Narromine Water Supply System

WATER SECURITY
OPTIONS REPORT

Narromine Shire Council

November 2023

1.0

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Executive Summary

Project background

Narromine's drinking water is currently supplied five bores. Prior to 2020 these were all shallow bores in the upper and lower quaternary aquifers connected to the Macquarie River between Dubbo and Narromine.

To increase the water supply, new deeper bores were drilled into the upper and lower tertiary aquifers. The water drawn from these bores was high in iron and manganese which consumed chlorine and caused dirty water. A temporary water treatment plant was built to remove the iron and manganese.

Narromine Shire Council (NSC) holds a licence under the *Water Management Act 2000* to extract up to 2,000 ML/year of groundwater from their licenced bores. The Integrated Water Cycle Management (IWCM) Issues Paper (PWA, 2022) predicts that unrestricted future water demand will be 1,280 ML/year. While this is less than the licence allocation, the yield from the bores has not recovered since the drought and is not currently able to supply the unrestricted future demand.

Narromine was assessed under the NSW Safe Secure Water Risk Rating Framework has having a Level 5 risk score for water security.

Additional water source(s) are therefore required to supplement the existing bores in order to continue to supply sufficient water to Narromine.

Options assessment

The following options were assessed to improve water security:

1. Continue to use groundwater bores and locate sites for additional bores to meet demand.
2. Utilise the existing bores and supplement with water from the Macquarie River. A raw water pump station would need to be constructed on the site of the discussed pump station utilising the wet well with new pumps, intake and building. There are three possible options for the pipeline route.
3. Supply treated drinking water from Dubbo Regional Council to Nymangee Street Reservoir. There are two possible options for the pipeline route.

A triple bottom line methodology to assess environmental, social and financial impacts of each option. This methodology aligns with NSW Government Integrated Water Cycle Management Information Sheet 2 (DOI, 2019)

Environmental assessment

Expansion of the extraction from the current aquifer may exceed the environmentally sustainable abstraction volume. CSIRO have indicated that the current total entitlement for the Upper Macquarie Aquifer is 38.4 gigalitres per year (GL/yr) and that the 2004/05 abstraction was 37 GL.

As there is currently limited drawdown on the Macquarie River in the vicinity of Narromine, the River is likely to experience minor changes in hydrological flows downstream of the proposed

river offtake for Option 2. Route 1 for this option runs down Dandaloo St and has the potential to impact on heritage sites on this street.

Option 3 has a pipeline route of up to 38 km including areas mapped as supporting threatened ecological communities and threatened species. There is potential for direct and indirect impacts to up to 380 ha of native and non-native vegetation, and habitat for 440 threatened species. There were 142 objects or places of Aboriginal heritage significance along the pipeline route.

Social assessment

Option 1 relies on a single aquifer source and changes in raw water quality, bore yield or failure could result in reduced volume or quality of treated drinking water. This option therefore brings significant risks in that it will not meet the levels of service.

Option 2 has two separate water sources that provide redundancy if one source cannot be utilised due to quality or equipment failure. It can also be expanded to cater for unforeseen developments in Narromine by operating the river pump station more frequently. The pump station will be located on land already owned by Council. The pipeline for route 2 runs through the main street and will impact the community during construction and repairs.

For Option 3 Dubbo Regional Council have advised that they would not have any spare capacity during high summer demand. This option would not be able to meet the required levels of service without Narromine Shire Council constructing and maintaining its own raw water and treatment systems.

Financial assessment

T A preliminary high level concept was developed for each options to prepare a high level estimate of the capital cost for each item. Operating and maintenance costs were based on PSC's current costs for electricity and an allowance for maintenance.

Due to uncertainty on the location of any additional bores and the low scores for environmental and social impacts, costs of Option 1 have not been estimated and it is not considered further.

Option 2 has the lowest capital and whole of life costs (present value) with Route 1 being marginally lower costs than Route 2 due to shorter pipeline route.

Triple bottom line

The overall environmental and social scores and the present value were used to calculate and overall score and ranking for the options (see Table i-i).

Table i-i. Triple bottom line

Assessment	Option				
	2-1	2-2	2-3	3-1	3-2
Environmental score	5.7	6.3	6.3	1.7	1.7
Social score	6.8	7.8	7.0	2.4	2.4
Environmental & social score (ESS)	**12.50**	**14.10**	**13.30**	**4.10**	**4.10**
Total present value (PV)	**15.33**	**15.83**	**17.42**	**37.98**	**42.97**
ESS/PV	**0.82**	**0.89**	**0.76**	**0.11**	**0.10**

Assessment	Option				
	2-1	2-2	2-3	3-1	3-2
Ranking	**2**	**1**	**3**	**4**	**5**

Based on this assessment, Option 2 is preferred with lower costs and better outcomes for environmental and social factors. Of the possible routes for the pipeline from the river to the water treatment plant, Route 2 is preferred.

Water efficiency measures

The average water demand in Narromine is 264 L/person/day which is equivalent to a 1 STAR WELS rating for water fixtures.

All of Narromine's water is currently pumped from bores and any future water sources will also require pumping. Treated water is then pumped to the reservoirs. Any savings in water demand will also reduce energy costs to Narromine Shire Council through saved pumping costs.

A high-level assessment of possible water efficiency measures to reduce the demand for water in Narromine was undertaken with the following recommendations:

1. Consider water recycling in any future upgrade of Narromine STP
2. Develop and implement a community education program on water saving measures including:
    - Improving public understanding regarding the significance of the water restriction levels.
    - Education on water efficient appliances including evaporative coolers.
    - Continuing the distribution of annual newsletter with information about water pricing, water restrictions and water saving tips.
    - Hosting workshops to educate the public about water saving options in the garden and home.
    - Developing and implementing a school education program.
    - Development of a promotional video that will emphasise the importance of water conservation.
3. Develop and implement a water loss management plan
4. Consider limited time rebates for replacement of water fittings and appliances (including evaporative coolers).

Recommendations

Based on the options assessment, it is recommended that Option 2 Route 2 be taken forward to concept design. This option consists of the following:

- Maintain the existing bores
- Utilise this existing pump well and install new duty/standby pumps with a capacity of 102 L/s, suction pipeline, intake screen and building

- Pipeline route crossing the Mitchell Highway then travelling south down Third Avenue N, south down Square Lane onto Third Avenue S and south until Tancred Street and south-west along The McGrane Way to the water treatment plant.

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Glossary

Item	Detail
ADWG	Australian Drinking Water Guidelines
CCP	Critical Control Point
CTW	Central Tablelands Water
DICL	Ductile Iron Concrete Lined
DOI	Department of Industry
DPE	Department of Planning and Environment
DRC	Dubbo Regional Council
DWMS	Drinking Water Management System
ESS	Environmental and Social Score
GAC	Granular Activated Carbon
GL	Gigalitre
HBT	Health Based Targets
HEC	Harwood Environmental Consultants
ISO	International Organisation for Standardisation
IWCM	Integrated Water Resource Management
LOS	Levels of Service
LWU	Local Water Utility
ML	Megalitre
NPV	Net present value
NSC	Narromine Shire Council
NSW	New South Wales
NSW Health	NSW Ministry of Health
PV	Present Value
PWA	Public Works Advisory
STP	Sewage Treatment Plant
TBL	Triple Bottom Line
TEF	The Environmental Factor
TGO	Tomingley Gold Operations
TRB	Typical Residential Bill
WAL	Water Access Licence
WSP	Water Sharing Plan
WTP	Water Treatment Plant

1 Introduction

1.1 Project background

Narromine Shire located in central NSW approximately 330 km north-west of Sydney and about 40 km west of Dubbo. The major urban centre in the Narromine Shire is the Narromine township, along with two other towns Trangie and Tomingley.

Narromine's drinking water is currently supplied by five bores. Before 2020 these were all shallow bores in the upper and lower quaternary aquifers connected to the Macquarie River between Dubbo and Narromine. During the drought between 2017 and 2020, the yield of these shallow bores dropped up to 50%.

To increase the water supply, new deeper bores were drilled into the upper and lower tertiary aquifers. The water drawn from these bores was high in iron and manganese which consumed chlorine and caused dirty water. A temporary water treatment plant was built to remove the iron and manganese.

Narromine Shire Council (NSC) holds a licence under the *Water Management Act 2000* to extract up to 2,000 ML/year of groundwater from their licenced bores. The Integrated Water Cycle Management (IWCM) Issues Paper (PWA, 2022) predicts that unrestricted future water demand in 2042 will be 1,280 ML/year. While this is less than the licence allocation, the yield from the bores has not recovered since the drought and is not currently able to supply the unrestricted future demand.

Narromine was assessed under the NSW Safe Secure Water Risk Rating Framework has having a Level 5 risk score for water security.

Additional water source(s) are therefore required to supplement the existing bores to continue supplying sufficient water to Narromine.

1.2 Document purpose

The purpose of this document is to assess options to improve security of drinking water supply water to the town of Narromine. The preferred option must meet NSW legislative requirements and the levels of service acceptable to the community.

1.3 Current Narromine water supply system

1.3.1 Catchment

Narromine Shire sits within the Macquarie – Bogan River Catchment, which is 74,800 km^2. This catchment provides water to around 180,000 people, and includes a number of major cities and towns, including Dubbo and Nyngan, and also provides water to some of the smaller towns such as Warren and Narromine. Land use in this catchment is dominated by grazing (82%), with dryland cropping accounting for the second highest level of land use (9%) (Narromine DWMS, 2018).

Narromine gets its water from bores that are drilled along the Lower Macquarie Alluvium sediments associated with ancient channels of the Macquarie River, downstream of Narromine. Water in the aquifer is part replenished by water that leaks from the river or is pumped from the river and then seeps into the aquifer from irrigation channels and irrigated fields. (Narromine DWMS, 2018)

Raw water characteristics of Narromine Water supply vary depending on which bore is being used. Typical characteristics include:

- neutral pH
- variable turbidity (for a bore supply)
- high iron and manganese

1.3.2 Water treatment and distribution

Water extracted from Bores 6, 8D and 9 is processed through the temporary iron and manganese removal plant. This treated water is then combined with water from Bores 3 and chlorinated and distributed to customers.

The Narromine water supply systems are shown in Figure 1-1 and Figure 1-2.

Supply system changes in 2022 included installing a temporary iron and manganese removal system to treat water from bore 6, 8 and 9. The plant was brought online for the first time in June 2020. It is owned and operated by an external contractor.

Table 1-1. Summary of water supply systems

Category	Description
Customers	1,718
Consumers	567 private dwellings (census 2016),7 Hotels/Motels, Caravan Park, 11 schools, 2 Hospitals, 3 Nursing Homes and 216 businesses (including industrial). Irrigation of parks and ovals by separate surface water licence for extraction from the Macquarie River. (Swan 2016)
Temporary iron and manganese removal plant	Temporary WTP (bore 6, 8D and 9 only) • ISO reactor (aeration, ozonation, pH correction with Sodium Hydroxide) • Green sand filtration • Granular activated carbon (GAC) filtration • Clarified backwash water recycled to head of works
Aeration & disinfection	The water supply is pumped into the aeration tank which is not currently operating but provides storage for high lift pumping. It is then pumped through duty/standby high lift pumps and flow paced disinfected with gaseous chlorine (gas chlorine installed January 2018, previously sodium hypochlorite).
Reservoirs	Two 4.0 ML steel reservoirs, one on Nymagee St and the other on Duffy St both have top fill and bottom discharge. Reservoirs are interconnected through the rising main, with flow to Duffy St reservoir restricted to manage the flow to both reservoirs.
Critical control point (CCP) monitoring	Free & total chlorine, turbidity and pH are monitored through online instrumentation on the outlet of Duffy St and Nymagee St reservoirs. Free chlorine is also monitored by online instrumentation on the inlet to Nymagee St Reservoir.

Figure 1-1. Narromine water supply system flow diagram

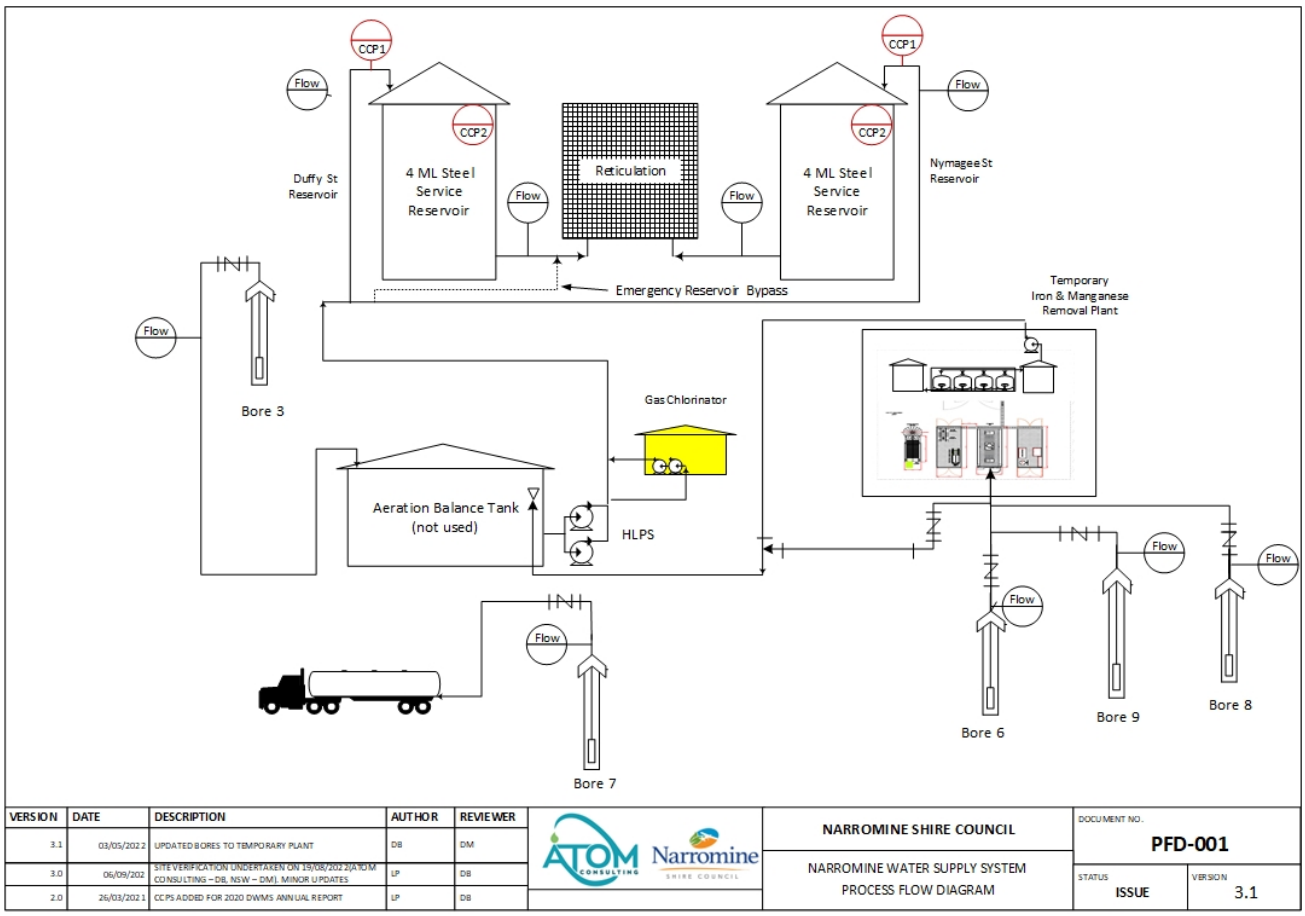
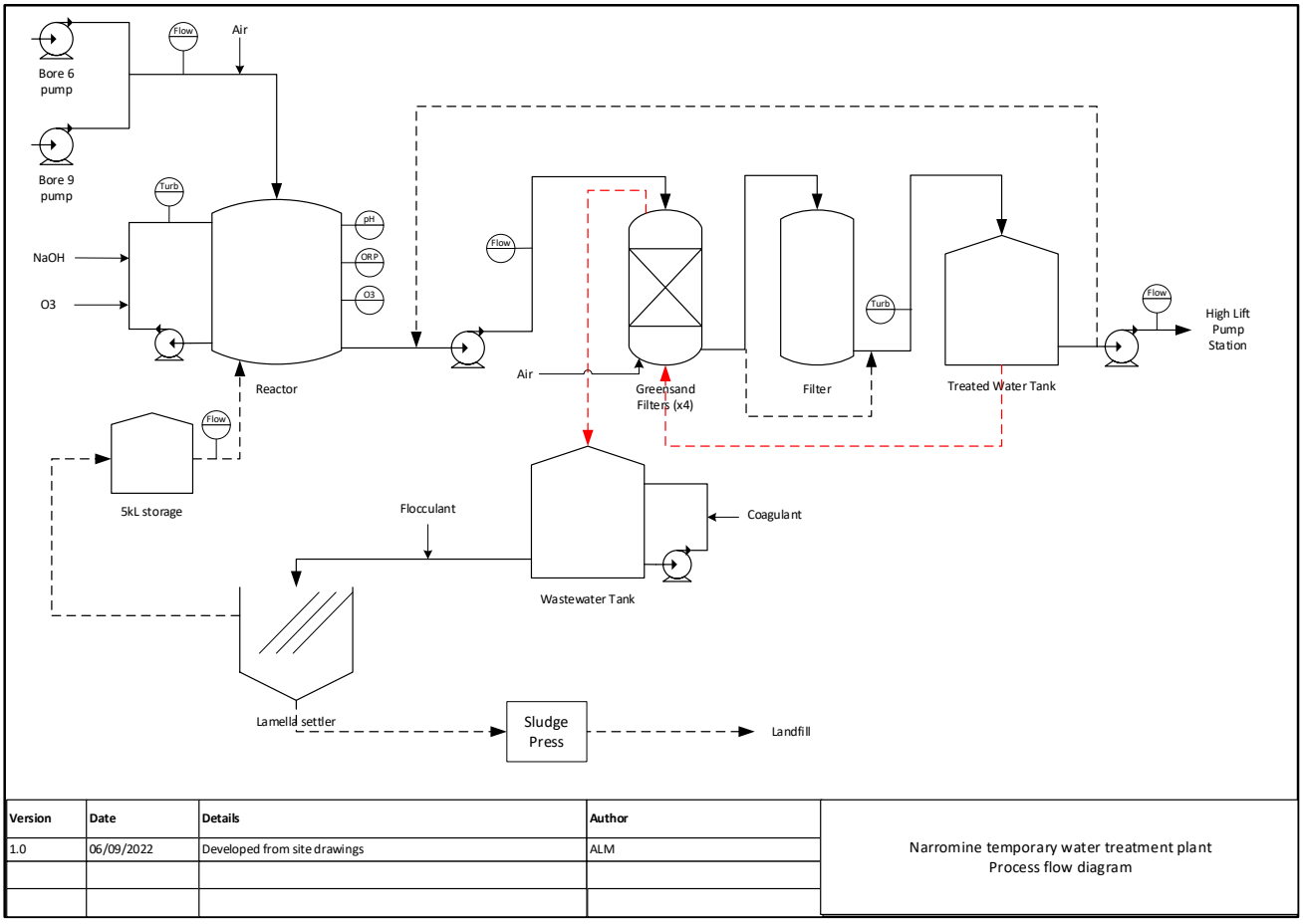


Figure 1-2. Narromine Temporary WTP flow diagram



1.4 Integrated Water Cycle Management

The Integrated Water Cycle Management (IWCM) Strategy is a local water utility's (LWU's) 30-year strategy for the provision of appropriate, affordable, cost-effective and sustainable urban water services that meet community needs and protect public health and the environment. The IWCM Strategy

- Identifies the water supply and sewerage needs of LWU
- Appropriately sizes' any infrastructure projects and determines their priority, and considering of whole-of-life costs
- Identifies the lowest level of sustainable Typical Residential Bill (TRB) to meet the levels of service, while maintaining cost recovery
- Includes a 30-year Total Asset Management Plan and Financial Plan.

The process of preparing an IWCM Strategy broadly includes the following:

- Preparation of an IWCM Issues Paper
- Evaluation of feasible options
- Creation of IWCM Scenarios
- Developing the IWCM Strategy
- Preparation of a Total Asset Management Plan and Financial Plan
- Public exhibition
- Concurrence by DPE and adoption by Council

The IWCM Issues Paper (PWA, 2022) identified that water quality from the Narromine Water Supply System was had very high risk of not being ablet to meet future water demand.

This report assesses options to reduce the water security risks in the Narromine Water Supply System

1.5 Levels of Service

The levels of service for drinking water supply proposed in Table 6-1 of the IWCM Issues Paper (PWA, 2022) are shown in Table 1-2.

Table 1-2. Current levels of service

Objective	Service Standard	Performance indicator	Target
Adequate potable water for current and future generations with reasonable level of restrictions	5/10/10 rule based on 99th percentile unrestricted future demand based on DPE Water's draft guidelines "Assuring future urban water security, Assessment and Adaption guidelines for NSW local water utilities"	Average duration of drought-related restrictions	Restrictions no more than 5% of time
		Frequency (average number) of drought-related Level 3 restrictions	Less than one event per 10 years
		Supply capacity during normal worst recorded drought demand	90% of normal demand
Projected town water supply extraction is within the upper limit of the water extraction licence and meets any licence conditions	Not exceeding the licensed entitlement and any other conditions	Annual volume of water extracted	Narromine Potable WAL: 2,000 ML/year
Minimise water resource dependent environmental and third-party impacts	100% compliance with the Water Sharing Plan (WSP) requirements.	Number of breaches with the WSP requirements	Nil breaches
	100% compliance with the work approval conditions	Number of breaches with the work approval conditions	Nil breaches

Source: PWA, 2022

2 Regulatory context

2.1 NSW Public Health Act

The *Public Health Act 2010 (NSW)* s25 (1) requires all drinking water suppliers to establish, and adhere to, a quality assurance program that addresses the elements of the Framework for Management of Drinking Water Quality (as set out in the Australian Drinking Water Guidelines published by the National Health and Medical Research Council) that are relevant to the operations of the supplier of drinking water concerned. To assist suppliers in preparing the drinking water systems NSW Health and NSW Department of Primary Industries - Office of Water have published the NSW Guidelines for Drinking Water Management Systems (NSW Ministry of Health 2013).

