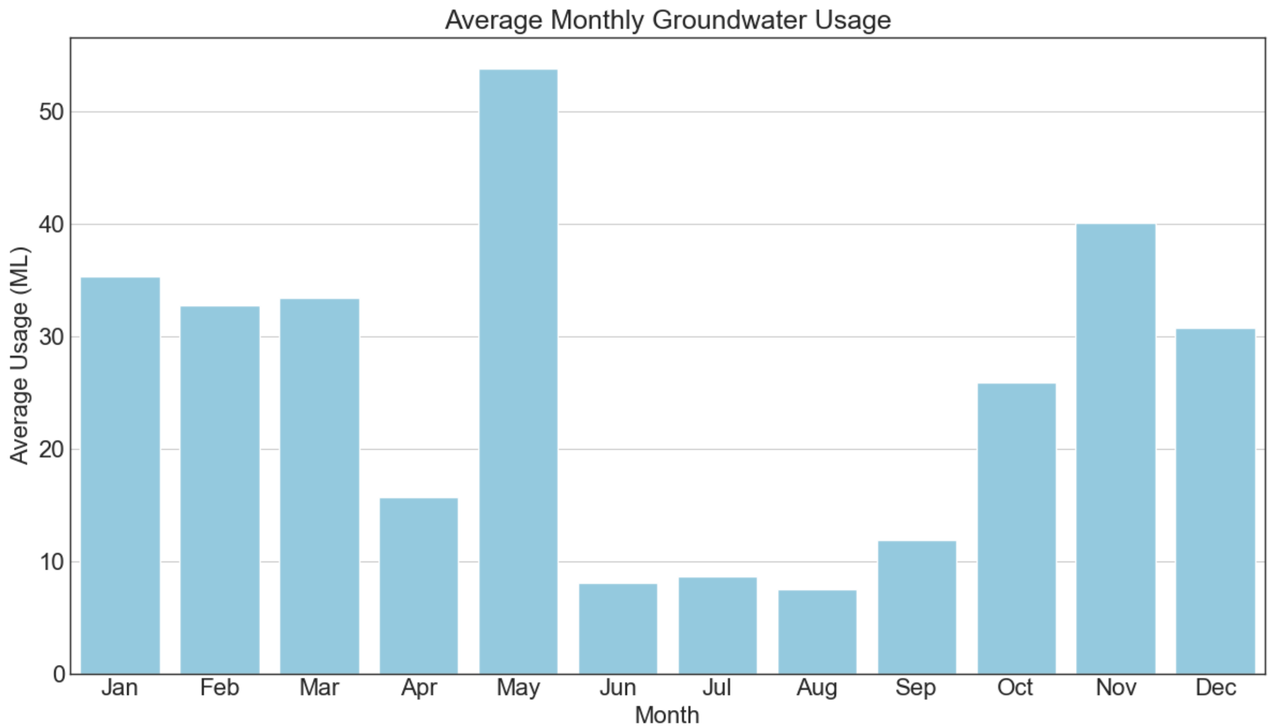
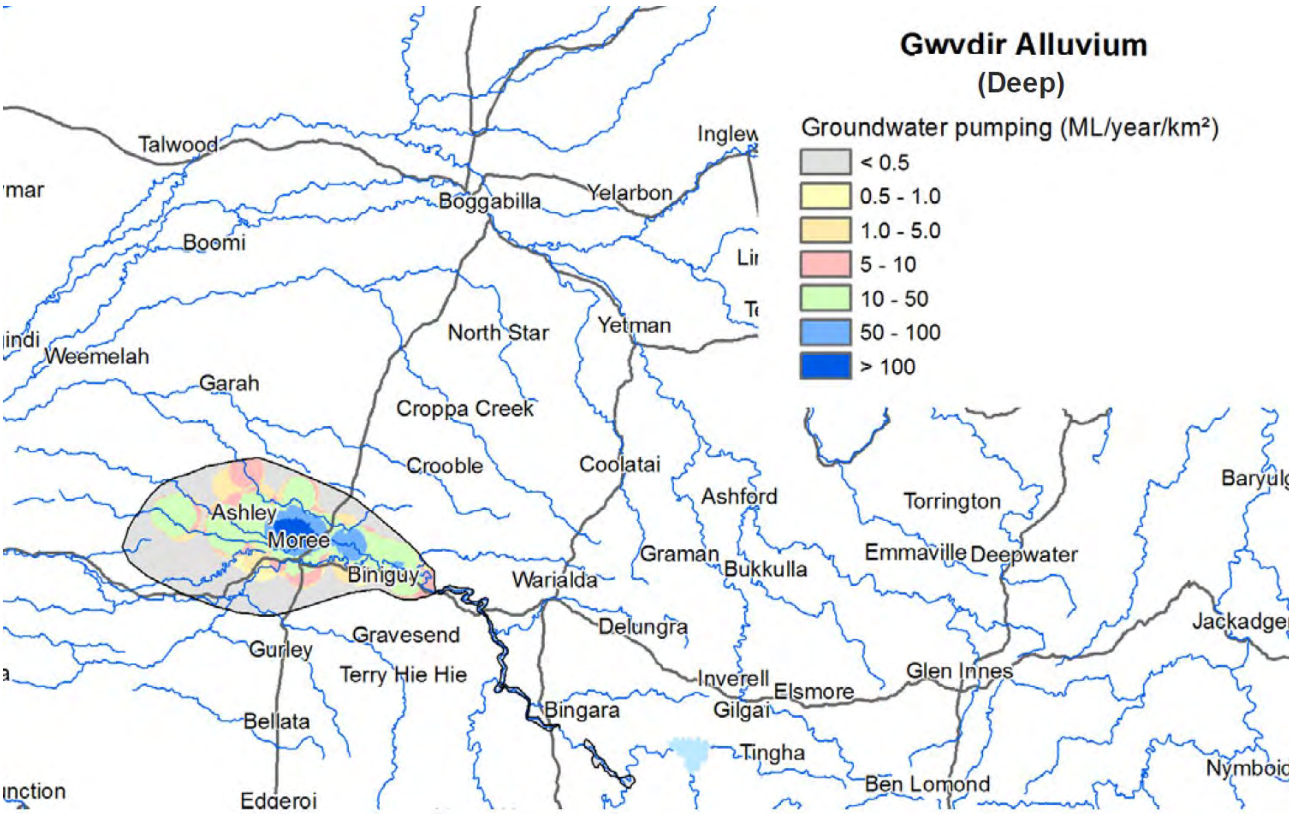


Figure 2.14: **Average monthly groundwater usage – Lower Gwydir Alluvium (2006-2020)**



Source: Risk Assessment for the Gwydir Alluvium Water Resource Plan Area (GW15)) Schedule D.

Figure 2.15: **Groundwater extraction density map**

An overview of average monthly groundwater usage recorded for the Lower Gwydir Alluvium between 2006-2020 is provided in Figure 2.14.

Groundwater extraction varies spatially throughout the Lower Gwydir Alluvium. Figure 2.15 provides the mapping of the density of groundwater extraction throughout the Lower Gwydir Alluvium which is influenced by several factors in space and time including:

- Historic development.
- Individual landholder behaviour, in terms of bore location (and depth), and groundwater extraction regime (timing and rate; trading options).
- Administrative controls, within water sharing plans that aim to minimise local drawdown impacts (including controls on bore location, groundwater extraction and trading).

Groundwater extraction density mapping provides a means of assessing the likelihood of groundwater extraction causing local drawdown in the Lower Gwydir Alluvium, which may then impact access for other consumptive users, due to well interference. The highest density (>100 ML/year/km^2) is currently shown to be occurring between Moree and Ashley. This area is considered as an area of concern with regard to the cumulative impacts on the aquifer and existing water users (as illustrated on Figure 2.16). As shown on Figure 2.17 and Figure 2.18 below, both the Narrabri and Gunnedah Formations in this area have experienced a considerable decline (over 10 m) in water levels compared with pre-development conditions, with the sharpest decline occurring during the 1986-96 and 2006-2016 periods. The most recent hydrographs (2019) show both pumping and recovered (winter) groundwater levels at historical lows in some monitoring bores. Inevitably, this has had an impact on bore yields and pumping costs.

The highly-impacted areas are located north of Moree and do not extend into the SAP investigation area, however, the experience north of Moree is indicative of potential consequences in the event of concentrated pumping from the Lower Gwydir Aquifer in the SAP area.

Potential impacts of long-term drawdown due to excessive pumping include:

- Aquifer compaction. This may result in storage and hydraulic conductivity, leading to reduced bore yields. In extreme cases damage to bores and pumping plant may occur.
- Mobilisation of poor-quality groundwater (if this is present in some areas / horizons) resulting in degradation of overall groundwater quality.
- Lower bore yields and increased pumping costs in areas subject to high extraction intensity and consequent local drawdown impacts.
- Reduced water access for groundwater dependent ecosystems.

It should be noted that currently there is no reporting of aquifer compaction in the Gwydir Alluvium. However, the alluvium properties, combined with the groundwater pumping regime, may provide the necessary conditions for aquifer or aquitard compaction, loss of storage and reduced yield from the aquifer system. This risk is real and should be taken into account for the planning of the SAP investigation area.

Table 3 summarises current groundwater water access licences in the Lower Gwydir Alluvial groundwater source. Currently there are a number of Local Water Utility groundwater abstractions by Moree Plains Shire Council (MPSC) north of the SAP investigation area.

There was a reduction in the total entitlements in the LGAA, which were reduced from approximately 70,000 ML to 32,300 ML, under the water sharing plan that commenced in 2006. Individual licence holders with previous extraction history in excess of their reduced entitlements were granted supplementary water access licences that were subject to annually decreasing levels of access that culminated in zero access at the commencement of the 2015/16 water year, after which supplementary access licences were cancelled. However, the annual pumping figures shown in Figure 2.13 and Table 2 do not show a corresponding reduction in actual pumping, with the annual groundwater pumping figures continuing to reflect the availability of water from other, cheaper sources (rainfall and surface water flows). In consequence, hydrographs for monitoring bores in this area (Example shown in Figure 19) do not indicate a decrease in the long-term declining trend in groundwater levels in both aquifers. Minor recoveries were observed during the late 1990s and from 2010-2012, due to the decrease in pumping during these periods (before and after the licence changes) when water was available from alternative sources.

Modelled water balances for the alluvium aquifer system for two periods from 07/2014 to 06/2019 and 07/2018 to 06/2019 are presented in Figure 2.20 and Figure 2.21, respectively. Both water balances show that currently there is a net loss of the amount of water stored in the aquifer due to outputs exceeding inputs.

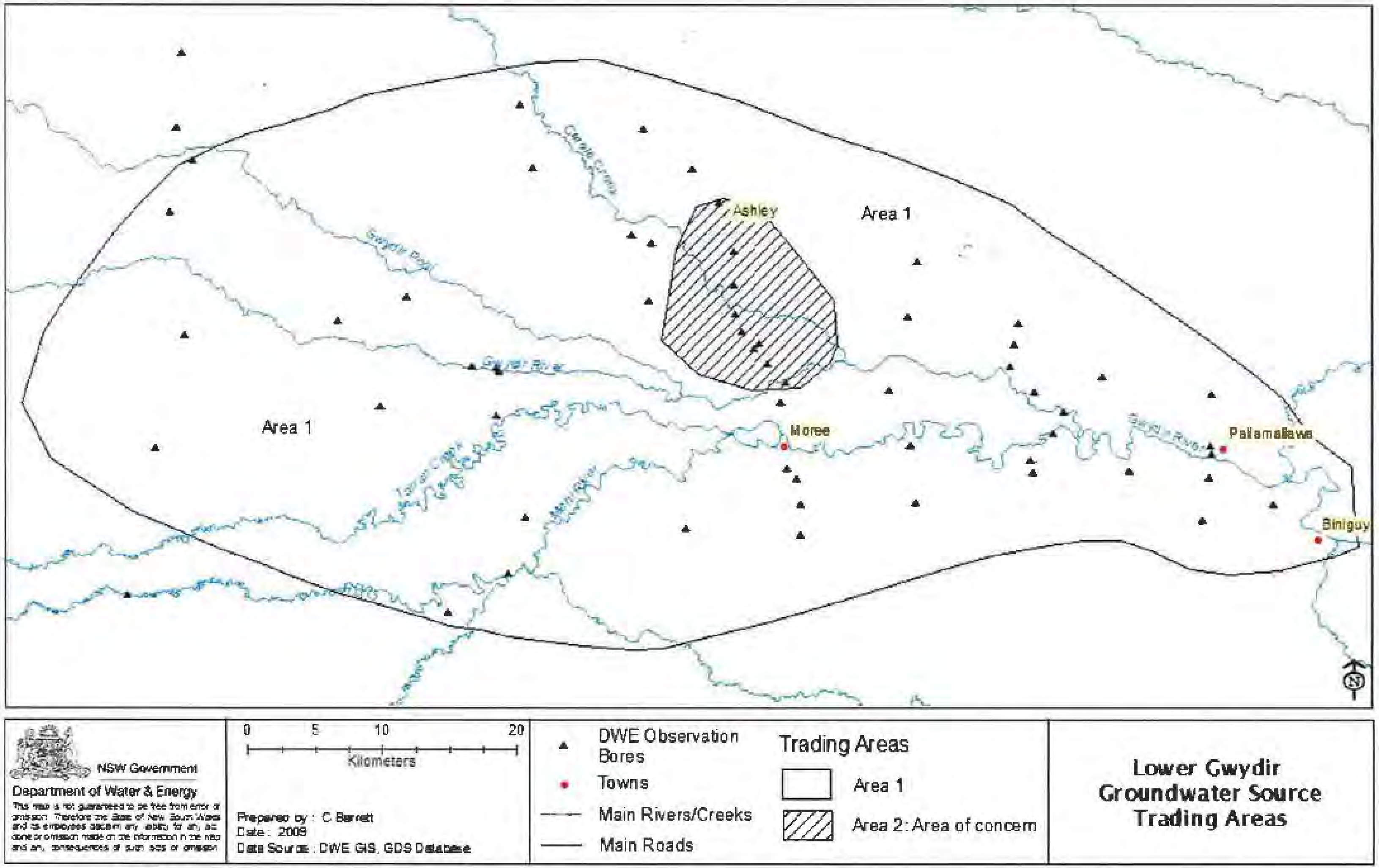


Figure 2.16: Lower Gwydir trading areas

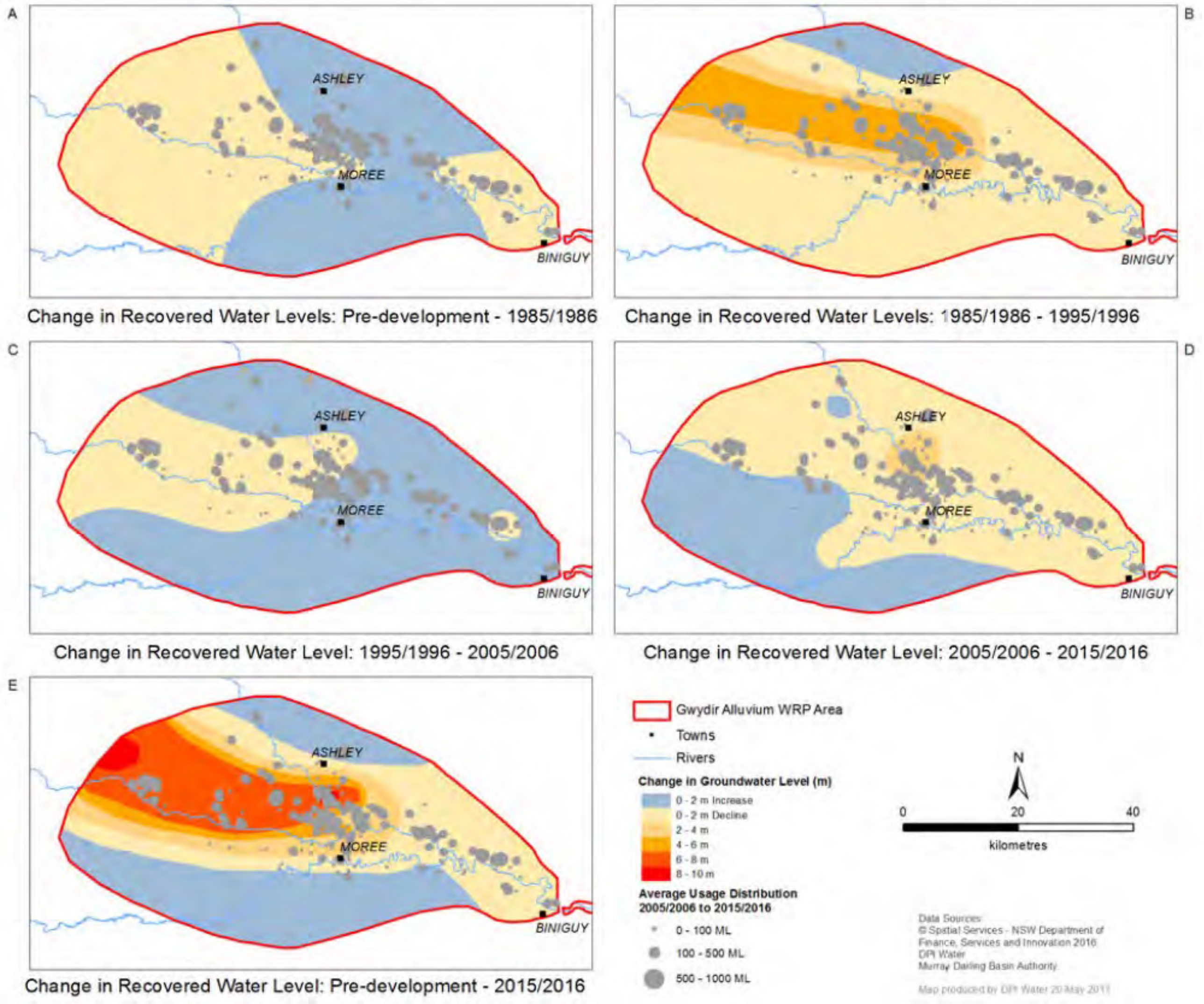


Figure 2.17: Long-term changes groundwater level in Narrabri Formation

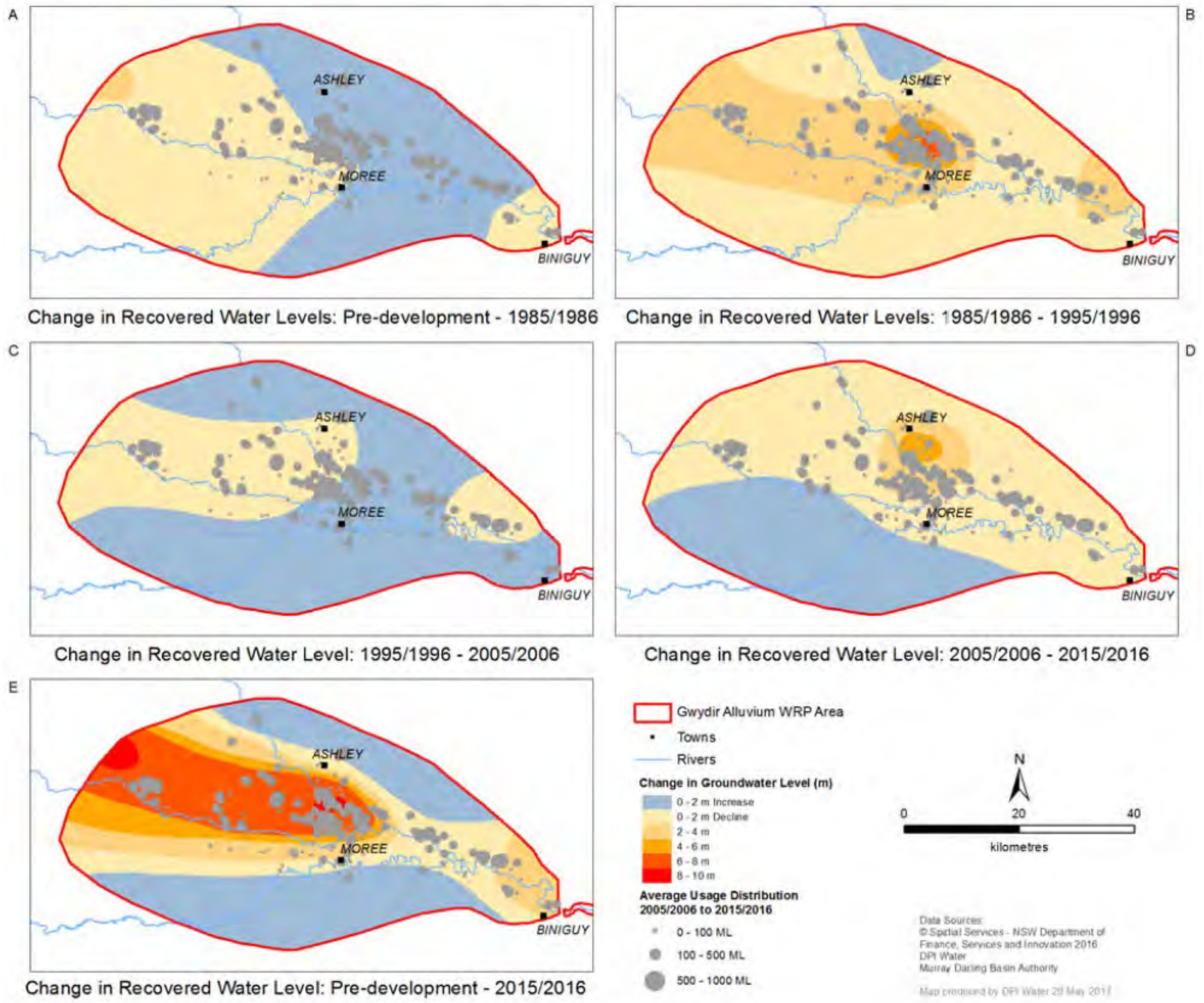


Figure 2.18: Lower Gwydir Alluvium (Gunnedah Formation): Long-term changes in recovered water levels over a range of periods

TABLE 3 Summary of groundwater water licences – Lower Gwydir			
LTAAEL (ML/yr)	**Total share component**[1]	**Licence category**	**Unit shares**[2]
33,000	32,630	Aquifer (162)	28,858
		Domestic and Stock (1)	200
		Local water utility (2)	3,572

[1] Data supplied to Aurecon by DPIE for Moree SAP investigation. Data obtained from the NSW Water Register on 23 June 2020. waterregister.waternsw.com.au/water-register-frame

[2] Data supplied to Aurecon by DPIE for Moree SAP investigation. Data obtained from the NSW Water Register on 23 June 2020. . waterregister.waternsw.com.au/water-register-frame

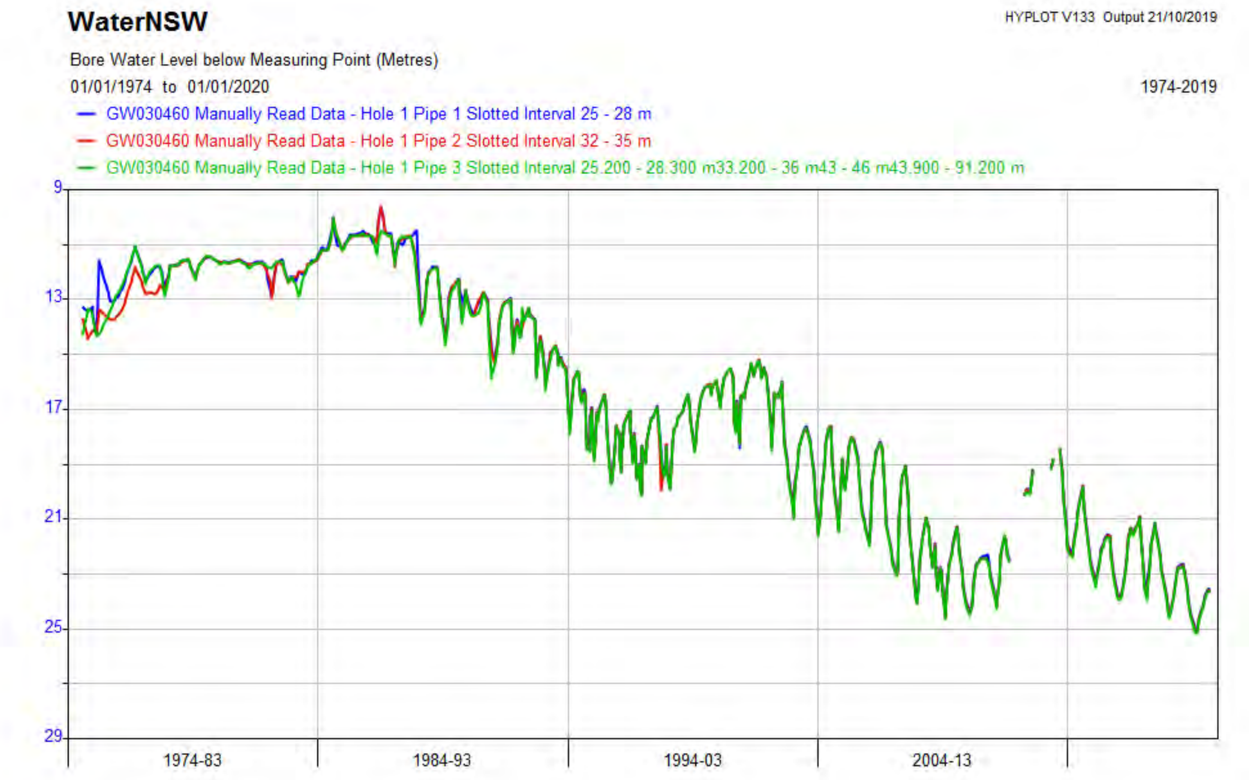


Figure 2.19: Hydrograph for monitoring bore GW030460, north of Moree

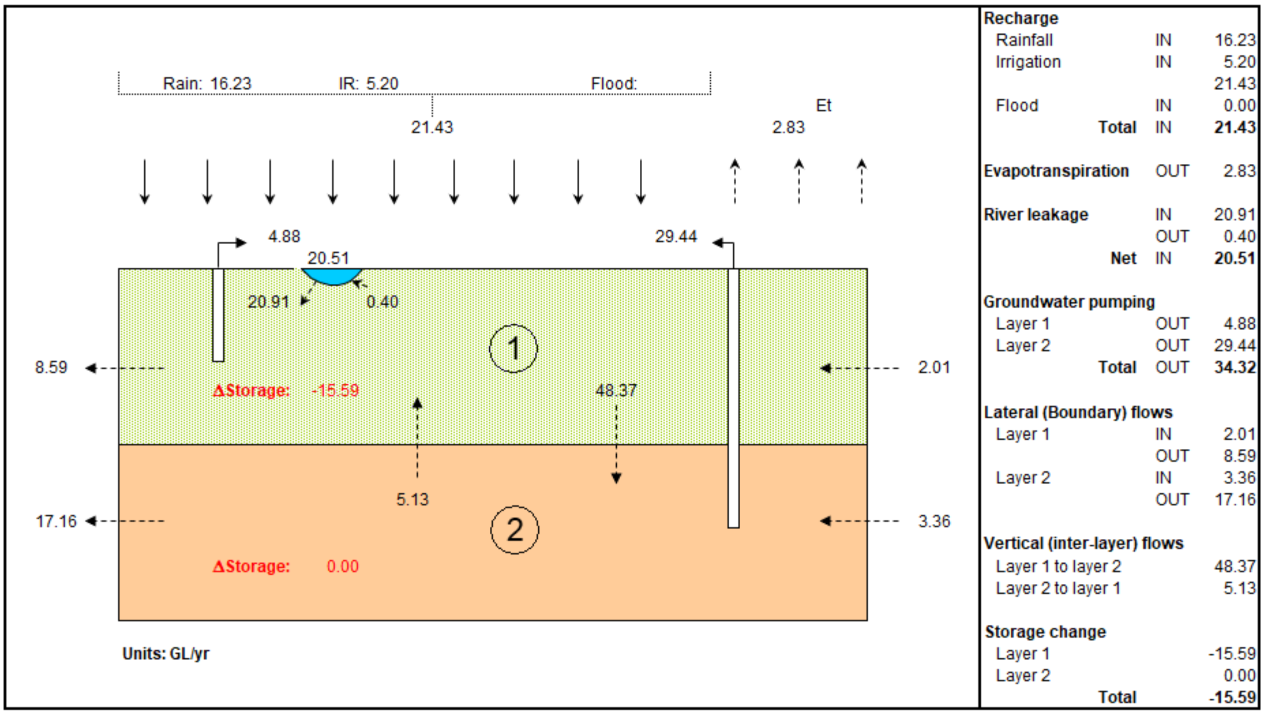


Figure 2.20: Lower Gwydir groundwater balance (07/2014 to 06/2019)

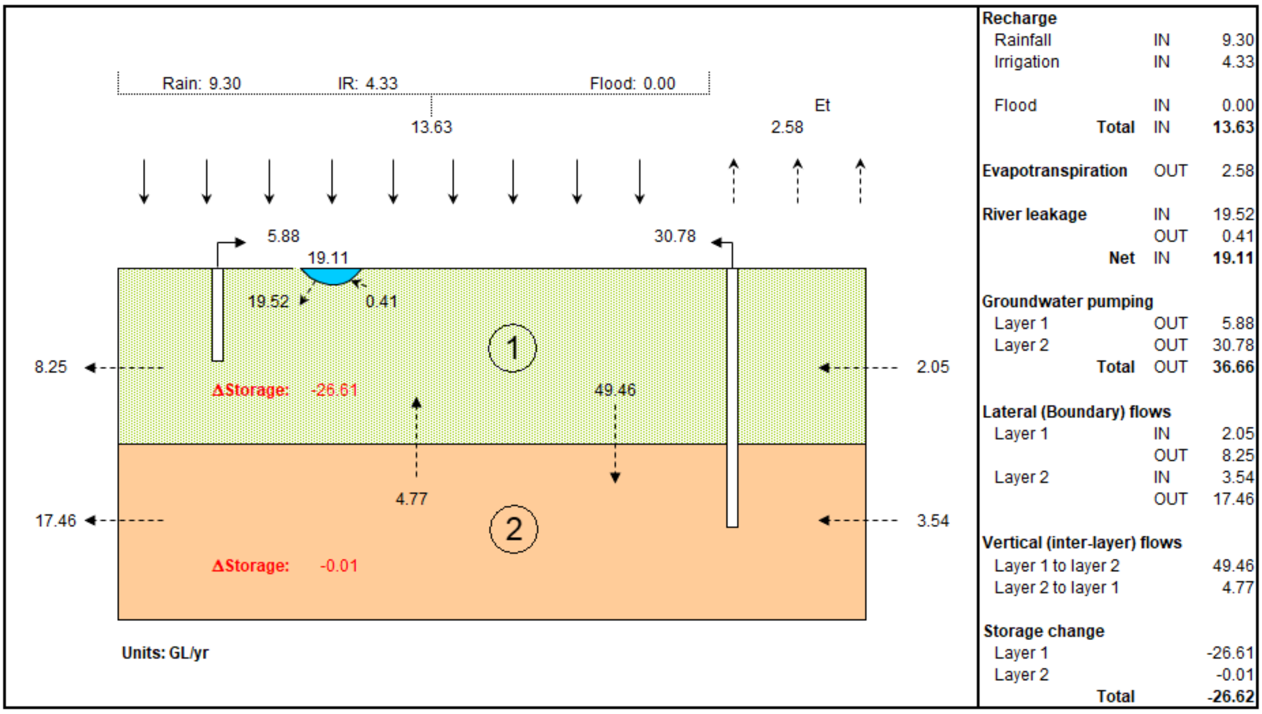


Figure 2.21: Lower Gwydir groundwater balance (07/2018 to 06/2019)

2.3 The Great Artesian Basin

The aquifers with which this section is concerned are part of the Great Artesian Basin (GAB), a "vast groundwater entity stretching across more than one-fifth of Australia" (Smerdon and Ransley 2012) as illustrated in Figure 2.22. The GAB groundwater basin spans three Mesozoic geological basins – the Eromanga, Carpenteria and Surat Basins, as shown on Figure 2.23. The area covered by this report lies within the Surat Basin. Moree is located within the southern part of the Surat Basin, which extends from south of Narrabri to the north-west through Roma to Tambo in Queensland, across an area of almost 300,000 km^2. In NSW, the Surat Basin covers 74,000 km^2.