The Public Health Regulation (NSW) was updated on 1 October 2018 to include specific DWMS requirements. The regulation requires (Clause 34B):

(i) an assessment of the risks to the drinking water supply system

(ii) an assessment of the maximum and residual risks to the drinking water supply system

(iii) identification of hazards to the drinking water supply system

(iv) measures to prevent any hazards to the drinking water supply system (preventive measures)

(v) actions to improve the drinking water supply system

(vi) management, if possible, of any risks to the drinking water supply system assessed (control points)

(vii) communication to staff about control points that are critical to the drinking water supply system and drinking water quality (critical control points).

2.2 NSW Water Management Act

The *Water Management Act 2000 (NSW)* Part 2 requires a Water Access Licence (WAL) be issued and complied with when extracting water from a water source including aquifers and rivers (regulated or unregulated). NSC currently has a WAL to extract water bore water in Narromine to supply drinking water.

The Act also defines the requirements for Water Sharing Plans which are used to define how WALs will be issued and rules for extraction under these licences. The following WSPs are currently in place for water that is accessible within NSC's local government area.

- Macquarie-Castlereagh Groundwater Sources 2020
- Macquarie and Cudgegong Regulators Rivers Water Source 2016
- Macquarie Bogan Unregulated Rivers Water Sources 2012

2.3 NSW Local Government Act

The *Local Government Act 1993 (NSW)* s60 requires councils to gain approval prior to constructing or extending any water treatment works. Narromine Shire Council will therefore need to seek approval through DPE to construct any water treatment options recommended by this report.

2.4 Australian Drinking Water Guidelines

The ADWG is the authoritative document for drinking water management in Australia. It contains information about the management of drinking water systems, monitoring regimes, and contaminants that may be present in drinking water. As the knowledge base has increased, the document has grown in both detail and complexity. The guiding principles have been developed to outline fundamental considerations for safe drinking water:

- The greatest risks to consumers of drinking water are pathogenic microorganisms.
- Protection of water sources and treatment are of paramount importance and must never be compromised.
- The drinking water system must have, and continuously maintain, robust multiple barriers appropriate to the level of potential contamination facing the raw water supply.
- Any sudden or extreme change in water quality, flow or environmental conditions (e.g. extreme rainfall or flooding) should arouse suspicion that drinking water might become contaminated.
- System operators must be able to respond quickly and effectively to adverse monitoring signals.
- System operators must maintain a personal sense of responsibility and dedication to providing consumers with safe water and should never ignore a consumer complaint about water quality.
- Ensuring drinking water safety and quality requires the application of a considered risk management approach.

3 Production requirements

The IWCM Issues Paper (PWA, 2022) Tables 8.12 to 8.14 provides average and peak demand for the Narromine water supply scheme. This average year demand peaks in 2037 and the peak day in 2042.

Depending on the coagulant dose and treatment process a water treatment plant typically produces wastewater between 2% and 15% of the raw water treated. Some of this may be returned following wastewater dewatering processes. It has therefore been assumed that 95% of the raw water volume treated is produced as drinking water following treatment.

The project demand and required raw water extraction are shown in Table 3-1.

Table 3-1. Expected demand and raw water volumes in 2042

Demand	Demand projection	Raw water extraction
Average year (ML/year)	825	868
Unrestricted future dry year (ML/year)	1,280	1,345
Peak day (ML/day)	7.5	7.9

4 Groundwater assessment

An assessment of the capacity to source water for Narromine from groundwater was undertaken by Harwood Environmental Consultants (HEC) and their report is included as Appendix A.

The methodology for this assessment included:

- Desktop review of the hydrogeology, hydrology and management of the aquifer
- Review of individual bore pumping tests
- Groundwater modelling of current system
- Assessment of options to supply the future peak daily demand and average yearly demand from groundwater alone.

4.1 Review of aquifer

NSC currently draws groundwater from five bores in the Lower Macquarie Alluvial Aquifer. Rainfall recharge is less than the current licenced abstraction and recharge is therefore reliant on leakage from the Macquarie River and irrigation return flows pumped from the river. As the Macquarie River is regulated, the long-term sustainability of groundwater abstraction is highly dependent on releases from Lake Burrendong.

4.1.1 Private bores

There are a large number of existing bores around Narromine with the paleochannel to the south of the town having a large number of bores for irrigation and stock. The extent of the bores are shown in Figure 4-1.

4.1.2 Water Access Licences

The five bores currently in operation draw water from the aquifer's lower quaternary, upper tertiary and lower tertiary layers. The WALs for these bores are summarised in Table 4-1.

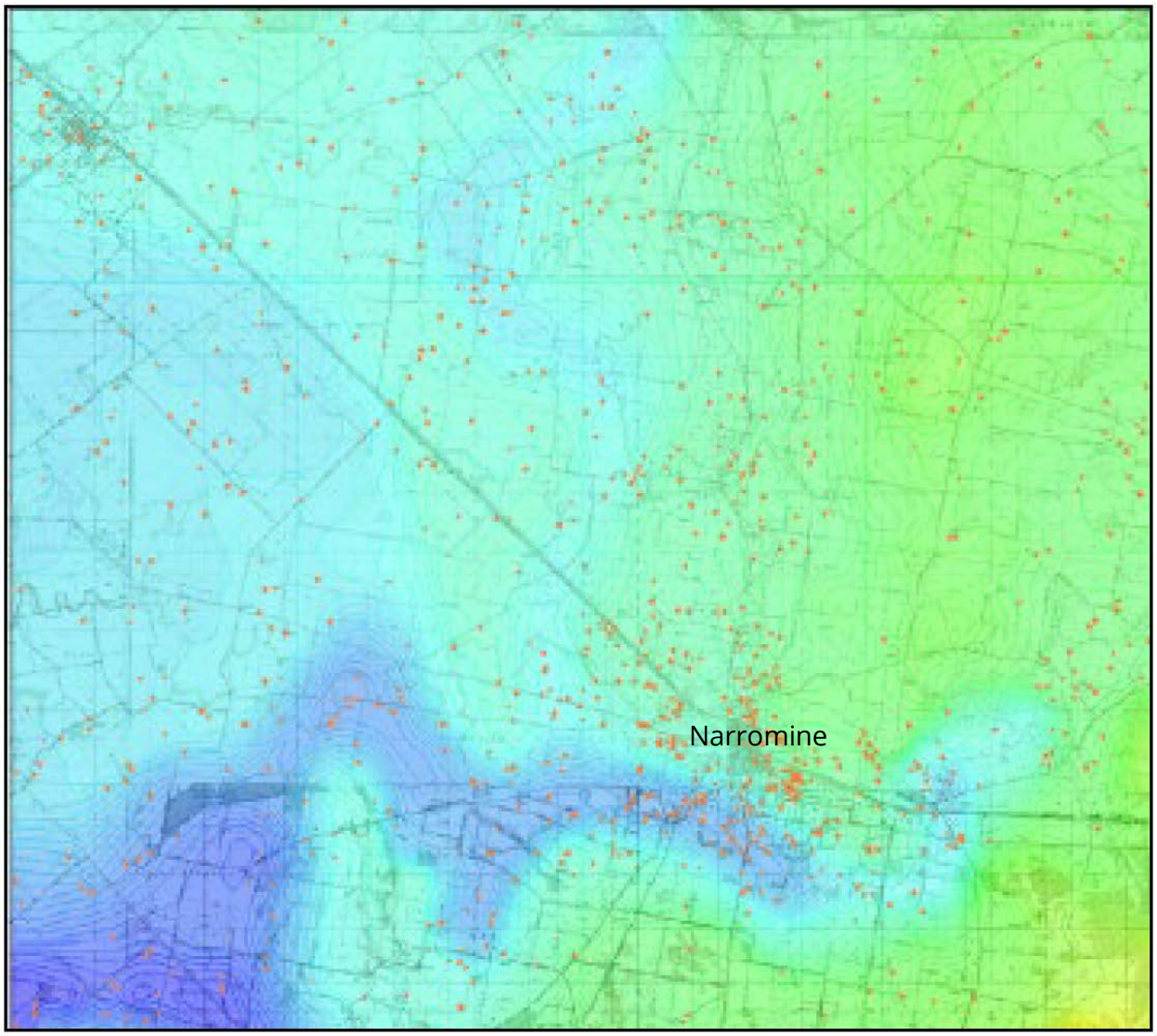
Table 4-1. Narromine Shire Council Water Access Licence

Item	Description
Licence number	WAL11603
Category	Local Water Utility
Entitlement	2,000 ML/year
Water Source	Lower Macquarie Zone 1 Groundwater Source
Water Sharing Plan	Macquaire-Castlereagh Groundwater Sources 2020

While the entitlement exceeds the unrestricted future dry year of 1,280 ML/year, NSC have not been able to access this amount of water from the aquifer.

Under the WSP, the annual extraction limit in Zone 1 is set to 21,675 ML/year.

Figure 4-1. Distribution of bores around Narromine



Source: HEC, 2023

4.2 Bore pumping tests

Early pumping test data by Impax Drilling was reviewed as there was no more recent drawdown data. Long term drawdown was assessed using the Cooper-Jacob straight line solution based on 70 days of continuous pumping.

The current yield of each bore is shown in Table 4-2. While the total yield can meet the 2042 peak day demand of 7.5 ML/day, this is based on individual pump draw down and modelling is required to confirm the capacity of the aquifer to supply this peak demand. It should also be noted that the loss of Bore 9 due to mechanical failure or poor water quality will result in a maximum flow of less than 7.5 ML/day.

Table 4-2. Yield of current bores

Bore	Completion date	Test Year	Ground water source	Yield (L/s)	Yield (ML/d)
3	1965 (renewed 2018)	2019	Lower quaternary	20	1.73
6	2016	2016	Upper tertiary	35	3.02
7	2016	2016	Upper tertiary	15	1.30
8	1979	2019	Lower quaternary	9.5	0.82
9	2016	2016	Lower tertiary	50	4.32
Total				**129.5**	**11.19**

4.2.1 Drought resilience

HEC have estimated that if river recharge was minimal over a ten year period due to low flow from Burrendong Dam, there is likely to be a drop in standing water level of up to 5m. This is likely to result in a decrease in yield of up to ten percent.

4.3 Groundwater modelling

A numerical groundwater model of the aquifer was developed by Manewell Groundwater and reviewed by HEC. The model was calibrated with historical data to provide a long term view into the future.

The six scenarios in Table 4-3 were simulated to determine the maximum groundwater drawdown in the unconsolidated aquifer and assess the viability of the Narromine town supply borefield from 2009 (start of the water sharing plan) to 2052.

Table 4-3. Groundwater model scenarios

Scenario	Active NCC bores	NCC target abstraction rate (ML/year
1	6D & 9D	Average up to 825
2	6D & 9D	Unrestricted up to 1,280
3	3, 6D, 7D, 8D & 9D	Average up to 825
4	3, 6D, 7D, 8D & 9D	Unrestricted up to 1,280
5	No pumping post 2009	None
6	No pumping post 2023	None

Modelling of the groundwater system shows some uncertainty that the current bores can supply the future needs of Narromine. There is little opportunity to construct new bores near the town. Groundwater with good yield and water quality would require long pumping distances when compared with alternative water sources such as the Macquarie River.

4.4 Tomingley Gold Operations

Tomingley Gold Operations (TGO) currently operate a bore within the Narromine groundwater source. This water is used for the mine and excess water is transferred to a dam at Tomingley under an agreement between TGO and NSC. NSC treat this water and distribute to customers within the town of Tomingley.

A pipeline could be constructed from the TGO bore to Narromine , The bore is located approximately 7km east of Narromine and a supply pipeline will needs to cross the Mitchell Highway.

Preliminary discussions with TGO for another project indicated that TGO currently uses its full allocation from this bore and that there would be little available for other sites. Further discussions with TGO would be warranted if this option was preferred. Once the mine reaches the end of its life, this bore may become a suitable future supply option, however the mine's end of life is unknown.

This option would be suitable if done in conjunction with the existing NSC bores and would only provide a single water source for Narromine.

4.5 Managed aquifer recharge

Given the high permeability of the deep alluvial sediments, there is some potential to inject water from the Macquarie River during high flow events to provide sufficient storage to enhance the town bores yield.

Prior to undertaking managed aquifer recharge, the compatibility of the water chemistry of the river and groundwater would need to be confirmed as well as understanding the sustainable volume of water that could be extracted from river and injected into the groundwater.

Managed aquifer recharge is also a regional solution that would provide improved yield to all the bores in the aquifer. Alternatively, a dedicated pump station and pipeline from the Macquarie River to NSC's WTP would be an asset that would provide water security to NSC's drinking water community.

5 Other water sources

Potential sources of water to supplement and provide backup to the bores are reviewed in the following sections.

5.1 Macquarie River

The Macquarie River runs to the north of Narromine and is approximately 3.5 km from the site of the proposed treatment plant. Council already owns a site on the River that contains a disused pump station and treatment plant (see Figure 5-1).

Figure 5-1. Macquarie River relative to proposed WTP site

As the Macquarie River is regulated, NCC would need to obtain a WAL. The water quality can have variable turbidity and colour, particularly during high river flows and rainfall. Jar testing of the river water has shown that it is treatable by the same treatment processes that would be required for the bore water with increased chemical dose (Atom Consulting, 2023).

The pipeline route from the river to the treatment plant would need to cross the Mitchell Highway and the railway line.

The option to supply raw water from the Macquarie River is discussed further in Section 7.2.1.

5.2 Burrendong Dam

Burrendong Dam is situated on the Macquarie River just below its junction with the Cudgegong River, about 30 kilometres upstream from Wellington. The dam has a capacity of 1,188,000 ML and is owned and operated by Water NSW.

There is an option to transfer water from Burrendong Dam to the John Gilbert WTP in Dubbo and transfer the treated water to Narromine. This option will include a pipeline from the Dubbo drinking water supply system and Narromine (see Section 5.3.1). The Burrendong Dam provides a secure source of water for regions downstream of the dam provided there is enough water in the dam at the time.

A conceptual design of a proposed pipeline from Burrendong Dam outlet to Dubbo WTP and Wellington WTP was completed by Hunter H_2O in March 2016. The report proposed a 90 km pipeline to transfer 14 ML/d of raw water by gravity. The pipeline was projected to have a cost of $90 million in 2015 which is likely to have significantly increased since.

The Burrendong Dam has a dead storage of 33,000 ML below the 0 % capacity of the dam. This is due to the floor level of the dam being below the invert level of the lowest pump in the dam. The proposed pipe would better utilise water in the dam during allowing for access to the dead storage within the dam during a drought. Dam discharge into the downstream Macquarie River would be cut off if the dam levels approached 0% capacity, the proposed pipeline would be the sole water provider to Dubbo and Wellington. This would allow the remaining water to last significantly longer as there would be reducd water evaporation when transferring the water through a pipeline when compared to an open river.

It is estimated that Dubbo and Wellington use approximately 10,000 ML/year which is assumed to increase in the future. Narromine is projected to have a total demand of 825 ML/year by 2052. By assuming a conservative 40% increase in water demand for Dubbo and Wellington over this time period, these three towns would have a projected water demand of approximately 15,000 ML/year. With a dead capacity of 33,000 ML in Burrendong Dam, water can be supplied to these towns for just over 2 years during a drought after the dam hits the nominal 0% capacity before the dam is below it's minimum operating level.

While this process would provide further water security to the residents living in the towns, people living and operating along the Macquarie River would not be provided water security as their supply would reduce.

As the pipeline from Burrendong Dam provides a regional benefit and would require significant state government funding, it is considered beyond the scope of this report.

5.3 Neighbouring local water utilities

The bore water supply to Narromine could be supplemented by the purchase of bulk water from a neighbouring water utility. Four LWUs share a border with NSC, and each are discussed in the following sections.

5.3.1 Dubbo Regional Council

Dubbo Regional Council (DRC) extract water from the Macquarie River and groundwater bores. This water is treated at John Gilbert WTP to supply the town of Dubbo. Dubbo is approximately 40 km from Narromine via the Mitchell Highway.

DRC were contacted regarding the potential to supply bulk water to Narromine. They advised that the John Gilbert WTP currently has no spare capacity during peak day demand from Dubbo. There is spare capacity during periods of lower demand which could help to conserve water in the Lower Macquarie Alluvial Aquifer to be used by NSC during peak demand.

This option is considered further in Section 7.

5.3.2 Parkes Shire Council

Parkes is approximately 100 km from Narromine which is considered too far to be feasible to construct a pipeline. The Parkes WTP is also currently running at capacity during peak day demand.

The Parkes WTP supplies the town of Peak Hill which is around 56 km from Narromine. Parkes Shire Council have advised that this system is currently limited by the transfer pipeline from Parkes and there is currently no spare capacity.

The option to supply NSC with water from Parkes has not been considered further.

5.3.3 Cabonne Council & Central Tablelands Water

Cabonne Council operate a water treatment plant at Molong which is approximately 140 km form Narromine. While water from Molong WTP supplies Yeoval, this is still around 90 km from Narromine and there is limited capacity in the main.

Other towns within the Cabonne Local Government Area are supplied with water by Central Tablelands Water (CTW). As CTW supply water to many small towns that are long distances apart their trunk mains have limited capacity to supply Narromine. CTW's treatment plants are at Blayney and Carcoar which are over 200 km from Narromine.

Due to the long distances, supplying water from Cabonne Council or Central Tablelands Water has not been considered further.

5.3.4 Warren Shire Council

Warren source water from bores to supply around 2,600 people. As this is smaller than Narromine, this option has not been considered further.

5.4 Narromine irrigation canals

The Narromine Irrigation Board of Management operates a system of irrigation canals that are fed by pumps in the Macquarie River that have a capacity of 1,000 ML/day. The Narromine Irrigation Board of Management operates as a private irrigation board under the *Water Management Act (NSW)*.

One of the irrigation canals is within 2.5 km of the proposed WTP site and would eliminate the requirement for a raw water pipeline crossing the Mitchell Highway and the Inland Rail.

The Narromine Irrigation Board of Management was created to provide water for its members to for agricultural purposes. Their licence therefore may not provide enough security to provide town drinking water and there could be conflict between NSC and irrigators during drought periods if the irrigation scheme was only used to supply town water.

This option has therefore not been considered further.

5.5 Stormwater harvesting

There is a wetland outside the centre of Narromine bounded by The McGrane Way and Gainsborough Road. This wetland receives stormwater from the town and is proposed to be expanded to provide stormwater detention. The location of the wetland and the proposed WTP site are shown in Figure 5-2.

Figure 5-2. Location of wetland and WTP site

NSC have advised that the ponds have a capacity of 290 ML which is around 80 days at the future unrestricted annual demand and 38 days at the future peak day demand.

As this storage will not be available during extended dry weather, the capacity of other sources will need to cater for the required demand. Use of water from the wetland, however, may conserve groundwater for use during these dry periods and therefore reduce the frequency of

water restrictions. Due to settling in the ponds, the water quality may also be better and less variable than the Macquarie River during high rainfall.

The wetlands are also adjacent to the proposed treatment plant site and the capital and operating costs of pumps and rising main will be lower than for other sources.

6 Water efficiency measures

The baseline internal demand in Narromine is 264 L/person/day (PWA, 2022). This is equivalent to a 1 STAR WELS rating for water fixtures (AS/NZS 6400). The peak day demand to average day demand ration for Narromine is 2.7 compared with a typical range of 2 to 2.5 (PWA, 2022).

All of Narromine's water is currently pumped from bores and any future water sources will also require pumping. Treated water is then pumped to the reservoirs. Any savings in water demand will also reduce energy costs to NSC through saved pumping costs.

A high level assessment of possible water efficiency measures to reduce the demand for water in Narromine.

6.1 Water recycling

Water recycling can reduce water demand where it replaces drinking water usage (e.g. irrigation of public space). The current Narromine Sewage Treatment Plant (STP) would require significant upgrades to meet the requirements for municipal irrigation in the Australian Guidelines for Water Recycling. Any industrial user would most likely also require higher water quality than the Narromine STP can currently produce.

It is recommended that water recycling be considered in any future upgrade planning for the Narromine STP.

6.2 Permanent water restrictions

Some LWUs in NSW have implemented permanent Level 1 water restrictions. The current demand is 264 L/person/day (PWA, 2022) which is close to the NSC's target for Level 1 water restrictions of 260 L/person/day.

It is, therefore, not considered worthwhile to implement permanent Level 1 water restrictions.

6.3 Community education

NSC currently have a link on their website with water saving tips. These tips are also added to posts on their Facebook page during water restrictions.

For this measure to effectively impact demand it must be implemented consistently, particularly in drought periods. Community education should include:

- Improving public understanding regarding the significance of the water restriction levels
- Education on water efficient appliances including evaporative coolers
- Continuing the distribution of annual newsletter with information about water pricing, water restrictions and water saving tips
- Hosting workshops to educate the public about water saving options in the garden and home
- Developing and implementing a school education program
- Development of a promotional video that will emphasise the importance of water conservation.