The GAB is a truly outstanding hydrogeological feature of global significance, being one of only two groundwater flow systems of comparable scale on the planet (the other being the Nubian Sandstone in North Africa, principally Libya). The rapid transmission of groundwater pressure and the slow movement of groundwater itself over thousands of kilometres, with flow times in excess of 10,000 years are, unsurprisingly, enthralling to water scientists; the emergence of groundwater at natural springs – often fault-controlled – in the middle of the desert was life-giving to the original inhabitants of this continent and continues to be of great cultural significance to Aboriginal people. It is essential that this resource be managed sustainably.

The Surat Basin contains sedimentary rocks of early Jurassic to early Cretaceous age, the former hosting significant coal-seam and conventional gas reserves in Queensland, whilst the late Jurassic and early Cretaceous rocks host the main aquifer units of the basin.

Figure 2.24 shows the groundwater resource units for the GAB system. Moree lies in the groundwater resource unit 28, about 25 km west of the groundwater resource units 29 and 30 which are the main recharge areas along the eastern margin of the GAB. East of Moree, the GAB sedimentary rocks are draped across a major north-south fault-zone in the underlying Gunnedah Basin, the Moonee-Goondiwindi Fault, which is a northward extension of the Hunter-Mooki Fault. The fault is a reverse-fault upthrown to the east and is associated with a westward increase in the thickness of the Surat basin rocks.

The GAB has been subject to investigations for many years – in fact over 100 years. However, it is a highly complex geological and hydrogeological system and the detailed interpretation of both its structure and flow regime have constantly evolved over that period. The most recent basin-wide interpretations are provided in the Hydrogeological Atlas of the Great Artesian Basin (Ransley et al 2015). An entire volume of the Hydrogeology Journal was devoted to the subject of 'Advances in Hydrogeological Understanding of the GAB' (Hydrogeol J (2020) Vol. 28). These references have been used to provide a regional context for some sections of this plan. The

Hydrogeological Atlas draws upon the earlier assessment by CSIRO, particularly Ransley and Smeardon 2012 and for the area of interest to this plan, Smeardon and Ransley 2012. These recent interpretations all developed upon the comprehensive documentation and conceptualisation of the GAB by Habermehl (1980) and, in NSW, Hawke and Cramsie (1984). More recently, the Groundwater Resource Description for the GAB has been published by NSW Department of Planning, Industry and Environment (DPIE February 2020). This document has been used to complement the previously-available information.

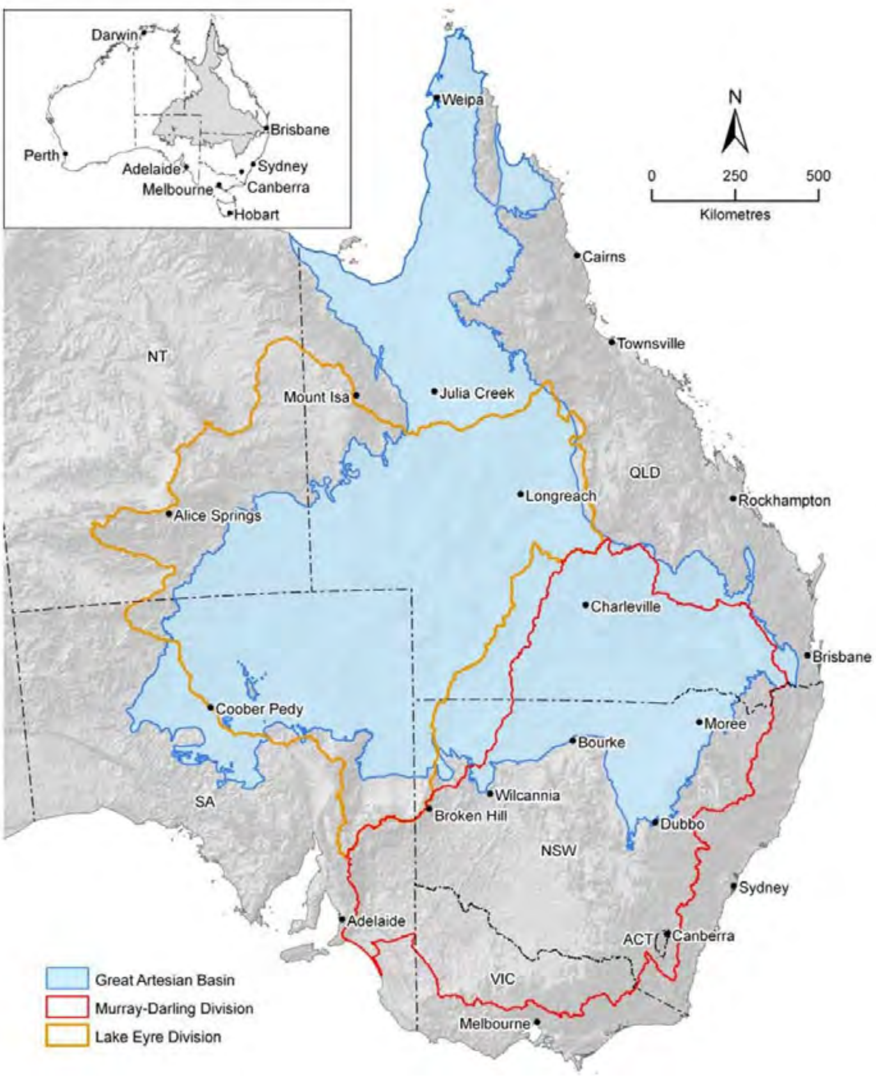


Figure 2.22: Geographic extent of the Great Artesian Basin (after Smeardon and Ransley 2012)

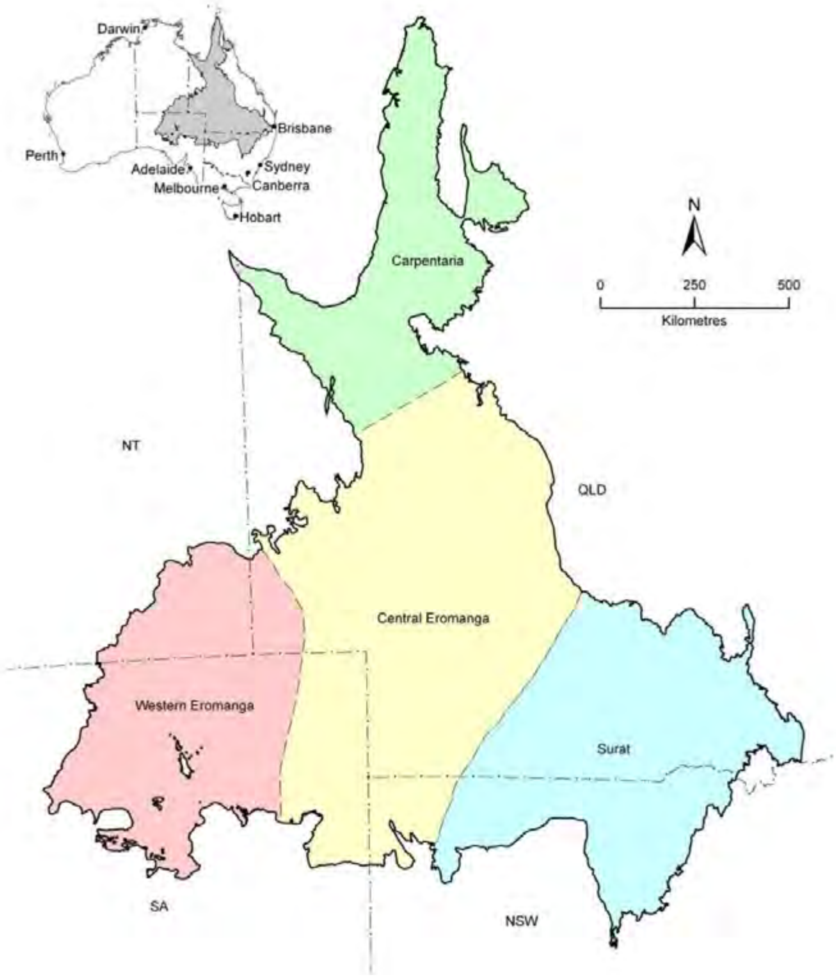


Figure 2.23: Major geological basins of the Great Artesian Basin (after Smeardon and Ransley 2012)

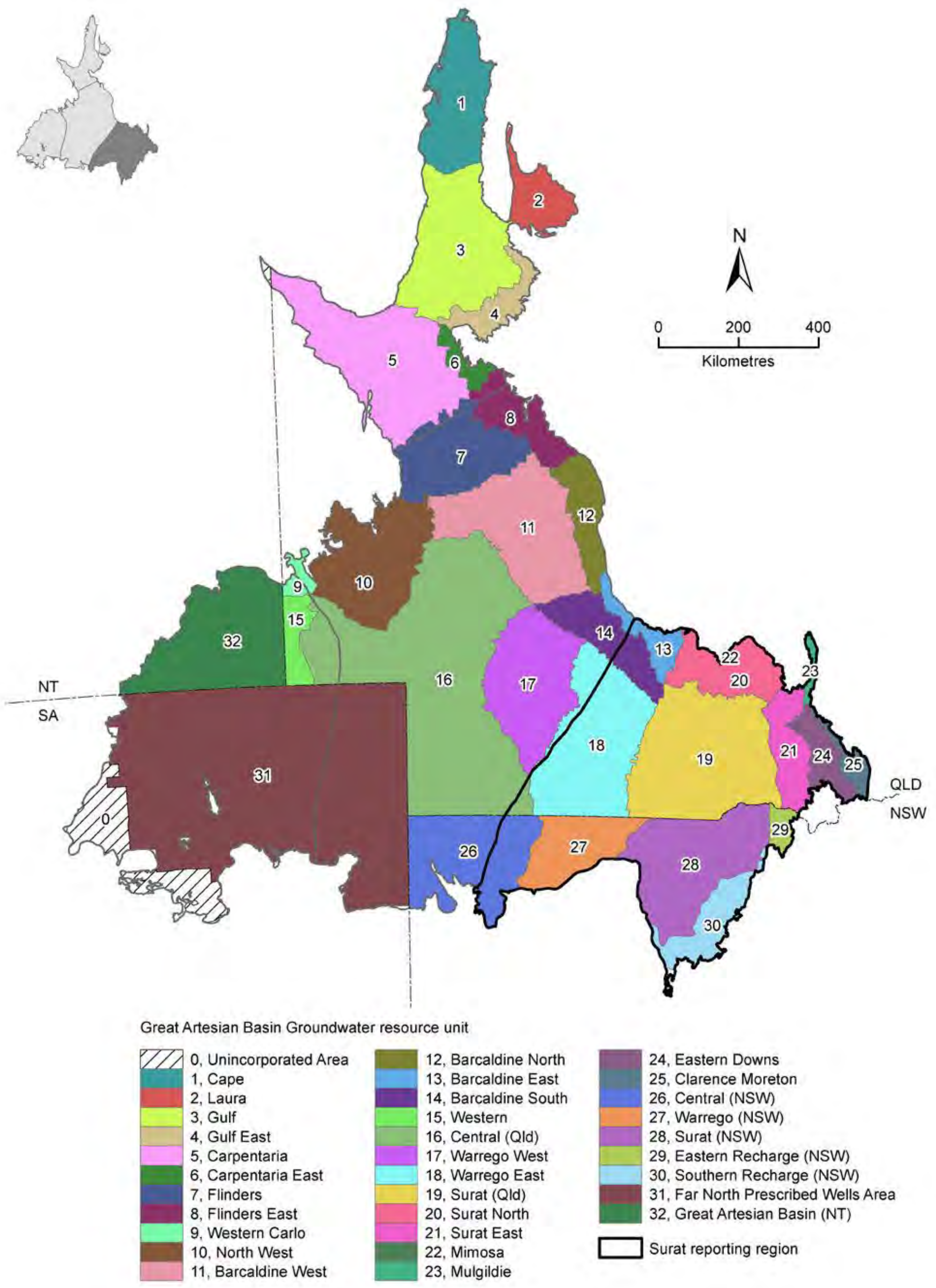


Figure 2.24: Groundwater resource units of the Great Artesian Basin

2.3.1 Hydrostratigraphy

A 3D representation of the conceptualisation of the whole GAB System is presented in Figure 2.25. The Surat Basin is NSW is represented to the southern arm of the D-C axis, with Moree just to the left of the 'C'.

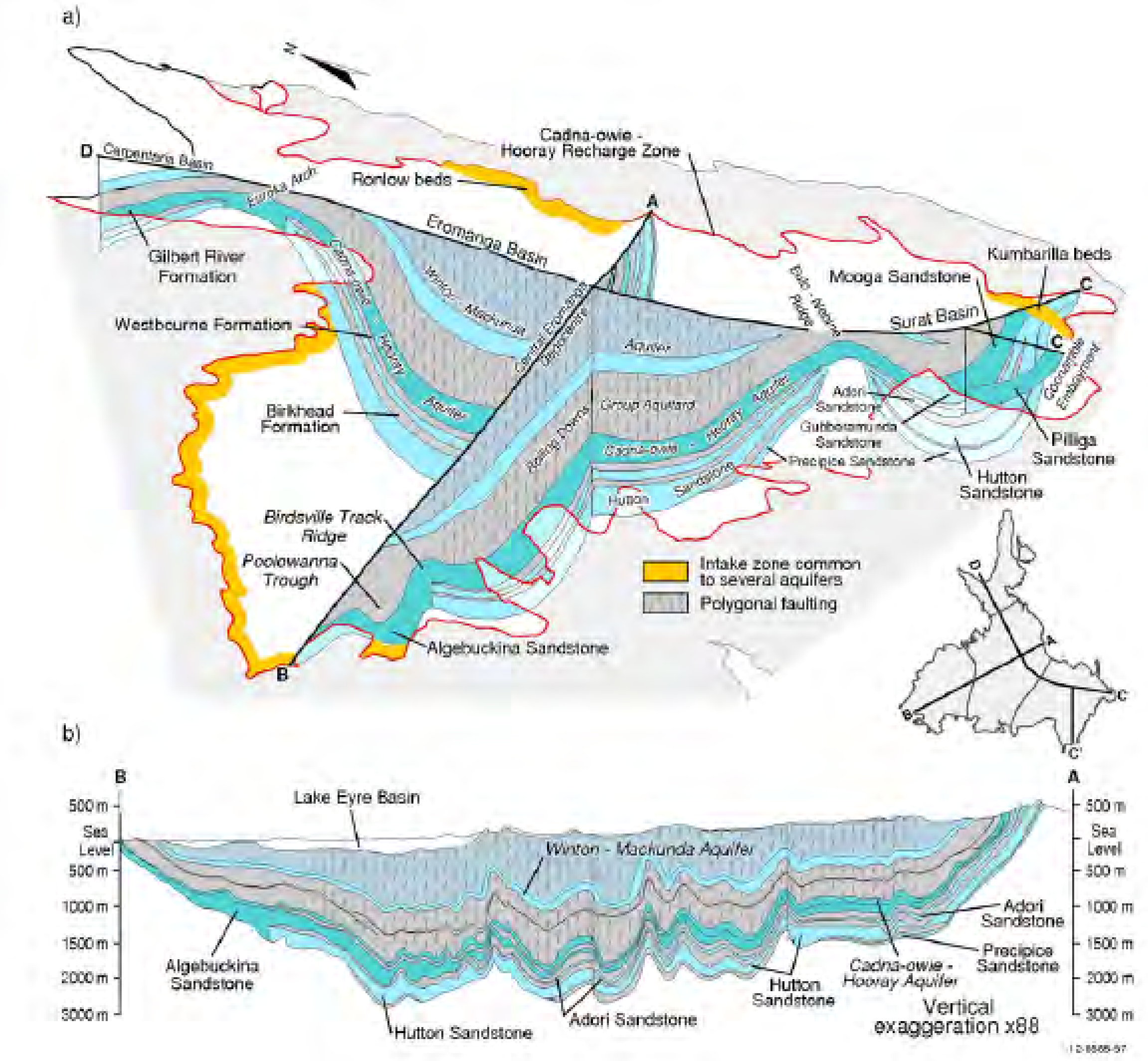


Figure 2.25: Three-dimensional conceptualisation of the GAB system (Ransley et al., 2012)

The spatial extent of the geological units depends on the complex depositional history, which differed considerably across the extent of the GAB. Consequently, some units have a broad extent across much of the GAB, with some only being present in part of the Surat Basin. The hydrostratigraphic sequence underlying Moree SAP area was assessed using the Geoscience Australia geology formation base surfaces for the GAB system described in Table 4 and compared with drillers' strata log descriptions of deep water- bores[3] near the SAP investigation area (see Figure 2.26), and the composite log of the Moree No.1 stratigraphic well drilled by Mayfair Minerals in 1972 and located east of the Carnarvon Highway, about 20 km north of Moree (29.290556S, 149.795833E) (see Figure 2.27). This is a primary local stratigraphic information source due to the high-quality geophysical logging supplemented by mud-logging and sidewall coring (Hawke and Cramsie, 1984). The unit identified as Gubberamunda Sandstone on the log is now considered to be the Pilliga Sandstone – top shown as -680 m AHD, 882 m bgl. This log is provided in Appendix A (note that depths on the log are shown in feet).

The drillers strata log forms with field notes including bore yields are also provided in Appendix A.

[3] As would be expected, there are inconsistencies between the drillers strata log forms, as drillers are not geologists and have their own way of describing rocks. There are also differences between those logs and the Mayfair Minerals Moree No.1 stratigraphic well strata. The latter was logged by a geologist and also geophysically logged; it is therefore of higher reliability for the assessment of the strata at the Moree SAP investigation area.

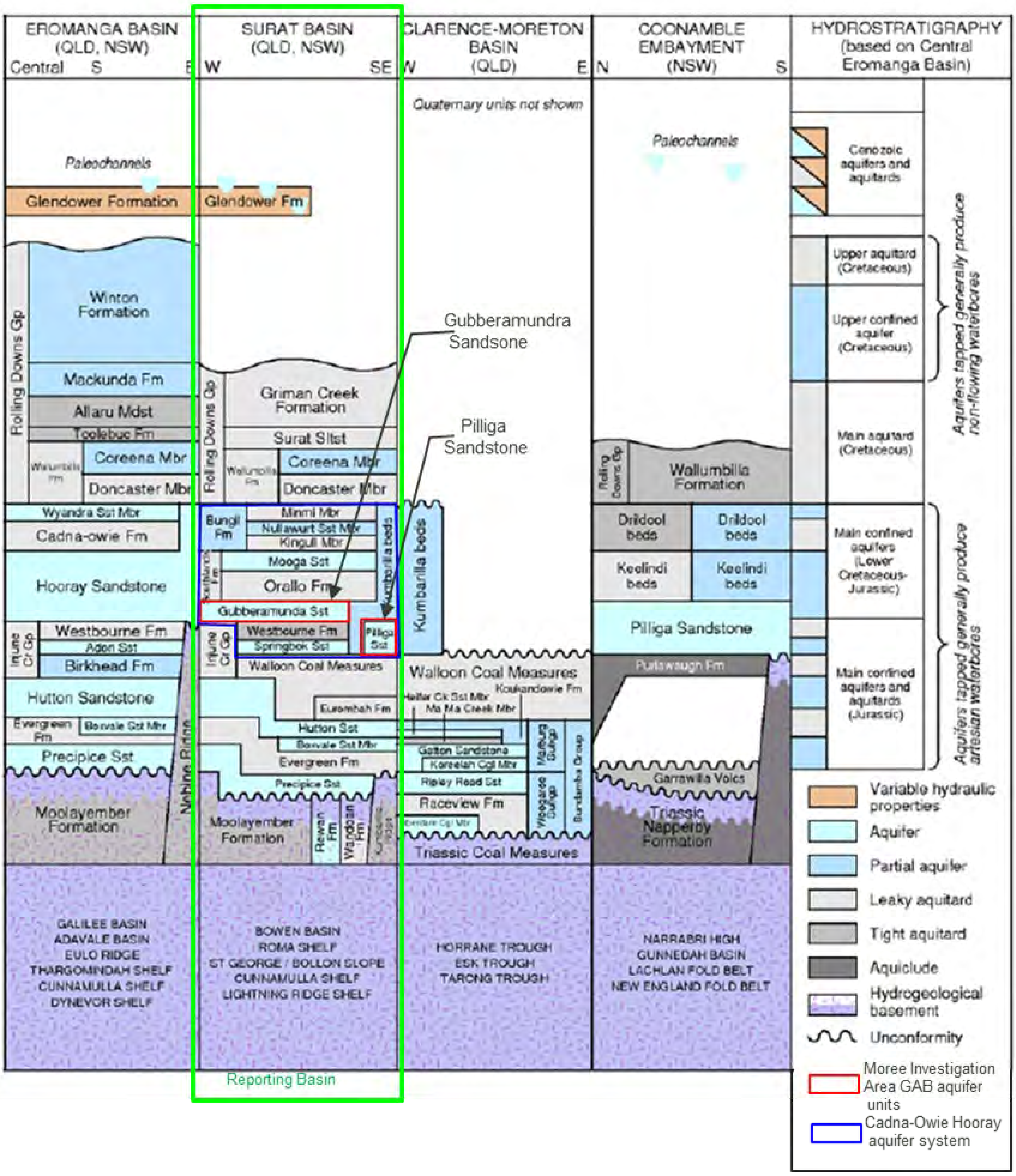
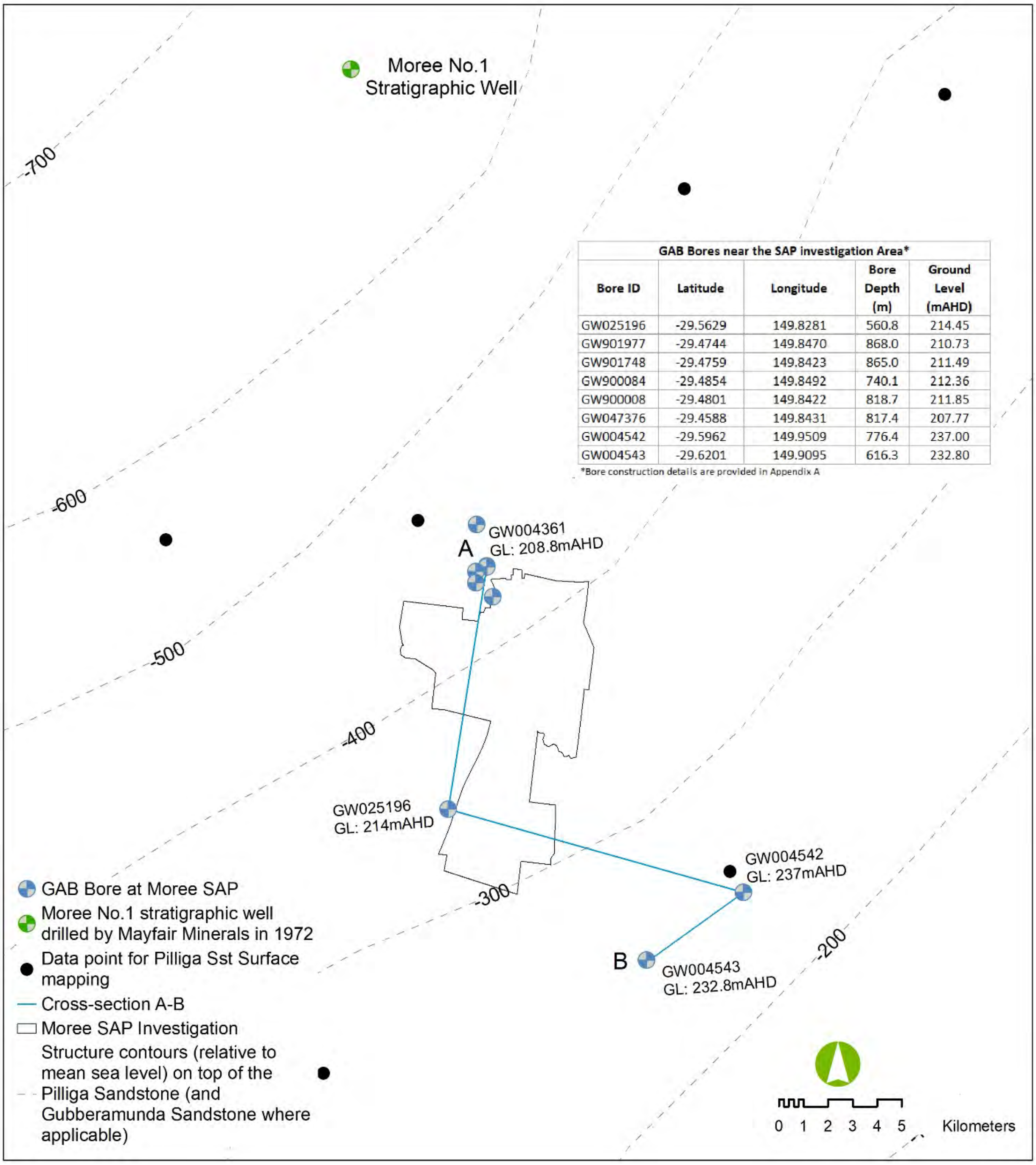


Figure 2.26: Hydrostratigraphic sequence of the Eromanga, Surat and Clarence-Moreton basins (after Ransley and Smerdon, 2012)

TABLE 4
Identification of regional stratigraphic units underlying Moree SAP area

Layer ID*	Stratigraphic Unit Base*	Aquifer type	Presence in Moree SAP Area
Layer 02	Base of Cenozoic surface (catalogue #75991)	Aquifer of highly variable hydrogeological properties	Present
Layer 03	*Base of Mackunda Formation and equivalents surface (catalogue #76021)* *In the Surat Sub-basin, the Griman Creek Formation is the equivalent of the Winton-Mackunda Aquifer.*	-	*Absent*
Layer 04	Base of Rolling Downs Group surface (catalogue #76022)	Aquitard	Present
Layer 05	Base of Pilliga Sandstone (Base of Hooray Sandstone and equivalents surface - catalogue #76023)	Main aquifer. This is part of the Cadna-owie – Hooray Aquifer and Equivalents. In the Surat Basin the equivalent units are the Pilliga Sandstone (south) and Gubberamunda Sandstone (north) (Hawke and Cramsie (Eds), 1984)	Present
Layer 05-07	*Base of Algebuckina Sandstone surface (catalogue #76952)*	-	*Absent*
Layer 06	*Base of Injune Creek Group surface (catalogue #76024)*	*Aquitard*	*Absent*
Layer 07	*Base of Hutton Sandstone surface (catalogue #76025)*	*Aquifer*	*Absent*
Layer 08A	*Base of Evergreen and Marburg formations (catalogue #76026)*	*Aquitard*	*Absent*
Layer 08B	*Base of Poolowanna Formation (catalogue #76953)*	*Aquitard*	*Absent*
Layer 09	*Base of Precipice Sandstone and equivalents surface (catalogue #76027)*	-	*Absent*
Layer 10	Base of Jurassic-Cretaceous sequence surface (catalogue #76028)	Base of GAB	Present

Sourced from http://www.ga.gov.au/scientific-topics/water/groundwater/gab/data/hydrogeology#heading-5 (July 2020)



GAB Bores near the SAP investigation Area*

Bore ID	Latitude	Longitude	Bore Depth (m)	Ground Level (mAHD)
GW025196	-29.5629	149.8281	560.8	214.45
GW901977	-29.4744	149.8470	868.0	210.73
GW901748	-29.4759	149.8423	865.0	211.49
GW900084	-29.4854	149.8492	740.1	212.36
GW900008	-29.4801	149.8422	818.7	211.85
GW047376	-29.4588	149.8431	817.4	207.77
GW004542	-29.5962	149.9509	776.4	237.00
GW004543	-29.6201	149.9095	616.3	232.80

*Bore construction details are provided in Appendix A

Figure 2.27: Location map for GAB bores near Moree SAP Area and contour map of top of Pilliga Sandstone surface

2.3.3 Nature and distribution of the Great Artesian Basin major aquifers

Consistent with the conceptualisation of the GAB system shown in Figure 2.27, the SAP investigation area hydrostratigraphy shown in Figure 2.26 indicates that the Pilliga Sandstone is the main aquifer in the Moree SAP area. The regional hydrostratigraphic equivalent in the northern Surat Basin is the Gubberamunda Sandstone, although this may be chronostratigraphically younger.

2.3.4 Hydraulic Characteristics

In order to make credible estimates of borehole yield and aquifer drawdown in response to pumping, it is necessary to have a reasonable understanding of the likely range in values of the hydraulic characteristics of the Pilliga Sandstone aquifer beneath the SAP investigation area.

The fundamental characteristics are aquifer thickness, hydraulic conductivity and specific storage. Other parameters, transmissivity and storage coefficient, can be derived from these values.

There is a good estimate of the aquifer thickness (about 150 m) from the 158 m Pilliga Sandstone intersection logged in the Mayfair-Moree stratigraphic bore drilled 25 km to the north of SAP investigation area. At Bellata, 40 km south of Moree, a thickness of 146 m was recorded.

Specific storage values are contrained by poroelastic theory to a range of 2 x 10^{-7} to 1.3 x 10^{-5} m^{-1}. Multiplying those values by the aquifer thickness gives a storage coefficient range of 3 x 10^{-5} to 2 x 10^{-3}. The mid-point of that range is 1.02 x 10^{-3}.

Figure 2.28 shows a box-and Whisker plot of the range of hydraulic conductivity values measured for the Orallo Formation (left) Gubberamunda Sandstone (right) during coal-seam gas exploration and development work in the nortern Surat basin. The Gubberamunda Sandstone is the northern hydrostratigraphic equivalent of the Pilliga Sandstone.

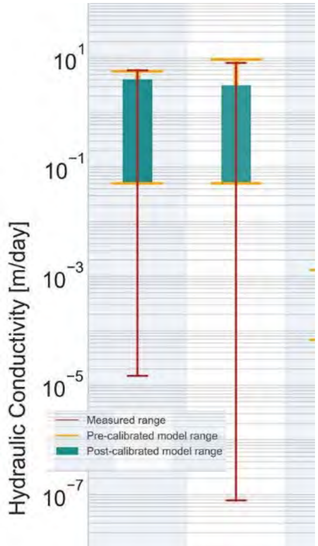
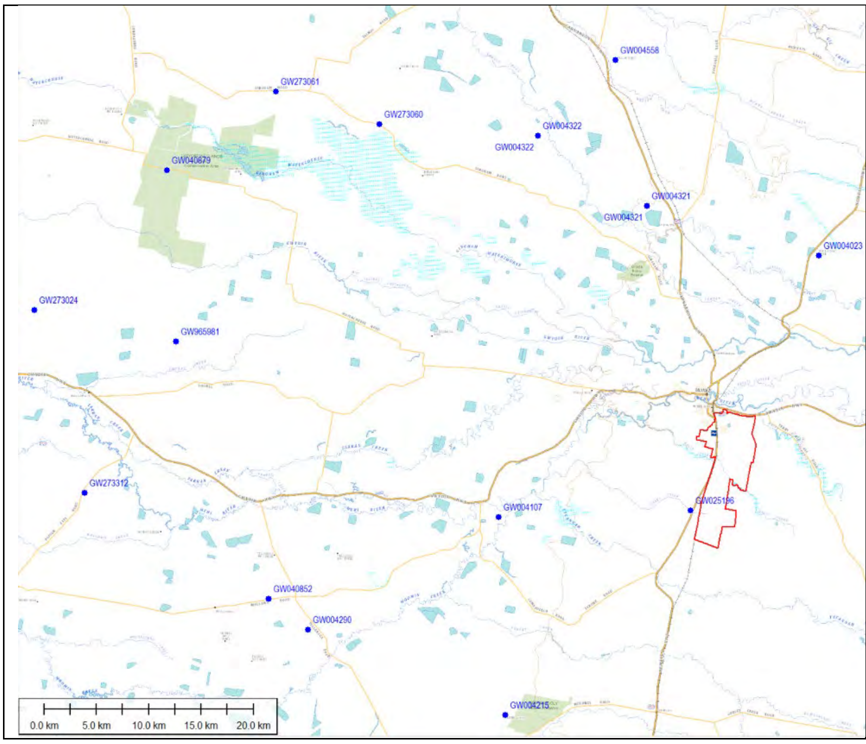


Figure 2.28: Measurement of Hydraulic Conductivity in the Northern Surat Basin (Queensland Office of Groundwater Impact Assessment 2010)

These measurements were made using many different methods over a wide range of scales – from laboratory measurements on core samples, through drill-stem tests and pumping test analysis to regional model calibration. It can be seen that the full range covers eght orders of magnitude, and the model-confirmed range almost two orders of magnitude.

Estimates of horizontal hydraulic conductivity made for the Pilliga Sandstone in the Narrabri area during Santos's investigation work for the Narrabri Gas Project (CDM Smith 2016) similarly covered a broad range - from 4 x 10^{-3} to 2.7 x 10^{-1} m/day.