6.4 Water loss management

Current water losses are estimated at 19% of the water produced (PWA, 2022). The unit water loss in 2020/21 was around 264 L/assessment/day which is 3 times the state median of 92 L/assessment/day (PWA, 2022). There is therefore potential to reduce water demand by reducing water losses.

The four methods to reduce leaks methods are:

- Active leak control: to actively detect and repair leaks that are currently undetected and unreported
- Pressure management: adjustment and control of water pressure in different zones of the water supply system to reduce the frequency of leaks and flow from leaks
- Infrastructure management: asset management process to replace assets which are the highest priority to reduce real losses
- Speed and quality of repairs: development of procedures and retention of critical spares to repair leaks quickly and reduce the likelihood of future leaks in the same location.

NSC should develop a water loss management plan including monitoring and maintenance to reduce water losses.

6.5 Key user internal efficiency audits

NSC should maintain a list of the high quantity water customers and during periods of water restrictions level 3 or higher. This will encourage internal water efficiency audits to be carried out by the customers. It is predicted that this will only require two years of implementation.

High quantity water customers may include:

- Commercial businesses
- Schools
- Industrial sites
- Parks and sporting ovals.

6.6 Rebates for water efficient appliances

The IWCM Issues Paper (PWA, 2022) noted the potential to reduce the residential internal demand by using water efficient fittings and appliances and reducing the number of evaporative coolers.

While NSC should continue to encourage residents to install water efficient fittings and appliances through community education as discussed in Section 6.3, incentive to achieve this earlier may be achieved by NSC offering rebates for a limited period.

For smaller communities like Narromine, the cost of rebates it typically higher the savings in water production. This however does not consider the benefits of allowing for more development without upgrading the water supply infrastructure and the environmental savings of reduced water extraction.

It is therefore recommended that NSC consider offering rebates for replacement of water fittings and appliances (including evaporative coolers) for a limited time.

7 Water security options

7.1 Water security requirements

The treatment options that are required to meet the levels of service are described in Table 1-2. Further details on the requirements to achieve these levels of service are provided in the following sections.

7.1.1 Production requirements

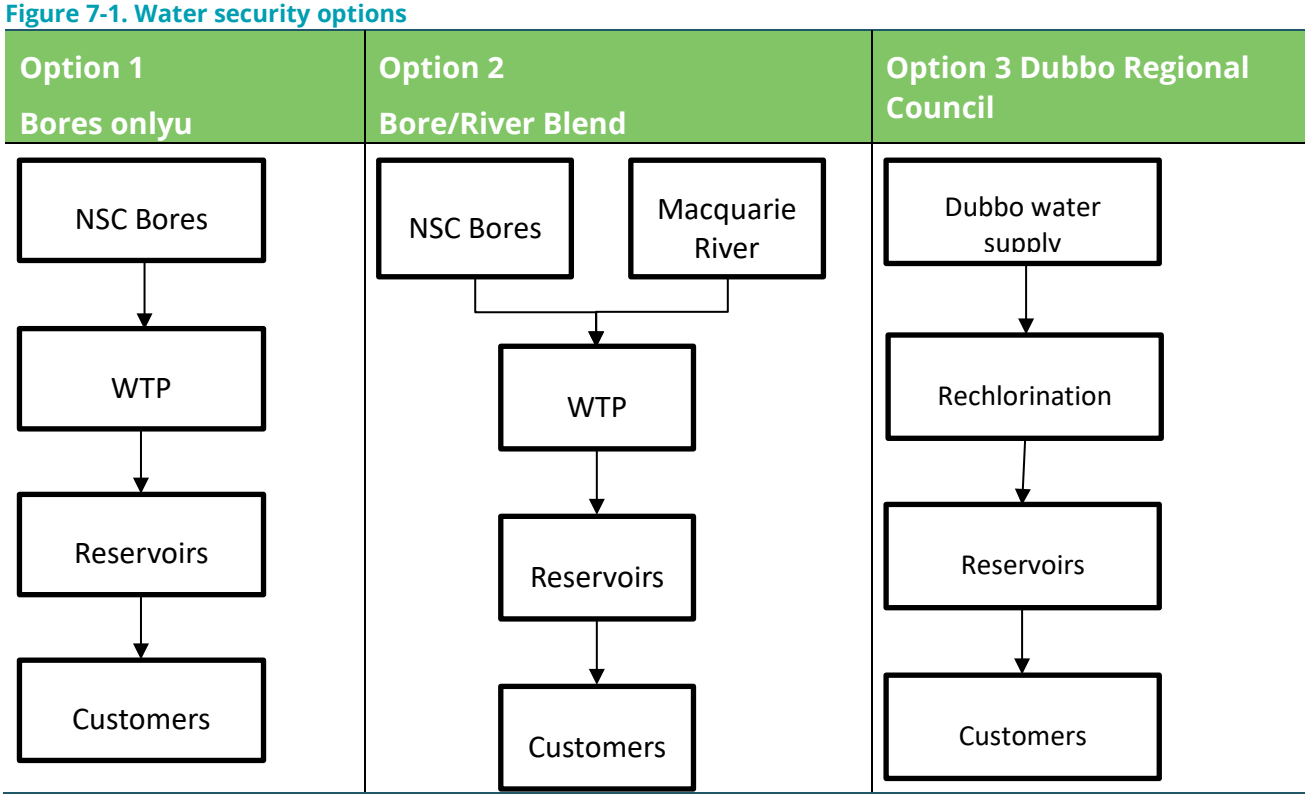
The IWCM Issues Paper (PWA, 2022) Table 8-14 provides peak day demand for the Narromine water supply scheme. This demand peaks at 7.5 ML/day in 2042 and has been used for the peak capacity of the water security options. For options with multiple sources, this capacity will be capable of being achieved by either source alone.

7.2 Options assessment

7.2.1 Water security options

The options from Sections 4 and 5, that were considered for detailed options assessment are shown in Figure 7-1and discussed in the following sections.

Figure 7-1. Water security options



Option 1 – Current groundwater source

This option continues to utilise the existing four bores and location of additional bores to meet the future demand.

Based on the aquifer modelling undertaken in Section 4.3, this option has a high risk of not being able to meet the levels of service in terms of frequency and duration of restrictions.

This option is also solely reliant on one water source. Raw water quality incidents in this source could reduce the capacity of the WTP and treated water would not meet the levels of service.

Option 2 – Current bores and Macquarie River

This option supplements the existing bores with water pumped from the Macquarie River. To reduce pumping and treatment costs. Only the volume of water that cannot be supplied by the bores will be pumped from the River. River water can also be used when the bore water quality is unsuitable or the bores are unavailable (e.g. maintenance).

Water from the Macquarie River was previously extracted to the north of Narromine via the redundant WTP's river pump station. The original concrete pump well and the top half that was visible looks to be in a relatively good condition. However, no inspection of the wet well has been undertaken so the condition at lower level is unknown.

It is proposed to utilise this existing pump well and install new pumps, suction pipeline and building. The four possible routes from the river pump station to the treatment plant site are shown in Table 7-1 and Figure 7-1.

Table 7-1. Routes from Macquarie River

No	Route description	Pump station	Pipeline
1	South down the western side of Dandaloo St then continuing south-west along The McGrane Way until it crosses into the water treatment facility. There is a single rail crossing approximately 75m south of Burraway Street.	Duty/standby pumps with capacity 102 L/s (7.5 ML/day in 20 hours) at 30 m head	DN450 DICL 3,920 m
2	Crossing the Mitchell Highway then travelling south down Third Avenue N. The route then crosses Nymagee Street and runs south down Square Lane. The route then passes under the rail line onto Third Avenue S and continues south until Tancred Street. The route continues east then runs south-west along The McGrane Way until it crosses over into the water treatment plant.		DN450 DICL 4,000 m

No	Route description	Pump station	Pipeline
3	East from the river pump station along the Mitchell Highway and Culling Street where it then travels south down Manildra Street. The watermain crosses the Mitchell Highway and has a single rail crossing approximately 50m south of the highway crossing. The route continues south down Manildra Street and crosses Cathundril Street and turns west along Cathundril Street then south down Algalah Street. The route crosses Dappo Road and Tomingley Road and goes west down Nellie Vale Road. The route continues south-west down The McGrane Way until it reaches the water treatment plant.		DN450 DICL 5,180 m
4	This route leaves the river pump station and travels west along the Mitchell Highway then crosses over to go south down the unnamed lane to the west of Sixth Avenue. The watermain continues south-east along Nymagee Street then Baxter Way until it reaches the proposed rail crossing location outlined in Route 2 and crosses onto Third Avenue S. The route then goes west along Dandaloo Road, south down Fifth Avenue S, west along Backwater Road and South down Wright Road. At the end of Wright Road, it travels east along Nellie Vale Road and runs south-west along The McGrane Way until it crosses over into the water treatment plant.		DN450 DICL 5,500 m

As Route 4 runs along Manildra Street which is proposed for a new heavy vehicle bypass it was not considered further.

Figure 7-2. Macquarie River pipeline route options

Option 3 – Drinking Water from Dubbo

This option supplies all drinking water into Nymangee Street Reservoir from the John Gilbert WTP in Dubbo. As discussed in Section 5.3.1, during peak demand, the John Gilbert WTP is currently operating near capacity. Upgrades to the WTP would therefore be required or NSC would need to continue to operate the bores and treatment plant during these times.

There are two possible routes for this pipeline which are shown in Figure 7-2.

Figure 7-3. Options for pipeline routes from Dubbo

As the pipeline will run downhill, it has been assumed there is sufficient head in Dubbo's drinking water supply system and a pump station is not required. The difference in the two pipeline routes is shown in Table 7-2.

Table 7-2. Dubbo pipeline routes

Component	Description	
	Route 1	Route 2
Pipe material/size		DN450 DICL
Pipeline length	34.2 km	38 km

7.2.2 Triple bottom line assessment

The water quality options have been assessed using a triple bottom line (TBL) assessment in accordance with DOI (2019). This method assessment compares the environmental, social and financial aspects of each option and assists NSC to ensure the option selected is the most sustainable.

The step to undertake the TBL assessment were:

1. The key criteria and weightings for the environmental and social impacts were agreed during a meeting on 29 September2023 between NSC, Atom Consulting and The Environmental Factor. This meeting was undertaken before the financial assessment was completed to ensure it did not influence the criteria.
2. A performance score from 1 to 10 was assigned to each criterion for each option.
3. The total weighted score for each option was calculated by summing the product of the performance score and the weighing.
4. The present value (PV) of each option was calculated from the estimated capital cost and estimated operations and maintenance cost of each option. The PV was calculated over 30 years using a discount rate of 7% per annum.
5. The TBL score for each option was calculated using the following formula:

$$TBL\ score = \frac{Total\ environmetal\ score + Total\ social\ score}{Present\ value}$$

Environmental assessment

A preliminary environmental assessment of the options was undertaken by The Environmental Factor (TEF, 2023). A copy of the report is included as Appendix C and the key environmental issues of each option are summarised in the following sections.

Option 1 – Current groundwater source

Due to uncertainty on the location of additional bores, it was difficult to quantify their environmental impact. However, given that NSC have not been able to locate water from test bores near the town, it has been assumed that any new bores would be up to 35 km away.

Pipelines from new bores would most likely be aligned with road reserves or rail corridors with potential for impacts on mature or remnant vegetation and/or threatened species.

CSIRO (2008) indicates that the current total entitlement for the Upper Macquarie Aquifer is 38.4 gigalitres per year (GL/yr), and that the 2004/05 abstraction was 37 GL. CSIRO estimated that long term average rainfall recharge to the aquifer is 7.1 GL/yr. As such, additional pressure on this water source, without diversifying, would likely further deplete groundwater in the locality and increase pressure/impacts on groundwater dependent ecosystems.

Given the groundwater vulnerability across much of the locality, risk of pollution of groundwater is considered moderate to high where upgrades to bores or establishment of pipelines to connect new bores are required.

Option 2 – Current bores and Macquarie River

Biodiversity in proximity to the proposed Macquarie River offtake and pipe alignments is limited to patches of native vegetation along road reserves, the rail corridor and in private land, as well as associated with the narrow strip of riparian vegetation along the Macquarie River Vegetated Riparian Zone.

Route 2 has the potential to impact upon the areas of remnant woodland present, including large mature and hollow-bearing trees that occur along The McGrane Way.

Three species of threatened waterbird have been recorded within the assessment area (500 m buffer from the proposed alignments). Bluegrass has also been recorded to the southeast of the assessment area and care should be taken to ensure this threatened plant is avoided prior to any of the alignments being selected.

As there is currently limited drawdown on the Macquarie River in the vicinity of Narromine, the River is likely to experience minor changes in hydrological flows downstream of the proposed river offtake. The extracted river water will supplement the existing groundwater source supplied by the bores and will not become the primary source of water for the Narromine water supply system. Impacts to aquatic ecology and downstream ecosystems are anticipated to be minor and manageable.

Narromine is rich in non-Aboriginal heritage, with a series of State and locally significant buildings recorded within the assessment area. Route 1 via Dandaloo Street passes the highest number of heritage items, passing through the centre of town.

No items of Aboriginal heritage significance are recorded in the assessment area for Option 2.

Impacts to air quality and land have the potential to occur during the construction phase of Option 2, for all alignments.

Option 3 – Drinking Water from Dubbo

The two proposed pipelines routes for this option each traverse up to 38 km of land, including areas mapped as supporting threatened ecological communities and threatened species. There is potential for direct and indirect impacts to up to 380 ha of native and non-native vegetation, and habitat for 440 threatened species records within a 10km locality, associated with either of the proposed routes.

Across the broad assessment area, which incorporates both pipeline options, there are 142 objects or places of Aboriginal heritage significance. This is a significant number of recorded sites and poses a constraint to this option.

Materials including up to 38 km of concrete pipeline and ancillary infrastructure will be required to construct and operate Option 3.

Environmental scoring

The environmental scoring is shown in Table 7-3. Scoring of each factor was from 1 to 10 with the higher scores having the least potential impact. Scoring was based on the following:

- High impact (1-3)
- Moderate impact (4-6)
- Low impact (7-10)

Table 7-3. Environmental scoring

Factor	Weighting	Option					
		1	2-1	2-2	2-3	3-1	3-2
Impact on terrestrial and aquatic biodiversity	30%	3.0	6.0	6.0	6.0	2.0	2.0
Environmental pollution risk (i.e POEO Act)	30%	3.0	5.0	5.0	5.0	1.0	1.0
Impact on heritage – Aboriginal and non-Aboriginal	20%	3.0	5.0	8.0	8.0	1.0	1.0
Use of resources	20%	3.0	7.0	7.0	7.0	3.0	3.0
Total weighted score		**3.0**	**5.7**	**6.3**	**6.3**	**1.7**	**1.7**

Social *assessment*

Option 1 – Current groundwater source

Option 1 relies on a single aquifer source and changes in raw water quality, bore yield or failure could result in reduced volume or poor quality of treated drinking water. There is therefore high risk that this option will not meet the levels of service outlined in Section 1.5.

There is also uncertainty if new bores can be found to increase the capacity to meet the future growth in Narromine (HEC, 2023).

Due to uncertainty on the location of any new bores, the impact on land use and disruption to the community is uncertain and may be significant if long pipeline runs are required.

Option 2 – Current bores and Macquarie River

Option 2 has two separate water sources that provide redundancy if one source cannot be utilised due to quality or equipment failure.

The option can be easily expanded to cater for unforeseen developments in Narromine by operating the river pump station more frequently.

The river pump station will be located on land already owned by NSC and the pipeline will follow existing road easements. There will be some community disruption during construction and repair of main breaks.

The pipeline for route 2 runs through the main street and will impact the community during construction and repairs.

Option 3 – Drinking Water from Dubbo

As discussed in Section 5.3.1, DRC would not have any spare capacity during high summer demand. This option would not be able to meet the required levels of service without NSC constructing and maintaining its own raw water and treatment systems.

Social scoring

The social scoring is shown in Table 7-4. Scoring of each factor was from 1 to 10 with the higher scores having the least potential impact. Scoring was based on the following:

- High impact (1-3)
- Moderate impact (4-6)
- Low impact (7-10)

Table 7-4. Social scoring

Factor	Weighting	Option					
		1	2-1	2-2	2-3	3-1	3-2
Risk of not meeting LOS (adequate water sources, water strategies)	40%	1.0	8.0	8.0	8.0	2.0	2.0
Impact on land – use and area (ha)/disruption to community	20%	3.0	3.0	8.0	4.0	1.0	1.0
Planned for future changes in development (right sizing)	20%	2.0	8.0	8.0	8.0	3.0	3.0
Community attraction/liveability	20%	3.0	7.0	7.0	7.0	4.0	4.0
Total weighted score		**2.0**	**6.8**	**7.8**	**7.0**	**2.4**	**2.4**

Financial assessment

Due to uncertainty on the location of any additional bores and the low scores for environmental and social impacts, costs of Option 1 have not been estimated and it is not considered further in this assessment.

A preliminary high level concept was developed for each options to prepare a high level estimate using the following:

- Sixmaps imagery
- Rawlinsons Australian Construction Handbook Edition 35
- Hunter Water Corporation Estimating Manual

- Quotes from suppliers for similar projects where appropriate
- Engineering judgement and experience from previous projects

Preliminaries were estimated using the Hunter Water Estimating Manual which contains percentages for various preliminary items based on the construction value.

The following allowances were made for design and project management:

- Design – 10% of estimated construction cost
- Design project management – 16% of design estimate
- Construction project management – 9% of estimated construction cost

No survey, geotechnical investigations or other preliminary design studies have been undertaken.

A contingency of 35% was added to allow for unforeseen scope and increased costs following detailed survey, geotechnical investigation and environmental assessment. An escalation factor of 12% was added to allow for increased construction costs between the date of the estimated and when the construction will be undertaken.

Ongoing operating and maintenance costs for each options was based on the following:

- Electricity costs of $0.22/kWh
- Maintenance as 1% of capital

Table 7-5. Financial assessment

Option	Capital cost ($M)	Annual recurrent cost ($k)	PV (20 years, 7%) ($M)
2-1	7.2	72 + 7.5/ML	15.33
2-2	7.3	73 + 7.9/ML	18.83
3-3	8.5	85 + 8.1/ML	17.42
3-1	33.8	338	37.98
3-2	38.3	382	42.97

7.2.3 Triple bottom line

Based on the environmental, social and present value of each option, the triple bottom line assessment is shown in Table 7-6.

Table 7-6. Triple bottom line

Assessment	Option				
	2-1	2-2	2-3	3-1	3-2
Environmental	5.7	6.3	6.3	1.7	1.7
Social	6.8	7.8	7.0	2.4	2.4
Environmental & social score (ESS)	**12.50**	**14.10**	**13.30**	**4.10**	**4.10**
Total PV	**15.33**	**15.83**	**17.42**	**37.98**	**42.97**
ESS/PV	**0.82**	**0.89**	**0.76**	**0.11**	**0.10**
Ranking	**2**	**1**	**3**	**4**	**5**

Based on this assessment, Option 2 is preferred with lower costs and better outcomes for environmental and social factors. Of the possible routes for the pipeline from the River to the water treatment plant, Route 2 is preferred. While Route 1 has marginally lower capital cost, it

runs down Danandoo St and therefore will impact the community during construction and maintenance and potentially will impact heritage sites.

8 Recommendations

Based on the options assessment, it is recommended that Option 2 Route 2 be taken forward to concept design. This option consists of the following:

- Maintain the existing bores
- Utilise this existing pump well and install new duty/standby pumps with a capacity of 102 L/s, suction pipeline, intake screen and building
- Pipeline route crossing the Mitchell Highway, then travelling south down Third Avenue N, south down Square Lane onto Third Avenue S and south until Tancred Street and south-west along The McGrane Way to the water treatment plant.
- Detailed environmental assessement

In addition, the following demand management actions are recommended:

1. Consider water recycling in any future upgrade of Narromine STP
2. Develop and implement a community education program on water saving measures including:
    - Improving public understanding regarding the significance of the water restriction levels
    - Education on water efficient appliances including evaporative coolers
    - Continuing the distribution of annual newsletter with information about water pricing, water restrictions and water saving tips
    - Hosting workshops to educate the public about water saving options in the garden and home
    - Developing and implementing a school education program
    - Development of a promotional video that will emphasise the importance of water conservation.
3. Develop and implement a water loss management plan.
4. Consider limited time rebates for the replacement of water fittings and appliances (including evaporative coolers).

9 References

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Appendix A Groundwater report

harwoodenviro.com.au

HARWOOD ENVIRONMENTAL CONSULTANTS

NARROMINE GROUNDWATER PROJECT

REPORT

Prepared for Atom Consulting and Narromine Shire Council | 25 June 2023

Version: 00

Harwoodenviro.com.au

DOCUMENT CONTROL

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APPENDICES

APPENDIX A REPORT REVIEWS

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1. INTRODUCTION

1.1. Background

The town of Narromine is situated in the west of NSW, and is located approximately 40 kms west from Dubbo, and 430 kms Northwest of Sydney. Narromine has a total Shire population of 6,425 based on the Australian Bureau of Statistics, Regional population, 2021/2022. Narromine Shire Council (Council) is concerned about the sustainability of the groundwater supply, and its quality.

The township of Narromine relies substantially upon groundwater pumped from the Lower Macquarie Alluvial Aquifer for its municipal water supply. As shown on Figure 1, the town is located close to the boundary between the upper and lower Macquarie Groundwater Management Areas (GWMA). A groundwater management area is set up to quantify and ensure that the allocation of water is based on sound professional understanding and judgement.

Seven bores are used to provide potable water to the town.

1.2. Objective

The objective of this project is to determine the potential for Narromine to source sufficient groundwater to sustain the township for the next 15 years.

1.3. Scope

The scope for the groundwater investigation of Narromine is as follows:

1. To assess the performance and capacity of the bores and their associated infrastructure to pump and deliver the towns' groundwater supply, and to determine any constraints in their design, construction, and condition.
    a. Review of the groundwater database and Narromine Council's STADIA system which outlines and has computerised output of discharge and drawdown.
2. To assess the sustainable daily and annual town water supply yield
    a. The yield of each bore is to be evaluated within the constraints of acceptable impacts on the environment, cultural values, surface water resources and other existing authorised groundwater supply bores under historic and future climate scenarios.
3. To determine the drought resilience of the town water supply
4. The identification of groundwater quality constraints to the town's supply
5. A statement of the authorised access to groundwater for the town
6. The identification of the need of, and options for future groundwater development to meet the towns future demands.

2. DESKTOP ANALYSIS

2.1. Regional Setting

The town of Narromine is located within the Murray-Darling drainage basin in central western NSW, as shown on Figure 1. Narromine lies on the Macquarie River, with the Bogan River, towards the south west. The Macquarie and Bogan Rivers flow north-west, roughly parallel and about 50 kilometres apart, flowing into the Barwon River respectively east and west of Brewarrina.

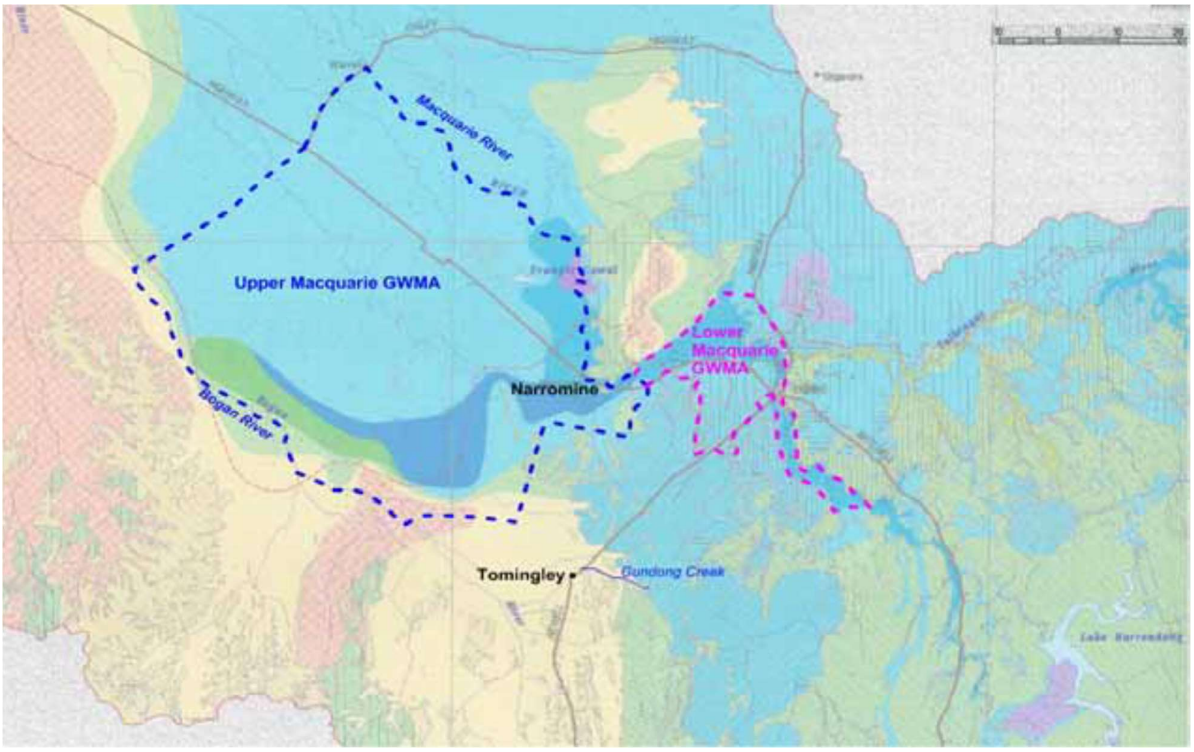


Figure 1: Regional Setting

The two rivers bound an extensive and complex flood plain. Numerous ephemeral channels and extensive marshlands exist on this plain, which supports significant agricultural development as well as internationally important ecosystems. The position of the main river channels and the relationship between them has changed, possibly many times, in the geologically recent past, as indicated by the presence of former channels.

The Macquarie River is a regulated stream; water is stored in Lake Burrendong and released to provide supplies for irrigation and some other uses. However, rainfall in the catchment is highly cyclical, and the past decade has seen eight years of drought, at the end of which Lake Burrendong was virtually dry, followed by a wet period in which major flooding of the Macquarie and Bogan Rivers occurred.

The Bogan River is unregulated.

The region is also hydrogeologically complex, as is discussed in more detail in Sections 2.3 and 2.4. Much of the area is underlain by two major aquifer systems - a superficial alluvial system of the Murray-Darling Basin, in part laid down within prior river channels, and a deeper sandstone system of the Great Artesian Basin (GAB). However, in some areas usable aquifers are absent.

2.2. Geology

Underlying the area covered by this report are three major geological systems – a blanket of predominantly alluvial deposits of Cainozoic (Quaternary and Tertiary) age, deposited on a surface eroded into underlying Mesozoic sedimentary rocks, which are in turn underlain by a basement of crystalline rocks of Palaeozoic age. The distribution and lithology of these materials is highly variable across the area.

To the north of Narromine, all three systems are present. The Mesozoic sedimentary rocks are thin at their southern edge, near Narromine, and thicken to the north at Trangie, while the alluvial deposits are sometimes thin but generally of at least moderate permeability. To the south and south-west of Narromine an eroded channel has been infilled with thicker deposits of sand and gravel, but the sandstones are absent.

Around Tomingley the alluvial deposits of the Bogan system are generally thin and composed predominantly of clay and silt.

2.3. Hydrogeology

Much of the area is underlain by two major aquifer systems - a superficial alluvial system of the Murray-Darling Basin composed of deposits of Quaternary and Tertiary age, in part laid down within prior river channels, and a deeper sandstone system of the Great Artesian Basin that is predominantly Mesozoic and Jurassic in age.

The widespread alluvial deposits of the Lower Macquarie were deposited by an ancestral river regime which occupied a valley system extending to the west of Narromine and is probably continuous with an alluvial filled valley along the present course of the Bogan River. The remnant surface drainage system which crosses the area now is quite complex and bears less relationship to the earlier river system than does the alluvial filled valley system. The Macquarie River turns sharply to the north near Narromine, and the main north-westerly drainage is along Boggy Cowal and Backwater Cowal which form a partial connector between the Macquarie and the Bogan Rivers.

Around Tomingley the alluvial deposits of the Bogan system form very poor aquifers with little or extraction taking place. The water supply for processing at the Alkane /Tomingley Gold Mine also provides water for the village water supply.

Trangie (approximately 20km northwest of Narrmoine), recieves groundwater from three bores, within the Mesozoic sandstone which is is relatively thick (over 150m) and provides a more than adequate supply to satisfy the township, albeit with typical sodium bicarbonate dominance which is typical of the productive sandstones within the Great Artesian Basin.

2.4. Hydrology and Groundwater Recharge

In the Macquarie Alluvial Aquifers rainfall recharge is less than both the allocated (licensed) abstraction and current abstraction. Recharge to the alluvial aquifer is highly dependent on two other components:

- Leakage from the river channel; and
- Irrigation returns flows derived from pumping from the river.

Thus, surface water and groundwater systems are highly connected.

Flow in the Macquarie River is regulated by the Burrendong Dam, and water is also held upstream in the Windermere Dam on the Cudgegong River, a tributary of the Macquarie.

In the decades since Burrendong Dam was completed, in 1967, the flow and stage in the river have been regulated and were maintained at higher average levels than those that occurred naturally. This resulted in higher rates of leakage from the river channel into the groundwater. Leakage from irrigated fields, also sustained by the regulated river, was a further major source of groundwater recharge.

In response, from 1970 through to the mid-1990s, groundwater levels in some parts of the Macquarie aquifers rose substantially. Due to a major increase in groundwater abstraction for irrigation since then, that trend has been reversed, and in many areas water levels were declining. The effect of recent rainfall events is not yet clear.

Whilst water-sharing plans have been gazetted for the Macquarie and Cudgegong regulated rivers and the Lower Macquarie Alluvial Aquifer, there is no water-sharing plan for the Upper Macquarie Alluvial Aquifer.

With much reduced releases from Burrendong Dam over most of the past decade, and consequently much lower irrigation use, recharge to the groundwater system by river leakage and irrigation returns must have fallen, and recharge would have been significantly less than abstraction. The next two years or so may see a return to high flows and higher recharge.

The long-term sustainability of groundwater abstraction from the Macquarie alluvium will be highly dependent upon the extent to which surface water flows can, in future, be maintained by release from Lake Burrendong, or the implementation of alternative means to supplement aquifer recharge.

CSIRO (2008) indicated that under the best-estimate 2030 climate there would be an overall 8% reduction in water availability in the Macquarie and a 9% reduction in end-of-system flows. However, when extreme cases are considered, the outcome is very uncertain.

Under the dry extreme for 2030 there would be a 25% reduction in overall water availability and a 28% reduction in end-of-system flows, whilst the wet extreme indicates corresponding increases of 25% and 41%.

HEC have engaged Manewell Groundwater to provide a new groundwater model, calibrated to groundwater levels and river flows. The model predicts groundwater impacts from the Narromine Township borefield to users, groundwater dependent ecosystems, the likelihood of borefield sustainability, and the impacts of climate change. This model provides some different interpretation than CSIRO, but also complimentary findings.

Groundwater Management

The Upper Macquarie Alluvial Aquifer GWMA N09 extends from Lake Burrendong to Narromine, but upstream of Wellington is just a narrow strip of valley-fill alluvium. Downstream of Cumboogle it is a substantial aquifer 2 to 4 kilometres wide and 50 to 60 metres deep. Aquifer materials include sands and gravels, and there is also a significant volume of finer grained materials, i.e. silts and clays.

The deepest and most permeable aquifer units are located in paleochannels cut by the river and subsequently infilled with alluvium.

CSIRO (2008) indicates that the current total entitlement for the Upper Macquarie Aquifer is 38.4 gigalitres per year (GL/yr), and that the 2004/05 abstraction was 37 GL. CSIRO estimated that long term average rainfall recharge to the aquifer is 7.1 GL/yr.

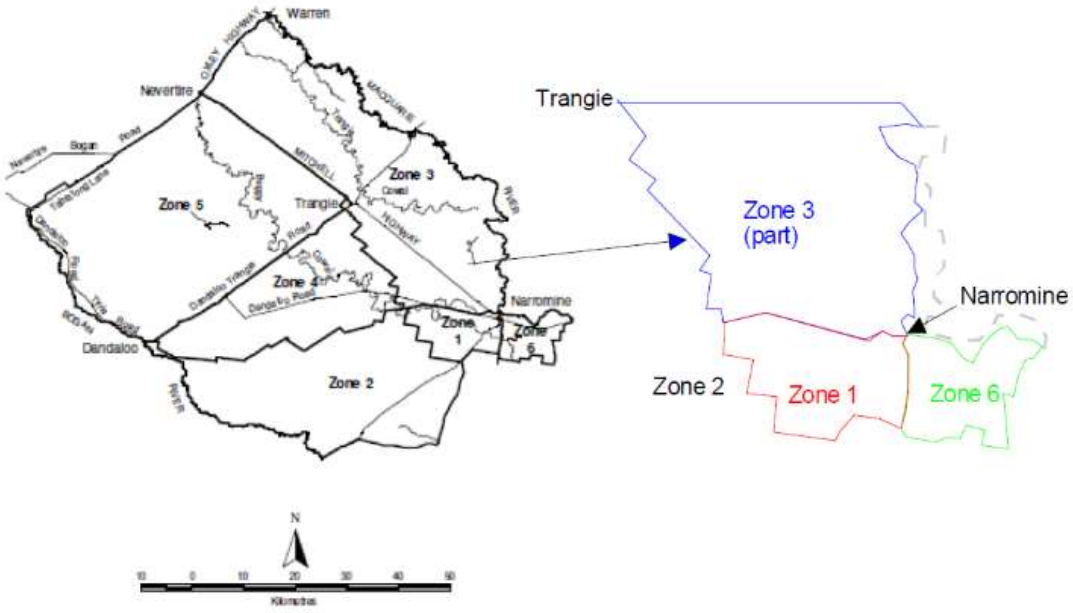
The Lower Macquarie Alluvial Aquifer (formerly GWMA N08, now the Lower Macquarie Groundwater Source) occupies a large area of flat country between the Macquarie and Bogan Rivers to the west and north-west of Narromine. The alluvial deposits are continuous with Upper Macquarie Alluvial Aquifer.

The eastern boundary of the Lower Macquarie aquifer is formed by the limit of alluvial deposits against the underlying Mesozoic sandstone. The southern and south-western borders are mostly marked by the limit of the alluvial deposits against the Palaeozoic rocks. The underlying rocks have poor outcrop in the south-west of the area and the alluvial limit is difficult to determine precisely so the groundwater source boundary is somewhat arbitrary. The north-western border of the source is quite arbitrary, marked by the Oxley Highway, and is well beyond the limit of the high yielding, low salinity aquifer.

For management purposes the Lower Macquarie Groundwater Source is divided into six zones, as shown on Figure 2. Not all zones are equally developed. Zone 1 is by far the most developed and Zone 5 is probably the least developed. Zones 1 and 2 contain the main productive parts of the alluvial aquifer system. In the remaining zones, the alluvial cover is present, but thinner and without high yielding sandy aquifers. Moderate to high yields are available from the underlying sandstone aquifers of the GAB. The

obvious constraints of distance result in only Zones 1 and 6, together with the southern part of Zone 3, being relevant to this study, as also shown on Figure 2.

As well as forming the western boundary of the Lower Macquarie Groundwater Source, the eroded surface of the GAB sandstones forms the depositional base for the alluvial material. The sandstones of both the basement and the bordering hills are part of the intake beds of the GAB. CSIRO (2008) indicates that the current total entitlement for the Lower Macquarie Aquifer is 70.4 GL/yr, and that the 2004/05 abstraction was 56 GL. CSIRO estimated that long-term average rainfall recharge to the aquifer is 79 GL/yr, and the long-term average extraction limit is 69 GL/yr.



2.5. Water Sharing Plans

The text from this chapter has been sourced mainly from C.M. Jewell ,2011.

A commenced water-sharing plan applies to the area covered in this report. This is the Water Sharing Plan for the Lower Macquarie Groundwater Sources 2003 (the Lower Macquarie Plan) which includes the Cainozoic alluvial aquifers around Narromine and also the GAB aquifers in this area. The Water Sharing plan to the NSW Great Artesian Basin Groundwater Sources does not currently apply to the GAB aquifers in the area covered by the Lower Macquarie Plan.

Within the Lower Macquarie Plan, annual extraction limits were set at:

- 21,675 ML/yr in Zone 1 (current use 19,675 access + 2000 utility)
- 9,350 ML/yr in Zone 3 (current use 8,260 access + 1090 utility)
- 8,160 ML/yr in Zone 6 (current use 7,481 access + 3 utility)

In each case plus the total requirements for basic landholder rights at the commencement of the plan and in the case of Zones 1 and 3, water allocations made to supplementary water access licences.

Figure 2: Management Zones

Aquifer access licences (subcategory 'town water supply'), may be granted for the purpose of supply to communities for domestic consumption and commercial activities.

Required set-back distances from existing water users in Zones 1and 6 are:

a. 1,000 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract up to and including 10 ML/day,
b. 2,000 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract greater than 10 ML/day and up to and including 20 ML/day, and
c. 3,000 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract greater than 20 ML/day.

And in Zone 3 are:

a. 1,000 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract up to and including 5 ML/day,
b. 2,500 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract greater than 5 ML/day and up to and including 10 ML/day,
c. 3,500 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract greater than 10 ML/day and up to and including 15 ML/day, and
d. 4,000 metres of an existing water supply work (bore) nominated by an access licence, if the new water supply work (bore) will extract greater than 15 ML/day.

Currently all water in all zones is fully allocated and there has been difficulty in obtaining approval to extract any additional groundwater from the alluvial aquifer system, even from the more transmissive and deeper Backwater Cowal system which has strong competition from existing irrigation bores.

HEC was unable to easily obtain current abstraction data from irrigation bores from regulatory authorities and the predictive modelling completed relies on the most current published data available.

3. NARROMINE WATER SUPPLY

3.1. Local Setting

Narromine lies on the Mitchell Highway about 40 kilometres west of Dubbo. As shown on Figure 1, the town is located on a major bend in the Macquarie River – at this point the river, which flows west from Dubbo, swings to the north and flows in that direction for 25 kilometres before resuming its regional north-west course towards Brewarrina. This change in direction is significant from a hydrological and hydrogeological perspective because it is likely that this change in course isn't relatively recent, and that previously the river continued on a westerly course to the south of Narromine, following the approximate line of the Backwater Cowal - Boggy Cowal system and joining the Bogan River somewhere in the vicinity of Nyngan.

The major Quaternary alluvial aquifer system in the Narromine is associated with this prior course of the Macquarie River, rather than with the current course.

The current water supply system in Narromine utilises five bores that are completed in relatively shallow Quaternary alluvial deposits beneath the town, and 6 to 10 kilometres north of the sub-crop of the main aquifer.

3.2. Geology

As indicated in Section 2, there are three major geological systems underlying the area around Narromine. The superficial, predominantly alluvial deposits are of Cainozoic (Quaternary and Tertiary) age and are deposited on a surface eroded into underlying Mesozoic sedimentary rocks, which are in turn underlain by a basement of crystalline rocks of Palaeozoic age.

The Palaeozoic basement around Narromine is formed by Devonian granite and folded metasediments of Ordovician to mid Devonian age, part of the Lachlan fold belt sequence. Mesozoic sedimentary rocks (predominantly sandstone) that form the intake-beds of the GAB aquifer system unconformably overlie the eroded surface of Palaeozoic rocks. The Cainozoic unconsolidated sediments unconformably overlie the Mesozoic rocks. These Mesozoic rocks form the southern part of the Coonamble Embayment of the Surat Basin of the Great Artesian Basin. The sediments that formed these rocks were laid down by a north to northwest flowing braided riverine system during the Jurassic to Cretaceous period; the thickness of the Mesozoic sedimentary sequence increases eastwards between the Bogan and Macquarie Rivers, and the depth to the base of the sequence generally increases to the north and east.

In this area, Jurassic-age rocks of the Purlawaugh and overlying Pilliga formations make up most of the Mesozoic GAB sequence. The Purlawaugh formation is represented by conglomerate overlain by ferruginous mudstone and shale, which contains plant fragments. The Pilliga formation comprises a sequence of whitish quartzose friable sandstone and grey shale. The Pilliga sandstone is at outcrop in the east of the study area.

The top of the now buried Mesozoic sedimentary rock sequence is an old deeply weathered erosion surface which was dissected by ancient river systems. Subsequent tectonic uplift and changes in climatic conditions initiated renewed erosion and sedimentation during the Miocene period in the late Tertiary. This sedimentation completely buried the valleys and ridges of the older Mesozoic rock sequence with alluvial deposits comprising of interbedded clay, silt, gravel and sand, which have formed the present alluvial plains of the area (Keshwan & O'Shaughnessy 1999, cited by Bilge 2007).

3.3. Hydrology

As indicated previously, interaction between the Macquarie River and the aquifer system is known to have an important influence on groundwater recharge within the area. The Macquarie and Bogan Rivers are considered to be hydraulically connected to the upper alluvial aquifer system. The flow in the Macquarie River is maintained by river regulation releases, while the Bogan River flows occasionally after rainfall and otherwise remains mostly dry.

The Backwater – Boggy Cowal is a system of small depressions, which carries local runoff and the overflow floodwater from the Macquarie River in a north westerly direction towards Nevertire. This Cowal is reported by Bilge (2007) to be an important aquifer recharge zone.

In addition, there is a channel system which distributes surface water and groundwater for irrigation purposes.

There are seven gauging stations along the stretch of the river considered in the regional model; of these, five stations had continuous records of river gauging data covering the entire model calibration period. River stage data at not available after 1978 because measurements were discontinued at that time.

The gauges at Baroona (421127), Narromine (421006) and Gin Gin (421031) are relevant to this report, but it was decided to simply adopt the calibrated leakance values, for the relevant river reaches, from the regional model.

3.4. Hydrogeology

3.4.1. Alluvial Aquifers

Bilge (2007) divided the Cainozoic alluvial unconsolidated sediment sequence into two aquifers, shallow alluvium (Aquifer 1) and deeper alluvium (Aquifer 2). The younger shallow alluvial sediments have a maximum thickness of 60 metres and are extensive across the area of this study, and the wider Upper Macquarie GWMA. The deeper alluvium is spatially confined to a palaeochannel to the south of Narromine and contains the most productive aquifer. It underlies the upper alluvium and may overly either the Mesozoic sandstone or Palaeozoic bedrock. The thickness of the deep alluvial sediments varies from 20 to 80 metres.

Yields in general are in the order of 5 to 100 litres per second (L/s) depending on the depth and size of the bore. However, one of the high yielding irrigation bores; placed in the most productive zone of the alluvium, yields as much as 300 L/s (Keshwan & O'Shaughnessy 1999).

Groundwater flow in both Aquifer 1 and Aquifer 2 is to the west.