NSW DPIE Water provided data from a number of historical shut-in tests carried out on flowing artesian bores within 50 km of Moree. Unfortunately, not all of the data were able to be intepreted either due to absence of corresponding flow data or very fast recovery with little transient data. However, some of the tests, mainly from bores to the west of Moree were interpreted. Results are summarised in Figure 2.29. The shut-in recovery plots are included in Appendix C.



Bore	Year	Hydraulic Conductivity (m/d)
GW004023	1916	0.74
GW004023	1921	0.74
GW004023	1922	0.89
GW004107	1921	1.27
GW004107	2014	1.61
GW004215	1932	0.75
GW004290	1917	0.29
GW004290	1931	0.25

Figure 2.29: Shut-in test data summary

The closest high-quality pumping test data relates to a replacement bore for the town water supply at Bellata, about 40 km south of the SAP investigation area, which was drilled in 2017. This bore encountered 146 m of Pilliga Sandstone, from 366 to 512 m bgl, of which 48 m was screened. The bore is sub-artesian, with a standing water level 11 m bgl. A 48 hour constant rate pumping test was carried out at a rate (Q) of 13.5 L/s (1,166 cubic metres per day (m^3/d)); well drawdown (s_w) at the end of the test was 10.5 m, giving a specific capacity (s_w/Q) of 111 square metres per day (m^2/d). Interpretation of this test using a number of methods derived an average value for transmissivity of 350 m^2/d. Dividing this value by the aquifer thickness of 146 m gives an estimated average hydraulic conductivity of 2.4 m/d. The recommended sustainable pumping rate for this bore was 23 L/s.

These data are considered to be the most relevant available for extrapolation to the SAP investigation area.

A general comparison can also be made with hydraulic conductivity values calculated from pumping-test transmissivities obtained in distant areas where the Pilliga Sandstone aquifer thickness and depth are different to those at Moree, but it is unrealistic to try to scale these values to fit the conditions at Moree.

Examples are:

- Pumping tests in the Coonamble Embayment area 200 km to the south-west (where the aquifer is much thinner) where a hydraulic conductivity of 25 to 35 m/d was calculated.
- Median of hydraulic conductivity values measured in the Pilliga Sandstone in the Narrabri Gas Project area (80 to 100 km to the south) using a numerous laboratory and field methods (range 0.0001 to 1.0 m/d).
- Specific capacity and hydraulic data calculated form pumping tests on bores in the Pilliga Sandstone recently drilled at Walgett (effective aquifer thickness 25 m, SC=42 m^2/d, K=2.5 m/d) and Collarenebri (effective aquifer thickness 161 m, SC=27 m^2/d).

For prediction purposes in this report a hydraulic conductivity of 2.5 m/d has been adopted. Multiplying this value by the estimated aquifer thickness of 160 m gives a transmissivity of 400 m^2/d.

3.0 OVERVIEW OF REGULATORY FRAMEWORK AND RELEVANT GUIDELINES

3.1 Water Management Act 2000

Groundwater resources in NSW are managed subject to the requirements of the *Water Management Act 2000 (NSW)* and water sharing plans developed under that Act.

The Act and the Plans together define two layers of management:

> **Licences** and **Rights** that provide an entitlement to a defined share in, or a right to make reasonable use of, a water source. Licence categories are defined in s57 of the Act and include aquifer access licences (which include a specific subcategory for town water supply) and local water utility access licences. Section 58(1) of the Act and clause 6(2) of the Regulation provide that local and major water utility access licences have equivalent priority to stock and domestic access licences, and priority over other aquifer access licences. Rights include Basic Landholder Rights and Native Title Rights.
>
> **Approvals** that allow a specific volume of water, or rate of abstraction, to be taken at a specific place, in a specific manner, for a specific use.

Part 2 of Chapter 3 of the Act sets out provisions related to water access Licences. It is an offence to take water from a source to which Part 2 applies, otherwise than authorised by an access licence. Section 56(1) provides that an access licence entitles its holder:

(a) to specified shares in the available water within a specified water management area or from a specified water source, (the share component), and

(b) to take water:

  (i) at specified times, at specified rates or in specified circumstances, or in any combination of these, and

  (ii) in specified areas or from specified locations (the extraction component).

Part 3 specifies types of approval required under the Act. Of relevance to this plan are:

(i) Water use approvals, which confer a right on their holder to use water for a particular purpose at a particular location, and

(ii) Water supply works approvals which authorise their holder to construct and use a specified water supply work at a specified location.

For individual water sources, or groups of water sources, the basis for water sharing, and rules governing the provision of environmental water, granting of, and dealing in, access licences and granting of approvals are set out in a water sharing plan developed for that source.

3.2 Regulatory framework for Gwydir Alluvial groundwater sources

3.2.1 Gwydir Alluvial Groundwater Sources Water Sharing Plan

Groundwater abstraction from the LGAA in NSW is regulated under the provisions of the Water Sharing Plan for the Gwydir Alluvial Groundwater Sources 2020 (the WSP) which commenced on 1 July 2020. The WSP applies to both the Upper and Lower Gwydir aquifers. The description below applies to the Lower Gwydir aquifer only.

Part 2 of the WSP defines the Plan's vision, objectives, strategies and performance indicators. Objectives are defined in relation to the spiritual, social, customary and economic benefits of groundwater to Aboriginal communities, cultural and social benefits and in environmental and economic terms.

Part 3 sets out the basis for the bulk access regime for the water source.

Part 4 (in conjunction with Part 6) defines the planned environmental water provisions. The water reserved for the environment under the plan is the water remaining after water has been taken under basic landholder rights, access licences and any other rights under the Act, and the water that cannot be carried over from one water year to the next.

Part 5 provides that at the commencement of the Plan it was estimated that:

- the water requirements of holders of domestic and stock basic rights are a total of 700 ML/yr;
- the share components of domestic and stock access licences authorised to extract water from this groundwater source will total 200 ML/yr;
- the share components of local water utility access licences authorised to extract water from this groundwater source will total 3,572 ML/yr; and
- the share components of aquifer access licences authorised to extract water from this groundwater source will total 28,858 ML/yr.

These estimated requirements total 33,330 ML/yr.

Part 6 sets out a long-term average annual extraction limit (LTAAEL) for the Lower Gwydir Groundwater Source of 33,000 ML/year. It is understood that the basis for this limit was the average annual recharge to the groundwater source, estimated to be 38,000 ML, plus the requirements for basic landholder rights (700 ML) minus a 15% allocation to environmental water (5,700 ML)[4].

The estimated requirements currently exceed the LTAAEL by a small margin (300 ML/yr). Thus, no water is available for further allocation.

Access licences are subject to annual allocation of a proportion of the share component, on the basis of availability. Clause 31(4) of the WSP provides that the available water determination for domestic and stock and local water utility licences shall be 100% of the share component. As of 1 July 2020, the available water determination for all access licences in the Lower Gwydir Groundwater Source is 100% of the share component.

Section 97(2) of the *Water Management Act 2000* and Part 9 of the WSP set out the rules for granting or amending water supply works approvals. Key provisions are that:

- The Minister may only grant a water supply work approval if satisfied that adequate arrangements are in place to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of the construction or use of the proposed water supply work (Section 97 (2) of the Act).
- The Minister must not grant a water supply work approval unless satisfied that adequate arrangements are in place to ensure that there will be:
    - no more than a minimal detrimental effect on the ability of a person to take water using an existing approved water supply work and any associated access licences,
    - no more than minimal harm to public health and safety or to a groundwater-dependent culturally significant area, and
- A water supply work approval (other for basic landholder rights) must not be granted or amended if the water supply work is located within:
    - 200 metres of a water supply work that is located on another landholding and authorised to take water solely for basic landholder rights from the same groundwater source, or
    - 400 metres of a water supply work that is located on another landholding and nominated by another access licence to take water from the same groundwater source
    - 200 metres of the boundary of the landholding on which the water supply work is located, unless the owner of the landholding adjoining the boundary has provided consent in writing.
    - 500 metres of a water supply work that is nominated by a local water utility access licence or a major utility access licence authorised to take water from the same groundwater source, unless the holder of the local water utility access licence or major utility access licence has provided consent in writing, or

[4] Lower Gwydir Groundwater Source: Groundwater Management Area 004 Groundwater Status Report – 2008. Section 6

  - 400 metres of a Government monitoring or observation bore.

- A water supply work approval must not be granted if, in the Minister's opinion, the water supply work is located within any of the following:
  - 200 metres of the top of the high bank of a river,
  - 200 metres of any of the high priority groundwater-dependent ecosystems shown on the High Priority Groundwater-Dependent Ecosystem Map
  - 200 metres of a groundwater-dependent culturally significant area.

The location restrictions do not apply if the water supply work is solely for basic landholder rights or the Minister is satisfied that the location of the water supply work at a lesser distance would result in no more than a minimal detrimental effect or minimal harm.

3.2.2 DPIE Policy for implementing WSP

The Plan's requirement for "no more than minimal harm" is qualitative and discretionary. In order to provide certainty and consistency, the NSW Department of Industry (responsibility now with DPIE Water) published a set of deterministic criteria that will be applied to all the inland aquifer systems in NSW. DPIE Water has indicated that these criteria will be strictly applied within the Moree SAP.

In assessing the risk of detrimental effects during the works approval process, the criteria summarised in Table 5 will be applied in the LGAA (NSW Department of Industry, September 2018, PUB18/580).

TABLE 5
Gwydir alluvial groundwater source approval process

Impact on water table (unconfined aquifers) **Narrabri Aquifer**	**Impact on groundwater pressure (confined/semi-confined aquifers)** **Gunnedah Aquifer**
1. Less than 0.1 m cumulative drawdown in the water table, 40 m from any: a. high-priority, groundwater dependent ecosystem, or b. high-priority, culturally significant site.	1. A cumulative drawdown of not more than 40% of the pre-development TAD above the base of the water source at a distance of 200 m from any water supply works including the pumping bores.
2. An additional drawdown of not more than 10% of the pre-development TAD above the base of the water source to a maximum of 2 metres at any: a. 3rd or higher order surface water source measured at 40 metres from the high bank, or b. water supply works (excluding those on the same property) subject to negotiation with impacted parties.	2. An additional drawdown of not more than 10% of the pre-development TAD above the base of the water source to a maximum of 2 m at any water supply works (excluding those on the same property), subject to negotiation with impacted parties.
3. A cumulative drawdown of not more than 10% of the pre-development TAD of the water source to a maximum of 2 m at a distance of 200 m from any water supply works (including the pumping bores) subject to negotiation with impacted parties.	

3.3 NSW Great Artesian Basin System

3.3.1 Water Sharing Plan

The GAB is a multi-layered aquifer system comprising generally confined (artesian) aquifers in Jurassic and Cretaceous fluvial, fluvio-lacustrine and other continental and shallow marine sandstones. The aquifers may be unconfined or semi-confined in the recharge areas along the eastern and southern margins of the GAB.

Groundwater abstraction from the confined GAB aquifers in NSW is regulated under the provisions of the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020* (the WSP) which commenced on 1 July 2020. This plan applies to the GAB aquifers beneath Moree.

Part 2 of the WSP defines the Plan's vision, objectives, strategies and performance indicators. Objectives are defined in relation to Aboriginal cultural heritage, and in environmental, economic, social and cultural terms.

As indicated above, the GAB aquifers in the Moree area lie within the Surat Basin. They form part of the Surat Groundwater Source, as defined in the Registered Map attached to the WSP. Clause 24 of the WSP states that the long-term average annual extraction limit (LTAAEL) in the Surat Groundwater Source is 43,446 ML plus the volume of water lost through the use of inefficient water distribution systems in the exercise of stock and domestic rights, plus 30% of the water savings made under cap and pipe projects since the start of the plan (currently effectively zero). The WSP itself does not indicate how the volume of 43,446 ML was derived but it is understood, from DPIE (2020), that this is the sum of the entitlements authorised at the start of the 2008 WSP, the estimate of current basic landholder rights and 30% of the savings attributed to cap and pipe programs between 2009 and 2020. At present, 20,400 ML is allocated under stock and domestic rights (and a further 15,000 ML is estimated to be taken that is excess to requirements or wasted water); 3,393 ML is allocated under local water utility access licences and 5,527 ML under aquifer access licences, a total of 29,320 ML (plus 15,000 ML wastage). Thus, the estimated volume available for further sharing in the Surat groundwater source is 14,126 ML/yr as summarised in Table 6. It should be noted that the estimated 15,000 ML of wasted water appears on both sides of the balance, effectively being cancelled out of the calculations. If all the wasted water were saved, 4,500 ML would accrue to the LTAAEL and 10,500 ML to planned environmental water.

TABLE 6
Groundwater availability in the NSW Surat (GAB) groundwater source

Available (ML)		**Maximum allowable use (ML)**	
LTAAEL (incorporates savings made between 2009 and 2020)	43,446	Stock and domestic rights	20,400
Assumed current wastage from leaking bores and drains	15,000	Local water utility	3,393
Current savings from cap and pipe program	0	Aquifer access licences	5,527
Subtotal			**29,320**
-	-	Assumed current wastage from leaking bores and drains	15,000
Total available	58,446	Total maximum allowable use	44,320
Current available[A]	14,126[B]		

A Determined as the difference between 'total available' (58,446 ML) and 'total maximum allowable use' (44,320 ML)
B Plus 30% of any future savings from cap and pipe programs (and any savings accruing from better estimation of stock and domestic use).

Planned environmental water in the Surat Groundwater Source under the 2008 WSP was defined in relation to the sustainable pressure estimate equivalent, i.e. the entitlements in existence in 1990 adjusted (downwards) to allow for increased abstraction between 1990 and 2008, and (upwards) for water savings made through the bore capping and piping program between 1990 and 1999, and a proportion of the savings between 1990 and 1998. This general principle is honoured in the 2020 plan, but planned environmental water is defined differently.

Access licences are subject to annual allocation of a proportion of the share component, on the basis of availability. As of 1 July 2020, the available water determination for all access licences in all the NSW Great Artesian Basin groundwater sources is 100% of the share component. This may reduce if usage increases.

Section 97(2) of the *Water Management Act 2000* and Part 9 of the WSP set out the rules for granting or amending water supply works approvals. Key provisions are that:

> The Minister may only grant a water supply work approval if satisfied that adequate arrangements are in place to ensure that no more than minimal harm will be done to any water source, or its dependent ecosystems, as a consequence of the construction or use of the proposed water supply work (Section 97 (2) of the Act).
>
> The Minister must not grant a water supply work approval unless satisfied that adequate arrangements are in place to ensure that there will be:
>
> - no more than a minimal detrimental effect on the ability of a person to take water using an existing approved water supply work and any associated access licences,
> - no more than minimal harm to public health and safety or to a groundwater-dependent culturally significant area, and
> - no more than a minimal detrimental effect on groundwater levels and pressure at the border of New South Wales and Queensland or South Australia (Cl 36 of the Plan)
>
> A water supply work approval (other than for basic landholder rights) must not be granted or amended if the water supply work is located within 500 metres of a water supply work that is:
>
> - located on another landholding and authorised to take water solely for basic landholder rights from the same groundwater source, or
> - located on another landholding and nominated by another access licence, other than a local water utility access licence.
> - within 200 metres of the boundary of the landholding on which the water supply work is located, unless the owner of the landholding adjoining the boundary has provided consent in writing:
> - within 1,000 metres of a water supply work that is nominated by a local water utility access licence or a major utility access licence authorised to take water from the same groundwater source, unless the holder of the local water utility access licence or major utility access licence has provided consent in writing, or
> - within 400 metres of a Government monitoring or observation bore.
>
> A water supply work approval must not be granted, or in the Minister's opinion, the water supply work is located within any of the following:
>
> - 40 metres of the top of the high bank of a river,
> - 50,000 metres of any of the high priority groundwater-dependent ecosystems identified in Schedule 2 of the Plan, or
> - 50,000 metres of a groundwater-dependent culturally significant area.

The location restrictions do not apply if the Minister is satisfied that the location of the water supply work at a lesser distance and would result in no more than a minimal detrimental effect.

3.3.2 DPIE Policy for Implementing WSP

In assessing the risk of unacceptable impact during the works approval process, the following criteria will be applied (NSW Department of Industry, September 2018, PUB18/580).

> Impact on Groundwater Pressure (confined aquifers)
>
> (1) Less than 0.2 metres drawdown in the groundwater pressure relative to natural variation 40 metres from any:
>
>   a. high-priority, groundwater-dependent ecosystem, or
>   b. high-priority, culturally significant site
>
> (2) Pressure level decline should:
>
>   a. not cause any flowing bore to cease to flow

b. be no more than 1 metre at any flowing water supply work, or

c. be no more than 2 metres at any non-flowing water supply work.

(3) A pressure level decline of not more than 30 metres at a distance of 200 m from any water supply works including the pumping bores.

(4) The cumulative pressure level decline of no more than 10% of the 2008 pressure level above ground surface at the NSW state border.

3.4 Groundwater Policies

The NSW government has published several groundwater policy documents that, although now quite old, are understood to remain in effect:

- NSW State Groundwater Policy Framework[5] (Department of Land and Water Conservation (DLWC) 1997).
- The NSW State Groundwater Policy Framework introduced three policy documents:
  - NSW Groundwater Quality Protection Policy (DLWC, 1998)[6]
  - NSW Groundwater Quantity Management Policy
  - NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002)[7]
- The NSW Aquifer Interference Policy[8] (AIP) was finalised in 2012 following several rounds of public review

3.4.1 NSW State Groundwater Policy Framework

The Policy Framework goals were to slow, halt or reverse degradation in groundwater resources, ensure long-term sustainability of the biophysical characteristics of the groundwater system, maintain the full range of beneficial uses of these resources and maximise the economic benefit to the region and state.

The Groundwater Quality Protection Policy (DLWC, 1998) was developed to protect groundwater resources against pollution and ensure that that the sustainability of groundwater resources and their ecosystem support functions was given explicit consideration in resource management decision making. One of its major roles was to assist the selection of priorities for the later development of groundwater management plans in groundwater water sharing plans. It set out nine key principles for groundwater quality management and protection.

NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002) has not been revised since it was issued in 2002 and is now substantially superseded by the provisions of the WSP and the research described in Section 2.4.5 above.

The NSW Aquifer Interference Policy (DPI, 2012) defines aquifer interference activities and describes how these will be managed under the licensing and approvals regime in the *Water Management Act 2000*. Under this policy, the requirements for a licence and approval are determined based on a risk and minimal impact assessment process. The process for assessment is also influenced by the location of the activity with respect to designated Biophysical 'Strategic Agricultural Land', and where the development is deemed to be 'State Significant'.

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[5] http://www.water.nsw.gov.au/__data/assets/pdf_file/0008/547550/avail_ground_nsw_state_groundwater_policy_framework_document.pdf

[6] http://www.water.nsw.gov.au/__data/assets/pdf_file/0006/548286/nsw_state_groundwater_quality_policy.pdf

[7] http://www.water.nsw.gov.au/__data/assets/pdf_file/0005/547844/groundwater_dependent_ecosystem_policy_300402.pdf

[8] https://www.industry.nsw.gov.au/__data/assets/pdf_file/0005/151772/NSW-Aquifer-Interference-Policy.pdf

All accessed July 2020

4.0 GROUNDWATER AVAILABILITY

4.1 Potential of the Lower Gwydir Alluvium as a water supply source for the SAP investigation area

As described in Section 2 above, the LGAA is comprised of two distinct hydrostratigraphic units, the shallow (40 m) Narrabri Formation and the deeper (up to 90 m) Gunnedah Formation, which are sometimes separated by a laterally discontinuous clayey layer. Within these units, numerous aquifers ranging in texture from fine sands to coarse gravels are present. The standing water level is currently at about 190 to 195 mAHD, approximately 15 to 20 m bgl, but during the pumping season the water level may draw down more than 10 m below these levels.

The deeper unit of the LGAA, the Gunnedah Formation, is localised within a channel incised into the underlying sedimentary rocks and is, where present, physically capable of providing high yields (>500 ML/yr, with pumping rates of up to 50 L/s) of low-salinity, low-SAR water that is suitable for most uses, including public water supply and irrigation. It reaches it greatest thickness north of Moree but is also present beneath Moree and between Moree and the SAP investigation area. However, as shown on figures 4.1 and 4.2, the unit is only present beneath the northernmost 25% of the SAP investigation area.

The effect of this distribution can be illustrated as follows. Within and immediately adjacent to the SAP investigation area, between the the line showing the limit of the Gunnedah Formation and the Mehi River, there are 20 bores with aquifer access licences that are used for industrial or irrigation purposes. South of the line there are none. To the south there are a number of stock and domestic bores, many monitoring bores associated with the water ski park and some investigation bores drilled by MPSC in the 1960s. However, where yields for these bores are reported, they do not exceed 1 L/s. The Narrabri Formation also progressively thins and becomes more argillaceous and less productive to the south; water quality also deteriorates in that direction. The Narrabri Formation and the LGAA feather out altogether north of the southern boundary of the SAP investigation area.

In addition to these physical hydrogeological limitations, the LGAA as a whole cannot sustainably, or legally, provide more groundwater than is currently being abstracted from it. The LTAAEL for the Lower Gwydir Groundwater Source set in the *Water Sharing Plan for the Gwydir Alluvial Groundwater Sources 2020* is 33,000 ML/yr and the volume of water currently committed under access licences and basic rights is marginally above that LTAAEL; actual pumping during the 2017-18 and 2018-19 water years (drought conditions) was about 10% above the LTAAEL.

As shown on figures 2.17 and 2.18 in Section 2 above, recovered water levels across both the (shallow) Narrabri and the (deep) Gunnedah Formations have declined substantially from pre-development levels, with a significant increase in drawdown between 2006 and 2016. Both recovered and pumping levels in some monitoring bores are currently at historically low levels, although the area around the SAP is not as severely impacted as the areas north of Moree.

In summary, whilst in the northern part of the SAP investigation area the LGAA is physically capable of providing water suitable for agricultural use within the SAP, useful yields will probably not be possible in the southern two-thirds of the area.

Of equal significance, the LGAA as a whole is a stressed resource that is fully allocated. Water availability will be limited to that which can be provided by MPSC, water that can be diverted from the aquifer access licence share currently allocated to existing bores within the SAP and whatever shares can be purchased from holders of aquifer access licences with extractions from the LGAA outside the SAP, and for which works approval can be obtained for transfer to new bores drilled within the SAP. It should also be recognised that approval to transfer the shares to other bores may not be granted and it would therefore be necessary to access the groundwater via the existing bores, through a commercial arrangement with the owner. Thus, making additional groundwater for the SAP available from the LGAA whilst maintaining compliance with the requirements of the WSP will be difficult and require the purchase of existing entitlements.

It has been indicated that MPSC may have approximately 500 ML/yr of entitlement that is surplus to projected requirements and approximately 40 ML/yr may currently be supplied to businesses within the SAP area. If available, this 540 ML of water would need to be supplied to industries within the SAP on a water utility basis, as is stipulated in s.71M(2) of the *Water Management Act 2000* (i.e. it could not be transferred to an aquifer access licence, whether held by MPSC or another party).

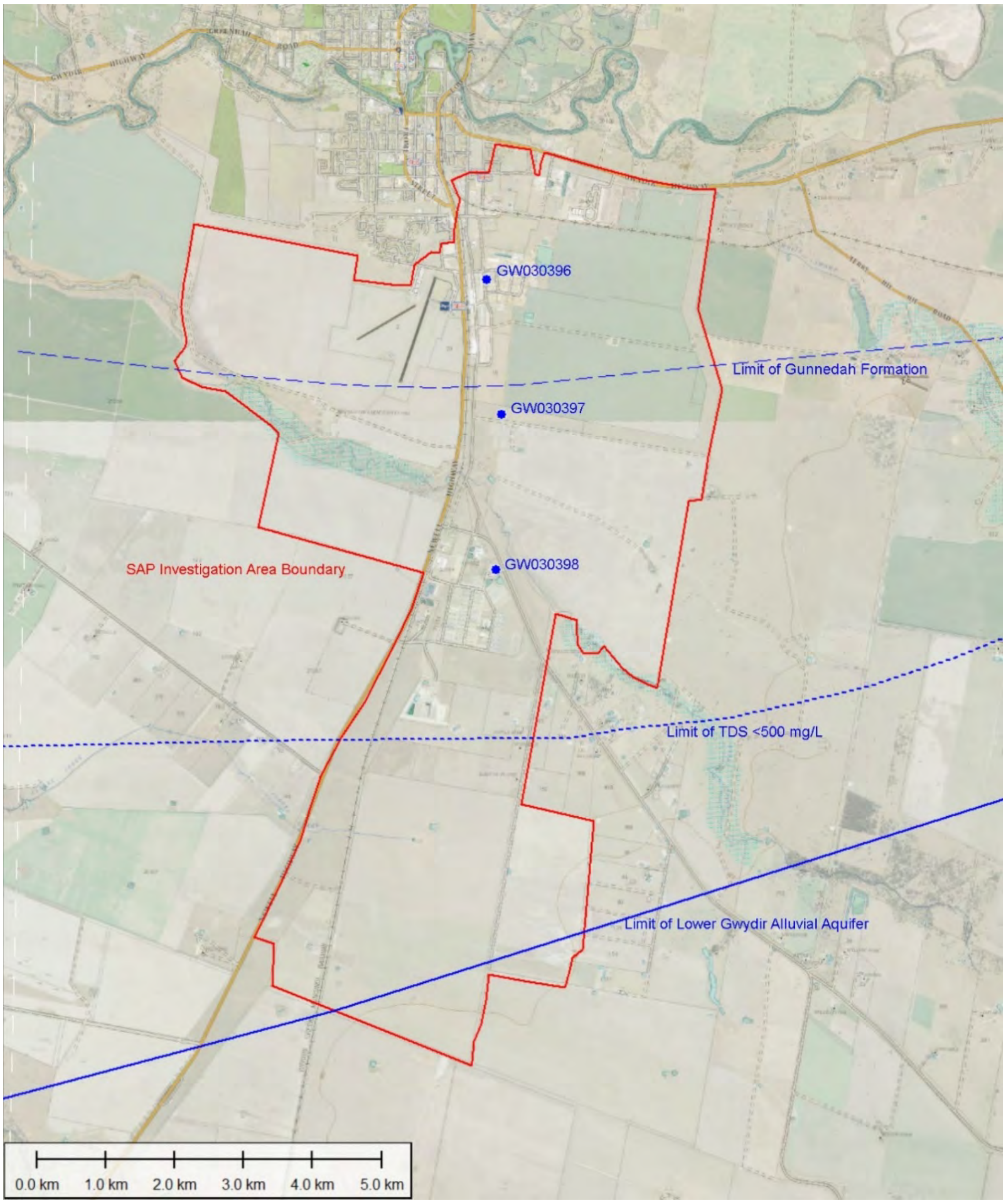


Figure 4.1: Limits of Gunnedah Formation and Lower Gwydir Alluvial Aquifer

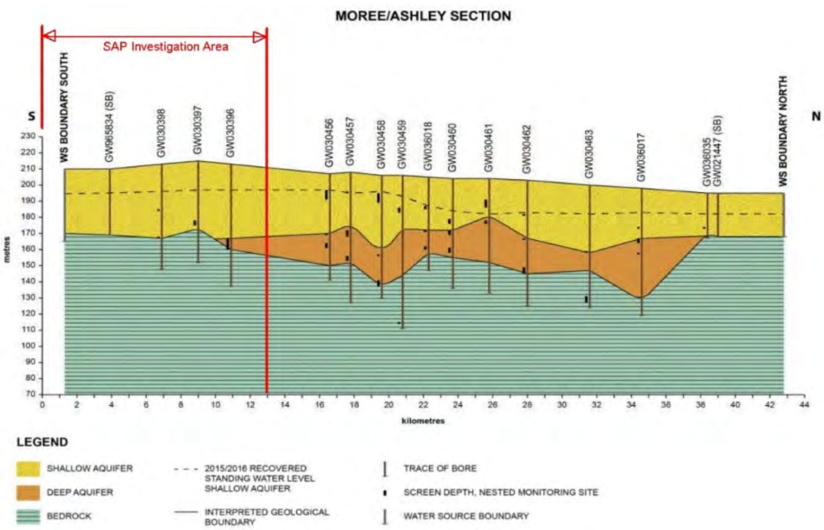


Figure 4.2: Cross-section South to North across SAP investigation area (NSW Department of Industry 2018)

4.2 Potential of the GAB as a Water Supply Source for the SAP Investigation Area

On the basis of the information presented in Section 2 above, it is assessed that the main aquifer within the NSW part of the GAB Surat Basin, the Pilliga Sandstone, is likely to be encountered beneath the Moree SAP investigation area at a depth of about 700 m and have an aquifer thickness of about 150 m of predominantly clean quartzose sandstone. This aquifer should provide a good supply of relatively low-salinity (800 mg/L total dissolved solids (TDS)) groundwater with a dominant sodium-bicarbonate ionic balance and a sodium absorption ratio (SAR) between 8 and 32. The water is therefore not suitable for irrigation onto the reactive clay soils that are present in the SAP area. It is possible that individual bore yields (to adequately constructed and well-developed bores) could be in excess of 30 L/s but, as discussed below, such yields are not likely to be consistent across the SAP and may well be lower.

Groundwater abstraction from the confined GAB aquifers in NSW is regulated under the provisions of the *Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources 2020* (the WSP) which commenced on 1 July 2020. This plan applies to the GAB aquifers beneath Moree. Current annual usage from the NSW Surat Groundwater Source totals about 29,320 ML compared with the long-term average annual extraction limit (LTAAEL) set by the WSP of 43,446 ML. Thus, the estimated volume available for further sharing from the Surat groundwater source is 15,126 ML/yr. It is possible that in the future, additional water may be made available either via controlled allocation or auction of additional shares, or through release of 30% of water savings from the cap and pipe program, as detailed in the WSP.

The Pilliga Sandstone at Moree is a confined aquifer that will have a low specific storage and, despite its considerable thickness, relatively low storativity. Thus, the drawdown caused by pumping is likely to extend several kilometres from the pumped bore. This means that there is likely to be interference (i.e. additive drawdown) between neighbouring bores. There is also potential for pumping bores within the SAP investigation area to affect existing bores that obtain water from the GAB, including the Moree Artesian Aquatic Centre. These effects will need to be carefully managed by the entity established to supply water to the Moree SAP investigation area, in consultation with DPIE Water.

DPIE Water's policy guidelines for assessing works approval applications set a maximum of 2 m of incremental drawdown at existing sub-artesian bores. DPIE usually uses and analytical model to assess such impacts.

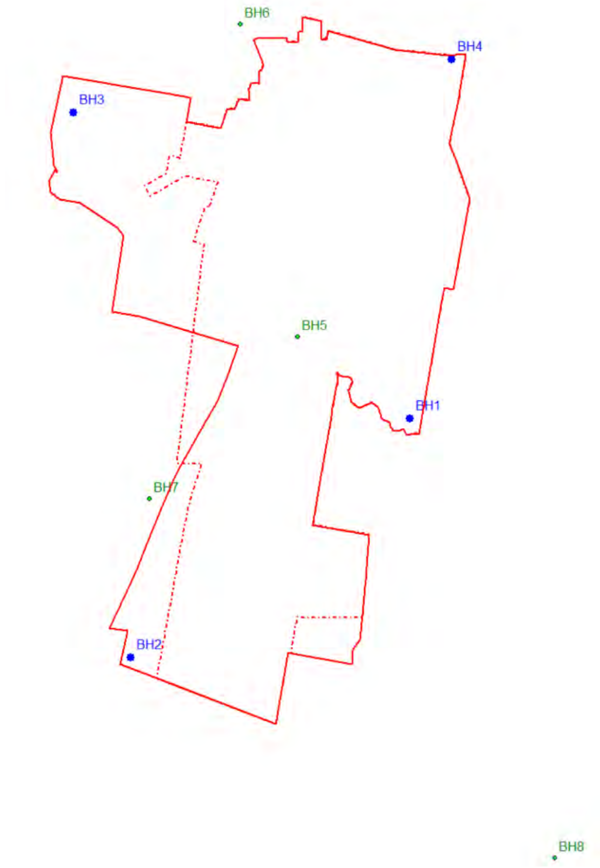
It is considered unlikely that pumping from the GAB within the SAP investigation area will impact upon any high priority groundwater-dependent ecosystem as the nearest such systems identified in the WSP are in excess of 50 km distant from the SAP.