3.4.2. Mesozoic Sandstone Aquifers

The Mesozoic sandstone sequence contains two aquifers. These were designated as Aquifer 3a and Aquifer 3b by Bilge. Aquifer 3a is the shallowest aquifer in the GAB. Groundwater extraction from this aquifer is insignificant with all irrigation bores and the majority of stock and domestic bores being completed in the underlying deeper Aquifer 3b. The shallow GAB aquifer pinches out to the north.

Groundwater flow in sandstones occurs primarily through fractures and faults where deep sub areal weathering and dissolution of the cementing material have increased the permeability of the aquifer. Yields in general are restricted to stock & domestic supplies of 5 to 6 L/s. Irrigation bores sited within the major fractured zones may yield up to 100 L/s (Keshwan & O'Shaughnessy 1999).

3.5. Mapping of Existing Groundwater System

3.5.1. Extent

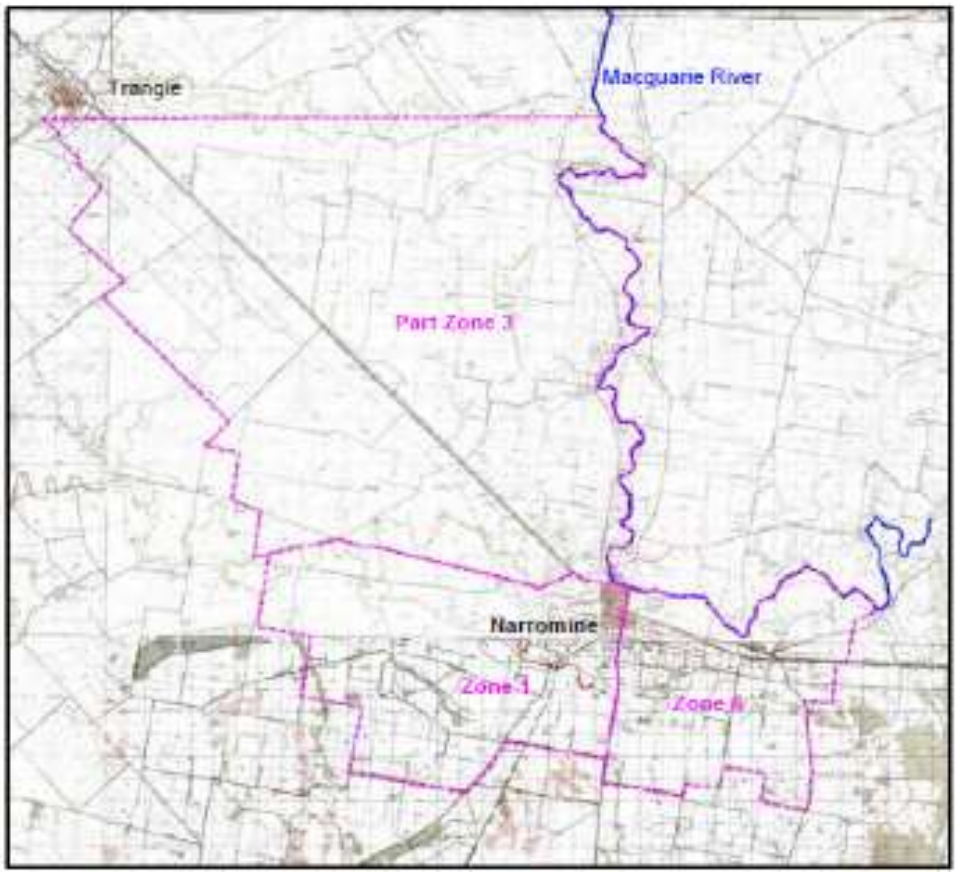


Figure 3: Modelled Area (C.M. and Jewell, 2011)

As indicated in Section 4.1, the groundwater system with which this report is concerned includes the south-eastern section of the Lower Macquarie alluvial aquifer, and the underlying portion of the intake beds of the GAB aquifers.

This groundwater system effectively extends across an area that is bounded to the east by the Macquarie River and extends north-west as far as Trangie. It includes Zone 1, Zone 6 and the southern part of Zone 3 of the Lower Macquarie Groundwater Source as shown on Figure 3.

3.5.2. Aquifers

As described by Bilge (2007) the aquifer system has four components. From the top, these were termed Aquifer 1, Aquifer 2, Aquifer 3a and Aquifer 3b by Bilge. The same nomenclature has been used in this report.

Aquifer 1 is an alluvial aquifer that is essentially unconfined and extends across most of the Lower Macquarie Groundwater Source, . This aquifer is composed of sands and gravels interbedded with lower permeability materials such as silt and clay, and is the only aquifer present beneath the town of Narromine. This aquifer gives low to moderate yields of groundwater. Yields are quite variable from place to place, and the groundwater has been subject to surface-derived contamination.

Aquifer 2 is an alluvial aquifer that is present within a paleochannel - probably a buried former course of the

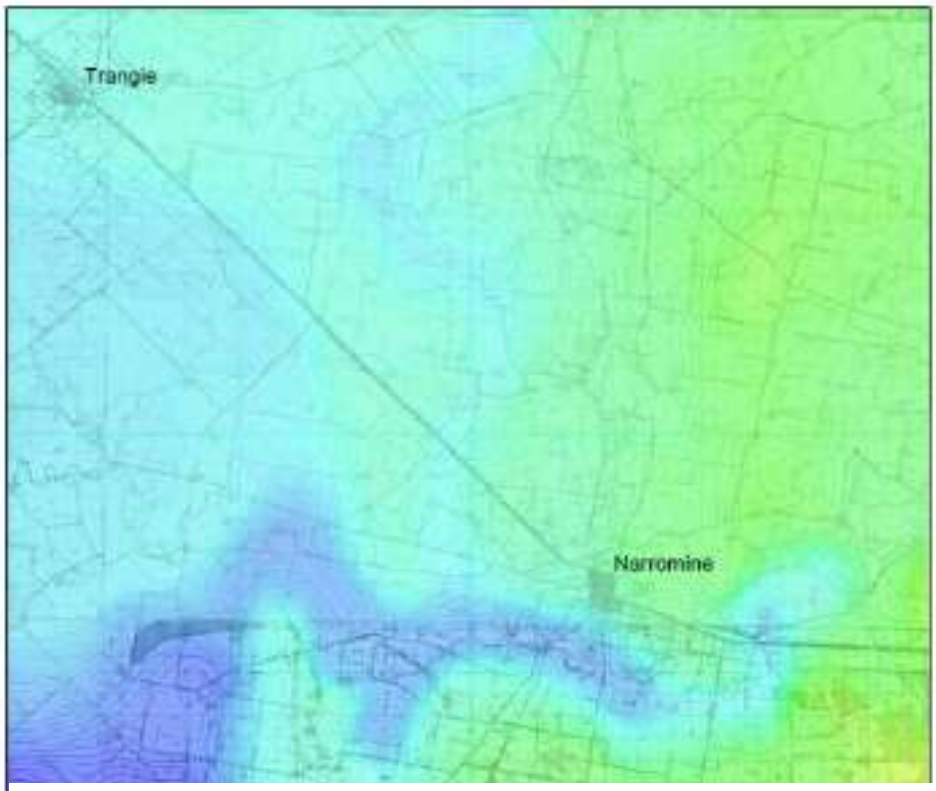


Figure 4: Extent of Palaeochannel Aquifer

Macquarie River that runs from east to west, south of Narromine, as shown by the dark blue shading on Figure 4. This aquifer can give reliable high yields of good quality water. It is confined by clay units at the base of Aquifer 1 and is therefore substantially protected from surface-derived contamination.

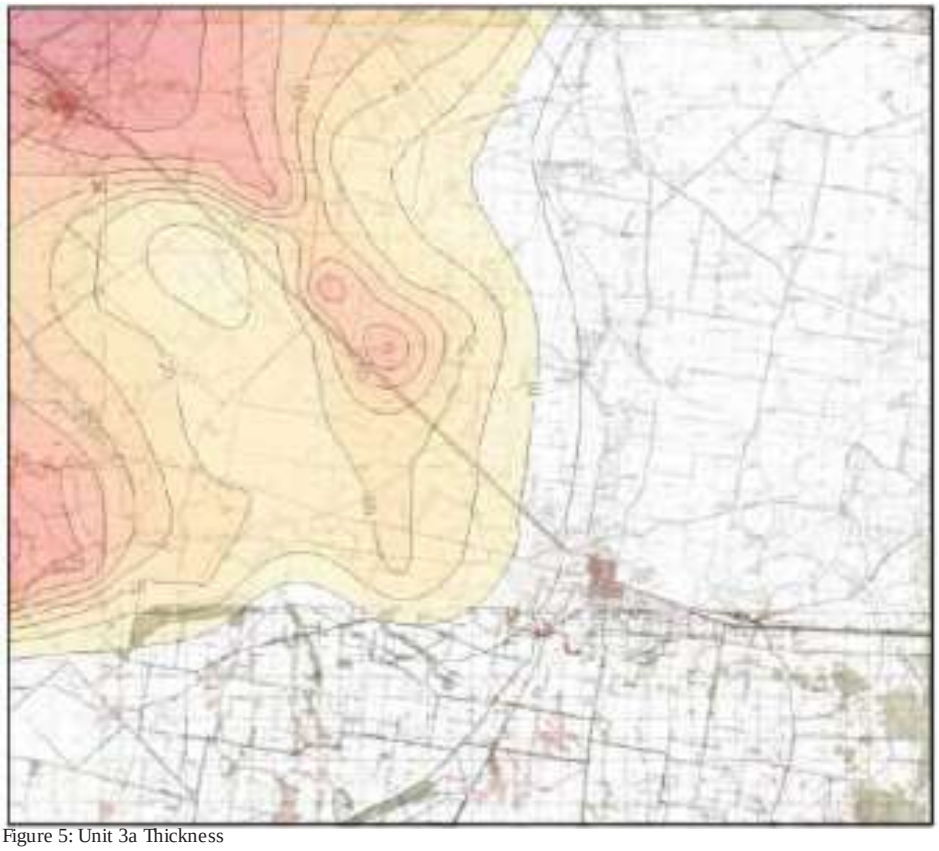


Figure 5: Unit 3a Thickness

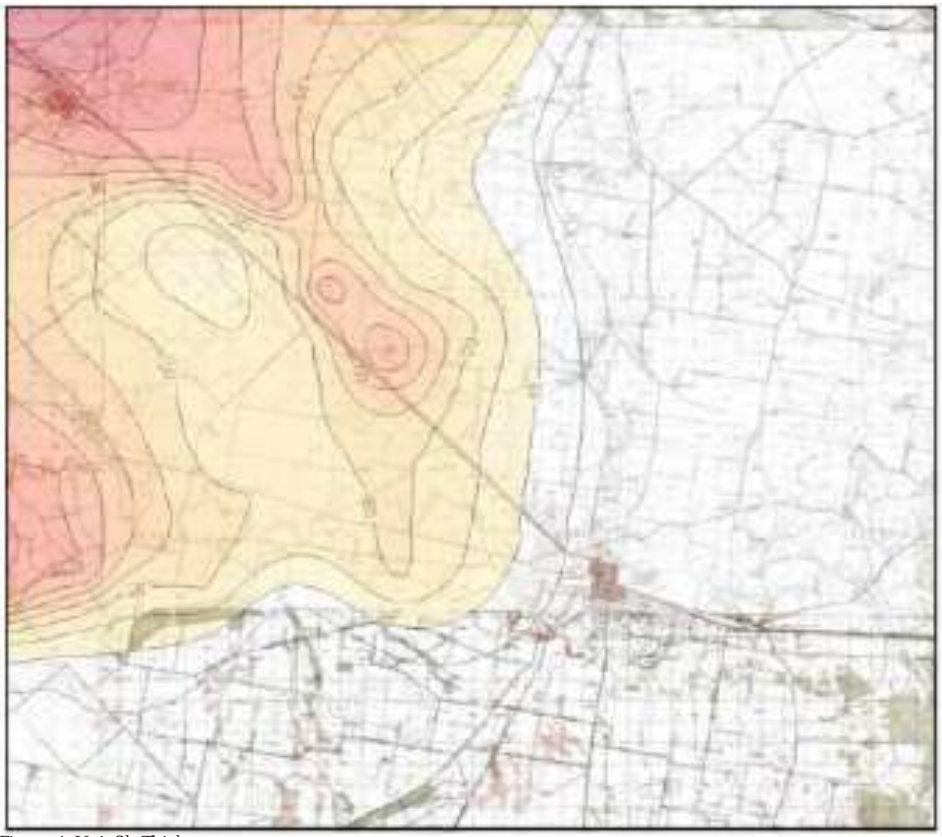


Figure 4: Unit 3b Thickness

Aquifer 3a is formed by the uppermost sandstone units of the Great Artesian Basin sequence. It is generally low-yielding. Its thickness is shown on Figure 6.

Aquifer 3b is the uppermost GAB sandstone aquifer unit that provides reliable high yields. Its thickness is shown on Figure 6. It can be seen that this unit approaches the north-west corner of Narromine but is too thin to be of practical use closer than about 10 kilometres to the north-west.

3.5.3. Existing Abstractions

There are a large number of existing bores around Narromine, with the Palaeochannel to the south of the town being particularly heavily developed by irrigation and stock / domestic bores. Figure 9 shows borehole development across the model area.

3.5.4. Yields

The Macquarie Catchment Groundwater Availability Map (DLWC 2000) indicates that in the shallow aquifer beneath and north of Narromine, bore yield range from 5 to 50 litres per second, whereas in the palaeochannel aquifer south of Narromine, yields in excess of 50 litres per second may be obtained.

3.5.5. Quality

The Macquarie Catchment Groundwater Availability Map (DLWC 2000) indicates that throughout the area, alluvial groundwater salinity lies in the range 500 to 1500 mg/L total dissolved solids, which is not the acceptable, range for potable use. The Australian Drinking Water Guidelines aesthetic limit for total dissolved solids is 600mg/L. Locally, particularly in the higher permeability aquifers, quality is better. Surface-derived contamination issues are restricted to the shallow aquifer in the Narromine urban and peri-urban area.

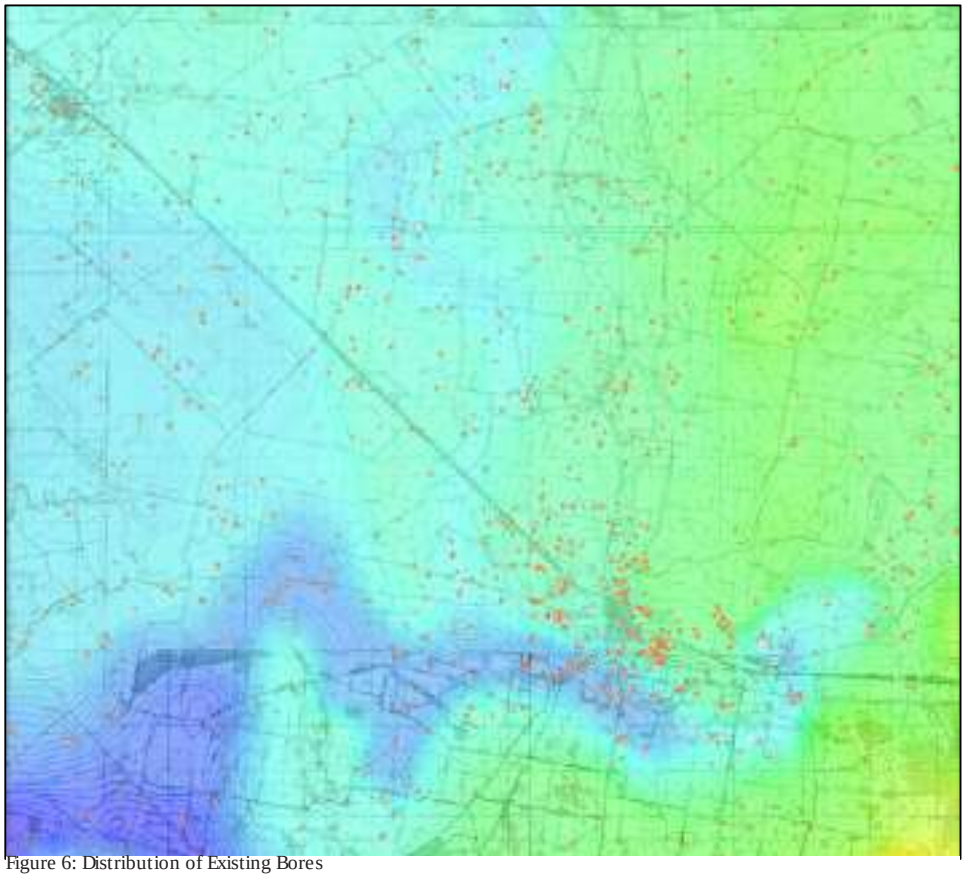


Figure 6: Distribution of Existing Bores

The local groundwater differs in quality depending on the source and geological setting.

The shallow Quaternary alluvial aquifer with water bearing zones generally within 60 metres of the surface has characteristically been susceptible to drought (particularly in the last twenty years with declining water levels) and to iron and manganese which is consistent with the yellow and polymictic gravels which are found in this sequence. In addition, this sequence is susceptible to surface contamination and several bores have been backfilled and abandoned due to this potential. There is a known nitrate problem from surface features which has/had impacted this aquifer.

The lower alluvial aquifer is of Tertiary age and comprises interbedded grey quartzose sands and gravels which have maximum depth of 140metres in the Backwater Cowal and have characteristically obtained lower salinity water with acceptable concentrations of iron and manganese. In recent times,the quality of water for drinking water purposes from existing water supply bores in this aquifer has also been challenged and NSC has had to augment the town water supply bores with sophisticated treatment options to ensure reliable quality water to meet township requirements.

The Mesozoic Sandstone, which outcrops north west of Narromine (and subcrops to depths of several hundred metres) provides a reliable and long term water supply for Trangie township and for numerous landowners. As previously mentioned, this sequence sub crops below the deep alluvial groundwater, particularly north of Narromine.

This aquifer contains large volumes of groundwater within a low Storage coefficient groundwater system which is capable of satisfying long term needs of Trangie with the following constraints:-

High sodium bicarbonate and sodium absorption ratio/

High calcium and magnesium hardness.

3.6. Narromine Drinking Water System

Narromine Shire Council (NSC) draws its water supplies from ground water sources for Narromine and Trangie and a ground water source from a mine supply to the recently completed Tomingley Water Treatment Plant . Council previously operated a raw untreated surface water system in Narromine for the irrigation of public spaces on the northern side of the western rail line system is no longer in use.

Figure 7: Production Bore Locations and Site of State Monitoring Bores

The township of Narromine draws its drinking water supply from five active bores connected to the Macquarie River between the City of Dubbo and Narromine. Refer to Figure 8 for town production bore locations.

e Performance of the Existing Bores to Meet Demand and Determine Constraints

HEC have reviewed the early pumping test data provided by Impax Drilling (see Appendix B) but at this stage have not researched more recent drawdown data from the Council SCADA system.

In relation to the pumping tests of existing bores, HEC have employed the Cooper-Jacob straight line solution to assess long term drawdown based on 700 days of continuous pumping and allowing some mutual interference and pump intake submergence as factors.

Observation bore data was not available to calculate Storage coefficient (S) to calibrate against the assumed Storage Coefficient used in the Manewell Groundwater numerical model but the modelling S values ranged from unconfined to semi confined values.

Th
stated above.

It is noted that the regional water level has likely not decreased dramatically since 2019 due to the excessive rainfall which has been experienced over the las twelve months or so but the trend of dropping groundwater levels in the Aquifer 2 system is likely to continue as shown in the Figure below.

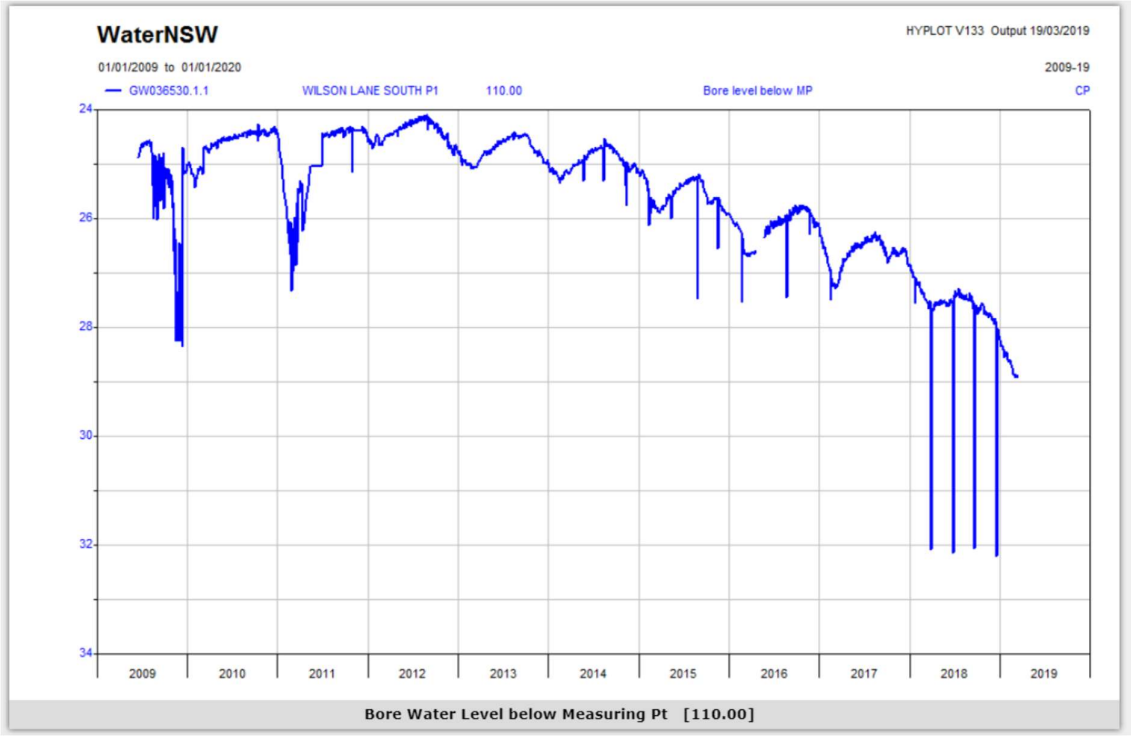


Table 1: Previous Yields of Narromine Bores

Bore	Completion Date	Yield 2015a	Yield 2016b	Yield (early 2019)	Current Yield (April 2019)	Comments
Bore 3	1965 renewed 2018	23 L/s	14 L/s	20 L/s	20 L/s	This bore was re-drilled in 2018 on the same site. Current yield reflects the new bore.
Bore 6	1978	19 L/s	-	6 L/s	Taken offline in May 2019 due to Cavitation	The 2016 yield is not available, Only the yield of bore 6D was noted in the 2016 Swan Report. The yield of this bore dropped as low as 4.1 L/s a few times. This bore has been decommissioned.
Bore 7	1979	11 L/s	-	7 L/s	Taken off in March 2019 due to Cavitation	The 2016 yield is not available, Only the yield of bore 7D was noted in the 2016 Swan Report.

						As the current yield is below the safety threshold of 4 L/s, the bore was taken offline on 9 March 2019.
Bore 8	1979	20 L/s	15 L/s	9.5 L/s	9.5 L/s	
Bore 9	1987	18.8 L/s	-	12.5 L/s	12.5 L/s	The 2016 yield is not available, only the yield of bore 9D was noted in the 2016 Swan Report. This bore has been decommissioned.
Total Yield	-	91.8 L/s	-	42.0 L/s	-	

Three new deeper bores were drilled next to Bores # 6, 7 and 9 by Council to supplement the water supply:

Bore	Pump Test Estimated Safe yield 2015a	Yield 2016b	Comments
Bore 6D	35 L/s	35 L/s	New, deeper bore drilled in 2015/16, and is currently supplying water through the temporary water treatment plant due to high levels of iron and manganese. This bore has high turbidity from inorganic sand and clay and can only be treated at the temporary WTP if the other bores are operating.
Bore 7D	17 L/s	15 L/s	New, deeper bore drilled in 2012/13, and is currently not supplying water through the temporary water treatment plant due to high levels of iron and manganese.
Bore 9D	135 L/s	50 L/s	New, deeper bore drilled in 2015/16, and is currently supplying water through the temporary water treatment plant due to high levels of iron and manganese.

It is noted that these figures are different than those quoted by PWA in their Integrated Water Management Strategy (2022)

Bore ID (GW number)	Make – Serial	Install year	Flow rate (L/s)	Head (m)	Flow rate according to 2015 hydrogeological report (L/s) [10]
3 (GW021185) – shallow	N/A	1965	N/A	N/A	23.0
6D (GW042924)	Aquawest – FPS-140FS8-4E	2016	40.0	55.0	-
7D (GW273272)	-	2013	-	-	17.0
8D (GW030746) – constructed, not operational without treatment	Aquawest – FPS-140FS8-3B/L/N	2020	36.0	56.0	20.0
9D (GW062210)	Aquawest – FPS-110-FS-5I	2015	31.8	70.0	22.4

Council has advised that the current peak daily demand is in the order of 5 ML/d and the 2040 peak daily demand to be around 7.5 ML/d.

The average extraction of Narromine Township is seasonal with demand generally driven by temperature variability and as the township is in the west of NSW it is often subject to prolonged periods of hot dry weather.

The total yield from the current bore system is barely sufficient to meet the town's demand and water restrictions are imposed on consumers for prolonged periods. If any of the current bores are offline, the town is placed under further restrictions. In addition, NSC has seen a decrease in the yield from the current bores during the past few years and expects the yield reduction to continue for expansion on these issues refer to (NSC 2019 Drought Security Report). This reduction in yield adversely impacts the economic development growth in Narromine.

Under current licensing arrangements NSC has a limited opportunity to apply for additional bores.

There is an opportunity to increase the water supply by using deeper bores as replacements for the current bores. NSC has drilled three deeper replacement bores since 2012 with the hope that a sufficient and reliable water source can be found. The locations of these deep bores (Bores # 6D, 7D and 9D) are on the same sites as the current shallow bores (Bores # 6, 7 and 9).

HEC consider that based on historical and classical pumping test analysis, the current replacement bores will meet the peak daily demand for NSC, except for the requirement for water treatment.

The most recent issues (which will be dealt with in more detail by Atom Consulting) is the problem with the water quality in this deeper aquifer requiring water treatment to meet the limits n the ADWG.

HEC have recently reviewed a report by Sci Dev in relation to problems with replacement bore #6, to ascertain the cause of the water supply issues which involve increased turbidity and iron and manganese and other issues. There is no evidence that the chemical issues have been caused by excessive drawdown and it is reasonable to assume that the chemical signature is natural to the formation.

HEC consider that the current deepened bores are capable of delivering the quantity of water required for Narromine TWS but consider that there are other sources to be assessed as to provide greater water security.

HEC have been asked to provide input to a number of important issues to satisfy the concerns of NSC.

These include the following :-

1. To assess the sustainable daily and annual town water supply yield
2. To determine the drought resilience of the town water supply
3. The identification of groundwater quality constraints to the town's supply
4. A statement of the authorised access to groundwater for the town
5. A statement on indigenous heritage requirements
6. The identification of the need of, and options for future groundwater development to meet the towns future demands.

3.8. Asses Sustainable and Peak Daily Yield

HEC have used classical drawdown groundwater hydraulics to agree that the current deepened borefield of three wells will meet a peak daily demand of 8ML/day which will meet Narromine's requirements in the foreseeable future.

In addition, HEC engaged Manewell Groundwater to provide a MODFLOW model calibrated to historical data to provide a longer-term view into the future. Modelling output is available for review if required by NSC and its client.

Manewell Groundwater predicted that the bore field will meet Narromine's quantity needs well into the future. However, predictive uncertainty analysis reveals that it's unlikely, yet possible, that the bore fields sustainability will be compromised after 2033.

The historical model was extended to continue to 2052 at quarterly stress periods. Surrounding water supply and irrigation was assumed to maintain 2023 allocations. Uncertainty analysis included increasing surrounding abstraction.

Six scenarios were simulated to determine maximum groundwater drawdown in the unconsolidated aquifer and assess the viability of the Narromine town supply borefield from 2009 (start of the water sharing plan) to 2052. Table 3.8.1 of the modelling report (see Table 2 below) summarises predicted abstracted simulated rate within the model domain. The cumulative scenario (scenario 1) simulated existing pumping and proposed borefield pumping (average demand) at the 2 bores Narromine currently utilise. A second scenario (2) simulated existing pumping and proposed borefield pumping ("unrestricted" future demand) using the current 2 bores. A third scenario (3) distributes pumping across all 5 Narromine Town Supply bores using average demand. A fourth scenario (4) simulates distributes pumping across all 5 Narromine Town Supply bores using the unrestricted demand. A fifth (5) scenario simulates no pumping at Narromine post 2009. Finally, a sixth scenario simulates no pumping at Narromine post 2023.

Table 2: Predictive Scenarios

Scenario	Surrounding Water supply + Irrigation pumping	Active Narromine Water Supply bores	Narromine target abstraction rate (ML/year)
1	2023 repeated	6D, 9D	Average (up to 825)
2	2023 repeated	6D, 9D	Unrestricted (up to 1,280)
3	2023 repeated	3, 6D, 7D, 8D, 9D	Average (up to 825)
4	2023 repeated	3, 6D, 7D, 8D, 9D	Unrestricted (up to 1,280)
5	2023 repeated	No pumping post 2009	None
6	2023 repeated	No pumping post 2023	None

To quote from Narromine Modelling Report (Manewell Groundwater, 2023)

The results indicate that there is a 50 % chance the Narromine borefield operating with 6D and 9D in isolation will be able to meet average water use until 2052. It is unlikely that the borefield will not be able to meet average demands after 2033, and very unlikely demand will not be met after 2025 (Scenario 1).

Unrestricted water demands tell a different story; there is a 50% chance demand will not be met after 2033. The results indicate it is unlikely the borefield will fall short of unrestricted demands in 2027 (Scenario 2).

When pumping is distributed across 5 wells borefield demands are achievable. The uncertainty analysis indicate there is a 50% chance demands for the average demand scenario are met through to 2052. It is unlikely demand is not met after 2041 (Scenario 3).

Uncertainty analysis indicates the majority of models are able to meet unrestricted water demands in the 5 well scenario. Although the 50% percentile result is below the target, the models indicate Bore 8D falls 100 – 200 KL/day short of the target. This shortfall could be easily accommodated across the other deeper wells. The results indicate it is unlikely abstraction will fall short of unrestricted targets in 2028 (Scenario 4).

The unrestricted demand from 2 bores is calculated a 1,280 megalitres per year from bores 6D and 9D.This yield is the maximum pumping rate required during dry weather. These were used in the modelling predictions and come from the IWCM from Public Works Report Number ISR22031 27/05/22

3.9. Drought Resilience

From a perspective of available drawdown from the three deep bores , HEC have estimated that if river recharge was minimal over a ten year period due to low flow from Burrendong Dam there is likely to be a drop in standing water level of up to 5m(or less).Assuming that the likely event is that the hydraulic properties do not change (and the Jacob solution still applies) this is likely to result in a decrease in yield of up to ten percent-still more than sufficient to meet future demand , based on the three well scenario described in Manewell.

The Manewell report states that when measurement data is used to history match, hydraulic conductivity and specific yield are the most significant contributors to the uncertainty of groundwater level there would be likely to be a less than or equal to 5 metre drop in the standing water level (based on historical data).

3.10. Groundwater Recharge and Climate Change

Various studies (Williams R.M et al and Hamilton,S) have tried to address the input of recharge to the storage within the alluvial aquifer system in Narromine

The estimation of recharge is also constrained by the restricted flow in the Macquarie River and the average annual rainfall which is 544mm.It is understood that recharge is low compared to the storage in the aquifer system but a significant drop in water level over the last 20 years cannot be simply assessed as lack of recharge due to intermittent rainfall, lack of flow from Burrendong Dam or groundwater use.

In terms of recharge, the Manewell Model used recharge events from 2000 to 2023 and divided the area into the groundwater management zones and used a normal distribution around the most frequent recharge, which was 19mm/year to assess the affect of recharge on the available groundwater resource.

To address climate change, the model used a sensitivity analysis where rainfall was decreased, evaporation was increased and a transient recharge amount was added to the model. The results of the model have included both a recharge component and one related to climate change.

3.11. Groundwater Quality Constraints

This aspect will be reported in great detail by Atom, but It is apparent that in the vicinity of the deepened replacement bores for Narromine, there are recurrent water quality issues with turbidity, hardness, iron and manganese which exceed ADWG criteria and may require treatment.

As stated in section 40 page 28 of the Lower Macquarie Water Sharing Plan 2019 (Water Quality Management), "It is not recommended that the water from this groundwater source be consumed without prior treatment. Land use activities may have polluted the groundwater in some areas." Groundwater from around Narromine will therefore require similar levels of treatment to surface water sources

3.12. Authorised Access for the Town

As previously mentioned the Zone 1 and 3 have all been allocated, and there is no provision for increasing those allocations.

The Water Access License for NSC has been divided between Narromine and Trangie and is included below based on our current understanding:-

Council holds a Local Water Utility Water Access Licenses (WAL11603), issued under the Water Management Act 2000, which relates to the water supply to Narromine. The following apply to the WAL:

WAL license number	WAL11603
Category [Subcategory]	Local Water Utility
Entitlement	2,000 ML/ year
Water Source	Lower Macquarie Zone 1 Groundwater Source
Water Sharing Plan (WSP)	Macquarie-Castlereagh Groundwater Sources 2020

Trangie:

WAL license number	WAL11645
Category [Subcategory]	Local Water Utility
Entitlement	350 ML/year
Water Source	Lower Macquarie Zone 3 Groundwater Source
Water Sharing Plan (WSP)	Macquarie-Castlereagh Groundwater Sources 2020

While the, entitlement of 2,000 ML/annum is sufficient for the long term projected peak daily and annual demand for Narromine , Council have been unable to extract this volume and the town struggles to meet the current peak demands. Council have sunk test bores to locate additional sites to meet the allocation but have not been able to find any sources with sufficient yield. It is understood that Council has tested purchase of an existing bore and there is no cost effective means to access water from existing irrigators.

3.13. Indigenous Heritage Requirements

It is understood that this requirement is closely aligned to the maintenance of environmental flows in the Macquarie River to protect the health of the River System and maintain sensitive ecological communities like the Macquarie Marshes.

There is currently insufficient study of part of this report to comment except to say that the regulator has a responsibility to maintain environmental flows and that it would be considered that given the indigenous population has such a minimal use of water, there is no strong evidence that such considerations have not been addressed.

3.14. Needs and Options for Future Groundwater Development

The options for significantly improving groundwater supply to Narromine without either creating interference to existing bores or needing to cope with interference (and increased drawdown) due to pumping from such bores are very limited. The options covered here relate to those discussed with C.M Jewell

As indicated previously, the town itself lies to the north of the Quaternary alluvial palaeochannel aquifer (Aquifer 2) where relatively high and sustainable groundwater yields can be reliably obtained, and to the south-east of the thicker confined sandstone aquifers of the GAB intake beds.

The existing Narromine water supply bores obtain water from the shallow alluvial aquifer (Aquifer 1) and Aquifer 2. Aquifer 1 has relatively low yield, many existing groundwater users, and, because it is vulnerable to surface derived contamination, poor quality.

Constructing a new bore or bores in Aquifer 1 is not likely to solve the current supply problems and could exacerbate them. Beneath Narromine, both the upper and lower sandstone aquifers are less than 20

metres thick, and it is unlikely that adequate sustainable yields can be obtained from these aquifers in this location.

This means that a new bore or bores will have to be located at some distance from Narromine.

There are three possible options:

1. A borehole in the alluvial palaeochannel up to4 kilometres south of Narromine
2. A borehole drilled to intercept the thicker GAB intake beds about 10 to 15 kilometres north-west of Narromine.
3. A borehole in the deepest part of the Quaternary alluvial palaeochannel approximately 12 kilometres west of Narromine

3.14.1.Option 1

The Backwater Cowal palaeochannel aquifer (Aquifer 2) south of Narromine has been heavily developed by irrigation abstractions. Many of these established irrigation bores have high yields and develop significant drawdown cones when pumping. There are also a large number of relatively shallow stock and domestic bores, and a high yielding town bore that was constantly pumped may interfere -- with these existing bores. Therefore, it is necessary to find a location where it will be possible to locate a new bore without significant interference, and where it is possible to maintain the setback distances required by the Water Sharing Plan.

The closest location to Narromine where there is a reasonable prospect of obtaining groundwater from Aquifer 2 without such interference is about 4 kilometres south of Narromine, as shown on Figure 9. These solutions were tested during the millennium drought and proved to be not viable due to costs of associated power infrastructure and crossing of Aboriginal heritage areas and rail corridors Council have alsoundertaken exploratory test bores in this area previously and were not able to find a reliable groundwater source.

Figure 8: Option 1

3.14.2. Option 2

As shown on Figure 7, the GAB intake beds thicken to the north-west. Quite good yields of high quality water have been obtained on properties to the east of the Mitchell Highway such as Mungeribar Station. The 30-metre contour on Figure 7 shows the limit of the area where Aquifer 3b is likely to have a productive sandstone thickness of greater than 40 metres.

The advantage of this area is that, currently, it is likely to be possible to obtain good yield from sandstone at a depth of about 100 to 130 metres. The disadvantage is that while a specific-purpose access licence may be granted to a local water utility, the annual abstraction may be limited by the terms of the water sharing plan to the minimum necessary to meet to meet the circumstances requiring the licence. Also, under Section 36(4) of the Lower Macquarie water sharing plan, annual abstraction for a new bore in the sandstone aquifers is limited to 500 ML.

This option would also not likely to be viable due to costs of associated power infrastructure pipelie costs.

3.14.3. Option 3

Approximately 12 kilometres west of Narromine there is an area where Aquifer 2 is relatively undeveloped. This is shown on Figure 15. This area offers good prospects for location of a new town water supply bore, with drilling depth less than 100 metres.

HEC consider that this area is quite distant from the township and the cost of infrastructure piping and providing power to the site this option not likely to be cost effective.

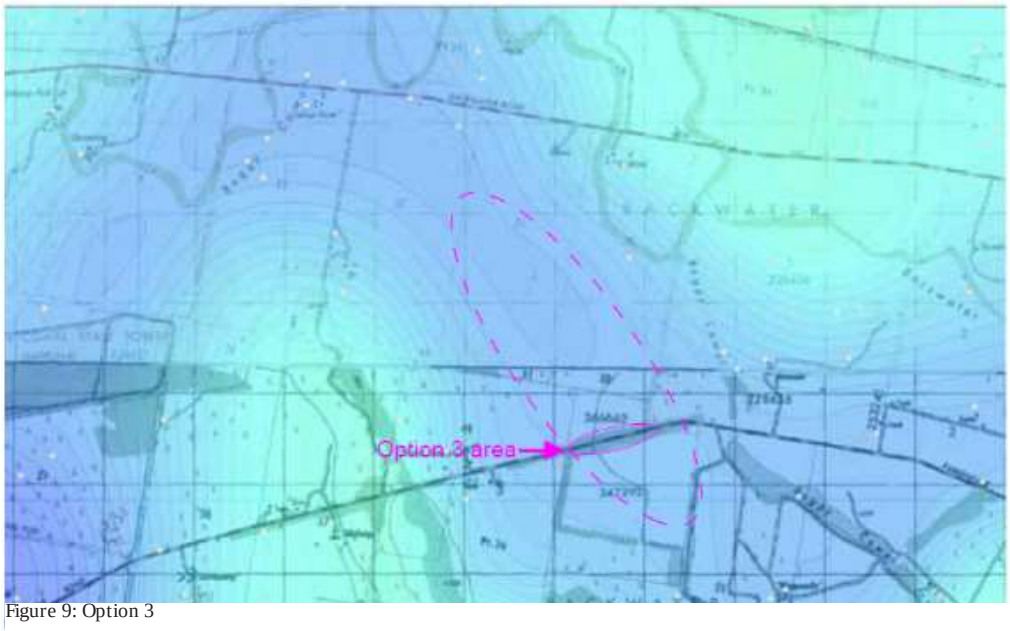


Figure 9: Option 3

3.14.4. Managed Aquifer Recharge(MAR).

Given the high permeability of the deep alluvial sediments, this is some potential to inject surface water during high rainfall events to provide sufficient storage to enhance the town water yield. Such projects have been successful and encouraging in the Murray Darling Basin at Menindee but there are several technical challenges including the chemistry of the river water and the compatibility of the river water chemistry as well as understanding the sustainable volume of river water which could be injected, whilst at the same time ensuring the needs of the ecological environment, are satisfied.

The technical aspect of MAR will require further study outside of this report.

3.15. Ranking of Options

Option 1 has the advantage of being closest to Narromine, but the available area is small, and located on private land. The area is also flood-prone. Of the three options, Option 1 is considered least likely to provide the required yield.

Option 2 is very likely to provide the required yield in the short-term, is not flood-prone, and can probably be accessed from the Mitchell Highway. However, this option may not be sustainable in the long-term, and new shares in this part of the GAB aquifer have restrictions.

Option 3 is some distance from Narromine and would require a pipeline approximately 25 kilometres long. There is some flood risk, but a suitable site can probably be in the reserve next to Farrendale Road. This option is very likely to provide the required yield without interference with existing users, should be sustainable in the long term, and should be licensable without restrictions. This option was explored, and exploratory drilling carried out in 2012. It was again examined as part of the IMPAX 2015 review and was discounted due to lack of success in 2012 and the distance from Narromine.

The preferred option is therefore Option 3 but due to the high costs of pumping other water sources such as the Macquarie River may be more cost effective.

4. CONCLUSIONS

Modelling of the groundwater system shows some uncertainty- that the current bores can supply the future needs of Narromine. There is little opportunity to construct new bores near the town and groundwater with

good yield and water quality would require long pumping distances when compared with alternative water sources such as the Macquarie River.

As the groundwater around Narromine has been affected by land use activities, it will require similar treatment to water from surface water sources. With the additional pumping costs, additional groundwater bores are unlikely to be more cost effective than surface water.

The decision on the pathway forward will require stakeholder involvement and further analysis with the muti faceted team at Atom, as well as Council and government stakeholders. The recommendations included here have not considered alternatives, cost comparisons and risk factors but hopefully will guide current opinions.

5. REFERENCES

NSC (2019) Narromine Shire Council Drought Security Update Report

Public Works Advisory ISR19015 (2019) Narromine Drinking Water Supply – Scoping Study Report

Impax Group (2015) Narromine-Trangie Water Supply Augmentation

Cape Associates (2013) Strategic Business Plan: Water Supply and Sewerage Businesses

Manewell Groundwater (2023) Narromine Modelling Report

Narromine Shire Council WSR 12077 (2013) Lower Macquarie Water Utilities Alliance Integrated Water Cycle Management Strategy

Narromine Shire Council (2020) DPIE-W Approved TOR

Public Works Advisory (2022) Integrated Water Cycle Management Strategy Issues Paper

C. M. Jewell and Associates Pty Ltd. (2011) Groundwater Investigation, Narromine and Tomingley for Narromine Shire Council (J1540.2R-rev0)

C. M. Jewell and Associates Pty Ltd. (2012) Narromine Groundwater Issues for Narromine Shire Council

APPENDIX A

REPORT REVIEWS

Lower Macquarie Water Utilities Alliance Integrated Water Cycle Management Strategy – Narromine Shire Council WSR 12077 (April 2013)

In case of severe drought reducing water availability in Narromine, the Drought Management Plan recommends the commissioning of new deeper bores to access the deeper alluvial ground water as the water table drops and the current bores fail. If the new bores are not able to be drilled in time or are not viable, the other options to be considered under the plan are:

- if there is water in the river, install appropriate treatment units and then use the treated river water otherwise
- implement potable reuse

Strategic Business Plan: Water Supply and Sewerage Businesses – Cape Associates (November 2013)

No pertinent information.