The major uncertainties in these estimates are the lack of local data concerning aquifer characteristics, particularly the hydraulic conductivity of the Pilliga Sandstone aquifer, beneath the SAP investigation area, as discussed in Section 2.3.4 above.

As indicated in that section, some data are available from analysis of shut-in tests carried out on flowing artesian bores in the areas north and west of the SAP between 1916 and 2014. There are also good data from the analysis of a pumping test at Bellata, 40 km to the south. These data are considered to be the most relevant available for extrapolation to the SAP investigation area. For prediction purposes in this report a hydraulic conductivity of 2.5 m/d has been adopted. Multiplying this value by the estimated aquifer thickness of 150 m gives a transmissivity of 375 m^2/d.

A hypothetical borefield consisting of four bores at a separation of about 7.5 km, spread out across the SAP investigation area was developed. This work was carried out using the SAP investigation area boundaries to position the bores. They are shown in relation to those boundaries and the current structure plan boundaries on Figure 4.3 below.

An analytical model similar to that used by DPIE was then used to estimate drawdown at four existing bores surrounding the SAP, and at a hypothetical bore within the SAP, for the base case values of hydraulic conductivity (2.5 m/d) and specific storage (6.8 x 10^{-6} m^{-1}), and for sensitivity case values (in the case of hydraulic conductivity, 1.5 m/d and 5 m/d).



BH1, BH2, BH3, BH4	hypothetical pumping bores
BH5	hypothetical monitoring bore
BH6	represents the bore cluster: GW004361 (WAL 20248 – 200 ML/yr) GW901977 (WAL 15747 – 420 ML/yr) (Moree Bore Baths) GW900084 (WAL 15749 – 60 ML/yr and WAL 20281 – 200 ML/yr) (Gwydir thermal pools and caravan park) GW900008 (WAL 15748 – 463 ML/yr) (Frome Street Investments Pty Ltd - Hardman Outdoors) GW901748 (WAL unknown)
BH7	represents GW025196 (WAL21389 – 10 ML/yr)
BH8	represents GW004543 (basic rights stock bore, windpump)

Figure 4.3: Modelled pumping and hypothetical monitoring bores

For this arrangement of pumping bores, the drawdown after 10 years at BH6, representing the bore-bath cluster, was estimated to be 2 m for a combined pumping rate of 3,900 ML/yr (2,670 KL/d per bore).

The combined drawdown at the mid-point of the borefield is estimated to be 2.3 m, and the pumping drawdown at each bore will be about 10 m, plus well losses which will depend upon the efficiency of the bore.

The sensitivity cases indicated low sensitivity to changes in specific storage within the theoretically possible range. Reducing the hydraulic conductivity to 1.5 m/d (a 40% reduction) indicated that the yield available within the drawdown constraints would be reduced to 3,360 ML/yr (a 14% reduction).

Moving the two northernmost pumping bores approximately 3.5 km to the SSE does significantly reduce the modelled drawdown at BH6 (the bore-bath cluster north-west of the SAP investigation area), by about 0.6 m, but this is at the expense of significantly increased drawdown at BH7 located to the west of the Newell Highway in the southern part of the SAP. This is increased by about 0.5 m. However, this bore has an aquifer access licence for just 10 ML/yr; replacement of this water from the SAP system could therefore be an economically favourable option.

Moving BH2 and BH3 to within the proposed SAP boundary (the dotted line shown on Figure 4.3) would reduce overall system yield by about 20%.

A further complication is that in any sandstone aquifer, fracturing makes a significant contribution to transmissivity. The prevalence of fracturing in the SAP area (or indeed the other areas used for comparison) is unknown, but it is very unlikely to be consistent across the area, thus transmissivity and bore yield will vary between bore locations within the same borefield.

4.3 Wellfield Assessment and Groundwater Impact Assessment

Some consideration has been given to a conceptual design for the supply of groundwater to the SAP.

A few businesses currently operating in the SAP investigation area have their own private bores, and there is a larger number of stock and domestic - basic landholder rights (BLR) bores (there are about 60 registered bores within the SAP investigation area, although some of these may be abandoned or disused). Most, if not all, of the BLR bores take water from the Lower Gwydir Groundwater Source, most commonly obtaining low yields from the Narrabri Formation. It is clear, however, that a single shared supply would be preferable for new businesses setting up in the SAP investigation area. The reasons for this are as follows:

- The Lower Gwydir Groundwater Source is fully allocated (i.e. the volume of water currently permitted to be taken under access licences and basic rights is at (in fact marginally above) the LTAAEL. Therefore, share component for aquifer access licences for any new bores would have to be purchased through on-market dealings, an uncertain and potentially expensive process (Lower Gwydir groundwater is typically the most expensive in NSW). The market price of Lower Gwydir groundwater share component is currently >$3,000/ML, and has reportedly reached $7,100 in the past year, so 1,000 ML would cost over $3,000,000, perhaps substantially more. Pumping costs from the LGAA are also likely to be at least equivalent to, if not higher than, pumping costs from the GAB.

- Due to the limited volume of water available from the LGAA, it is strongly recommended that this water be reserved for users who cannot use water sourced from the GAB due to chemical unsuitability. In any event, it is likely that bores providing an adequate yield for industrial (or irrigation) purposes would need to be constructed in the northern part of the SAP Investigation Area; thus, reticulation would be needed to serve businesses in the southern part of the area.

- Current groundwater usage in the NSW Surat Groundwater Source is well below the LTAAEL for that source. Good yields should be available from the Pilliga Sandstone within the Surat Groundwater Source beneath the Moree SAP investigation area so, subject to appropriate management of drawdown and interference effects, this aquifer should provide a suitable, but not unlimited, supply for the Moree SAP investigation area. However, due to the absence of local data, investigation drilling and testing would be necessary to establish that this is indeed the case.

- For cost-comparison purposes, the typical cost for a GAB deep bore is about $500,000 and it could yield 1,000 to perhaps 1,650 ML/yr. Controlled allocation of small volumes of NSW Surat Basin groundwater has previously been made at a cost of $500/ML.

- The high potential for bore interference would make it difficult to effectively manage the combined effect of a large number of private bores in the GAB, and it would be equally difficult to comply with the boundary and neighbouring bore offset requirements for works approval, as set out in the WSP.

- As indicated above, drilling and completing water bores in the deeper aquifers of the GAB is expensive and would be a high cost impost on individual businesses.

In summary, the option of individual landowners installing their own bores in the GAB aquifer is not considered to be economically or hydrogeologically viable, and the option of individual landowners installing their own bores in the LGAA would only be available if sufficient share component could be purchased by those landholders. Furthermore, only relatively low yields are likely to be obtained in the southern part of the SAP investigation area.

Adoption of a single shared GAB supply option would allow the basic water infrastructure, including a small number of bores, to be installed at the beginning of operations in the SAP investigation area, then be added to as demand increased. This would allow adaptive planning, design and management to optimise the system as it was progressively developed. At the time of issue of this report, the expected water demands for the SAP investigation area had not been fully defined, but estimates have been provided for the structure plan. Ultimately, a system of four bores evenly spaced across the SAP at a separation of about 7.5 km may be optimal. However, two bores plus a standby should be sufficient for some time as development will be staged. Two will give a much clearer picture of the resource than just one, as inter-bore drawdown effects can be quantified. A third bore provides the necessary redundancy. Bores can be operated on a duty/standby basis, at least initially.

One option, which would be applicable to the draft Structure Plan, would be to:

- drill and pump-test two bores in the SAP investigation area, with a separation of about 7.5 km;
- install a water reticulation backbone along the north-south axis of the SAP investigation area, to which businesses could be connected as required;
- initially operate one bore, with continuous monitoring in the other; and
- base further expansion of the system to the south and west on modelling carried out using the data acquired.

Table 7 below summarises key factors identified throughout this report for the GAB Pilliga Sandstone and Lower Gwydir Alluvium, for consideration in determining the best option to progress further for SAP investigation area groundwater supply.

TABLE 7
Summary of key factors for consideration for selection of Moree SAP area groundwater supply

Option	Option	Option Description	Pros	Cons
1	Shallow Aquifers (alluvial deposits)	Underground water stored in unconsolidated alluvial sediment aquifers in the Lower Gwydir alluvium.	a) Locally relatively high-yielding aquifers at shallow to moderate depth and consequently relatively low bore construction cost. Pumping costs will be somewhat higher than for the GAB aquifer due to lower water levels. b) High quality groundwater (low salinity, low SAR, no odour) suitable for most uses.	a) Lower Gwydir Groundwater Source is fully allocated. b) Consequently, additional aquifer access licence shares unavailable – existing shares would have to be purchased from other parties c) Trading of licences is restricted to within groundwater zones. d) Such use is unlikely to be supported by Moree's existing water users. e) Competition with local water users in a relatively tight water market – currently share cost exceeds \$3,000/ML and has recently reached \$7,100. f) The SAP investigation area is located within an area already experiencing declining water levels, particularly in the northern parts. Further development of the groundwater resource may result in excessive long-term drawdown. g) The shallow aquifer in the Lower Gwydir alluvium is susceptible to surface-derived contamination. Experience elsewhere indicates that mobile contaminants (PFAS, PCE and other chlorinated hydrocarbons, MTBE, etc) may migrate down to the deeper aquifer, as aquitards are discontinuous.

TABLE 7 Summary of key factors for consideration for selection of Moree SAP area groundwater supply				
Option	**Option**	**Option Description**	**Pros**	**Cons**
2	Deep confined sandstone aquifers	Aquifer in Pilliga Sandstone within the GAB Surat Groundwater Source beneath the SAP – approx. 700-850 m deep. Predicted to have adequate yield.	a) Likely adequate borehole yields. b) Current groundwater usage in the Surat Groundwater Source is well below the LTAAEL for that source. c) Additional share component may therefore be available either via controlled allocation or auction or additional shares or through release of 30% of water savings from the cap and pipe program, as detailed in the WSP. d) Adequate water quality for most industrial purposes, but not for irrigation on local soils. e) Minimal connectivity with shallow groundwater and surface systems. f) Lower pumping costs than LGAA. g) Not vulnerable to surface-derived contamination.	a) Extensive drawdown and interference effects require careful management. b) DPIE Water will impose restrictions on borehole pumping rates to manage impacts on existing bores to within limits set in the DPIE Water assessment policy. c) Water is not suitable for irrigation onto the local reactive clay soils due to high sodium adsorption ratio. d) Possibly some odour/taste tainting from hydrogen sulphide. e) Yield from the sandstone aquifers is not yet tested in the SAP investigation area, although known to be adequate 40 km south of SAP. f) High cost of drilling and bore construction, initially and when refurbishment/replacement required. g) Difficulty and high cost of hydrogeological assessment.

5.0 STRUCTURE PLAN ASSESSMENT

5.1 Introduction

The structure plan outlined in Section 1.3 has been assessed with respect to the following key considerations:

- The likely demand for water (provided by WSP Australia Pty Limited), as attached in Appendix D.
- The required water quality.
- Groundwater pollution risk.
- Location with respect to available water resources.
- Location with respect to groundwater vulnerability/pollution risk.
- Key attributes of the GAB as a groundwater resource for the SAP.
- An assessment of water supply infrastructure required for the SAP and who might operate that infrastructure.
- An outline of the recommended drilling and pumping tests.
- An assessment of potential supply of the limited amount of water that may be available from the Lower Gwydir Alluvial system for users who are unable to use water sourced from the GAB either because of its high sodium adsorption ratio or because the water quality is not suitable, for other reasons, for a particular industrial process, considering:
    - the feasibility of supply by a local water utility that can use the existing local water utility licence held by MPSC; or
    - the feasibility of revision of the Water Sharing Plan, which forms the basis for the draft Water Resources Plan that is currently under review by the Murray-Darling Basin Authority (MDBA), to permit the transfer of shares to an aquifer access licence held by a commercial entity for use within the SAP area. This would involve changes to the licence dealing rules in the WSP/WRP, which would in turn require amendment of the primary legislation (the *Water Management Act 2000*). Also, once the WRP is approved, any changes would require the agreement of the MDBA.

5.2 Hydrogeological assessment methodology

The volume of groundwater water likely to be available from the LGAA and the GAB (Pilliga Sandstone) for the new developments in the SAP area proposed in the structure plan was assessed as described in Section 4 above. These figures were then compared with the demand assessment for each of the land uses as identified in the Water Demand Final Report (December 2020 Draft) prepared by WSP Australia Pty Limited.

5.3 Assumptions and limitations

The following assumptions have been made and limitations acknowledged.

Volumetric water demands are based on the typical land use types and have been provided by WSP Australia Pty Limited. These water demands are detailed in Table 8 below.

- In terms of water quality, it is assumed that horticulture and native horticulture will require water of irrigation quality, which in this area means groundwater sourced from the LGAA. However, it is noted that water sourced from the GAB may be suitable for hydroponic irrigation systems.
- For all other uses it has been assumed that the following groundwater quality parameters, typical of GAB groundwater, are acceptable, either untreated or following on-site industry-specific treatment:
    - a salinity of 800 to 1,000 mg/L as TDS;
    - minor odour and taste taint due to the presence of low concentrations of hydrogen sulphide;

  - a sodium-bicarbonate ionic composition with sodium concentration above the aesthetic drinking water criterion, and a SAR in excess of 8 (possibly as high as 32); and
  - concentrations of dissolved iron between 0.05 and 0.5 mg/L.

  Clearly, industries that require the water as input to a manufacturing or agricultural process are likely to have more stringent water quality requirements than industries such as intermodal transport, freight and logistics, and solar energy generation where the water is used primary for purposes such as equipment cleaning and surface washing.

  These assumptions are considered reasonable (and necessary), given that specific industry requirements are not available at this time, and are unlikely to become available in advance of negotiations with individual companies that are considering the possibility of operations within the SAP. Each industrial process has its own specific water quality requirements and generic industrial water quality criteria have previously been shown to be unhelpful and are therefore not provided in current guidelines (*Australian and New Zealand Guidelines for Fresh Marine Water 2018*). Furthermore, it is normal practice in any area for industries to take water from the mains supply then treat it to meet their own specific requirements. A company will obviously consider the quality of the mains supply when assessing the feasibility of relocation to a new area and make its own decision as to the economic feasibility of any required treatment.

- It is understood that hydrogen generation by electrolysis using the oxygen pathway would, using currently-available technology, require pre-treatment (probably by reverse-osmosis desalination) to reduce the salinity of all available groundwater (LGAA and GAB), although new technology permitting the use of such water may later become available. There would be little cost benefit in using water from the LGAA rather than the GAB as the source of raw water, particularly as additional pumping costs would probably be incurred.

- As outlined above, it is assumed that a single shared supply of GAB groundwater would be provided, with a secondary, also shared, supply of the LGAA water to users requiring it. The reasons for this are that:

  - pumping from the GAB needs to be carefully managed, with appropriately-spaced, well-designed bores and pumping rates matched to local aquifer and bore characteristics. It is necessary to keep incremental drawdown at existing bores below 2 m. This is best achieved through a shared supply that utilises the full available area of the SAP; and
  - water from the LGAA is required to be substantially provided from the 500 ML/yr surplus that may be available under MPSC's local water utility licence. Under the provisions of s71M(2) of the *Water Management Act 2000* this cannot be transferred to another type of licence. It is understood that a further 40 ML/yr is currently provided to the SAP area, and that supply will continue.

TABLE 8
Structure plan – Water demand estimate (based on WSP Australia Pty Limited as revised following final CIE report)

Precinct	Land Use	Structure Plan Area (ha)	CIE Area (ha, gross)	% of Gross Area Considered	Area (ha, net)	Water Demand Rate (Annual)		Water Demand (Annual)		Assumptions/Comments
						Min (ML/ha)	Max (ML/ha)	Min (ML)	Max (ML)	
GE	Horticulture / native horticulture	220	520	50%	260	4	8	1,040	2,080	Possible land uses include: greenhouses; storage areas; processing facilities; buildings for administration purposes; hardstand areas; aquaculture ponds; intensive plant agriculture; ancillary activities. Demand rates taken as upper end of typical broadscale ag. Irrigation rates (however will vary significantly with proposed land use and intensity/practices) for 75% gross area. Note that some alternative methods were used to check demands with similar order of magnitude results. Note that greenhouse horticulture may have lower demand rates than this (2-5 ML/ha order of magnitude) if efficient recirculating practices are used - unclear what would be grown (medical marijuana, mushrooms and leaf vegetables?) Net ha area and % building footprint adopted from final CIE Report figures. Maximum demand rate taken as upper end of typical broadscale ag. irrigation rates, (noting this significantly with proposed land-use and intensity/practices). Minimum demand rate assumes 50% proportion of area is greenhouse horticulture with efficient recirculating and 50% broadscale. Although an opportunity, it is assumed that aquaponics would only implemented at a limited scale (i.e. a minor overall % which doesn't impact the rates)
	Intermodal	140	30	30%	9	3	3	27	27	Possible land uses include: rail sidings and marshalling yards; storage areas; transfer facilities; assembly and parking of vehicles; buildings for administration purposes; ancillary activities. Demand rate for light industry (based on gross ha) adopted but only applied to 10% of gross area due to expectation of very large lots/yards with minimal buildings. Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: rail sidings and marshalling yards; storage areas; transfer facilities; parking of vehicles; buildings for administration purposes; ancillary activities. Demand rate for light industry (typically based on gross ha) adopted, however applied to the footprint area only - which is considered more applicable for this purpose.
	Freight and logistics	105	20	30%	6	3	3	18	18	Possible land uses include: warehouses; storage areas for goods; transfer facilities; parking and assembly; buildings for offices and administration; ancillary activities. Demand rate for light industry (based on gross ha) adopted but were only applied to 25% of gross area due to expectation of large lots/parking areas compared to typical light industry.

TABLE 8 Structure plan – Water demand estimate (based on WSP Australia Pty Limited as revised following final CIE report)										
Precinct	**Land Use**	**Structure Plan Area (ha)**	**CIE Area (ha, gross)**	**% of Gross Area Considered**	**Area (ha, net)**	**Water Demand Rate (Annual)**		**Water Demand (Annual)**		**Assumptions/Comments**
						Min (ML/ha)	**Max (ML/ha)**	**Min (ML)**	**Max (ML)**	
										Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: warehouses; storage areas for goods; transfer facilities; parking and ass buildings for offices and administration; ancillary activities. Demand rate for light industry (typically based on gross ha) adopted, however applied to the building footprint which is considered more applicable for this purpose.
RRR	Resource recovery	90	60	16.6%	10	3	3	30	30	Possible land uses include: intermodal facilities; resource recovery facilities; waste transfer stations; storage areas; waste processing facilities; micro-factories (specific recycling products); industrial uses; refuse storage; waste to energy production; landfill. Demand rate for light industry (based on gross ha) adopted but only applied to 10% of gross area due to expectation of very large lots/yards within minimal buildings. Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: intermodal facilities; resource recovery facilities; waste transfer stations, storage areas; waste processing facilities; micro-factories (specific recycling products); industrial uses; refuse storage; waste to energy production; landfill. Demand rate for light industry based on gross ha) adopted, however applied to the building footprint area only - which is considered more applicable for this purpose.
GE	Value-add agriculture	70	80	17.5%	14	3	82	42	1,148	Possible land uses include: intermodal facilities; industrial facilities; warehouses and production facilities; goods transfer and storage. Minimum demand rate based on typical rates for flour mills (the lowest water usage type of food processing and similar to general light industry), maximum demand rate weighted based on assumption of 20% cereals and 20% food oils (both water intensive), with 20% flour mills and 40% general light industry/warehouses (both lower demand). Demand rate (based on built up ha, applied to 13% of gross area - approx. existing proportion of built up area in south Moree). Note that an alternative approach could be to significantly reduce the 20% + 20% cereals and oils assumption and increase the 13% (if appropriate) - possibly similar outcome overall.

TABLE 8 Structure plan – Water demand estimate (based on WSP Australia Pty Limited as revised following final CIE report)										
Precinct	Land Use	Structure Plan Area (ha)	CIE Area (ha, gross)	% of Gross Area Considered	Area (ha, net)	Water Demand Rate (Annual)		Water Demand (Annual)		Assumptions/Comments
						Min (ML/ha)	Max (ML/ha)	Min (ML)	Max (ML)	
										Net ha area and % building footprint adopted from final CIE Report figures. The building footprint % is similar to existing South Moree industrial area density. Minimum based on typical rates for flour mills (the lowest water usage type of food processing and similar to general light industry), maximum demand rate weighted based on as cereals and 20% food oils (both water intensive), with 20% flour mills and 40% general light industry/warehouses (both lower demand).
	Potentially hazardous	30	25	8%	2	3	15	6	30	Assumed similar to 'Energy' category, with possible land-uses: intermodal facilities; waste collection and storage; industrial facilities; waste processing; energy production, warehouses and production facilities; storage and transfer. Minimum demand rate for light industry (based on gross ha) adopted. Maximum demand rate based on 50% light industry and 50% heavy industry adopted. Demand rates applied to only applied to 25% of gross area (29% of net area) due to expected low density of development relative to typical industrial areas (large lots, buffers, not constrained by land).
										Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses: chemical and fertilizer manufacturing. Minimum demand rate for light industry (gross ha) adopted. Maximum demand rate based on 100% heavy industry adopted. Demand rates (typically based on gross ha) applied to the building footprint area only considered more applicable for this purpose.
	Bio-energy	60	30	16.6%	5	3	15	15	75	Possible land uses include: intermodal Facilities; waste collection and storage; waste processing; energy production; storage and transfer. Demand parameters assumed equivalent to 'Energy' or 'Hazardous' category.
										Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: resource recovery facilities; waste processing facilities; waste to energy production. Minimum demand rate for light industry (based on gross ha) adopted. Maximum demand rate based on 100% heavy industry adopted. Demand rates (typically gross ha) applied to the building footprint area only - which is considered more applicable for this purpose

TABLE 8
Structure plan – Water demand estimate (based on WSP Australia Pty Limited as revised following final CIE report)

Precinct	Land Use	Structure Plan Area (ha)	CIE Area (ha, gross)	% of Gross Area Considered	Area (ha, net)	Water Demand Rate (Annual)		Water Demand (Annual)		Assumptions/Comments
						Min (ML/ha)	Max (ML/ha)	Min (ML)	Max (ML)	
	Enterprise/ hub	10	10	40%	4	3	3	12	12	Possible land uses include: offices; showrooms; service centres; warehouses; bulky goods retailing; recreation facilities; industrial retail outlets; rural supplies; etc. Demand rate for light industry was used (based on gross ha) however was only applied to 75% of gross area due to expected lower density of development in a regional context, compared to typical light industry (less land constrained, larger lots).
										Net ha area and % building footprint adopted from final CIE Report figures. Possible land uses include: offices; showrooms; service centres; warehouses; bulky goods retail facilities; industrial retail outlets, rural supplies; etc. Demand rate for light industry (typically based on gross ha) adopted, however applied to the building footprint area only as considered more applicable for this purpose.
S&H LI&S	Solar	305	710	0%	0.0			24	24	Solar farm; energy production facilities. Typically, low or near-zero water demand, primarily cleaning. One hydrogen generation facility – capacity and operational assumptions from final CIE report. (14kL water/tonne hydrogen)
										Solar farms; energy production facilities. Typically, zero or near-zero water demand, hence zero area based demand applied.
LGAA								1,040	2,080	Must be supplied from the LGAA due to quality requirements.
GAB								174	1,364	May be supplied from GAB.
Total			**1030**		**297**		**118**	**1,210**	**3,440**	Total Water Demand for SAP (rounded to 3 significant figures).

5.4 Hydrogeological assessment criteria

Tables 11 and 12 identify the assumptions and testing criteria utilised for the assessment of the structure plan.

TABLE 9
Assumptions made in structure plan analysis

Selection Criteria	Details
Availability of water from the GAB	Assuming that a centralised supply utilising up to four bores distributed across the SAP and linked by a pipeline is used, GAB water will be available across the site and all locations would be equally suitable for the various users from a water supply perspective. A minimum of three bores is required to provide an acceptable level of redundancy in the event of pump or other system failures.
Availability of water from the LGAA	As shown on Figures 2.22 and 2.23, the deeper, high-yielding aquifer (Gunnedah Formation) within the LGAA system is only present beneath the northern part of the SAP investigation area. Industries needing water of that quality should be located there. Alternatively, a second distribution system servicing those industries will be required and additional pumping costs will be incurred.
Groundwater vulnerability	Potentially-polluting land uses should preferably be located in the southernmost part of the SAP investigation area, as in that area a thin superficial cover directly overlies claystones and siltstones of the Cretaceous Rolling Downs Group (an upper unit of the GAB) and the only aquifers present beneath that area, deeper within the GAB, are protected by many hundreds of metres of low-permeability sedimentary rocks. Conversely, potentially polluting industries should not be located above the LGAA where this is avoidable. Depending on the land-use, it may be possible to develop site-specific measures to reduce pollution risk in areas above the LGAA, but this generates a need for additional planning controls, and additional cost. In the central part of the SAP investigation area, the lower-yielding upper aquifer (Narrabri Formation) of the LGAA system is present overlying low-permeability sedimentary rocks of the Rolling Downs Group.

TABLE 10
Criteria used for structure plan analysis

Selection Criteria	Details
Availability of water from the GAB	Evaluate the suitability of using the GAB as a potential water supply for the SAP, including available quantity and water quality. Assess the feasibility of accessing this groundwater resource and establishing a distribution system to meet the water demands of each land use retained in the structure plan.
Availability of water from the LGAA	Evaluate the suitability of using the LGAA as a potential water supply for the SAP, including available quantity and water quality. Assess the feasibility of accessing this groundwater resource and establishing a distribution system to meet the water demands of each land use retained in the structure plan.
Groundwater vulnerability	Evaluate the risks associated with groundwater impacts from surface-derived contamination, including the potential need for additional planning controls and mitigation measures.

5.5 Analysis

A structure plan analysis is provided in Table 11.

TABLE 11
Analysis of Hydrogeological Considerations

Assessment Criteria	Structure Plan Assessment *Green = adequate resources available and environmental values protected and/or enhanced* *Amber = resources have limited availability or environmental values moderately protected* *Red = adequate resources not available or environmental values not protected*
Availability of groundwater from the LGAA	The estimated total water demand for the structure plan is between 1,308 and 3,030ML/yr. The water demand for horticulture/native horticulture, which must be sourced from the LGAA due to more stringent water quality requirements, is 1,000–2,603 ML/yr (WSP Australia Pty Limited 2020). The volume of water available from the LGAA is likely to be restricted to that provided by MPSC under its existing Local Water Utility Licence share (500 ML/yr), some of the 40 ML/yr estimated to be currently supplied to businesses in the SAP area and whatever can be diverted from the approximately 300 ML/yr Aquifer Access Licence share held by existing businesses in the SAP area. Even assuming that all this water would be available, there would be a shortfall below the minimum estimated requirement that would have to be met by market purchase. This may be possible but works approval would still be required to transfer this share onto bores located in the SAP. DPIE Water has indicated that this may not be granted. Thus, the horticultural/agricultural demand cannot be met at any point in the range without substantial on-market purchase, with a likely cost of >>$3,000/ML. It is unlikely that demand at the upper end of the projected range could be met from the LGAA without gross market distortion (i.e. forcing up prices to unprecedented levels). It is noted that share purchase involves diverting water from existing profitable agricultural use elsewhere in the LGAA around Moree. The net economic and social benefit of doing this needs to be carefully assessed. The LGAA is much more productive beneath the northern part of the SAP investigation area and future land uses with more stringent water quality requirements should be located there. This is the case for the northern General Enterprise sub-precinct, which is where much of the horticulture/native horticulture and value-added agriculture land use is likely to be located. It is not the case for the central General Enterprise sub-precinct. Groundwater would probably need to be piped to that area.
Availability of groundwater from the GAB	The water demand for all land uses for which GAB water would be suitable (i.e. excluding horticultural/agricultural uses) is between 174 and 1360 ML/yr (WSP Australia Pty Limited 2021). This quantity of water can be sourced from the GAB Surat aquifer and could be made available within the LTAAEL and physically from bores within the SAP. It is also very likely that this relatively small demand can be met without any more than minor impact on any existing bores outside the SAP, and without exceeding the limit of 2 m of incremental drawdown over 10 years imposed by DPIE Water. Assuming that a centralised supply utilising bores distributed across the SAP and linked by a pipeline is used, GAB water will be available across the SAP and all locations would be equally suitable. The bores should be spaced out within the SAP to optimise yields and reduce inter-bore interference effects. A centralised distribution system would be required. The number of bores required will depend on the degree of redundancy considered necessary. This relatively small demand could probably be met from a single bore, with a second bore for redundancy.

<table>
<tr><th colspan="2">TABLE 11
Analysis of Hydrogeological Considerations</th></tr>
<tr><th>Assessment Criteria</th><th>Structure Plan Assessment
Green = adequate resources available and environmental values protected and/or enhanced
Amber = resources have limited availability or environmental values moderately protected
Red = adequate resources not available or environmental values not protected</th></tr>
<tr><td>Groundwater vulnerability</td><td>The final structure plan includes relatively few activities with a high potential to cause groundwater contamination. Those that are identified, such as fuel storage tanks, are located in the Regional Enterprise precinct. The structure plan places the Regional Enterprise precinct above the more vulnerable part of the LGAA.
In general, the contaminants of greatest potential concern for groundwater contamination are:
• Nutrients;
• Pesticides and herbicides;
• Hydrocarbon Fuels; and
• particularly, highly mobile organic contaminants such as chlorinated hydrocarbon solvents.
It is recommended that site-specific controls to prevent and mitigate the risk of groundwater contamination be identified for each precinct. It is noted that while the Gwydir Alluvium Water Quality Management Plan (DPIE 2018), which was prepared to support the draft Water Resource Plan submitted to the MDBA considers these issues, it does not identify any such controls, and notes that:
• There are no accredited levers within scope of water planning in NSW to reduce nutrients entering the SDL resource unit from animal faeces and fertilisers.
• There are no accredited levers within scope of water planning to reduce pesticides entering the SDL resource unit.
• In NSW a risk-based approach to the management of potential point source groundwater contaminants is implemented under the Protection of the Environment Operations Act 1997 (POEO ACT).
Clearly, s120 of the Act makes any pollution of groundwater an offence, but this is not of itself an effective risk mitigation measure.
The primary mechanism for pollution risk management is through Environment Protection Licences (EPL) issued under that Act. However, EPLs are only applicable to activities listed in Schedule 1 of the Act. Not all activities that may be associated with significant groundwater contamination risk are so listed.
Risks associated with underground fuel storage are managed under the provisions of the Protection of the Environment Operations (Underground Petroleum Storage Systems) Regulation 2019.
The groundwater supply from the LGAA is essential to the functioning of the SAP. Therefore, when drafting the planning controls applicable to the SAP, the activities permissible in each precinct need to be reviewed in the context of groundwater pollution risk. The applicability of controls available under the POEO Act and its regulations should also be reviewed. Provision must then be made for any additional groundwater pollution prevention and mitigation measures required to address regulatory gaps. These prevention/mitigation measures should then be implemented through adaptive environmental management plans throughout design, construction and operation stages.</td></tr>
<tr><td></td><td>The GAB is protected by hundreds of metres of low-permeability sedimentary rocks and is therefore not susceptible to surface-derived contamination.</td></tr>
<tr><td>Summary</td><td>Only the lower end of the anticipated range of demand for water of irrigation quality is likely to be available from the LGAA; this would require the provision of 500 ML/yr under the MPSC licence, some provision from the existing MPSC supply to the SAP area, some diversion of water from existing private WAL holders in the SAP area and some purchase of share component from elsewhere in the LGAA with works approval to transfer the extraction component into the SAP area.
Provision needs to be made in the planning controls applicable to the SAP for groundwater pollution prevention and mitigation measures.</td></tr>
</table>

6.0 CONSTRAINTS AND OPPORTUNITIES

As indicated in Section 5 above, the availability of groundwater will be a significant constraint on the development of the SAP proposed in the structure plan.

Groundwater of suitable quality for irrigation (required for horticulture) is only available from the LGAA. This aquifer is under stress and is fully allocated. The only water likely to be available is estimated to be 40 ML/yr currently provided by MPSC to businesses in the SAP area, 500 ML/yr that may be available within MPSC's local water utility access licence share and is not currently utilised, and possibly a portion of the 334 ML/yr aquifer access licence share currently held by existing businesses located within the SAP. The maximum volume available is less than the 968 ML/yr minimum indicated as being required for horticulture/native horticulture in the Water Demand report (see Table 8 above), and much less than the maximum of 1,742 indicated there. Therefore, water availability will constrain this activity at a level below that indicated in the structure plan.