Narromine-Trangie Water Supply Augmentation – Impax Group (January 2015)

Recent drilling by Impax and NOW has indicated that:-

- Whilst deep groundwater and aquifer material does exist in the Cowal area (data from a 92m Test hole 144m south of town water supply bore 9. Drilled by NOW Feb 2013) it was not suitable for conversion to a production bore due to its location.
- This recent test bore from Impax (with strata reviewed by the author) shows 6 metres of clean gravel to a depth of 60m) which may yield 2 to 3ML/D however this test bore was located south of the Backwater Cowal.
- A recent pumping test on a NOW bore has been analysed by NOW as capable of pumping at 12 litres per second – a review of this pumping test has conclude that this analysis is very conservative and a yield of double this amount may be possible – we recommend an additional pumping test at this higher rate, be performed.

Narromine Drinking Water Supply – Scoping Study Report – Public Works Advisory ISR19015 (April 2019)

Five existing town water supply bores:

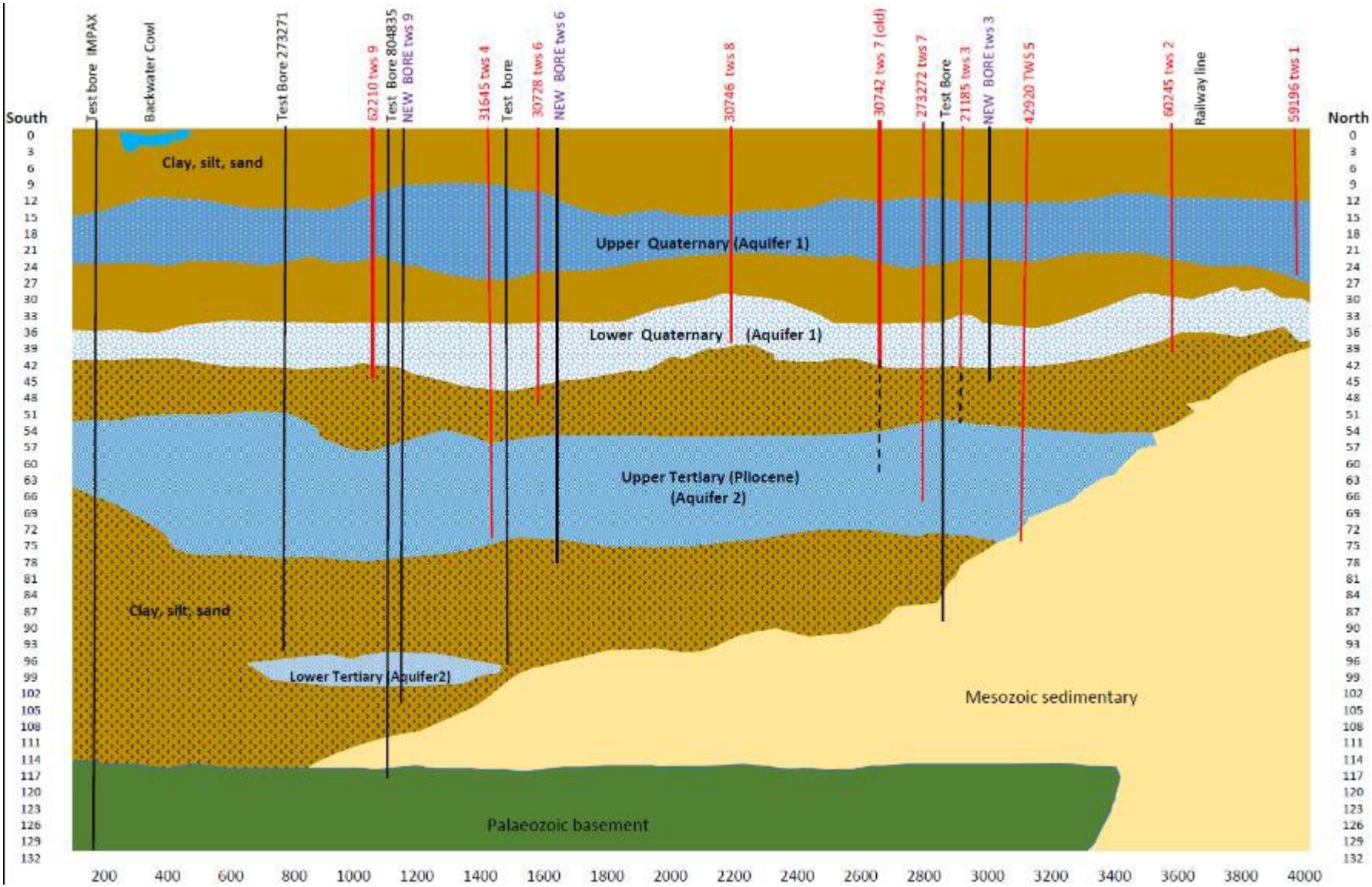
Bore	Completion Date	Yield 2015a	Yield 2016b	2019 Yield (early 2019)	Current Yield (April 2019)	Comments
Bore 3	1965 renewed 2018	23 L/s	14 L/s	20 L/s	20 L/s	This bore was re-drilled in 2018 on the same site. Current yield reflects the new bore.

Bore 6	1978	19 L/s	-	6 L/s	5.5 L/s	The 2016 yield is not available, Only the yield of bore 6D was noted in the 2016 Swan Report. The yield of this bore dropped as low as 4.1 L/s a few times, if it drops below the safety threshold of 4 L/s, the bore will be taken off.
Bore 7	1979	11 L/s	-	7 L/s	Taken off in March 2009	The 2016 yield is not available, Only the yield of bore 7D was noted in the 2016 Swan Report. As the current yield is below the safety threshold of 4 L/s, the bore was taken offline on 9 March 2019.
Bore 8	1979	20 L/s	15 L/s	9.5 L/s	9.5 L/s	
Bore 9	1987	18.8 L/s	-	12.5 L/s	12.5 L/s	The 2016 yield is not available, Only the yield of bore 9D was noted in the 2016 Swan Report.
Total yield		91.8 L/s			47.5 L/s	.

Three new deeper bores were drilled next to Bores # 6, 7 and 9 by Council to supplement the water supply:

Bore	Pump Test Estimated Safe Yield 2015a	Yield 2016b	Comments
Bore 6D	35 L/s	35 L/s	New, deeper bore drilled in 2015/16, but is not equipped due to water quality concerns.
Bore 7D	17 L/s	15 L/s	New, deeper bore drilled in 2012/13, but not equipped due to water quality concerns.
Bore 9D	135 L/s	50 L/s	New, deeper bore drilled in 2015/16, but not concerns.

Council has advised that the current peak day demand is in the order of 6.5 ML/d and the 2040 demand to be around 7.5 ML/d.


South
North
Test bore IMPAX
Backwater Cowl
Test Bore 273271
62210 tws 9
Test Bore 804835
NEW BORE tws 9
31645 tws 4
Test bore
30728 tws 6
NEW BORE tws 6
30746 tws 8
30742 tws 7 (old)
273272 tws 7
Test Bore
21185 tws 3
NEW BORE tws 3
42920 TWS 5
60245 tws 2
Railway line
59196 tws 1
Clay, silt, sand
Upper Quaternary (Aquifer 1)
Lower Quaternary (Aquifer 1)
Upper Tertiary (Pliocene)
(Aquifer 2)
Clay, silt, sand
Lower Tertiary (Aquifer2)
Mesozoic sedimentary
Palaeozoic basement
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84 87 90 93 96 99 102 105 108 111 114 117 120 123 126 129 132
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000

- The quality of the existing bores complies with the health based limits of the ADWG most of the time, except for a few exceedances in hardness, turbidity, and corrosiveness.
- There are several water quality parameters with noncompliance to the ADWG in the new deeper bores. The main water quality issues are high levels of turbidity, presence of iron, manganese and hardness.

Construction of the following new facilities is recommended to overcome the current water restrictions and give the level of water security required to promote further economic growth of the township of Narromine:

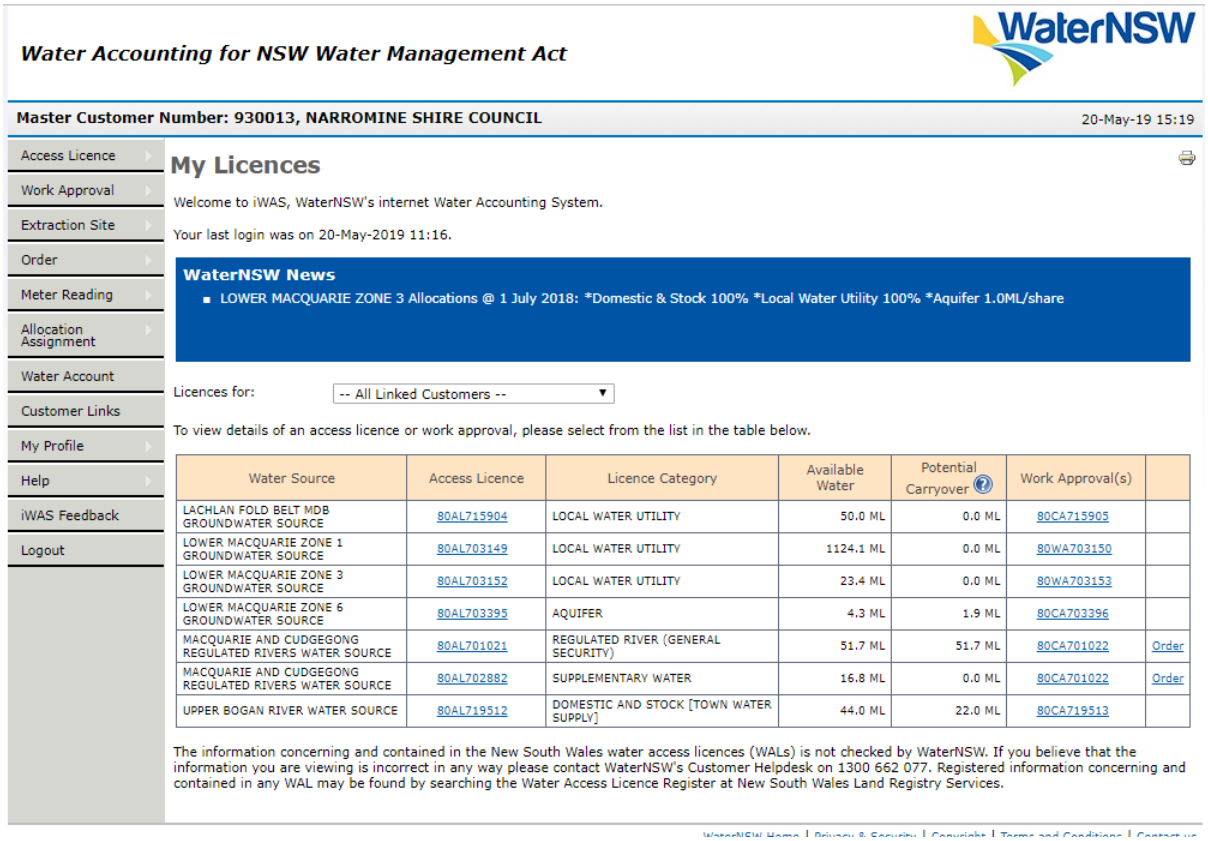
- a complete new water treatment plant to treat the water from Bores # 3, 8, 6D, 7D and 9D.
- a new clearwater rising main to pump the treated water to the town.
- a new service reservoir to provide for additional town water storage.
- a new trunk main to supply the treated water to the new reservoir.

Form 1 DPIEW Background Information

Great summary of Bores 3, 6, 7, 8, 9 containing:

- GW numbers
- WAL Extraction limits
- Well depth
- Screened intervals
- Extraction rates
- Pump depths
- Pump size and rating
- Links to Form As, pumping test data/analysis, photos

DPIE-W Approved TOR (Narromine Shire Council 2020)



Water Accounting for NSW Water Management Act

Master Customer Number: 930013, NARROMINE SHIRE COUNCIL 20-May-19 15:19

Access Licence
Work Approval
Extraction Site
Order
Meter Reading
Allocation Assignment
Water Account
Customer Links
My Profile
Help
iWAS Feedback
Logout

My Licences

Welcome to iWAS, WaterNSW's internet Water Accounting System.

Your last login was on 20-May-2019 11:16.

WaterNSW News

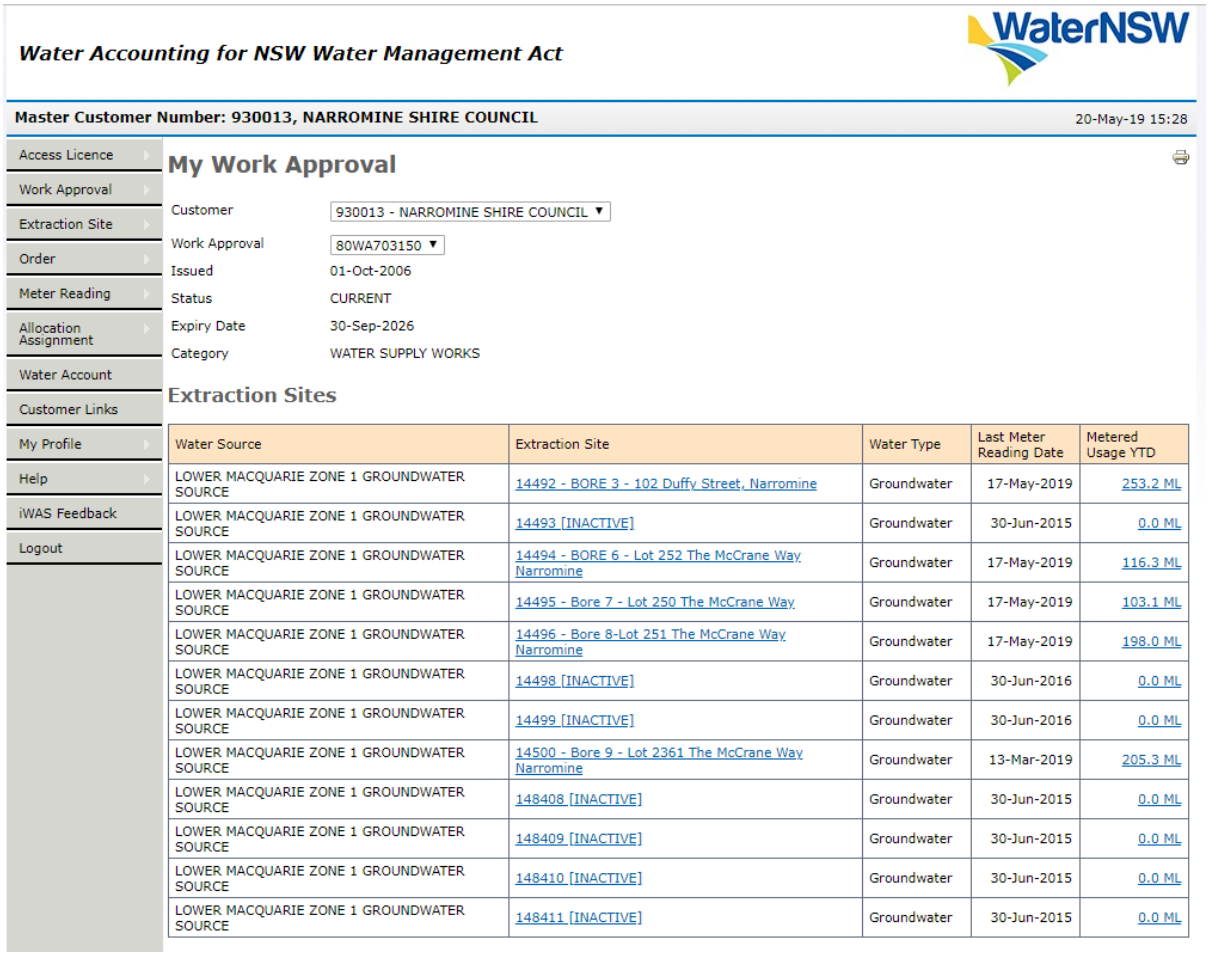
- LOWER MACQUARIE ZONE 3 Allocations @ 1 July 2018: *Domestic & Stock 100% *Local Water Utility 100% *Aquifer 1.0ML/share

Licences for: -- All Linked Customers --

To view details of an access licence or work approval, please select from the list in the table below.

Water Source	Access Licence	Licence Category	Available Water	Potential Carryover	Work Approval(s)	
LACHLAN FOLD BELT MDB GROUNDWATER SOURCE	80AL715904	LOCAL WATER UTILITY	50.0 ML	0.0 ML	80CA715905	
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	80AL703149	LOCAL WATER UTILITY	1124.1 ML	0.0 ML	80WA703150	
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	80AL703152	LOCAL WATER UTILITY	23.4 ML	0.0 ML	80WA703153	
LOWER MACQUARIE ZONE 6 GROUNDWATER SOURCE	80AL703395	AQUIFER	4.3 ML	1.9 ML	80CA703396	
MACQUARIE AND CUDGEGONG REGULATED RIVERS WATER SOURCE	80AL701021	REGULATED RIVER (GENERAL SECURITY)	51.7 ML	51.7 ML	80CA701022	Order
MACQUARIE AND CUDGEGONG REGULATED RIVERS WATER SOURCE	80AL702882	SUPPLEMENTARY WATER	16.8 ML	0.0 ML	80CA701022	Order
UPPER BOGAN RIVER WATER SOURCE	80AL719512	DOMESTIC AND STOCK [TOWN WATER SUPPLY]	44.0 ML	22.0 ML	80CA719513	

The information concerning and contained in the New South Wales water access licences (WALs) is not checked by WaterNSW. If you believe that the information you are viewing is incorrect in any way please contact WaterNSW's Customer Helpdesk on 1300 662 077. Registered information concerning and contained in any WAL may be found by searching the Water Access Licence Register at New South Wales Land Registry Services.