It is assumed that water from the GAB would be suitable for all other uses. The minimum requirement of 340 ML/yr could comfortably be supplied from this source, and supply of the maximum requirement of 1,290 ML/yr would also be possible.

An opportunity identified is that water from the GAB is likely to be as suitable as water from the LGAA for hydrogen production by electrolysis since both would require similar pre-treatment by reverse osmosis.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Groundwater in the Moree Area is available from two aquifers – the Tertiary-Quaternary LGAA and the Jurassic-age Pilliga Sandstone, which forms part of the Great Artesian Basin aquifer complex (GAB). However, only the LGAA is able to supply water suitable for irrigation onto local soils.

The lower unit of the LGAA, the Gunnedah Formation, is capable of providing high yields of irrigation-quality groundwater and is extensively used for that purpose in the area north of Moree. However, the Gunnedah Formation is only present beneath the northern part of the proposed SAP area, and the access licence shares currently issued, and in some years the actual extractions, are at or slightly above the long-term average annual extraction limit (LTAAEL) set by the water sharing plan.

Therefore, the only water from the LGWA that is likely to be available is 40 ML/yr currently provided by MPSC to businesses in the SAP area, the 500 ML/yr that MPSC has indicated that it can provide under its existing Local Water Utility access licence, and possibly some of the 340 ML/yr currently held under aquifer access licences by businesses operating in the SAP area.

Whilst it may be possible to purchase aquifer access licence shares from existing users elsewhere in the LGAA, it is not certain (in fact it is unlikely) that works approval would be given to attach such shares to new bores within the SAP area. The cost of such shares is likely to be well above $3,000/ML. Purchase of shares would transfer water from existing commercially viable irrigation operations in the area around Moree, so the net benefit to the local economy may be small.

The maximum volume of groundwater likely to be available from the LGAA will therefore be less than the 1,040 ML/yr that is the minimum anticipated requirement for horticulture and native horticulture, which require water of irrigation quality, which cannot be supplied from the GAB. It is much less than the maximum requirement of 2,080 ML/yr. Thus, it may not be possible to develop this land use to the extent desired.

The Pilliga Sandstone is part of the NSW Surat Groundwater Source. Currently, groundwater extraction from that source is well below the LTAAEL, so water is available, subject to works approval. Water from the GAB is not suitable for irrigation, due to its high sodium adsorption ratio. However, it is of potable quality (TDS<1,000 mg/L, probably about 800 mg/L), although it is outside the desirable range of <600 mg/L indicated in the Australian Drinking Water Guidelines (NHMRC, NRMMC 2011 rev 2019) and may have a sulphurous odour and cause staining due to its iron content. It is suitable for many industrial purposes.

In this area the Pilliga Sandstone is a confined aquifer with a low specific storage; thus, the drawdown in the aquifer caused by pumping extends a long way from the pumped bore. Where multiple bores are in use, drawdown from the bores is additive.

Rules for groundwater works approval implemented by NSW DPIE Water stipulate that the incremental drawdown at an existing sub-artesian bore due to pumping from a proposed bore or bores, as estimated by modelling carried out by DPIE Water, must not exceed 2 m.

There are a number of existing GAB bores around the proposed SAP area. Two of these bores are located to the south east and are used for stock watering. These are low-yield bores with windpumps and are located a significant distance (over 8 km) from the SAP boundary. There is a private bore located close to the western boundary of the SAP; this bore has an aquifer access licence share component of only 10 ML/yr and it may be economical to offer alternative supplies to the owner.

Of greatest concern is a cluster of four bores located to the north-west of the SAP. These are a mixture of public (MPSC) and private bores that are used to provide water to public and private bore baths and pools. These bores will be impacted by pumping from proposed SAP bores and this drawdown impact must be limited to less than 2 m.

Modelling of drawdown impacts requires estimates of aquifer thickness, hydraulic conductivity and specific storage. The thickness of the Pilliga Sandstone in this area is reasonably well defined; it is likely to be about 150 m. Specific storage can vary over a defined theoretical range of about two orders of magnitude. Within that range, and for this aquifer, drawdown is relatively insensitive to the value estimated. Drawdown is sensitive to the value of hydraulic conductivity used in modelling.

Values of hydraulic conductivity estimated for the Pilliga Sandstone regionally (and other hydrostratigraphically equivalent formations) vary over a range of several orders of magnitude. There is variation with the scale of measurement, from laboratory to borehole scale to regional model calibration, and variability with local lithology and stratigraphy. The most robust value available was obtained from a well-executed 48-hour pumping test carried out on a bore drilled at Bellata, 50 km south of Moree, in 2017. The hydraulic conductivity estimated from this test was 2.4 m/d, which is within the upper part of the overall range.

Analytical modelling carried out using these parameters has indicated that up to 3,900 ML/yr could be available from four well-spaced bores located within the SAP investigation area, within the drawdown constraints imposed by DPIE. A sensitivity analysis reducing the assumed hydraulic conductivity by 40% indicated that 3,360 ML/yr would then be available. If the two northernmost bores were moved to the south, away from the most sensitive impact area, then a higher yield would be possible. This would, however, require an alternative supply to be provided to one of the existing bores west of the SAP area, as this would be more severely impacted.

If bores were relocated to be within the structure plan area, then the overall yield would need to be reduced by about 20% to remain within external drawdown constraints.

In reality, of course, there will be significant variation in drawdown and acceptable yield between bores, due to variation in local aquifer conditions. The number of bores required may be more or less than four.

It must be stressed that all these values are estimates and attempts at precision beyond that provided would not be meaningful. When test bores are drilled and pumping tests carried out, there will be more certainty, but still substantial uncertainty about the total yield that will be achievable within the drawdown parameters set by DPIE Water.

The most recent estimates of water demand for the SAP area (as provided by WSP Australia Pty Limited) on the basis of the CIE final report) indicate that a minimum of 174 ML/yr and a maximum of 1,360 ML/yr would be required from the GAB aquifer. This is much less than previously indicated. On the basis of the modelling described above, this volume could be supplied comfortably without unacceptable impact (>2 m drawdown) on external bores. It is possible that only three bores would be required to provide adequate redundancy.

It is recommended that:

1. Two high-efficiency bores be designed and drilled to fully penetrate the Pilliga Sandstone within the SAP area.
2. Extended pumping tests be carried out on both bores, with measurement of cross-bore drawdown.
3. The tests be analysed and further analytical or analytic element modelling be carried out.
4. A borefield and distribution network design be completed on the basis of the results.
5. An analysis of the net economic benefit of purchasing aquifer licence shares from irrigation operations elsewhere in the LGAA and transfer into the SAP area be carried out.
6. When drafting the planning controls applicable to the SAP, the activities permissible in each precinct should be reviewed in the context of groundwater pollution risk. The applicability of controls available under the POEO Act and its regulations should also be reviewed. Provision must then be made for any additional groundwater pollution prevention and mitigation measures required to address regulatory gaps. These prevention/mitigation measures should then be implemented through adaptive environmental management plans throughout design, construction and operation stages.

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IMPORTANT INFORMATION ABOUT THIS REPORT

This report has been prepared by C. M. Jewell & Associates Pty Limited (CMJA), on behalf of Aurecon Australasia Pty Ltd (Aurecon), for the NSW Department of Planning, Industry and Environment (DPIE). It is part of a suite of environmental technical studies prepared to support the Moree SAP Master Plan. Use of this, and reliance on, this report is restricted to DPIE and Aurecon, for that specific purpose.

The work has been carried out, and this report prepared, utilising the standards of skill and care normally expected of professional scientists practising in the fields of hydrogeology and contaminated land management in Australia. The level of confidence of the conclusions reached is governed, as in all such work, by the scope of the investigation carried out and by the availability and quality of existing data. Where limitations or uncertainties in conclusions are known, they are identified in this report. However, no liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been assessed or predicted using the adopted scope of investigation and the data derived from that investigation.

Where data collected by others have been used to support the conclusions of this report, the source has been acknowledged where possible and the data have been subjected to reasonable scrutiny. However, such data have essentially, and necessarily, been used in good faith. Liability cannot be accepted for errors in data collected by others.

This report should not be used by other persons or for other purposes than those identified above and should not be reproduced except in full and with the permission of CMJA.

APPENDIX A
Moree Stratigraphic Bore Log and Summaries

D001449140

COMPOSITE WELL LOG

MOREE - 1

LATITUDE: 29° 17' 26" S	STATE: NEW SOUTH WALES
LONGITUDE: 149° 47' 45" E	BASIN: SURAT
ELEVATION: K.B. 663·42 G.L. 651·42	PERMIT: P.E.L. 182 (N.S.W.)
DATE SPUDDED: DECEMBER 4, 1972	STATUS: PLUGGED & ABANDONED
DATE RIG RELEASED: DECEMBER 12, 1972.	RIG: RICHTER NATIONAL T-32
TOTAL DEPTH: 3765' (Schl.)	OTHER LOGS: Gamma-Ray-Sonic-Caliper: CST
	INTERPRETED BY: N. PAPALIA

LEGEND

- Sandstone
- Conglomerate
- Shale
- Siltstone
- Limestone
- Coal
- Carbonaceous
- Glauconite
- Cement Plug
- Casing
- Sidewall Cores

SPONTANEOUS POTENTIAL millivolts	RESISTIVITY ohms-m²/m	CONDUCTIVITY millimhos/m = 1000 / ohms-m²/m
10 MV − ⟷ +	A-16"-M SHORT NORMAL 0 – 500; 0 – 50	6FF40 INDUCTION 1000 – 500; 500 – 0
	AMP. SHORT NORMAL 0 – 10	
	INDUCTION 0 – 500; 0 – 50	

GRIMAN CREEK FM. (?) 300'-680'
THICKNESS 380'+
Interbedded Sandstone, salt and pepper, very fine to fine grained, glauconitic, carbonaceous and calcareous matrix, tite and Shale, grey to grey-green, fissile to blocky, silty, micaceous, carbonaceous in part and Siltstone, grey to brown, fissile to blocky, carbonaceous, micaceous, minor Coal.

WALLUMBILLA FM. 680'-2174'
THICKNESS 1494'
Surat Siltstone Member 680'-1245'
Shale, grey to dark grey, grey, green, fissile to blocky, occasionally silty, micaceous and carbonaceous and Siltstone, grey to dark grey and grey-brown, fissile, blocky, micaceous, carbonaceous with interbedded Sandstone, salt and pepper, very fine to fine grained, tite and minor Limestone, brown, micrite.

COREENA MEMBER 1245'-1554'
Shale, grey to brown, dark grey to black, fissile, micaceous, carbonaceous and Siltstone grey to brown, fissile, carbonaceous interbedded with Sandstone, grey to brown, very fine to medium grained, carbonaceous Kaolinitic, tite and Coal black, soft to brittle, bitumenous in part.

DONCASTER MEMBER [illegible]
[illegible]

BUNGIL FORMATION [illegible]
[illegible]

MOOGA SANDSTONE 2676'-2764'
THICKNESS 88'
Sandstone, grey to grey brown, fine to very coarse grained, pebbly, friable angular to subrounded grains, occasionally Kaolinitic, good porosity with very minor interbedded Siltstone and Shale, grey to brown, fissile, micaceous

ORALLO FORMATION 2764'-2893'
THICKNESS 129'
Siltstone and Shale, grey to grey brown fissile, micaceous. Sandstone, grey to brown, fine to very coarse grained, pebbly, friable, angular to subrounded grains, occasionally Kaolinitic, poor porosity in thicker units

GUBBERAMUNDA SANDSTONE 2893'-3411'
THICKNESS 518'
Sandstone, grey, white, grey-brown, medium to very coarse grained, pebbly, subangular to subrounded grains, Kaolinitic in part, generally friable, good porosity with very minor interbedded Shale and Siltstone, grey to grey-brown, fissile, micaceous occasionally carbonaceous.

WALLON FORMATION 3411'-3485'
THICKNESS 74'
Shale, grey to dark grey, grey-brown, brown, red brown, fissle, micaceous, carbonaceous, lignitic and Siltstone, grading to sandstone, grey to grey brown, occasionally mottled, very fine to fine grained occassionally medium grained, Kaolinitic, to subrounded, tite and Coal, black, brittle, concochoidal fracture

WANDOAN FORMATION 3485'-3765' T.D.
THICKNESS 280'
Shale, grey, dark grey, grey-brown, black occassionally greenish-brown, fissile, micaceous, carbonaceous, cooly in part and Siltstone, grey to brown, dark grey and black, fissile, micaceous, carbonaceous, tuffaceous in part and Coal, black, shaley to brittle, bitumenous, interbedded with minor Sandstone, grey to brown and green, tuffaceous, very fine to medium grained, lithic, calcareous, Kaolinitic, generally tite and Tuff, brown to green, grey-green, feldspathic, chloritic.
3692'-3765' Shale, grey to grey-brown, brownish-green, silty, slightly micaceous, tuffaceous and Siltstone, grey to green, mottled green, very fine to medium grained, lithic, chloritic, tite interbedded with Andesite-Basalt, dark grey-green, with felspars and mafics (weathered) to chlorite and calcite and Tuff, grey to green, feldspathic, chloritic.

WaterNSW
Work Summary

GW004361

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): NOT KNOWN

Work Type: Bore - GAB
Work Status: Needs Reconditioning
Construct.Method: Cable Tool
Owner Type: Local Govt

Commenced Date:
Completion Date: 01/11/1895

Final Depth: 851.20 m
Drilled Depth: 851.20 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:

GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MOREE	L17 (SEC 10)
Licensed:			

Region: 90 - Barwon
River Basin: 418 - GWYDIR RIVER
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 208.80 m (A.H.D.)
Elevation Source: R.L. at Surface

Northing: 6736125.000
Easting: 776075.000

Latitude: 29°28'26.3"S
Longitude: 149°50'48.9"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,PR. MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Pressure Cemented	0.00	61.00	152			
1	1	Casing	Threaded Steel	0.00	289.40	203			
1	1	Casing	Steel	0.00	92.90	254			
1	1	Casing	Threaded Steel	0.00	776.70	152			Cemented
1	1	Opening	Slots	635.80	739.10	152		1	A: 12.70mm
1	1	Casing	Threaded Steel	751.90	843.30	127			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
12.10	12.10	0.00	Unconsolidated						
213.80	213.80	0.00	Consolidated	3.00					
246.80	246.80	0.00	Consolidated (natural flow)			0.16			
486.10	498.20	12.10	Consolidated (natural flow)			0.21			
554.40	555.90	1.50	Consolidated (natural flow)						
618.40	619.60	1.20	Consolidated (natural flow)			4.47			
728.40	731.40	3.00	Consolidated (natural flow)						
737.30	740.60	3.30	Consolidated (natural flow)			15.79			
751.30	760.40	9.10	Consolidated (natural flow)			65.78			
786.90	816.10	29.20	Consolidated (natural flow)			157.88			
816.20	828.30	12.10	Consolidated (natural flow)						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.21	1.21	Soil	Soil	
1.21	10.66	9.45	Clay Gravel	Clay	
10.66	21.33	10.67	Sand Drift Water Supply	Sand	
21.33	26.51	5.18	Clay	Clay	
26.51	30.48	3.97	Sand Quick	Sand	
30.48	35.05	4.57	Conglomerate	Conglomerate	
35.05	48.76	13.71	Loam Red Drift	Loam	
48.76	53.34	4.58	Sand Quick	Sand	
53.34	60.96	7.62	Sandstone Soft	Sandstone	
60.96	67.05	6.09	Sand Drift Red	Sand	
67.05	71.62	4.57	Sand Rock Soft	Sandstone	
71.62	79.24	7.62	Sand Drift	Sand	
79.24	91.44	12.20	Sandstone	Sandstone	
91.44	204.82	113.38	Shale	Shale	
204.82	213.81	8.99	Shale Carbonaceou	Shale	
213.81	214.27	0.46	Sand Gravel Water Supply	Sand	
214.27	219.76	5.49	Mudstone	Mudstone	
219.76	245.36	25.60	Shale	Shale	
245.36	245.66	0.30	Lignite	Lignite	
245.66	248.71	3.05	Shale Dark Lignite Water Supply	Shale	
248.71	268.52	19.81	Lignite Clay	Lignite	
268.52	280.72	12.20	Sandstone	Sandstone	
280.72	313.94	33.22	Shale	Shale	
313.94	348.99	35.05	Shale	Shale	
348.99	350.52	1.53	Sandstone Soft	Sandstone	
350.52	375.81	25.29	Shale	Shale	
375.81	402.94	27.13	Shale	Shale	
402.94	404.46	1.52	Rock	Rock	
404.46	408.73	4.27	Shale	Shale	
408.73	409.95	1.22	Rock	Rock	
409.95	423.97	14.02	Shale	Shale	
423.97	425.50	1.53	Rock	Rock	
425.50	478.84	53.34	Shale	Shale	
478.84	498.34	19.50	Sandstone Water Supply	Sandstone	
498.34	503.83	5.49	Shale	Shale	
503.83	506.27	2.44	Sand White	Sand	
506.27	507.18	0.91	Hard Streaks	(Unknown)	
507.18	508.71	1.53	Sand White	Sand	
508.71	554.43	45.72	Shale	Shale	
554.43	560.83	6.40	Sand White Water Supply	Sand	
560.83	599.23	38.40	Shale Dark	Shale	
599.23	616.30	17.07	Shale Very Dark	Shale	
616.30	637.33	21.03	Sandstone White	Sandstone	
637.33	637.64	0.31	Hard Streaks	(Unknown)	
637.64	640.08	2.44	Sand Drift Water Supply	Sand	
640.08	672.99	32.91	Sandstone	Sandstone	
672.99	684.58	11.59	Shale	Shale	
684.58	688.54	3.96	Sandstone	Sandstone	
688.54	696.77	8.23	Sandstone Shale	Sandstone	
696.77	702.86	6.09	Shale	Shale	

702.86	703.47	0.61	Hard Streaks	(Unknown)	
703.47	704.39	0.92	Sandstone	Sandstone	
704.39	705.00	0.61	Sand Gravel Coarse	Sand	
705.00	708.96	3.96	Sandstone	Sandstone	
708.96	710.48	1.52	Sand Coarse	Sand	
710.48	731.52	21.04	Sandstone Water Supply	Sandstone	
731.52	737.31	5.79	Shale Hard	Shale	
737.31	760.47	23.16	Drift Coarse Water Supply	Invalid Code	
760.47	762.00	1.53	Hard Streaks	(Unknown)	
762.00	828.44	66.44	Sandstone Water Supply	Sandstone	
828.44	851.18	22.74	Shale Very	Shale	
268.52	280.72	12.20	Some Lignite Streaks	Unknown	
508.71	554.43	45.72	Some Hard Streaks	Unknown	
554.43	560.83	6.40	Some Hard Streaks	Unknown	
737.31	760.47	23.16	Sandstone Soft	Sandstone	

WaterNSW
Work Summary

GW004542

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): NOT KNOWN

Work Type: Bore - GAB
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/04/1908

Final Depth: 776.40 m
Drilled Depth: 776.50 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MENADOOL	41
Licensed:			

Region: 90 - Barwon
CMA Map: 8838-N

River Basin: 418 - GWYDIR RIVER
Grid Zone:
Scale:
Area/District:

Elevation: 237.00 m (A.H.D.)
Elevation Source: R.L. at Surface

Northing: 6722320.000
Easting: 785813.000

Latitude: 29°35'46.3"S
Longitude: 149°57'03.1"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing		-0.30	-0.30				
1	1	Casing	Threaded Steel	0.00	776.40	152			Seated on Bottom
1	1	Casing	Threaded Steel	0.00	121.30	203			
1	1	Casing	Threaded Steel	0.00	66.10	254			
1	1	Opening	Slots	320.60	585.10	152		1	SL: 6.0mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)

36.50	36.50	0.00	Unconsolidated						
58.80	58.80	0.00	Unconsolidated						
316.90	316.90	0.00	Consolidated (natural flow)			5.26			
545.50	545.50	0.00	Consolidated (natural flow)			5.26			
577.50	585.10	7.60	Consolidated (natural flow)						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.09	6.09	Topsoil	Topsoil	
6.09	13.71	7.62	Clay	Clay	
13.71	39.01	25.30	Clay Sand Water Supply	Clay	
39.01	48.15	9.14	Clay Yellow	Clay	
48.15	56.69	8.54	Clay	Clay	
56.69	63.39	6.70	Clay Sand Water Supply	Clay	
63.39	75.59	12.20	Clay	Clay	
75.59	87.17	11.58	Shale	Shale	
87.17	93.26	6.09	Shale Coal Bands	Shale	
93.26	97.53	4.27	Shale Light	Shale	
97.53	154.22	56.69	Shale	Shale	
154.22	176.78	22.56	Sandstone Hard	Sandstone	
176.78	321.86	145.08	Shale Water Supply	Shale	
321.86	334.67	12.81	Sandstone	Sandstone	
334.67	338.32	3.65	Rock	Rock	
338.32	344.42	6.10	Shale Light	Shale	
344.42	351.12	6.70	Shale	Shale	
351.12	364.54	13.42	Shale Sandy	Shale	
364.54	369.41	4.87	Rock	Rock	
369.41	377.95	8.54	Shale Sandy	Shale	
377.95	415.13	37.18	Shale Light	Shale	
415.13	423.67	8.54	Shale Black	Shale	
423.67	431.90	8.23	Shale	Shale	
431.90	455.98	24.08	Sandstone	Sandstone	
455.98	490.72	34.74	Shale	Shale	
490.72	545.59	54.87	Sandstone Water Supply	Sandstone	
545.59	552.90	7.31	Rock Hard	Rock	
552.90	646.17	93.27	Sandstone Water Supply	Sandstone	
646.17	677.57	31.40	Shale	Shale	
677.57	690.06	12.49	Shale Hard Streaks	Shale	
690.06	723.90	33.84	Shale	Shale	
723.90	726.33	2.43	Rock Pink	Rock	
726.33	743.71	17.38	Shale	Shale	
743.71	762.00	18.29	Sandstone	Sandstone	
762.00	762.60	0.60	Hard Streaks	(Unknown)	
762.60	773.88	11.28	Slate	Slate	
773.88	776.47	2.59	Dolerite Bedrock	Dolerite	

Remarks

14/04/1976: TYCANNAH (GOVT)
09/07/1997: Water from bore is pumped to tank and troughs with a Southern Cross windmill.
24/11/1997: Water from bore is pumped to tank and troughs with a Southern Cross windmill.
19/10/1998: Water from bore is pumped to tank and troughs with a Southern Cross windmill.
15/09/1999: Water from bore is pumped to tank and troughs with a Southern Cross windmill.
14/11/2001: Water from bore is pumped to tank and troughs with a Southern Cross windmill.
10/11/2003: NO ACCESS BORE OVERGROWN WITH HUGE BOXTHORN BUSHES

***** End of GW004542 *****

WaterNSW
Work Summary

GW004543

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): NOT KNOWN

Work Type: Bore - GAB
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/05/1901

Final Depth: 616.30 m
Drilled Depth: 616.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:

GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: 501-1000 ppm
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MENADOOL	63
Licensed:			

Region: 90 - Barwon
River Basin: 418 - GWYDIR RIVER
Area/District:

CMA Map: 8838-N
Grid Zone:
Scale:

Elevation: 232.80 m (A.H.D.)
Elevation Source: R.L. at Surface

Northing: 6719772.000
Easting: 781736.000

Latitude: 29°37'12.4"S
Longitude: 149°54'34.1"E

GS Map: -
MGA Zone: 55
Coordinate Source:

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Withdrawn	-0.30	8.60	152			
1	1	Casing	Threaded Steel	-0.30	550.50	152			Seated on Bottom
1	1	Casing	Withdrawn	0.00	0.00	203			
1	1	Casing	Concrete Cylnder	0.00	9.10	1067			
1	1	Casing	Threaded Steel	0.00	76.20	203			
1	1	Opening	Slots	379.40	379.40	152		1	
1	1	Opening	Slots	423.60	423.60	152		2	
1	1	Opening	Slots	429.70	429.70	152		3	
1	1	Opening	Slots	486.10	486.10	152		4	
1	1	Opening	Slots	492.20	492.20	152		5	

1	1	Opening	Slots	514.10	514.10	152		6	
1	1	Opening	Slots	518.70	518.70	152		7	
1	1	Opening	Slots	521.50	521.50	152		8	
1	1	Opening	Slots	525.40	525.40	152		9	
1	1	Opening	Slots	527.30	527.30	152		10	
1	1	Opening	Slots	531.20	531.20	152		11	
1	1	Opening	Slots	536.70	536.70	152		12	
1	1	Opening	Slots	542.50	542.50	152		13	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
0.00	0.00	0.00	(Unknown)						
15.20	15.20	0.00	Unconsolidated						
45.70	45.70	0.00	Unconsolidated						
274.30	274.30	0.00	Consolidated (natural flow)						
298.70	298.70	0.00	Consolidated (natural flow)						
377.90	380.90	3.00	Consolidated (natural flow)						
423.60	423.60	0.00	Consolidated (natural flow)						
486.10	486.10	0.00	Consolidated (natural flow)						
514.10	514.10	0.00	Consolidated (natural flow)						
557.70	609.50	51.80	Consolidated (natural flow)						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.70	6.70	Sand Gravel	Sand	
6.70	14.93	8.23	Limestone	Limestone	
14.93	18.89	3.96	Sand Gravel Water Supply	Sand	
18.89	28.65	9.76	Clay	Clay	
28.65	46.63	17.98	Clay Water Supply	Clay	
46.63	66.44	19.81	Shale	Shale	
66.44	67.66	1.22	Sandstone Hard	Sandstone	
67.66	275.23	207.57	Shale	Shale	
275.23	305.71	30.48	Sandstone Water Supply	Sandstone	
305.71	375.81	70.10	Shale	Shale	
375.81	381.91	6.10	Sandstone Water Supply	Sandstone	
381.91	423.06	41.15	Shale	Shale	
423.06	433.73	10.67	Sandstone Water Supply	Sandstone	
433.73	439.82	6.09	Shale Sandstone	Shale	
439.82	472.74	32.92	Shale	Shale	
472.74	475.18	2.44	Rock Hard	Rock	
475.18	484.02	8.84	Shale	Shale	
484.02	494.69	10.67	Sandstone Water Supply	Sandstone	
494.69	514.50	19.81	Shale Sandy	Shale	
514.50	542.84	28.34	Sandstone Water Supply	Sandstone	
542.84	547.42	4.58	Sandstone Hard Shale	Sandstone	
547.42	550.46	3.04	Shale	Shale	
550.46	551.38	0.92	Rock Hard	Rock	
551.38	571.19	19.81	Sandstone Water Supply	Sandstone	
571.19	577.90	6.71	Sandstone Hard Water Supply	Sandstone	
577.90	584.60	6.70	Sandstone Water Supply	Sandstone	
584.60	595.88	11.28	Sandstone Hard Water Supply	Sandstone	
595.88	597.10	1.22	Very Hard Bands Water Supply	(Unknown)	
597.10	612.64	15.54	Sandstone Water Supply	Sandstone	
612.64	614.17	1.53	Sandstone Hard	Sandstone	
614.17	616.30	2.13	Shale	Shale	
18.89	28.65	9.76	Sand Streaks	Sand	

Remarks

14/04/1976: TYCANNAH (PRIVATE)
14/04/1976: Changed from 550.47m to 616.31m on 27/03/12 R/C & DEEPENED
14/04/1976: R/C 1923 CASLN 3, 4&5 REFER
09/07/1997: Bore is located in well. Water is pumped from bore with windmill to tank and troughs.
24/11/1997: Bore is located in well. Water is pumped from bore with windmill to tank and troughs.
19/10/1998: Bore is located in well. Water is pumped from bore with windmill to tank and troughs.
06/11/1998: Bore is located in well. Water is pumped from bore with windmill to tank and troughs.

WaterNSW
Work Summary

GW025196

Licence: 90CA812978

Licence Status: CURRENT

Authorised Purpose(s): IRRIGATION,STOCK,DOMESTIC

Intended Purpose(s): IRRIGATION

Work Type: Bore - GAB

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/08/1969

Final Depth: 560.80 m

Drilled Depth: 560.80 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property: MOOR PARK NSW

GWMA: 601 - GREAT ARTESIAN BASIN

GW Zone: 014 - SURAT GROUNDWATER SOURCE

Standing Water Level (m):

Salinity Description: 1001-3000 ppm

Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MOOEE	LT DP 751779
Licensed:	COURALLIE	MOOEE	Whole Lot 8//748421

Region: 90 - Barwon

CMA Map: 8838-N

River Basin: 418 - GWYDIR RIVER

Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)

Elevation Source: (Unknown)

Northing: 6726312.000

Easting: 774006.000

Latitude: 29°33'46.4"S

Longitude: 149°49'41.1"E

GS Map: -

MGA Zone: 55

Coordinate Source:

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-1.50	559.80	152			Cemented at Shoe
1		Casing	Casing Protector	0.00	0.00				
1	1	Casing	Threaded Steel	0.00	67.90	203			
1	1	Opening	Slots	494.60	496.10	152		1	
1	1	Opening	Slots	496.50	497.80	152		2	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
494.30	499.70	5.40	Consolidated (natural flow)			0.01			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.52	1.52	Clay Black	Clay	
1.52	22.86	21.34	Clay Light Brown Sticky Gravel	Clay	
22.86	40.84	17.98	Clay Red Sticky	Clay	
40.84	44.19	3.35	Clay Yellow Sticky	Clay	
44.19	52.42	8.23	Shale Yellow Sandy Sticky	Shale	
52.42	74.06	21.64	Shale Coloured Sandy Sticky	Shale	
74.06	86.86	12.80	Shale Coloured	Shale	
86.86	150.26	63.40	Shale Grey Hard Bands	Shale	
150.26	154.22	3.96	Shale Black	Shale	
154.22	166.11	11.89	Shale Grey	Shale	
166.11	166.72	0.61	Coal Black	Coal	
166.72	185.31	18.59	Shale Black	Shale	
185.31	202.08	16.77	Shale Grey	Shale	
202.08	207.87	5.79	Shale Grey	Shale	
207.87	212.75	4.88	Shale	Shale	
212.75	215.49	2.74	Shale Grey	Shale	
215.49	284.07	68.58	Shale Grey	Shale	
284.07	314.55	30.48	Shale Grey	Shale	
314.55	324.61	10.06	Shale	Shale	
324.61	452.32	127.71	Shale Grey	Shale	
452.32	458.72	6.40	Shale Grey	Shale	
458.72	464.21	5.49	Shale Grey	Shale	
464.21	469.39	5.18	Shale Grey Hard Sandy	Shale	
469.39	486.46	17.07	Shale Grey	Shale	
486.46	493.77	7.31	Shale Grey	Shale	
493.77	494.38	0.61	Sandstone Hard Bands	Sandstone	
494.38	499.87	5.49	Sandstone Water Supply	Sandstone	
499.87	508.10	8.23	Shale Grey Hard Sandy	Shale	
508.10	530.96	22.86	Shale Grey	Shale	
530.96	560.83	29.87	Shale Grey Sloping	Shale	

Remarks

14/04/1976: MOOR PARK
14/04/1976: FLOW SEALED AT TOP NOT GAUGED
14/04/1976: DEEPENING TO 640M RECOMMENDED
11/07/2001: Bore flow is a trickle. Water trickles from hole in casing. Hole is 100mm from natural surface. Water is spreading out around bore. Some times water may run down earth drain into earth tank 20 metres east of bore. This bore should be capped as soon as possible. Completion date was 1969.
10/11/2003: OWNER SAID BORE WAS FLOWING 600 mm 4 YEARS AGO

***** End of GW025196 *****

WaterNSW
Work Summary

GW900008

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s):

Work Type: Bore - GAB
Work Status:
Construct.Method: Rotary Mud
Owner Type:

Commenced Date:
Completion Date: 21/10/1995

Final Depth: 818.70 m
Drilled Depth: 818.70 m

Contractor Name: Condamine Drilling Pty Ltd
Driller: Colin James Markham
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m): 8.300
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:		UNKNOWN	
Licensed:			

Region: 90 - Barwon
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6735454.000
Easting: 775599.000

Latitude: 29°28'48.4"S
Longitude: 149°50'31.9"E

GS Map: -
MGA Zone: 55
Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	112.00	250			Rotary Mud
1		Hole	Hole	1.20	819.00	175			Rotary Mud
1	1	Casing	Steel	-0.30	111.90	127	117		Suspended in Clamps
1	1	Casing	Steel	105.80	818.70	127	117		Suspended in Clamps,
1	1	Opening	Slots - Vertical	426.70	527.30	127		0	Oxy-Acetylene Slotted, Steel, SL: 300.0mm, A: 6.00mm

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.13	2.13	TOPSOIL	Unknown	
2.13	2.74	0.61	BROWN CLAY	Unknown	
2.74	9.14	6.40	BROWN & GREY CLAY	Unknown	
9.14	14.63	5.49	BROWN SANDY CLAY	Unknown	
14.63	21.95	7.32	SAND & GRAVEL	Unknown	
21.95	31.39	9.44	BROWN SANDY CLAY	Unknown	
31.39	34.14	2.75	BROWN SAND	Unknown	
34.14	42.06	7.92	BROWN & GREY SANDY CLAY	Unknown	
42.06	50.29	8.23	BROWN SAND & GRAVEL	Unknown	
50.29	54.25	3.96	BROWN & GREY SANDY CLAY	Unknown	
54.25	61.87	7.62	WHITE SAND	Unknown	
61.87	73.15	11.28	GREY & ORANGE CLAY	Unknown	
73.15	82.30	9.15	SOFT COARSE SANDSTONE	Unknown	
82.30	83.82	1.52	BROWN CLAY	Unknown	
83.82	85.34	1.52	SANDSTONE	Unknown	
85.34	92.96	7.62	MULTI-COLOURED SANDSTONE AND CLAYS	Unknown	
92.96	99.06	6.10	GREY SHALE	Unknown	
99.06	147.83	48.77	BLUE SHALE	Unknown	

147.83	148.44	0.61	VERY HARD MUDSTONE	Unknown	
148.44	160.02	11.58	BLUE SHALE	Unknown	
160.02	160.63	0.61	HARD MUDSTONE	Unknown	
160.63	186.23	25.60	BLUE SHALE	Unknown	
186.23	187.15	0.92	VERY HARD SILSTONE	Unknown	
187.15	205.74	18.59	SOFT PUGGY BLUE SHALE	Unknown	
205.74	224.33	18.59	BLUE SHALE	Unknown	
224.33	224.94	0.61	HARD MUDSTONE	Unknown	
224.94	228.60	3.66	BLUE SHALE	Unknown	
228.60	236.83	8.23	HARD BLUE SANDY SHALE	Unknown	
236.83	246.28	9.45	SANDY SHALE & SANDSTONE	Unknown	
246.28	247.50	1.22	VERY HARD MATERIAL	Unknown	
247.50	259.08	11.58	SANDSTONE & SHALE BANDS	Unknown	
259.08	272.80	13.72	BLUE SHALE	Unknown	
272.80	307.85	35.05	BLUE SHALE & NARROW COAL BANDS	Unknown	
307.85	308.46	0.61	COAL	Unknown	
308.46	311.81	3.35	SHALE & NARROW COAL BANDS	Unknown	
311.81	323.09	11.28	SANDSTONE & SHALE BANDS	Unknown	
323.09	337.72	14.63	SOFT PUGGY SHALE	Unknown	
337.72	338.33	0.61	VERY HARD MATERIAL	Unknown	
338.33	356.62	18.29	BLUE SHALE	Unknown	
356.62	368.81	12.19	SOFT PUGGY SHALE	Unknown	
368.81	399.29	30.48	SANDY BLUE SHALE AND SANDSTONE BANDS	Unknown	
399.29	405.38	6.09	SOFT SANDY SHALE	Unknown	
405.38	408.43	3.05	SANDSTONE	Unknown	
408.43	420.62	12.19	BLUE SHALE	Unknown	
420.62	451.10	30.48	SANDY SHALE	Unknown	
451.10	483.41	32.31	SANDSTONE	Unknown	
483.41	493.78	10.37	SANDSTONE & SANDY SHALE	Unknown	
493.78	508.41	14.63	SANDSTONE	Unknown	
508.41	511.76	3.35	SANDSTONE	Unknown	
511.76	512.98	1.22	VERY HARD SANDSTONE	Unknown	
512.98	527.30	14.32	SANDSTONE	Unknown	
527.30	537.06	9.76	SANDY BLUE SHALE	Unknown	
537.06	552.30	15.24	STICKY BLUE SHALE	Unknown	
552.30	558.40	6.10	SANDSTONE	Unknown	
558.40	609.60	51.20	SANDSTONE & BANDS SHALE	Unknown	
609.60	632.46	22.86	SANDY SHALE	Unknown	
632.46	660.50	28.04	SANDSTONE	Unknown	
660.50	673.61	13.11	SANDSTONE, HARD AND MUDDY	Unknown	
673.61	678.18	4.57	HARD FLAKEY, DARK SHALE	Unknown	
678.18	688.24	10.06	SANDSTONE	Unknown	
688.24	720.55	32.31	SANDSTONE	Unknown	
720.55	725.42	4.87	HARD SHALE	Unknown	
725.42	809.24	83.82	SANDSTONE	Unknown	
809.24	818.69	9.45	BROWN SHALE	Unknown	

Remarks

07/05/1998: Bore is constructed not equipped.
28/05/1998: Bore constructed not equipped.
26/06/1998: Bore constructed not equipped.
24/07/1998: Bore constructed not equipped.
19/08/1998: Bore constructed not equipped.
11/09/1998: Bore constructed not equipped.
23/09/1998: Bore constructed not equipped.
23/10/1998: Bore constructed not equipped.
20/11/1998: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
23/02/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
14/05/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
09/07/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
28/08/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
23/09/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
07/10/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
01/11/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
11/11/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
29/11/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
24/12/1999: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
25/01/2000: Bore constructed not equipped. Bore casing 0.40 metres above natural surface.
07/02/2000: Bore constructed not equipped. Bore casing 0.40 metres above natural surface
21/02/2000: Bore constructed not equipped. Bore casing 0.40 metres above natural surface
08/05/2000: Bore constructed not equipped. Bore casing 0.40 metres above natural surface
08/02/2002: PUMP BEING FITTED. PROBLEMS WITH DRAW DOWN. POSSIBLY COLD WATER.
02/04/2002: Bore is equipped but no meter fitted. Owner has been told to fit meter. One pool being filled.
19/12/2003: cadaster data obtained form GDS; Charting done at the center of the property using Arc View GIS due to lack of actual site data.
19/11/2007: BORE HAS BEEN TURNED OFF FOR SEVERAL MONTHS
19/11/2007: Tikiri Tennakoon: "BORE HAS BEEN UNUSED FOR 12 MONTHS AT LEAST" Transferref this comment dated 19-Nov-2007 from Water Levels Module & deleted duplicating record.
10/10/2011: Adjusted Inside, Outside Diameter and Thickness due to data entry errors with advice from Madhwan Keshwan. GDS Data Cleanup project 2011.

WaterNSW
Work Summary

GW901748

Licence: 90WA811427 | **Licence Status:** CURRENT

Authorised Purpose(s): RECREATION (GROUNDWATER)
Intended Purpose(s): RECREATION (GROU

Work Type: Bore - GAB
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 22/04/1998
Final Depth: 865.00 m
Drilled Depth: 865.00 m

Contractor Name: MITCHELL DRILLING
Driller:
Assistant Driller:

Property: N/A 361 Frome St MOREE 2400 NSW
GWMA: 601 - GREAT ARTESIAN BASIN
GW Zone: 014 - SURAT GROUNDWATER SOURCE
Standing Water Level (m): 8.600
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MOREE	LT 14 DP 864550
Licensed:	COURALLIE	MOREE	Whole Lot 14//864550

Region: 90 - Barwon
CMA Map:
River Basin: - Unknown
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6735917.000
Easting: 775619.000
Latitude: 29°28'33.4"S
Longitude: 149°50'32.2"E

GS Map: -
MGA Zone: 55
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	170.00	280			Rotary Mud
1		Hole	Hole	170.00	623.00	185			Rotary Mud
1		Hole	Hole	623.00	865.00	127			Rotary Mud
1	1	Casing	Steel	0.00	170.00	219	206		Suspended in Clamps, Cemented, Welded
1	1	Casing	Steel	158.00	623.00	141	131		Cemented, Welded
1	1	Casing	Steel	623.00	865.00	114	104		Seated on Bottom, Welded
1	1	Opening	Slots - Vertical	711.00	865.00	114		0	Oxy-Acetylene Slotted, Steel, SL: 4.0mm, A: 0.60mm

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	2.00	2.00	top soil	Topsoil	
2.00	4.00	2.00	brown clay	Clay	
4.00	8.00	4.00	sand	Sand	
8.00	10.00	2.00	sandy clay	Invalid Code	
10.00	16.00	6.00	sandy clay	Invalid Code	
16.00	21.00	5.00	gravel	Gravel	
21.00	44.00	23.00	brown clay	Clay	
44.00	51.00	7.00	gravel	Gravel	
51.00	90.00	39.00	sandstone	Sandstone	
90.00	101.00	11.00	gravel	Gravel	
101.00	131.00	30.00	grey shale	Invalid Code	
131.00	133.00	2.00	shale - hard	Shale	
133.00	168.00	35.00	grey shale	Invalid Code	
168.00	170.00	2.00	shale - hard	Shale	
170.00	189.00	19.00	shale	Shale	

189.00	200.00	11.00	gravel stone	Gravel	
200.00	211.00	11.00	grey shale	Invalid Code	
211.00	212.00	1.00	carbonated shale	Carbonate	
212.00	244.00	32.00	grey shale	Invalid Code	
244.00	247.00	3.00	shale - hard	Shale	
247.00	249.00	2.00	grey shale	Invalid Code	
249.00	251.00	2.00	mudstone	Mudstone	
251.00	253.00	2.00	grey shale	Invalid Code	
253.00	254.00	1.00	carbonated shale	Carbonate	
254.00	259.00	5.00	grey shale	Invalid Code	
259.00	260.00	1.00	carbonated shale	Carbonate	
260.00	265.00	5.00	grey shale	Invalid Code	
265.00	266.00	1.00	coal and carbonated shale	Coal	
266.00	269.00	3.00	siltstone	Siltstone	
269.00	278.00	9.00	grey shale	Invalid Code	
278.00	279.00	1.00	carbonated shale	Carbonate	
279.00	282.00	3.00	grey and carbonated shale	Invalid Code	
282.00	284.00	2.00	carbonated shale	Carbonate	
284.00	286.00	2.00	mudstone	Mudstone	
286.00	290.00	4.00	coal carbonated shale	Coal	
290.00	299.00	9.00	grey shale	Invalid Code	
299.00	300.00	1.00	shale	Shale	
300.00	304.00	4.00	sandstone	Sandstone	
304.00	306.00	2.00	mudstone	Mudstone	
306.00	312.00	6.00	grey shale	Invalid Code	
312.00	332.00	20.00	grey shale	Invalid Code	
332.00	333.00	1.00	sandstone	Sandstone	
333.00	340.00	7.00	greys shale	Invalid Code	
340.00	348.00	8.00	sandstone	Sandstone	
348.00	380.00	32.00	grey shale	Invalid Code	
380.00	386.00	6.00	sandstone with shale	Sandstone	
386.00	405.00	19.00	grey shale	Invalid Code	
405.00	411.00	6.00	sandstone	Sandstone	
411.00	456.00	45.00	grey shale with sandstone bands	Invalid Code	
456.00	463.00	7.00	sandstone	Sandstone	
463.00	476.00	13.00	grey shale	Invalid Code	
476.00	494.00	18.00	sandstone	Sandstone	
494.00	495.00	1.00	sandstone - hard	Sandstone	
495.00	504.00	9.00	grey shale	Invalid Code	
504.00	510.00	6.00	sandstone - hard	Sandstone	
510.00	512.00	2.00	mudstone	Mudstone	
512.00	514.00	2.00	sandstone - water	Sandstone	
514.00	520.00	6.00	sandstone	Sandstone	
520.00	523.00	3.00	grey shale	Invalid Code	
523.00	531.00	8.00	sandstone	Sandstone	
531.00	537.00	6.00	shale	Shale	
537.00	553.00	16.00	sandstone with hard bands	Sandstone	
553.00	559.00	6.00	shale	Shale	
559.00	571.00	12.00	sandstone	Sandstone	
571.00	576.00	5.00	grey shale	Invalid Code	
576.00	583.00	7.00	sandstone	Sandstone	
583.00	599.00	16.00	greys hale with sandstone bands	Invalid Code	
599.00	619.00	20.00	sandstone	Sandstone	
619.00	622.00	3.00	shale	Shale	
622.00	625.00	3.00	sandstone	Sandstone	
625.00	633.00	8.00	greys shale	Invalid Code	
633.00	649.00	16.00	sandstone	Sandstone	
649.00	650.00	1.00	mudstone	Mudstone	
650.00	667.00	17.00	sandstone	Sandstone	
667.00	668.00	1.00	grey shale	Invalid Code	
668.00	673.00	5.00	sandstone	Sandstone	
673.00	719.00	46.00	sandstone	Sandstone	
719.00	821.00	102.00	sandstone with hard bands	Sandstone	
821.00	822.00	1.00	oil carbonatisa shale band	Invalid Code	
822.00	852.00	30.00	sandstone with hard band of pink quartz	Sandstone	
852.00	865.00	13.00	grey shale	Invalid Code	

Remarks

28/05/1998: Bore constructed not equipped.
05/06/1998: Bore constructed not equipped.
26/06/1998: Bore constructed not equipped.
24/07/1998: Bore constructed not equipped
19/08/1998: Bore constructed not equipped
23/09/1998: Bore constructed not equipped.
09/11/1998: Bore constructed not equipped.
20/11/1998: Bore constructed not equipped.
23/02/1999: Bore is now equipped. Water being pumped to pools. Meter has been fitted. Zenner meter. Meter reading 10367.
14/05/1999: Bore is now equipped. Water being pumped to pools. Meter reading 59340. USAGE 48973
09/07/1999: Bore is now equipped. Water being pumped to pools. Meter reading 76992. USAGE 17652
26/08/1999: Bore is now equipped. Water being pumped to pools. Meter reading 76992. USAGE METER not working.
23/09/1999: Bore is now equipped. Water being pumped to pools. Meter reading 76992. USAGE Meter not working. Owner has been informed of problem.
07/10/1999: . Water being pumped to pools. Meter reading 76992. USAGE Meter not working. Owner has been informed of problem.

01/11/1999: . Water being pumped to pools. Meter reading 76992. USAGE Meter not working. Owner has been informed of problem. Owner waiting on new meter to be fitted.
11/11/1999: Water being pumped to pools. Meter reading 76992. USAGE Meter not working. Owner has been informed of problem. Owner still waiting on new meter to be fitted.
29/11/1999: Water being pumped to pools. Meter reading 76992. USAGE Meter not working. Owner has been informed of problem. Owner still waiting on new meter to be fitted.
24/12/1999: Water being pumped to pools. Meter reading 2886. USAGE 2886 NEW METER FITTED.
27/01/2000: Water being pumped to pools. Meter reading 18134. USAGE 15248 NEW METER FITTED.
07/02/2000: Water being pumped to pools. Meter reading 22128. USAGE 3994 NEW METER FITTED.
21/02/2000: Meter reading 27561. USAGE 5433
24/02/2000: Meter reading 28812. USAGE 1251
25/02/2000: Meter reading 29254. USAGE 442
28/02/2000: Meter reading 30746. USAGE 1492
29/02/2000: Meter reading 30778. USAGE 32
01/03/2000: Meter reading 30787. USAGE 9
02/03/2000: Meter reading 30818. USAGE 31
03/03/2000: Meter reading 30819. USAGE 1
09/03/2000: Meter reading 30822. USAGE 3
26/04/2000: Meter reading 25272. USAGE METER NOT WORKING.
02/05/2000: Meter reading 25233. USAGE METER NOT WORKING.
08/05/2000: Meter reading 25237. USAGE METER NOT WORKING.
15/06/2000: Meter reading 003926. USAGE METER WORKING.
28/06/2000: Meter reading 10239. USAGE 6313 METER WORKING.
26/07/2000: Meter reading 21463. USAGE 11224 METER WORKING.
24/08/2000: Meter reading 34455. USAGE 12992 METER WORKING.
04/09/2000: Meter reading 40234. USAGE 5779 METER WORKING.
13/09/2000: Meter reading 44645. USAGE 4411 METER WORKING.
22/09/2000: Meter reading 49070. USAGE 4425 METER WORKING.
28/09/2000: Meter reading 52193. USAGE 3123 METER WORKING.
13/10/2000: Meter reading 59372. USAGE 7179
25/10/2000: Meter reading 65222. USAGE 5850
07/11/2000: Meter reading 70935. USAGE 5713
22/11/2000: Meter reading 77532 USAGE 6597
11/12/2000: Meter reading 86773 USAGE 9241
27/12/2000: Meter reading 94228 USAGE 7455
24/01/2001: Meter reading 105923 USAGE 11695
08/02/2001: Meter reading 111885 USAGE 5962
22/02/2001: Meter reading 118163 USAGE 6278
09/03/2001: Meter reading 121469 USAGE3306
26/03/2001: Meter reading 127810 USAGE6341
08/05/2001: Meter reading 146846 USAGE19036
13/06/2001: Meter reading 163486 USAGE16640
02/07/2001: Meter reading 172294 USAGE8808
07/08/2001: Meter reading 189325 USAGE17031
04/10/2001: Meter reading 216233 USAGE 26908
19/10/2001: Meter reading 223214 USAGE 6981
02/11/2001: Meter reading 229667 USAGE 6453
26/11/2001: Meter reading 240439 USAGE 10772
17/12/2001: Meter reading 247929 USAGE 7490
08/02/2002: Meter reading 264899 USAGE 16970
20/03/2002: Meter reading 277748 USAGE 12849
02/04/2002: Meter reading 281875 USAGE 4127
17/04/2002: Meter reading 286400 USAGE 4525

***** End of GW901748 *****

WaterNSW
Work Summary

GW901977

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore - GAB
Work Status:
Construct.Method:
Owner Type: Private

Commenced Date:
Completion Date: 04/04/1999

Final Depth: 868.00 m
Drilled Depth: 868.00 m

Contractor Name: DALY BROS PTY. LTD.
Driller: Trevor John Hargrave
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	COURALLIE	MOREE	LT 16 DP 789779
Licensed:			

Region: 90 - Barwon
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6736075.000
Easting: 776083.000

Latitude: 29°28'27.9"S
Longitude: 149°50'49.3"E

GS Map: -
MGA Zone: 55
Coordinate Source: GIS - Geogra

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	108.00	280			Rotary Mud
1		Hole	Hole	108.00	677.00	200			Rotary Mud
1		Hole	Hole	677.00	868.00	152			Rotary Mud
1	1	Casing	Steel	-0.20	672.70	168	155		Welded
1	1	Casing	Steel	0.00	108.00	219	206		Cemented, Welded
1	1	Casing	Steel	662.00	868.00	127	117		Welded
1	1	Opening	Slots - Vertical	700.00	856.00	127		0	Oxy-Acetylene Slotted, SL: 83.0mm, A: 6.00mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
720.00	847.00	127.00	Unknown	9.50		10.50	868.00	05:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.50	1.50	topsoil	Topsoil	
1.50	9.00	7.50	yellow clay	Clay	
9.00	21.00	12.00	sand and gravel	Sand	
21.00	53.00	32.00	white clay	Invalid Code	
53.00	90.00	37.00	sandy clay	Invalid Code	
90.00	97.00	7.00	yellow clay	Clay	
97.00	183.70	86.70	shale	Shale	
183.70	185.00	1.30	hard band	Invalid Code	
185.00	380.00	195.00	grey shale	Invalid Code	

380.00	500.00	120.00	shale	Shale	
500.00	617.00	117.00	shale	Shale	
617.00	636.00	19.00	shale	Shale	
636.00	653.00	17.00	sandstone	Sandstone	
653.00	655.00	2.00	hard band	Invalid Code	
655.00	670.00	15.00	sandstone	Sandstone	
670.00	688.00	18.00	shale	Shale	
688.00	720.00	32.00	sandstone	Sandstone	
720.00	753.00	33.00	sandstone	Sandstone	
753.00	847.00	94.00	sandstone	Sandstone	
847.00	862.00	15.00	shale	Shale	
862.00	868.00	6.00	shale	Shale	

Remarks

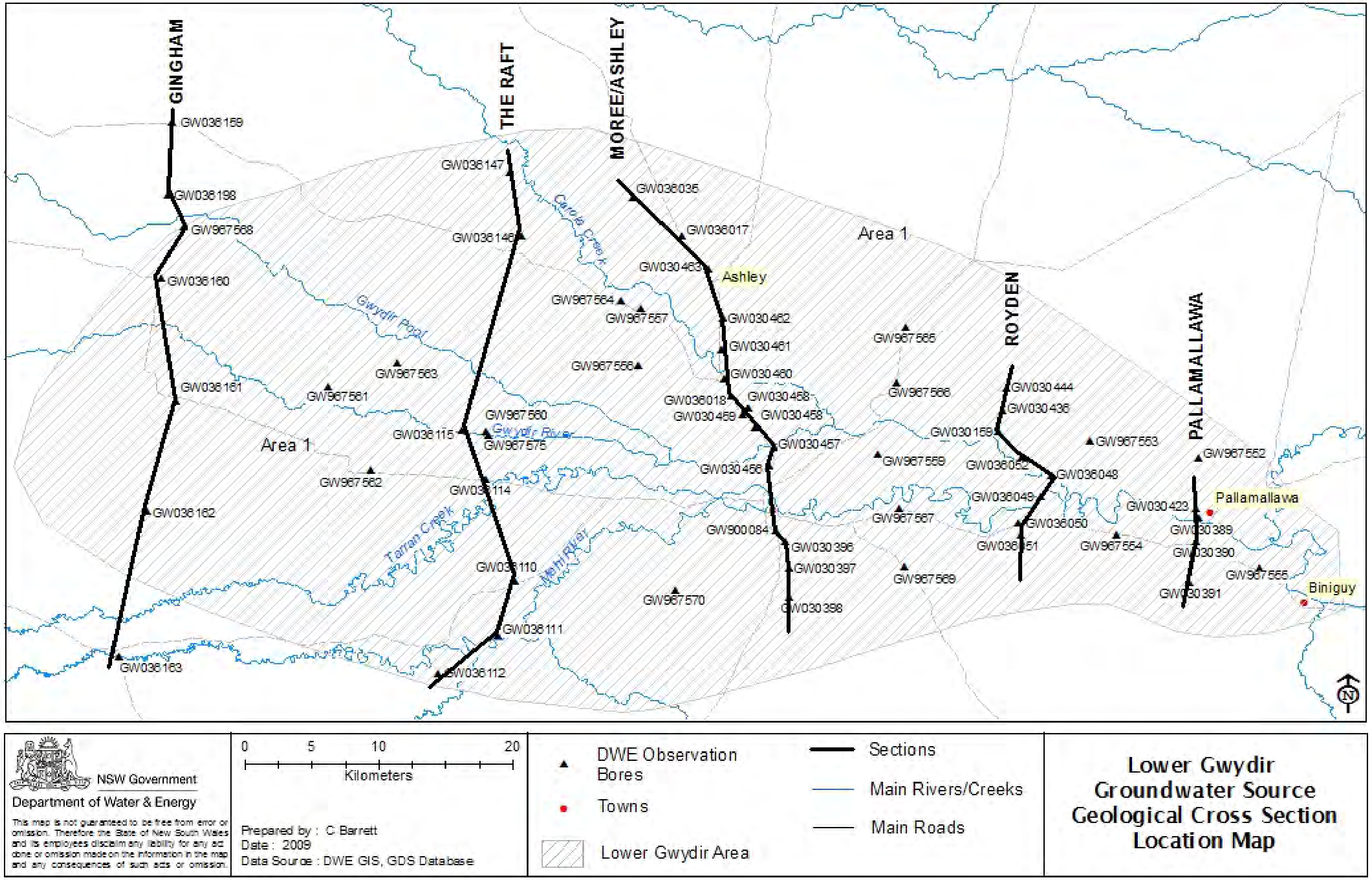
09/07/1999: Meter 5428950.9 Usage 88849.7
28/08/1999: Meter 5513077.2 Usage 84126.3
23/09/1999: Meter 5561646.5 Usage 48569.3
07/10/1999: Meter 5585678.5 Usage 24032.0
01/11/1999: Meter 5629022.8 Usage 43344.3
11/11/1999: Meter 5646737.1 Usage 17714.3
29/11/1999: Meter 5677906.9 Usage 31169.8
24/12/1999: Meter 5721801.8 Usage 43894.9
25/01/2000: Meter 5772164.2 Usage 50362.4
07/02/2000: Meter 5792333.2 Usage 20169.0
21/02/2000: Meter 5814568.2 Usage 22235.0
24/02/2000: Meter 5818511.8 Usage 3943.6
25/02/2000: Meter 5819975.7 Usage 1463.9
28/02/2000: Meter 5824324.8 Usage 4349.1
29/02/2000: Meter 5825825.7 Usage 1500.9
01/03/2000: Meter 5827277.1 Usage 1451.4
02/03/2000: Meter 5828733.3 Usage 1456.2
03/03/2000: Meter 5830325.9 Usage 1592.6
09/03/2000: Meter 5839835.4 Usage 9509.5
28/03/2000: Meter 5869837.6 Usage 30002.2
02/04/2000: Meter 5878520.0 Usage 8683 STAFF READING.
12/04/2000: Meter 5894412.0 Usage 15892 STAFF READING.
16/04/2000: Meter 5900684.0 Usage 6272 STAFF READING.
23/04/2000: Meter 5911467.0 Usage 10783 STAFF READING.
25/04/2000: Meter 5914316.8 Usage 2849 STAFF READING.
26/04/2000: Meter 5915919.2 Usage 1602.4
30/04/2000: Meter 5922573.0 Usage 6653.8 STAFF READING
06/05/2000: Meter 5932273.0 Usage 9700.0 STAFF READING
08/05/2000: Meter 5935017.9 Usage 2744.9 STAFF READING
15/06/2000: Meter 5995014.3 Usage 59996.4 STAFF READING
28/06/2000: Meter 6015410.4 Usage 20396.1 STAFF READING
26/07/2000: Meter 6059777.3 Usage 4909.3
24/08/2000: Meter 6104221.5 Usage 44444.2
04/09/2000: Meter 6123190.3 Usage 18968.8
13/09/2000: Meter 6137155.0 Usage 13964.7
22/09/2000: Meter 6151262.3 Usage 14107.3
28/09/2000: Meter 6161099.3 Usage 9837.0
13/10/2000: Meter 6185585.6 Usage 24486.3
25/10/2000: Meter 6206929.9 Usage 21344.3
07/11/2000: Meter 6227855.1 Usage 20925.2
22/11/2000: Meter 6256040.9 Usage 28185.8
11/12/2000: Meter 6289209.8 Usage 33168.9
27/12/2000: Meter 6317608.2 Usage 28398.4
24/01/2001: Meter 6367831.0 Usage 50222.8
08/02/2001: Meter 6392549.9 Usage 24718.9
22/02/2001: Meter 6416996.7 Usage 24446.8
09/03/2001: Meter 6443394.6 Usage 26397.9
26/03/2001: Meter 6473774.3 Usage 30379.7
08/05/2001: Meter 6549455.2 Usage 75680.9
13/06/2001: Meter 6608230.1 Usage 58774.9
02/07/2001: Meter 6635446.6 Usage 27216.5
07/08/2001: Meter 6688339.6 Usage 52893
04/10/2001: Meter 6774896.6 Usage 86557.0
19/10/2001: Meter 6796637.3 Usage 21740.7
02/11/2001: Meter 6814896.6 Usage 18259.3
07/11/2001: Meter 6824793.4 Usage 9896.8
26/11/2001: Meter 6852541.9 Usage 27748.5
17/12/2001: Meter 6878340.4 Usage 25798.5
08/02/2002: Meter 6944134.1 Usage 65793.7
20/03/2002: Meter 6991136.5 Usage 47002.4
02/04/2002: Meter 7007248.2 Usage 16111.7
17/04/2002: Meter 7027297.1 Usage 20048.9
17/02/2004: Nominated bore location based on cadastral details provided either by Form A or licence. Charted bore location will differ from actual location.
Krish

***** End of GW901977 *****

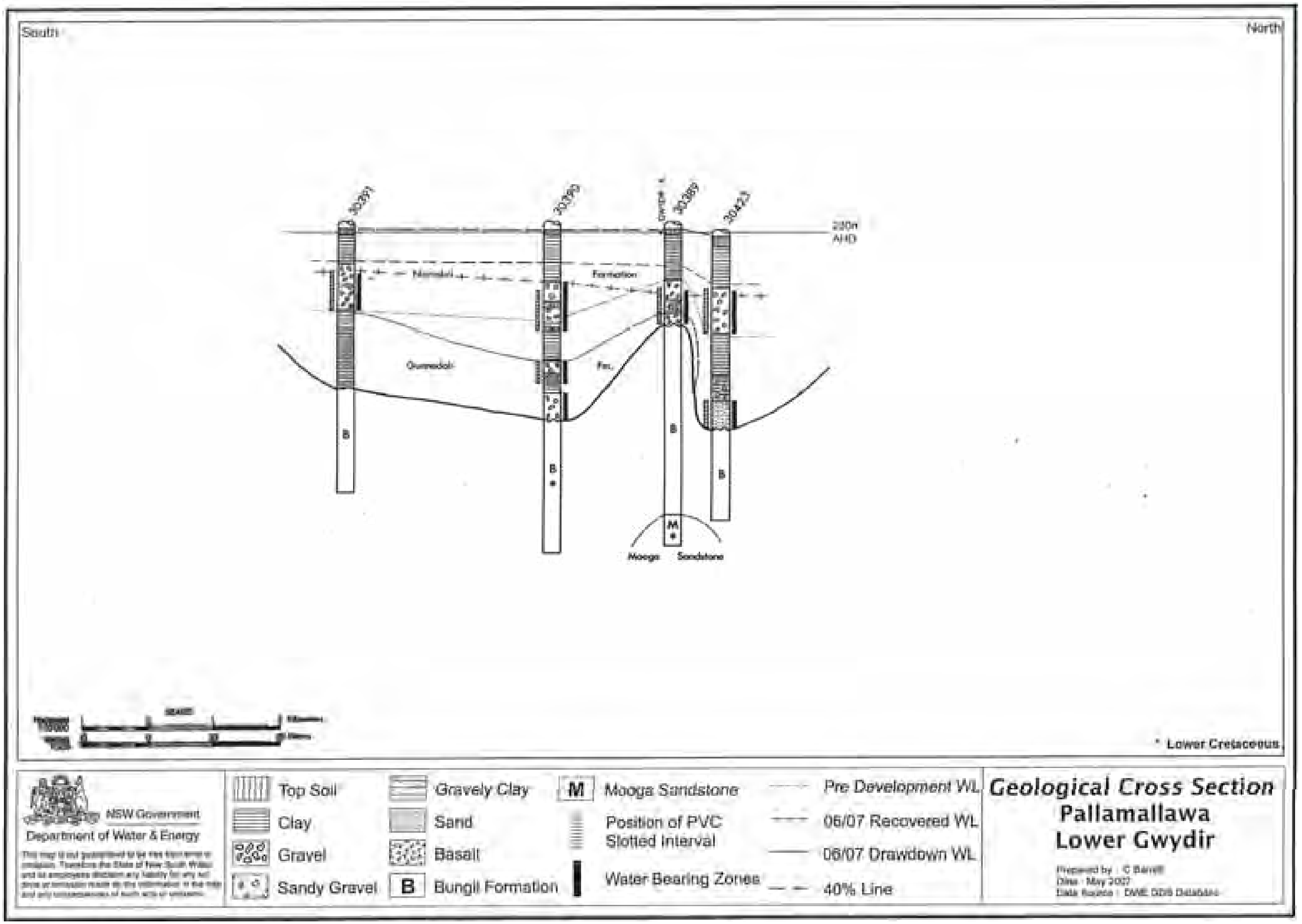
APPENDIX B
Geological Sections

Appendix B Geological Cross Sections

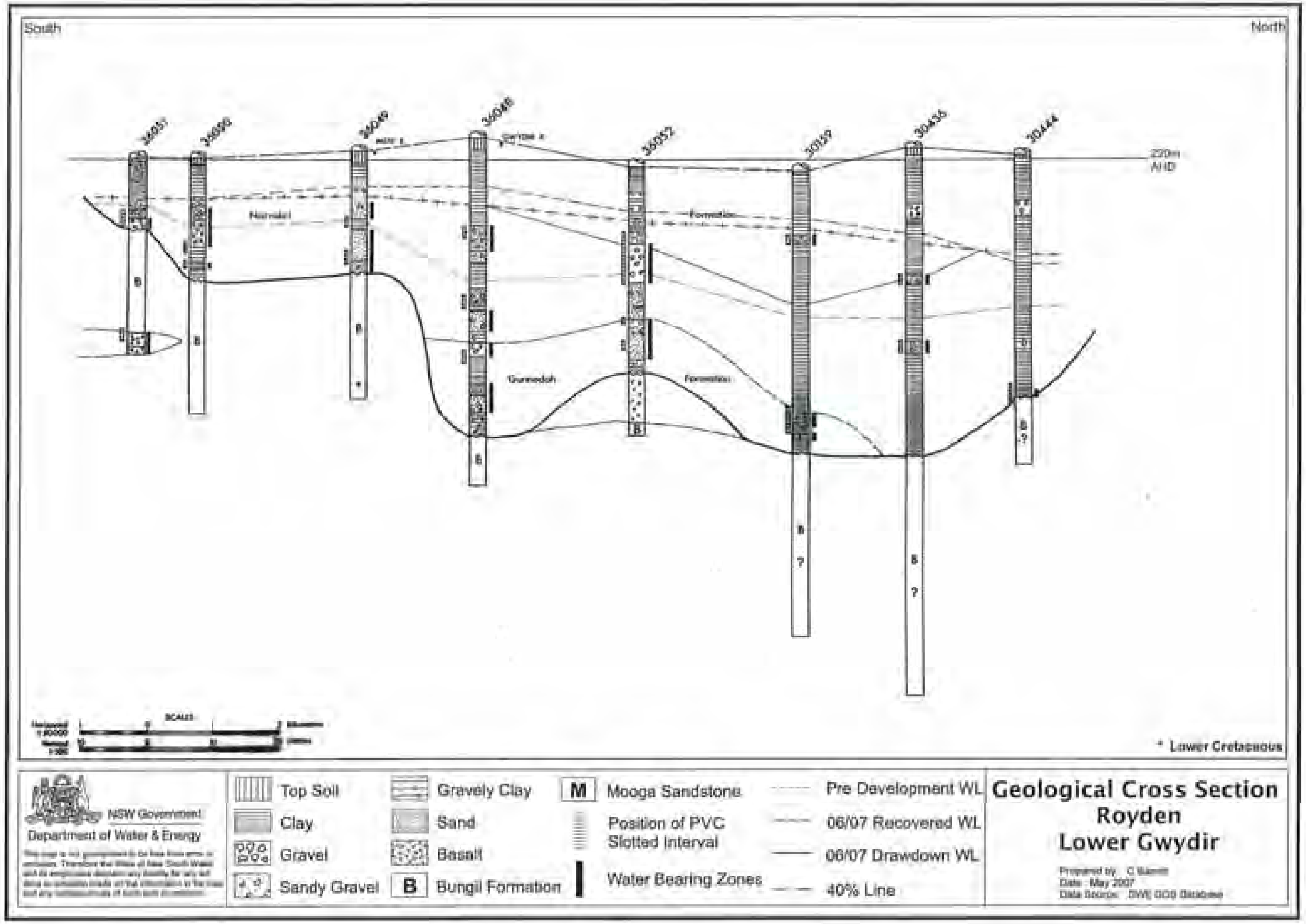
Map B1 Cross Section location map Lower Gwydir



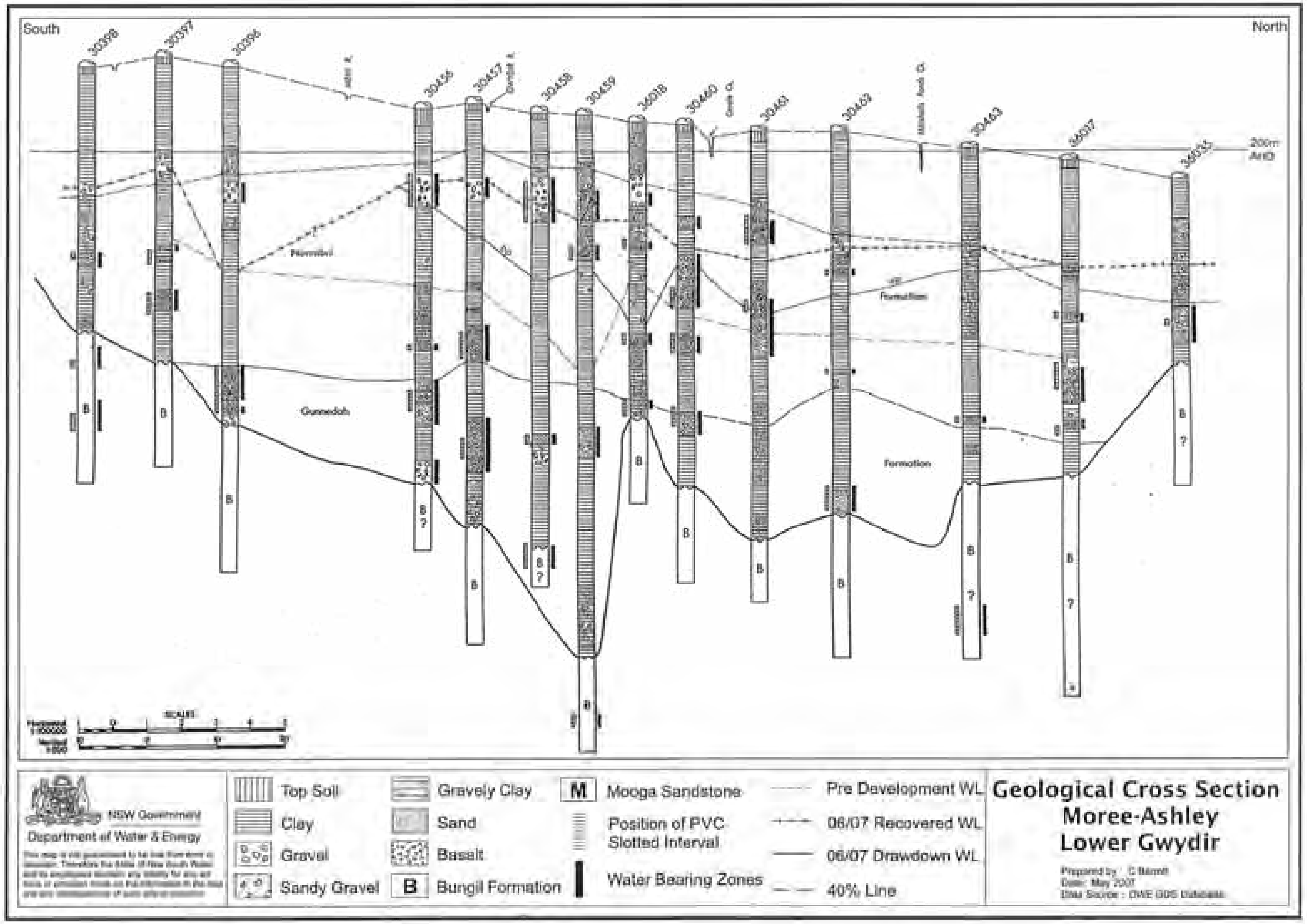
Map B2 Pallamallawa geological cross section



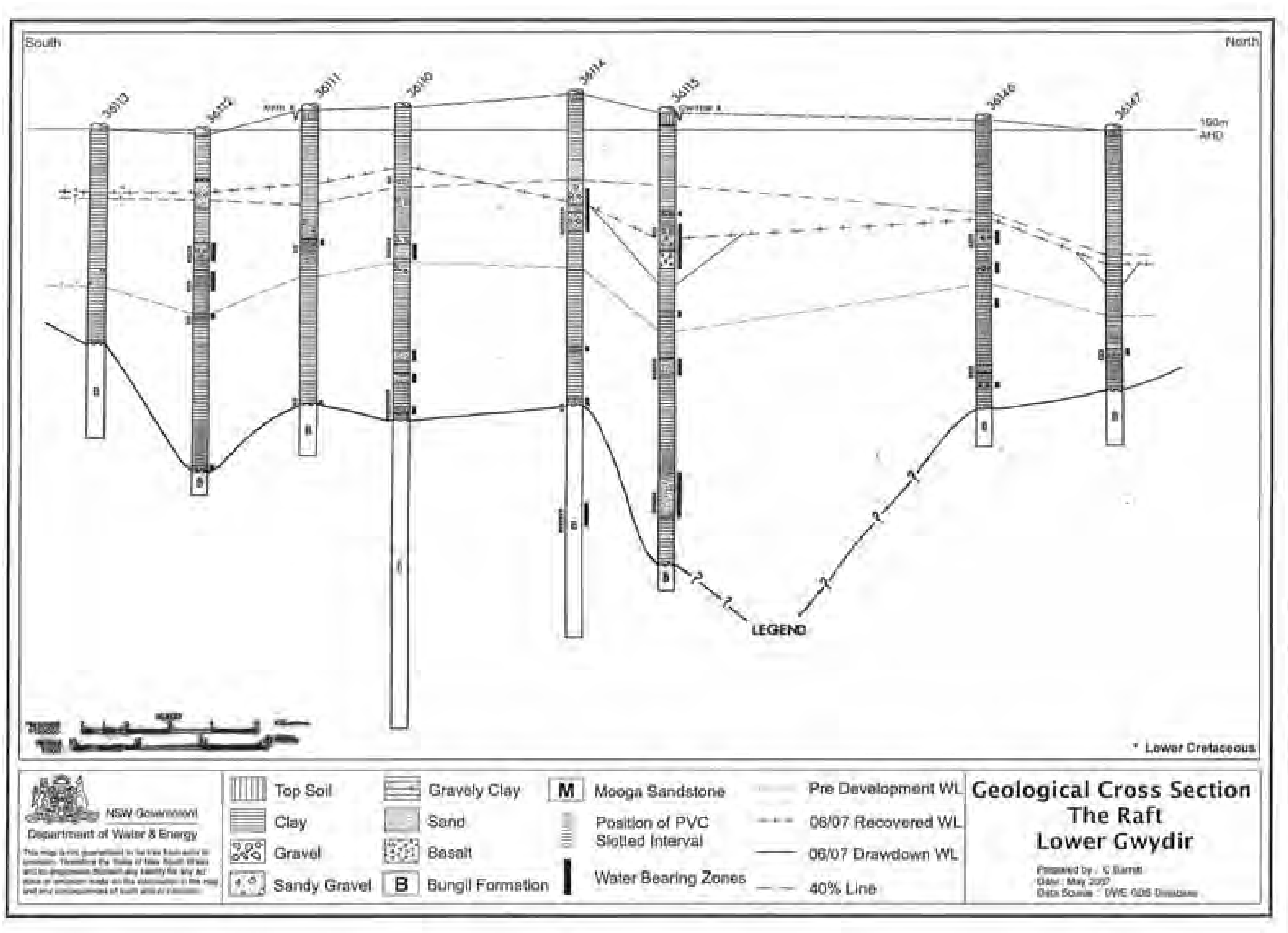
Map B3 Royden geological cross section



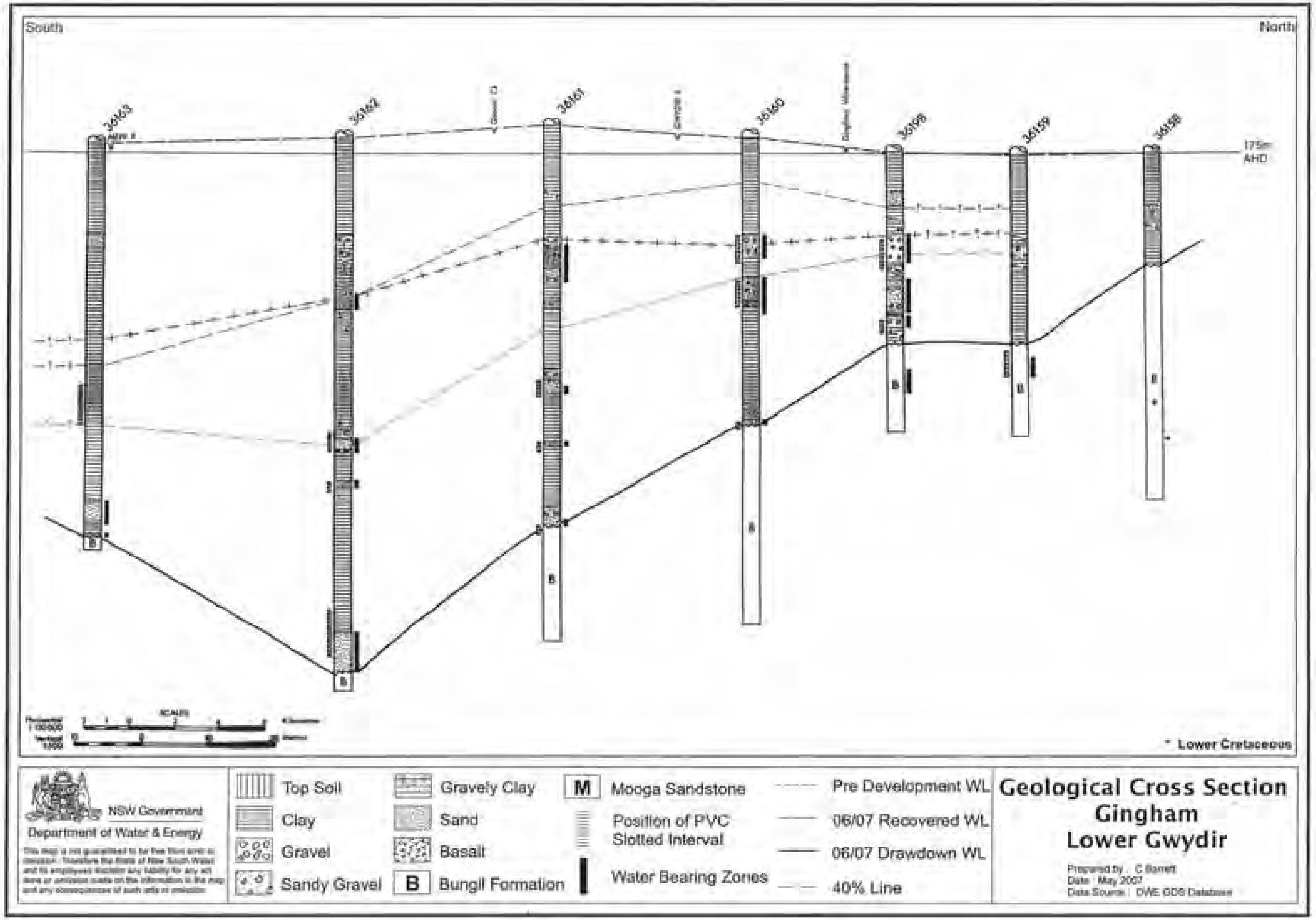
Map B4 Moree/Ashley geological cross section



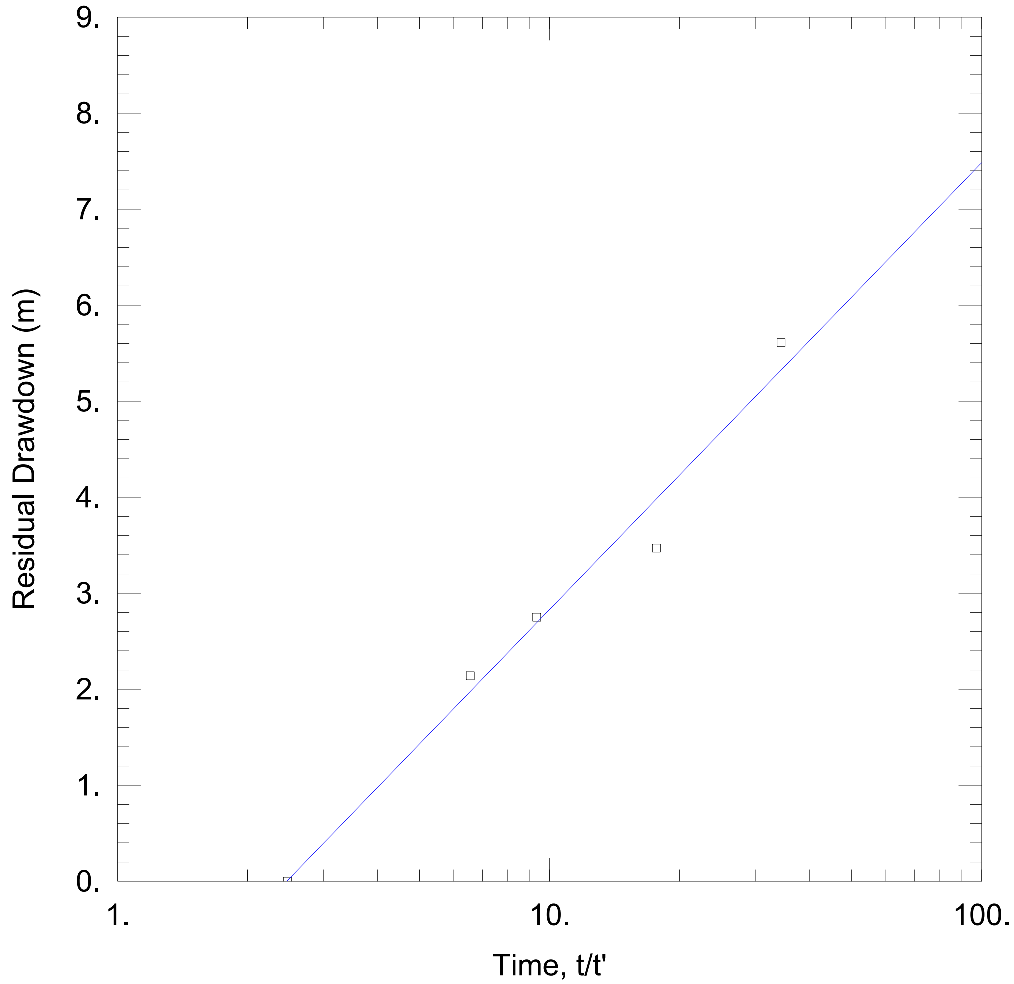
Map B5 The Raft geological cross section



Map B6 Gingham geological cross section



APPENDIX C
Shut-in Recovery Plots



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004023_1916.aqt
Date: 12/17/20 Time: 08:53:44

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004023
Test Date: 12 April 1916

AQUIFER DATA

Saturated Thickness: 109. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004023	786259	6750569

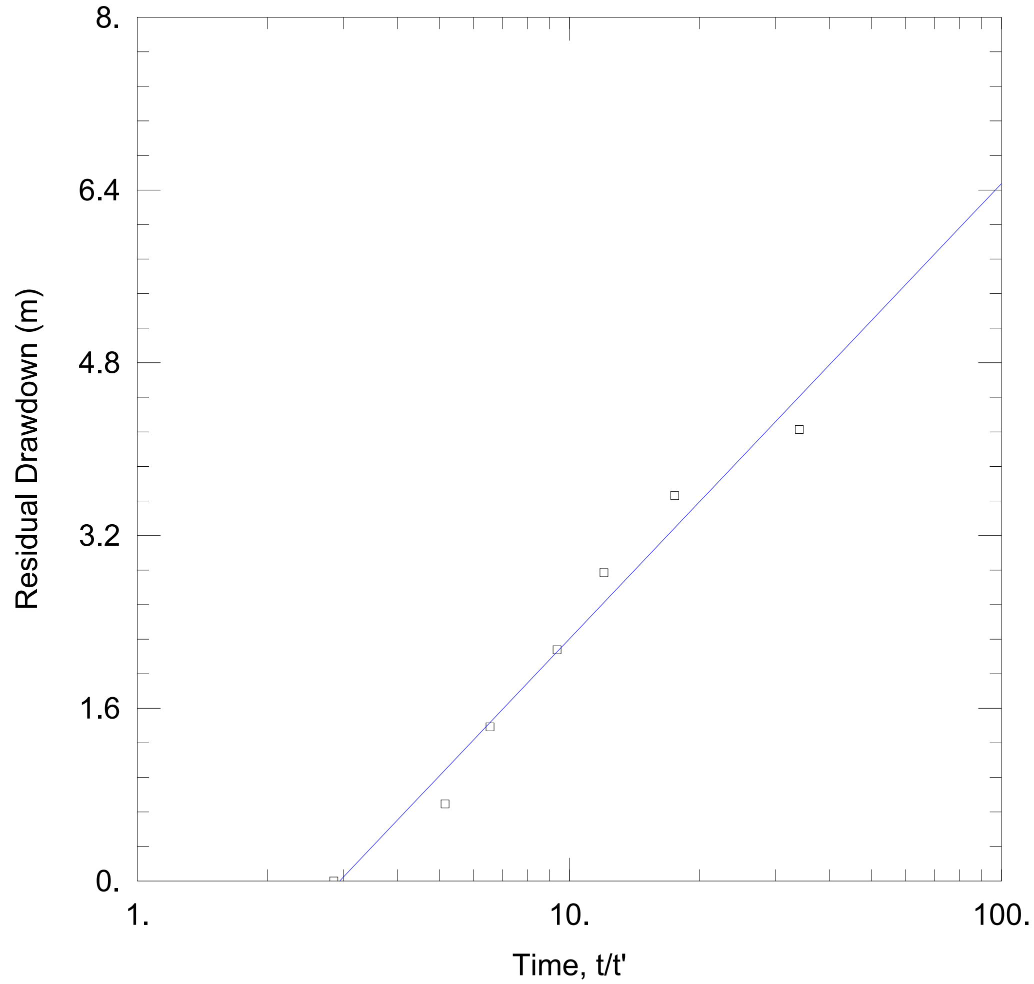
Observation Wells

Well Name	X (m)	Y (m)
□ GW004023	786259	6750569

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 80.65 m^2/day
S/S' = 2.466



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004023_1921.aqt
Date: 12/17/20 Time: 08:54:55

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004023
Test Date: 2 March 2021

AQUIFER DATA

Saturated Thickness: 109. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004023	786259	6750569

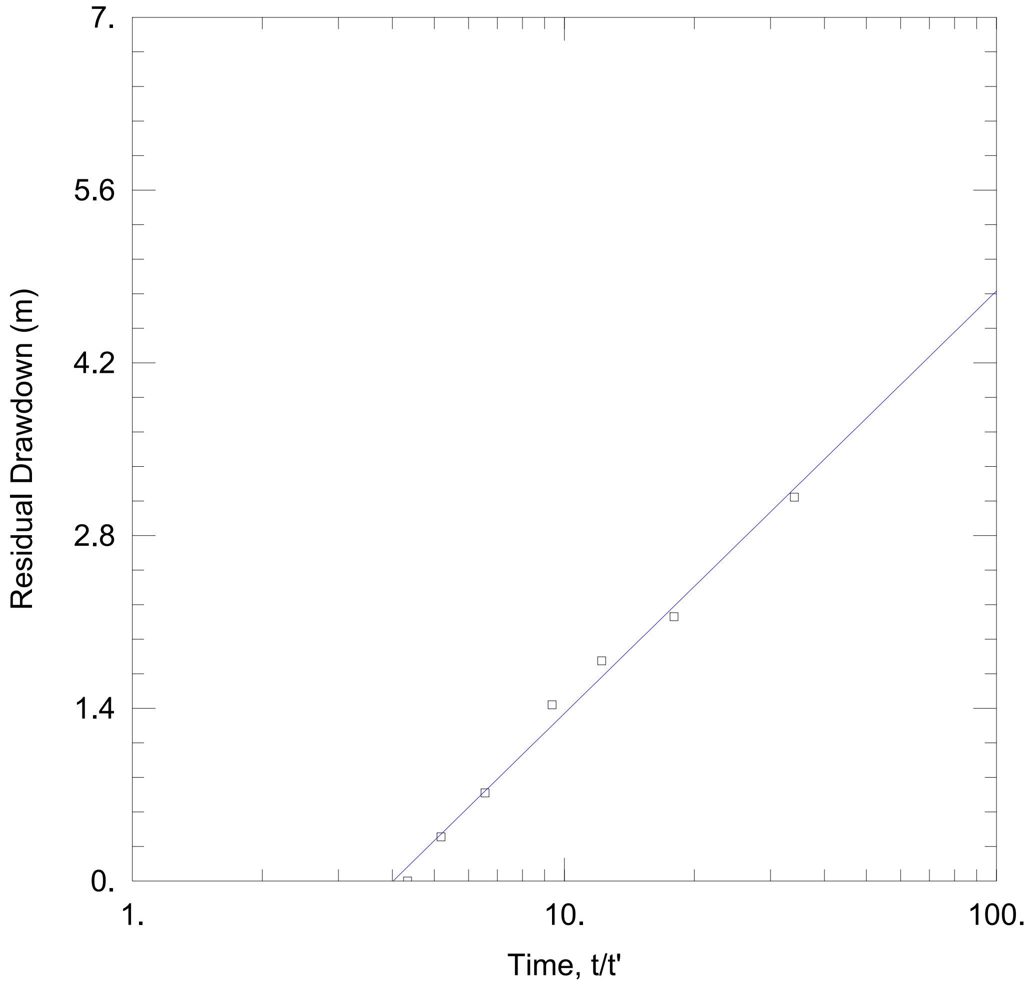
Observation Wells

Well Name	X (m)	Y (m)
□ GW004023	786259	6750569

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 81.08 m^2/day S/S' = 2.942



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004023_1922.aqt
Date: 12/17/20 Time: 08:56:17

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004023
Test Date: 28 March1922

AQUIFER DATA

Saturated Thickness: 109. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004023	786259	6750569

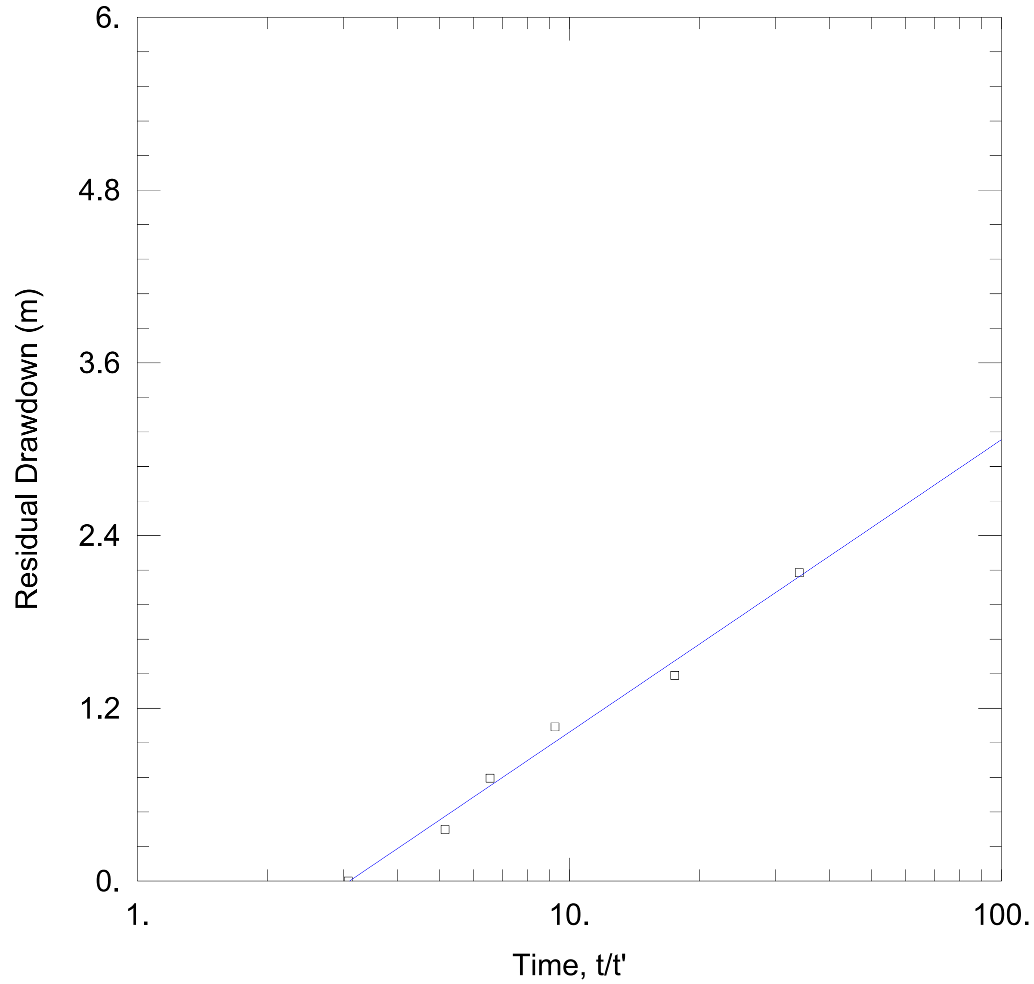
Observation Wells

Well Name	X (m)	Y (m)
□ GW004023	786259	6750569

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 96.65 m^2/day
S/S' = 4.017



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004107_1921.aqt
Date: 12/16/20 Time: 19:56:18

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004107
Test Date: 21 July 1921

AQUIFER DATA

Saturated Thickness: 150. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004107	755727	6725633

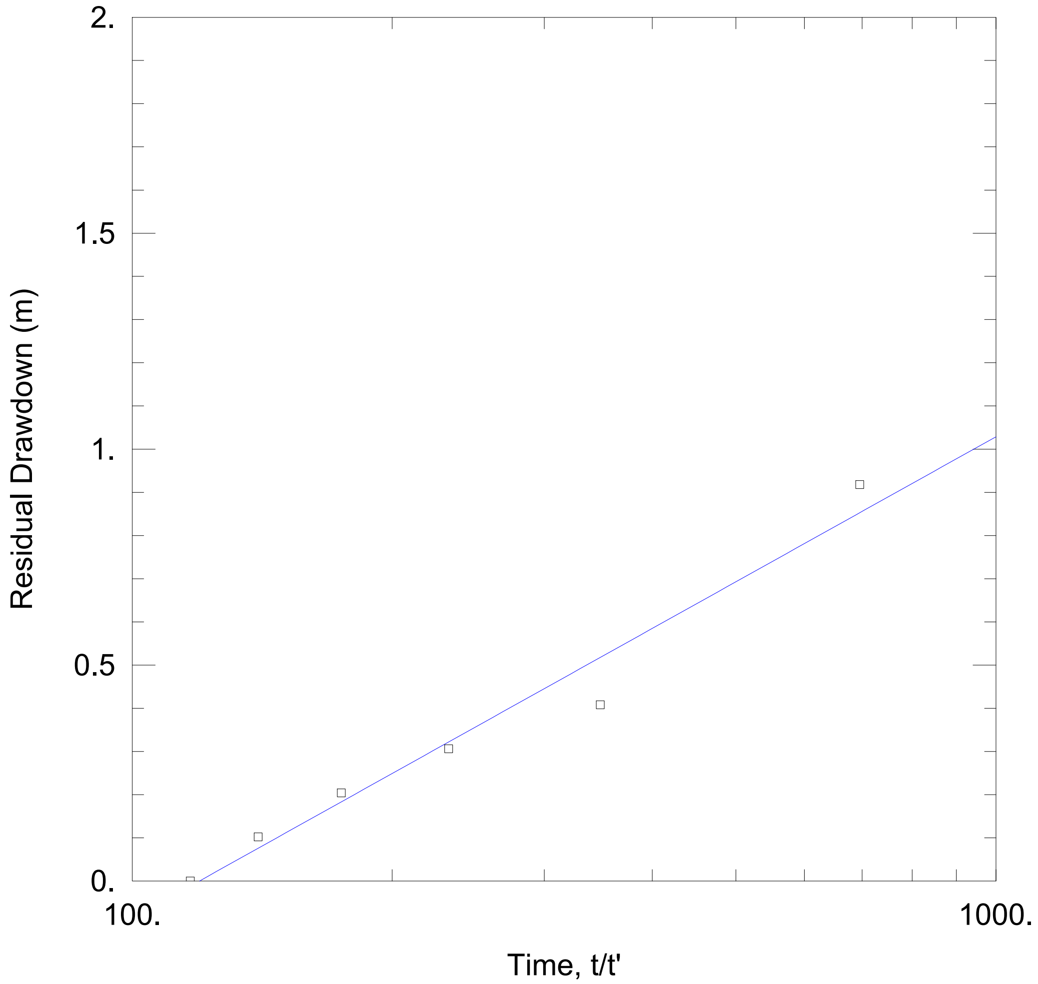
Observation Wells

Well Name	X (m)	Y (m)
□ GW004107	755727	6725633

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 190.1 m^2/day
S/S' = 3.101



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004107_2014.aqt
Date: 12/16/20 Time: 19:53:00

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004107
Test Date: 25 February 2014

AQUIFER DATA

Saturated Thickness: 150. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004107	755727	6725633

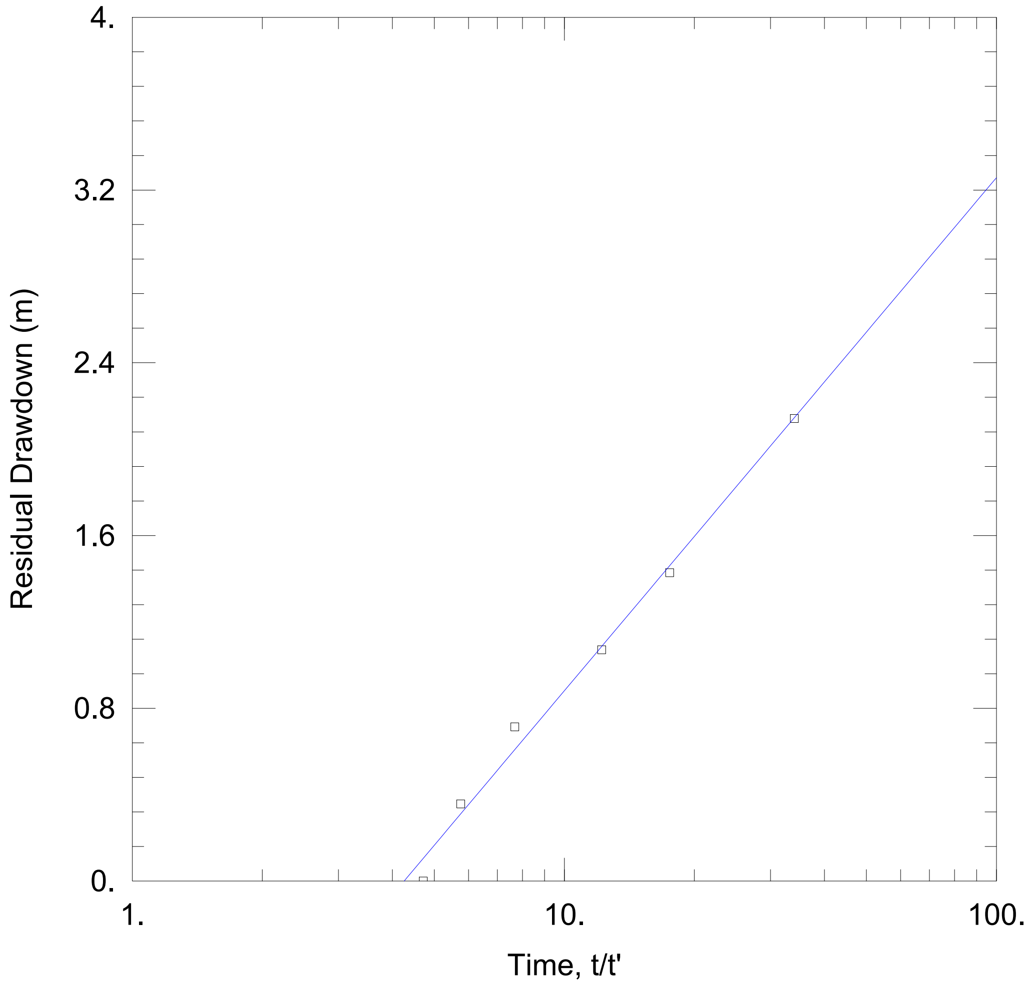
Observation Wells

Well Name	X (m)	Y (m)
□ GW004107	755727	6725633

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 241.3 m^2/day S/S' = 119.7



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004215_1932.aqt
Date: 12/16/20 Time: 19:48:03

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004215
Test Date: 12 February 1932

AQUIFER DATA

Saturated Thickness: 150. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004215	756373	6706762

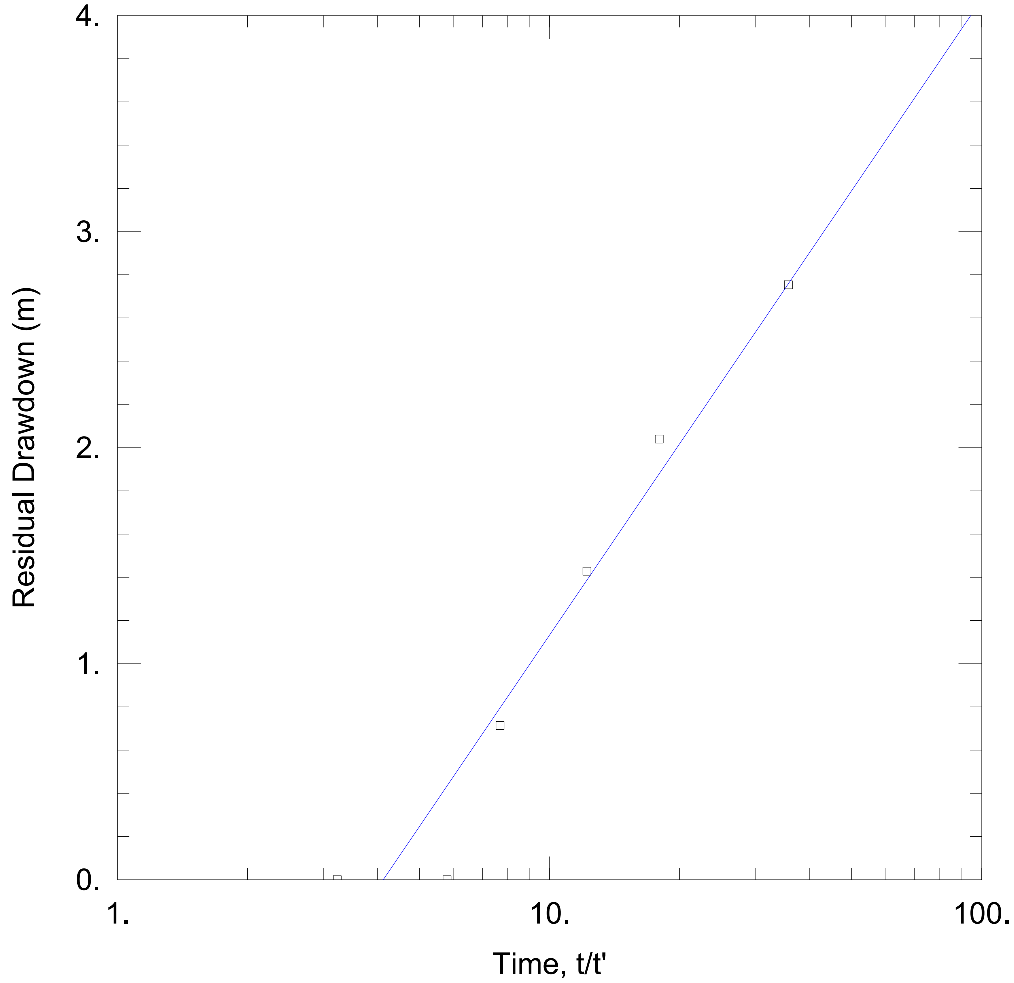
Observation Wells

Well Name	X (m)	Y (m)
□ GW004215	756373	6706762

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 112.6 m^2/day S/S' = 4.261



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004290_1913.aqt
Date: 12/17/20 Time: 08:25:57

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004290
Test Date: 26 November 1913

AQUIFER DATA

Saturated Thickness: 150. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004290	737565	6714941

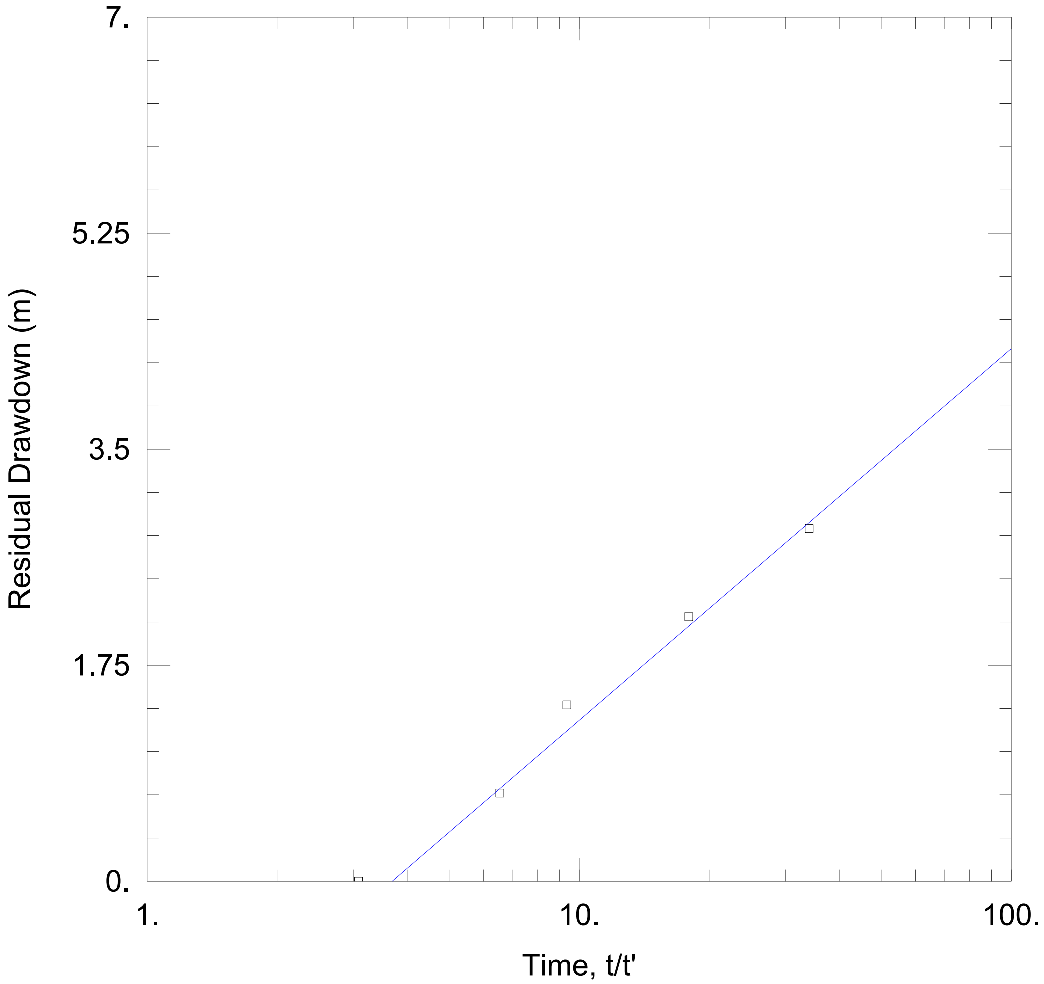
Observation Wells

Well Name	X (m)	Y (m)
□ GW004290	737565	6714941

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 44.1 m^2/day
S/S' = 4.124



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004290_1917.aqt
Date: 12/17/20 Time: 08:37:45

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004290
Test Date: 26 November 1913

AQUIFER DATA

Saturated Thickness: 150 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004290	737565	6714941

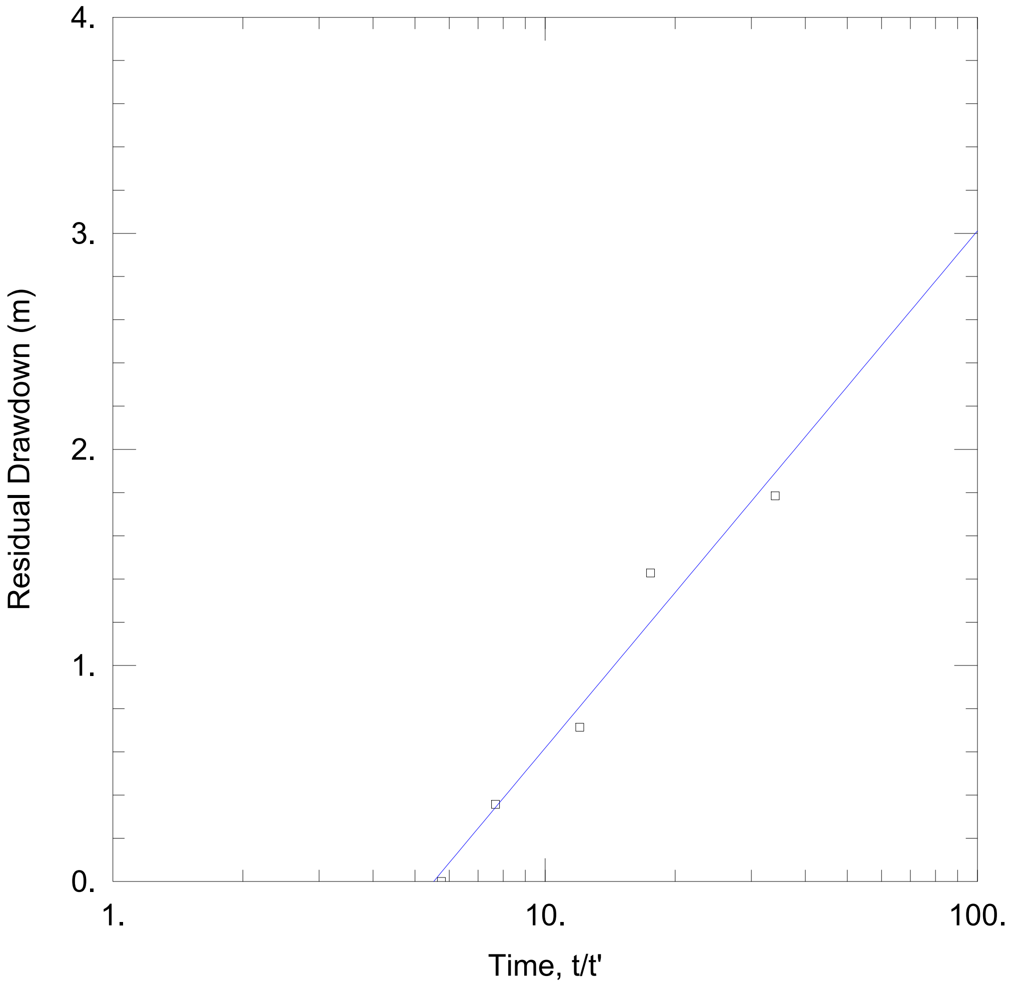
Observation Wells

Well Name	X (m)	Y (m)
□ GW004290	737565	6714941

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 37.86 m^2/day S/S' = 3.696



ARTESIAN SHUT-IN

Data Set: J:\AllJobs\Jobs2019\J1774 - Moree SAP\Flow Analysis\GW004290_1931.aqt
Date: 12/17/20 Time: 08:51:01

PROJECT INFORMATION

Company: C.M.Jewell & Associates P/L
Client: Depatment of Planning
Project: J1774
Location: Moree
Test Well: GW004290
Test Date: 26 November 1913

AQUIFER DATA

Saturated Thickness: 150. m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
GW004290	737565	6714941

Observation Wells

Well Name	X (m)	Y (m)
□ GW004290	737565	6714941

SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Recovery)

T = 35.06 m^2/day
S/S' = 5.526

APPENDIX D

Water Demand Estimate Provided by WSP

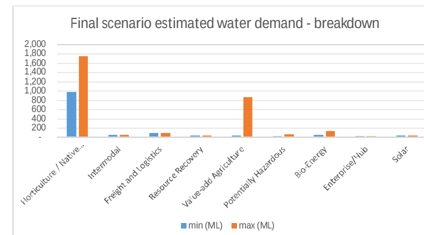
FINAL SCENARIO - Water demand estimate (based on high-level land uses inputs from final masterplan) - Updated 2/2/21 based on Final CIE Report and take areas and % building footprint assumptions

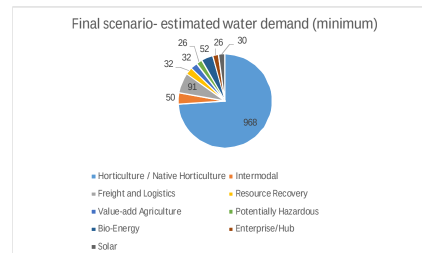
Land Use	Net Ha	*Previous Structure Plan - Net Ha developed*	Building footprint area (% of Net area)	Area demand rate applied to	Water demand rate (annual) min (ML/ha)	Water demand rate (annual) max (ML/ha)	Water demand (annual) min (ML)	Water demand (annual) max (ML)	*CIE Report Water Usage (ML)*	Assumptions/comments
Horticulture / Native Horticulture	520.00	*220.00*	50%	260	4	8	1,040	2,080	*1906*	Net ha area and % building footprint adopted from final CIE Report figures. Maximum demand rate taken as upper end of typical broadscale ag. irrigation rates, (noting significantly with proposed land-use and intesity/practices). Minimum demand rate assumes 50% propoprtion of area is greenhouse horticulture with efficient recircula and 50% broadscale. Although an opportunity, it is asssumed that aquaponics would only implemented at a limited scale (i.e. a minor overall % which doesnt imnpact rates)
Intermodal	30.00	*140.00*	30%	9	3	3	27	27	*Town water*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: rail sidings and marshalling yards; storage areas; transfer faciliti parking of vehicles; buildings for administration purposes; ancillary activities. Demand rate for light industry (typically based on gross ha) adopted, however applied to footprint area only - which is considered more applicable for this purpose
Freight and Logistics	20.00	*105.00*	30%	6	3	3	18	18	*Town water*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: warehouses; storage areas for goods; transfer facilities; parking buildings for offices and administration; ancillary activities. Demand rate for light industry (typically based on gross ha) adopted, however applied to the building footp which is considered more applicable for this purpose
Resource Recovery	60.00	*90.00*	16.6%	10	3	3	30	30	*Town water*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: intermodal facilities; resource recovery facilities; waste transfer area; waste processing facilities; micro-factories (specific recycling products); industrial uses; refuse storage; waste to energy production; landfill. Demand rate for light i based on gross ha) adopted, however applied to the building footprint area only - which is considered more applicable for this purpose
Value-add Agriculture	80.00	*70.00*	17.5%	14	3	82	42	1,148	*688*	Net ha area and % building footprint adopted from final CIE Report figures. The building footprint % is similar to existing South Moree industrial area density. Minimun based on typical rates for flour mills (the lowest water usage type of food processing and similar to general light industry), maximum demand rate weighted based on a cereals and 20% food oils (both water intensive), with 20% flour mills and 40% general light industry/warehouses (both lower demand).
Potentially Hazardous	25.00	*30.00*	8%	2	3	15	6	30	*30*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses: chemical and fertilizer manufacturing. Minimum demand rate for light ir gross ha) adopted. Maximum demand rate based on 100% heavy industry adopted. Demand rates (typically based on gross ha) applied to the building footprint area o considered more applicable for this purpose
Bio-Energy	30.00	*60.00*	16.6%	5	3	15	15	75	*N/A*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land-uses include: resource recovery facilities; waste processing facilities; waste to production. Minimum demand rate for light industry (based on gross ha) adopted. Maximum demand rate based on 100% heavy industry adopted. Demand rates (typi gross ha) applied to the building footprint area only - which is considered more applicable for this purpose
Enterprise/Hub	10.0	*10.0*	40%	4	3	3	12	12	*8.5*	Net ha area and % building footprint adopted from final CIE Report figures. Possible land uses include: offices; showrooms; service centres; warehouses; bulky goods re facilities; industrial retail outlets, rural supplies; etc. Demand rate for light industry (typically based on gross ha) adopted, however applied to the building footprint are considered more applicable for this purpose
Solar	710.0	*305.0*	0%	0	-	-	24	24	*85*	Solar farms; energy production facilities. Typically zero or near-zero water demand, hence zero area based demand applied Assumed to have one hydrogen generation facility - capacity and operational assumptions adopted from Final CIE Report (based on 14L water consumption per kg hydr which is potenially conservtive but reasonable)
TOTAL	*1485*	*1030*		310		132	1,213	3,443	*2,718*	Note - highlighted cells are for input into the Water Balance Spreadsheet

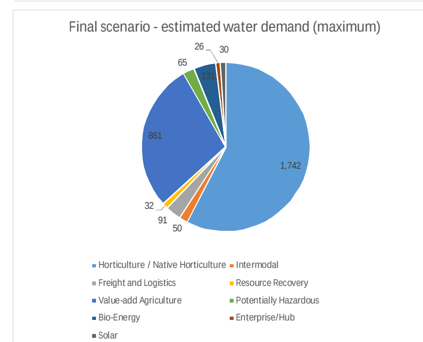
*Note CIE Report designation of town water is described as follows, "In the cases, where the production process of a business is unlikely to use water as an input, town or potable water has been required for employees at the site."

FINAL SCENARIO - Water demand estimate (based on high-level land uses inputs from final masterplan) 03-12-20

Land Use	Net Ha developed	Assumed % of net area applied to demand rate	Area demand rate applied to	Water demand rate (annual) min (ML/ha)	Water demand rate (annual) max (ML/ha)	Water demand (annual) min (ML)	Water demand (annual) max (ML)	Assumptions/comments
Horticulture / Native Horticulture	220.00	88%	193.60	5	9	968	1,742	Possible land-uses include: greenhouses; storage areas; processing facilities; buildings for administration purposes; hard stand areas; aquaculture ponds; intensive plant agriculture; ancillary activities. Demand rates taken as upper end of typical broadscale ag. irrigation rates, (however will vary significantly with proposed land-use and intesity/practices) for 75% of gross area (estimated 88% of net area). Note some alternative methods used to check demands with similar order of magnitude results. Note greenhouse horticulture may have lower demand rates than this (2-5ML/ha order of magnitude) if efficient recirculating practices can be used - unclear what would be grown (potential medical marijuana, mushrooms, leaf vegetables?)
Intermodal	140.00	12%	16.80	3	3	50	50	Possible land-uses include: rail sidings and marshalling yards; storage areas; transfer facilities; assembly and parking of vehicles; buildings for administration purposes; ancillary activities. Demand rate for light industry (based on gross ha) adopted but only applied to 10% of gross area (12% net area) due to expectation of very large lots/yards with minimal buildings
Freight and Logistics	105.00	29%	30.45	3	3	91	91	Possible land-uses include: warehouses; storage areas for goods; transfer facilities; parking and assembly; buildings for offices and administration; ancillary activities. Demand rate for light industry (based on gross ha) adopted but only applied to 25% of gross area (29% net area) due to large lots/parking areas compared to tyupical light industry
Resource Recovery	90.00	12%	10.80	3	3	32	32	Possible land-uses include: intermodal facilities; resource recovery facilities; waste transfer stations; storage area; waste processing facilities; micro-factories (specific recycling products); industrial uses; refuse storage; waste to energy production; landfill. Demand rate for light industry (based on gross ha) adopted but only applied to 10% of gross area (12% net) due to expectation of very large lots/yards with minimal buildings
Value-add Agriculture	70.00	15%	10.50	3	82	32	861	Possible land-uses include: intermodal facilities; industrial facilities; warehouses and production facilities; good transfer and storage. Minimum demand rate based on typical rates for flour mills (the lowest water usage type of food processing and similar to general light industry), maximum demand rate weighted based on assumtion of 20% cereals and 20% food oils (both water intensive), with 20% flour mills and 40% general light industry/warehouses (both lower demand). Demand rate (based on built up ha, applied to 13% of gross area, - approx existing proportion of built up area in south Moree - equivalent to 15% net area). Note - an alternative approach could be to significantly reduce the 20% + 20% cereals and oils assumption and increase the 13%/15% (if appropriate) - this would possibly give a similar outcome overall though
Potentially Hazardous	30.00	29%	8.70	3	7.5	26	65	Assumed similar to 'Energy' category, with possible land-uses: intermodal facilities; waste collection and storage; industrial facilities; waste processing; energy production, warehouses and production facilities; storage and transfer. Minimum demand rate for light industry (based on gross ha) adopted. Maximum demand rate based on 50% light industry and 50% heavy industry adopted. Demand rates applied to only applied to 25% of gross area (29% of net area) due to expected low density of development relative to typical industrial areas (large lots, buffers, not constrained by land)
Bio-Energy	60.00	29%	17.40	3	7.5	52	131	Possible land uses include: intermodal Facilities; waste collection and storage; waste processing; energy production; storage and transfer. Demand parameters assumed equivalent to 'Energy' or 'Hazardous' category
Enterprise/Hub	10.0	88%	8.80	3	3	26	26	Possible land uses include: offices; showrooms; service centres; warehouses; bulky goods retailing; recreation facilities; industrial retail outlets, rural supplies; etc. Demand rate for light industry used (based on gross ha) however only applied to 75% of gross area (88% net)due to expected lower density of development in a regional context, compared to typical light industry (less land constrained, larger lots)
Solar	305.0	0%	0.0	-	-	30	30	Solar farms; energy production facilities. Typically zero or near-zero water demand, hence zero area based demand applied Assumed to have one hydrogen generation facility of equivalent size to Wagga Wagga proposed facility (30ML/year demand based on proposal document)
TOTAL	*1030*		297.05		118	1,308	3,030	Note - highlighted cells are for input into the Water Balance Spreadsheet







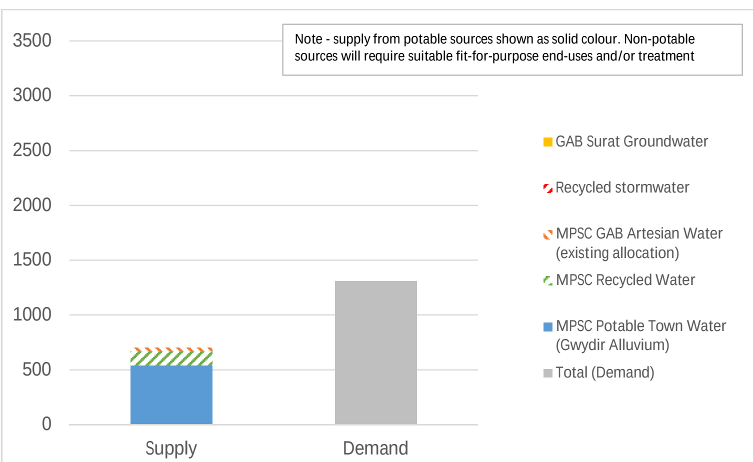
Minimum SAP Development Demand (i.e. of range considered in demand estimate)

			Notes
Supply			
MPSC Potable Town Water (Gwydir Alluvium)	540	ML/year	500ML additional available supply advised by MPSC + 40ML estimated current demand within SAP area
MPSC Recycled Water	122	ML/year	Manually input from Demand Estimate Spreadsheet
MPSC GAB Artesian Water (existing allocation)	40	ML/year	Available remaining component of MPSC allocation (620ML allocation - 580ML current demand)
GAB Surat Groundwater	0	ML/year	Zero current supply - can be increased/source developed to meet deficit
Recycled stormwater	0	ML/year	Zero current supply - can be increased/source developed to meet deficit
Total (supply)	702	ML/year	
Demand			
Total (Demand)	1308	ML/year	Manually input from Demand Estimate Spreadsheet
Surplus/Deficit			
Existing Supply minus Total Demand	-606	ML/year	i.e. required additional supply to support masterplan scenario

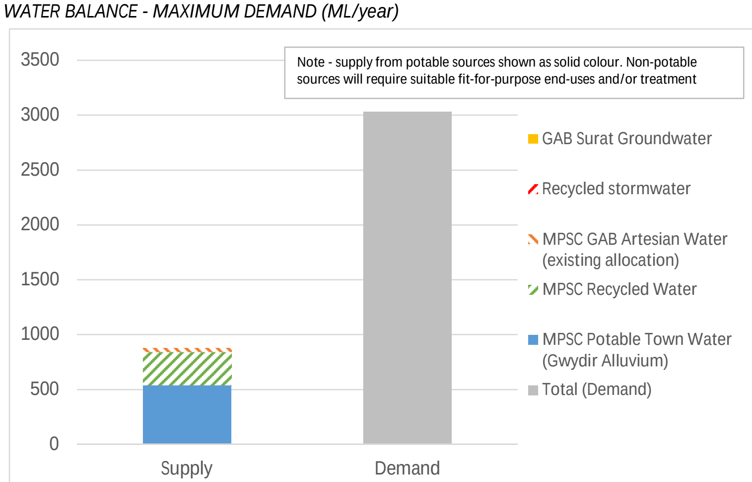
Maximum SAP Development Demand (i.e. of range considered in demand estimate)

			Notes
Supply			
MPSC Potable Town Water (Gwydir Alluvium)	540	ML/year	500ML additional available supply advised by MPSC + 40ML estimated current demand within SAP area
MPSC Recycled Water	300	ML/year	Manually input from Demand Estimate Spreadsheet
MPSC GAB Artesian Water (existing allocation)	40	ML/year	Available remaining component of MPSC allocation (620ML allocation - 580ML current demand)
GAB Surat Groundwater	0	ML/year	Zero current supply - can be increased/source developed to meet deficit
Recycled stormwater	0	ML/year	Zero current supply - can be increased/source developed to meet deficit
Total (supply)	880	ML/year	
Demand			
Total (Demand)	3030	ML/year	Manually input from Demand Estimate Spreadsheet
Surplus/Deficit			
Existing Supply minus Total Demand	-2150	ML/year	i.e. required additional supply to support masterplan scenario

WATER BALANCE - MINIMUM DEMAND (ML/year)



WATER BALANCE - MAXIMUM DEMAND (ML/year)



MOREE SAP WATER DEMAND ANALYSIS - FINAL MASTERPLAN SCENARIO (POTENTIAL FUTURE SOURCES INCLUDED) 11-12-20

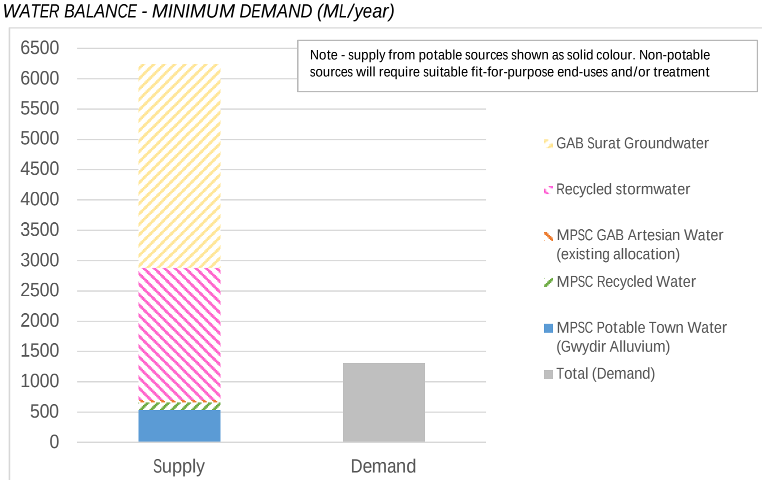
Minimum SAP Development Demand (i.e. of range considered in demand estimate)

			Notes
Supply			
MPSC Potable Town Water (Gwydir Alluvium)	540	ML/year	500ML additional available supply advised by MPSC + 40ML estimated current demand within SAP area
MPSC Recycled Water	122	ML/year	Manually input from Demand Estimate Spreadsheet
MPSC GAB Artesian Water (existing allocation)	40	ML/year	Available remaining component of MPSC allocation (620ML allocation - 580ML current demand)
GAB Surat Groundwater	3360	ML/year	Zero current supply - can be increased/source developed to meet deficit
Recycled stormwater	2180	ML/year	Zero current supply - can be increased/source developed to meet deficit
Total (supply)	6242	ML/year	
Demand			
Total (Demand)	1308	ML/year	Manually input from Demand Estimate Spreadsheet
Surplus/Deficit			
Existing Supply minus Total Demand	4934	ML/year	i.e. required additional supply to support masterplan scenario

Maximum SAP Development Demand (i.e. of range considered in demand estimate)

			Notes
Supply			
MPSC Potable Town Water (Gwydir Alluvium)	540	ML/year	500ML additional available supply advised by MPSC + 40ML estimated current demand within SAP area
MPSC Recycled Water	300	ML/year	Manually input from Demand Estimate Spreadsheet
MPSC GAB Artesian Water (existing allocation)	40	ML/year	Available remaining component of MPSC allocation (620ML allocation - 580ML current demand)
GAB Surat Groundwater	3900	ML/year	Zero current supply - can be increased/source developed to meet deficit
Recycled stormwater	2180	ML/year	Zero current supply - can be increased/source developed to meet deficit
Total (supply)	6960	ML/year	
Demand			
Total (Demand)	3030	ML/year	Manually input from Demand Estimate Spreadsheet
Surplus/Deficit			
Existing Supply minus Total Demand	3930	ML/year	i.e. required additional supply to support masterplan scenario

WATER BALANCE - MINIMUM DEMAND (ML/year)



WATER BALANCE - MAXIMUM DEMAND (ML/year)