Water Accounting for NSW Water Management Act

Master Customer Number: 930013, NARROMINE SHIRE COUNCIL 20-May-19 15:28

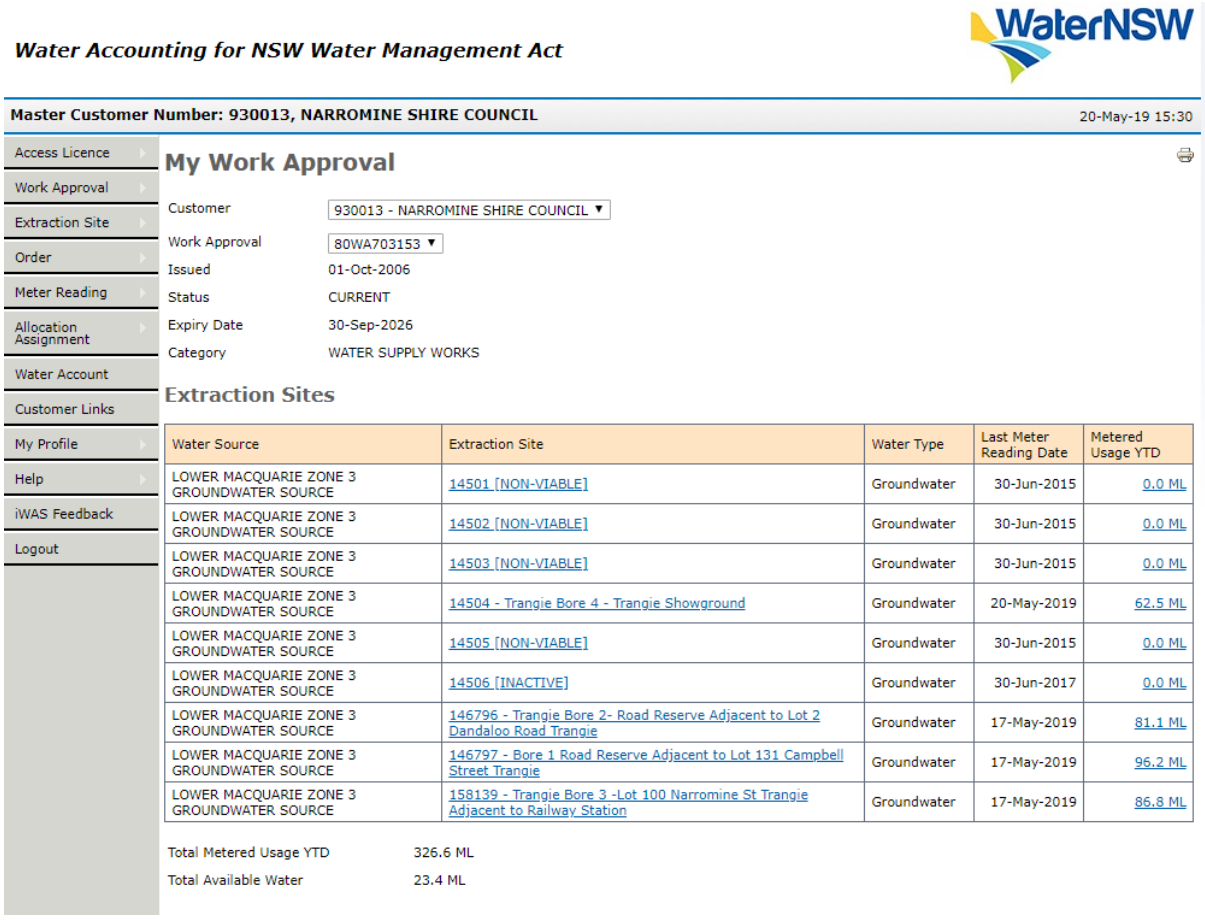
Access Licence
Work Approval
Extraction Site
Order
Meter Reading
Allocation Assignment
Water Account
Customer Links
My Profile
Help
iWAS Feedback
Logout

My Work Approval

Customer: 930013 - NARROMINE SHIRE COUNCIL
Work Approval: 80WA703150
Issued: 01-Oct-2006
Status: CURRENT
Expiry Date: 30-Sep-2026
Category: WATER SUPPLY WORKS

Extraction Sites

Water Source	Extraction Site	Water Type	Last Meter Reading Date	Metered Usage YTD
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14492 - BORE 3 - 102 Duffy Street, Narromine	Groundwater	17-May-2019	253.2 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14493 [INACTIVE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14494 - BORE 6 - Lot 252 The McCrane Way Narromine	Groundwater	17-May-2019	116.3 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14495 - Bore 7 - Lot 250 The McCrane Way	Groundwater	17-May-2019	103.1 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14496 - Bore 8-Lot 251 The McCrane Way Narromine	Groundwater	17-May-2019	198.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14498 [INACTIVE]	Groundwater	30-Jun-2016	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14499 [INACTIVE]	Groundwater	30-Jun-2016	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	14500 - Bore 9 - Lot 2361 The McCrane Way Narromine	Groundwater	13-Mar-2019	205.3 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	148408 [INACTIVE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	148409 [INACTIVE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	148410 [INACTIVE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 1 GROUNDWATER SOURCE	148411 [INACTIVE]	Groundwater	30-Jun-2015	0.0 ML



Water Accounting for NSW Water Management Act

WaterNSW

Master Customer Number: 930013, NARROMINE SHIRE COUNCIL 20-May-19 15:30

Access Licence
Work Approval
Extraction Site
Order
Meter Reading
Allocation Assignment
Water Account
Customer Links
My Profile
Help
iWAS Feedback
Logout

My Work Approval

Customer: 930013 - NARROMINE SHIRE COUNCIL
Work Approval: 80WA703153
Issued: 01-Oct-2006
Status: CURRENT
Expiry Date: 30-Sep-2026
Category: WATER SUPPLY WORKS

Extraction Sites

Water Source	Extraction Site	Water Type	Last Meter Reading Date	Metered Usage YTD
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14501 [NON-VIABLE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14502 [NON-VIABLE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14503 [NON-VIABLE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14504 - Trangie Bore 4 - Trangie Showground	Groundwater	20-May-2019	62.5 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14505 [NON-VIABLE]	Groundwater	30-Jun-2015	0.0 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	14506 [INACTIVE]	Groundwater	30-Jun-2017	0.0 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	146796 - Trangie Bore 2- Road Reserve Adjacent to Lot 2 Dandaloo Road Trangie	Groundwater	17-May-2019	81.1 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	146797 - Bore 1 Road Reserve Adjacent to Lot 131 Campbell Street Trangie	Groundwater	17-May-2019	96.2 ML
LOWER MACQUARIE ZONE 3 GROUNDWATER SOURCE	158139 - Trangie Bore 3 -Lot 100 Narromine St Trangie Adjacent to Railway Station	Groundwater	17-May-2019	86.8 ML

Total Metered Usage YTD 326.6 ML
Total Available Water 23.4 ML

Catchment: Macquarie Alluvial Aquifer – Recharge dependent upon rainfall, leakage from the river channel and irrigation flows derived from pumping from the river

The 2006-07 SBP identified the Peak Day Drinking Water Demand of Narromine as being 6.8ML/d while the 2014 SBP and IWCM identified a figure of 5,165 litres/tenement/day with a target of <5000litres/tenement/day set. At time of these studies very little accurate volumetric usage data was available.

Integrated Water Cycle Management Strategy Issues Paper – Public Works Advisory (May 2022)

The infrastructure leakage index (ILI) for the Narromine Potable WSS is 6.7, indicating a high water loss. The water loss is around 264 L/assessment/day, which is approximately three times the state median.

Based on PWA's water quality risk assessment tool, the inherent risk of the Narromine source water catchment is 'Very High, indicating a very high risk to chlorine-sensitive and chlorine-resistant pathogens. This is due to disused uncapped bores close to all of the town water supply bores, along with a large number of failed stock and domestic bores.

Bore ID (GW number)	Make - Serial	Install year	Flow rate (L/s)	Head (m)	Flow rate according to 2015 hydrogeological report (L/s) [10]
3 (GW021185) – shallow	N/A	1965	N/A	N/A	23.0
6D (GW042924)	Aquawest - FPS- 140FS8-4E	2016	40.0	55.0	-
7D (GW273272)	-	2013	-	-	17.0
8D (GW030746) – constructed, not operational without treatment	Aquawest - FPS- 140FS8-3B/L/N	2020	36.0	56.0	20.0
9D (GW062210)	Aquawest - FPS-110- FS-5I	2015	31.8	70.0	22.4

Council holds a *Local Water Utility* Water Access Licenses (WAL11603), issued under the *Water Management Act 2000*, which relates to the water supply to Narromine. The following apply to the WAL:

WAL license number	**WAL11603**
Category [Subcategory]	Local Water Utility
Entitlement	**2,000 ML/year**
Water Source	Lower Macquarie Zone 1 Groundwater Source
Water Sharing Plan (WSP)	Macquarie-Castlereagh Groundwater Sources 2020

Trangie:

WAL license number	**WAL11645**
Category [Subcategory]	Local Water Utility
Entitlement	**350 ML/year**
Water Source	Lower Macquarie Zone 3 Groundwater Source Macquarie-
Water Sharing Plan (WSP)	Castlereagh Groundwater Sources 2020

Tomingley

WAL license number **WAL35321**
Category [Subcategory] **Local Water Utility**
Entitlement **22 ML/year**
Water Source **Upper Bogan River Water Source**
Water Sharing Plan (WSP) **Macquarie Bogan Unregulated Rivers Water Sources 2012**

Water quality:

- **Current existing bores (Bores 3, 6, 7, 8 and 9)**

  - The raw water quality of the existing bores complied with the health-based limits of the Australian Drinking Water Guidelines (ADWG) most of the time, except for a few exceedances in hardness, turbidity and corrosiveness.

- **New bores (Bores 6D, 7D and 9D)**
  - Turbidity – Bores 6D and 7D have shown regular turbidity levels above 10 NTU and levels as high as 40 NTU after aeration. For effective disinfection, the turbidity in the water should be below 1 NTU as per the NSW Department of Health CCP Circular issued in December 2018.
  - Colour – Colour levels were much higher than the generally acceptable value of 15 HU which were seen in some of the bore samples after aeration.
  - Iron – Bores 6D and 7D had an iron concentration in the order of 1.5 and 2.5 mg/L respectively, which both exceeded the ADWG taste/aesthetic threshold of 0.3 mg/L. Bore 9D had acceptable levels of iron concentration for most of the time except for a few occasions where the value is in the order of 0.4 mg/L.
  - Manganese – all three new bores showed high manganese concentrations. Bore 7D had the highest concentration mostly ranging between 0.7 mg/L and 2.0 mg/L. Bore 9D had the lowest concentration with some samples having higher manganese levels of around 0.5 mg/L. These three bores all exceeded the ADWG taste/aesthetic threshold of 0.1 mg/L.
  - Hardness – all three new bores showed high hardness levels ranging between 200 and 350 mg/L as $CaCO_3$.
  - Corrosiveness – the water from all three new bores showed severe corrosive nature with CCPP (calcium carbonate precipitation potential) values in the order of -35 mg/L compared to a preferred value being closer to zero.

Treatment occurs in two stages, Bores 6 and 9 are initially treated at the Temporary Iron & Manganese Removal Plant (which will be referred as the "Temporary WTP") near Bores 6 and 9; treated water is transferred to the Aeration Balance Tank and chlorination facilities for further treatment. Extractions from Bores 3, 8 and 8D are also pumped and treated at the Aeration Balance Tank and chlorinated before distribution. The Narromine Temporary WTP can provide up to 2.5 ML/ day of treated drinking water.

The impact of climate change on peak day production is an increase in the frequency of peak weeks by up to double, indicating that peak weeks are expected to occur twice as often in a 1°C warming condition.

Within a 1 km radius, potential contamination sources are as follows:

- Several SPS, however there has been no known overflows
- The Narromine Waste Facility – landfill leachate may end up in the water source, however, based on EPA annual returns, there have been no exceedances in recorded pollutants
- Narromine Cemetery – potential for chemicals (such as formaldehyde), bacteria and viruses to pollute drinking water sources

Narromine and Tomingley Groundwater Investigation, C. M. Jewell and Associates Pty Ltd. For Narromine Shire Council (2011)

In-depth report, background and geology use as a basis for the report

Existing Town Water Supply Groundwater Investigations, NSW Department of Planning, Industry and Environment ()

This is a template or guideline for consultants to deliver a Sustainable Yield and Drought Resilience Assessment for existing town water supply.

Matches what has been done in HEC's proposal, and should be used as a guideline for the report

Narromine Groundwater Issues, C. M. Jewell and Associates Pty Ltd. Ref: J1540.4L (2012)

Summary of matters discussed in a meeting.

Upgrade/Deeping of Existing Bores

- TWS7 – encountered 2 alluvial aquifers 33.5 to 41.8m and 47 to 62.5m
- TWS6 – screened from 22.8 to its base at 44.5m. An adjacent bore was drilled to 68m and encountered a further 2 alluvial aquifer units deeper then TWS6.
- It was agreed that a deeper bore adjacent to TWS7 and possibly TWS6 could provide additional supply security.

Purchase of Existing Licenses

- They discuss the option of purchasing existing licenses. Go to the report to read more.

Justification for Additional Bores

- The primary justifications for considering new bores that are located outside the envelope of the existing water supply system are:
    - To obtain a secure long-term water supply that is not impacted by drawdown interference from other bores, including existing town water supply bores and other uses, including irrigation bores; and
    - To obtain better water quality by locating bores outside of the existing urban area.

Implications of Tomingley Gold Mine Project

- Alkane Resources has purchased an aquifer access licence that permits extraction of 800 megalitres per year (ML/yr) from a property 7 kilometres east of Narromine. Alkane proposes to drill a new bore on that property, and to construct a 22 kV powerline to provide electricity to the pump.

Current Demand of Other users

- Current annual groundwater usage is about 12 GL in Zone 1, 5 GL in Zone 3 and 1.5 GL in Zone 6.

Use of River Water and Mixing

- Notes that this is technically possible but suffers disadvantages due to surface water allocations during a drought.

Water Reuse and Stormwater Recycling

- These options are possible but not simple. Orange has just completed a major stormwater recycling study. Such a scheme would be less viable in Narromine given the differences in population, area and infrastructure.

Narromine Groundwater Scheme Works Approval Information and Asset Data

Water Supply Scheme		*Works Approval Details*		*Water Sharing Plan*			*Total WAL Entitlement*		*Location*	*NRAR Compliance*	*Asset Information and Maintenance Data*			
Narromine		*Combined Work Approval No 80WA703150*		*Lower Macquarie Water Sharing Plan Zone 1*			*2000 ML Per Annum*		*Narromine LGA*					
Council Bore No	Work No in Schedule 2 of Works Approval Document	GW Number	Maximum Extraction on WAL if Any	ESID No	Depth	Number of Screens and Depths	Approximete Distance to Nearest Bore	Idicative Extraction Rate	Lot and DP Number	NRAR Metering Comments	Pump Depth	Pump Size and Rating in KW	Date of Last Down Hole Inspection	Link to Construction Form A and Original Pump Test Report
3	5	GW807349	N/A	14492-2	41M	1 Screen 32 to 38m	420M to GW801040	20/lps	241//755131	LID and Seals to be applied	29M	150mm 30KW Sub		Bore Data\NRM_3
6	3	GW807347	N/A	14494-2	89M	2 Screens 57 to 63M 79 to 85M	233M to GW070852	34/lps	252//46112	LID and Seals to be applied	45M	196 mm 37 KW -Sub	9/06/2020	Narromine Bore 6 Data,Photos & Videos
7	1	GW273272	N/A	14495-2	63.5M	1 Screen 59.5 to 62.5M	660M to GW804668 and GW050828	16/lps	250//46112	LID and Seals to be applied	55M	150mm 15KW -Sub		Narromine Bore 7 Data, Photos & Videos
8	6	GW807350	1072 ML/AN	14496-2	73.0M	4 Screens 41 to 47M 53 to 56M 58 to 61M 64 to 70M	350M to GW804668 and GW050828	33/lps	251//46112	LID and Seals to be applied	49.5M	200mm 30Kw_ Sub		Narromine Bore 8 Data, Photos & Videos
9	2	GW807346	N/A	14500-3	104M	3 Screens 58 to 60M 70 to 76M 96 to 101M	500M to GW800082	36/lps	2361//629623	LID and Seals to be applied	55M	200mm 30Kw_ Sub		Narromine Bore 9 Data, Photos & Videos

Trangie Groundwater Scheme Works Approval Information and Asset Data

Water Supply Scheme		*Works Approval Details*		*Water Sharing Plan*			*Total WAL Entitlement*		*Location*	*NRAR Compliance*	*Asset Information and Maintenance Data*			
Trangie		*Combined Work Approval No 80WA703153*		*Lower Macquarie Water Sharing Plan Zone 3*			*350 ML Per Annum*		*Narromine LGA*					
Council Bore No	Schedule 2 of Works Approval Document	GW Number	Maximum Extraction on WAL if Any	ESID No	Depth	Screen Depths	Distance to Nearest Bore	Idicative Extraction Rate	Lot and DP Number	NRAR Metering Comments	Pump Depth	Pump Size and Rating in KW	Date of Last Down Hole Inspection	Link to Construction Form A and Original Pump Test Report
1	work 7	GW805584	500ML	146797	113M	I Screen 104M to 110M		19/lps	131/755126	LID and Seals to be applied	90M	200mm 37KW Sub		Trangie Bore1 Data, Photos & Videos
2	Work 6	GW805583	500ML	146796	99M	1 Screen 90M to 96M		28/lps	2//329094	LID and Seals to be applied	85M	200mm 45KW Sub		Trangie Bore 2 Data, Photos & Videos
3	work 8	Not Given	500ML	158139	104M	1 Screen 96 To 102M		28/lps	100/878264	LID and Seals to be applied	85M	200mm 55KW Sub		Trangie Bore 3 Data, Photos & Videos

Drinking Water Management System Annual Report 2020, Narromine Shire Council (2020)

This annual report documents Narromine Shire Council's (NSC's) Drinking Water Management System (DWMS) implementation and drinking water performance from 1 January to 31 December 2020.

There were no critical control point exceedances recorded in 2020 in the Narromine or Trangie water supply systems.

Narromine water quality

- When 2020 began, the Narromine water supply had no means of controlling iron and manganese levels in the treated water. This became an issue in March/April 2020 as the water quality from one of the bores (bore 9) deteriorated. There were water quality

complaints, and the bore was taken offline. To address this issue a temporary water treatment plant, capable of removing the iron and manganese, was installed in April and was brought online in July 2020 to treat water from bore 9 and bore 6. No monitoring results from this period were outside the AWDG guidelines.

- Water from the Narromine water supply system has been consistently within critical limits and ADWG guidelines. There was a decline in free chlorine in the first quarter due to the deterioration of raw water quality from bore 9 but water stayed within the critical limits. Once this issue was addressed water quality was stable.
- NSW Health verification monitoring of Narromine drinking water recorded a total coliforms result of 6 cfu/100 mL. There were no aesthetic or health guideline exceedances or E. coli detections.
- All free chlorine results from the Narromine reticulation were above 0.2 mg/L as recommended by the ADWG.

Trangie water quality

- NSW Health verification monitoring of Trangie drinking water recorded high sodium, high pH, high temperature, one occasion of low free chlorine with 0.15 mg/L and two total coliforms detections of 1 cfu/100 mL and 11 cfu/100 mL. There were no health or aesthetic guideline exceedances or E. coli detections.
- It is known that Trangie raw water has high sodium and pH and there are no treatment processes that can control those characteristics.
- When total coliforms or low free chlorine was detected, NSC investigated the water quality recorded leaving the reservoirs in the SCADA system. There was found to be no issue with the free chlorine at the time of the detections. Following the low free chlorine detection, the reticulation system was flushed, and additional monitoring undertaken to ensure the free chlorine returned to above the ADWG guideline (0.2 mg/L).

Narromine Shire Council Drought Security Update Report 2019, Narromine Shire Council (2021)

Narromine Shire Council services the Townships of Narromine, Trangie and the Village of Tomingley in The Great Western Plains of NSW. The current severe drought conditions across NSW are impacting heavily on the water supplies of the region and specifically on the security of the Narromine Town Water Supply. mNarromine has been subjected since January 2018 to a decreasing reliability of supply necessitating Level 3 water restrictions as a result of the continued fall in the aquifer water level.

This document discusses short, medium and long term plans to deal with these issues. Short term plans included redevelopment of existing bores and temporary treatment of water from deeper bores. Medium and long term plans include further demand analysis, water loss management studies and strategies and in all areas including a continued focus on conservation measures education and when required restrictions.

Narromine has a sufficient groundwater allocation, the ability however to utilise available ground water bores is limited by the lack of a Water Treatment Plant. This lack of a plant limits the ability to treat water with high iron and manganese from the new deep bores.

The aquifers rely entirely upon being replenished by flows in the Macquarie River. The Narromine Bores are located in what is designated via the Water Sharing Plan as Zone 3.

Further drilling on the existing sites of bores 6 and 9.The test bores at both these locations were gamma logged and showed that a substantial amount of water bearing gravels where present at lower levels. Both test holes where enlarged and production bores constructed. These bores were pump tested and safe yields of up to 35lps for bore 6 and up to 135lps for bore 9 were estimated.

FIGURE 1: TOWN BORE LOCATIONS AND STATE WATER MONITORING BORE LOCATIONS

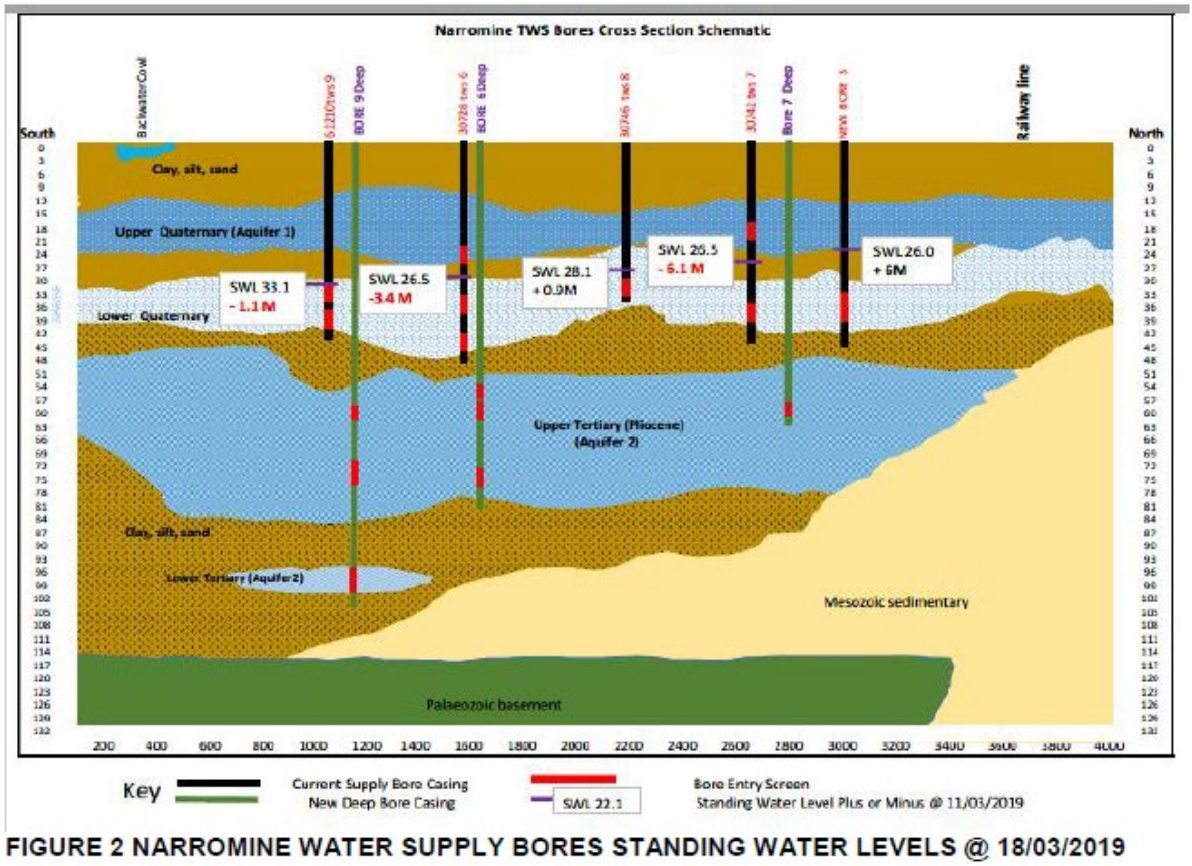


FIGURE 2 NARROMINE WATER SUPPLY BORES STANDING WATER LEVELS @ 18/03/2019

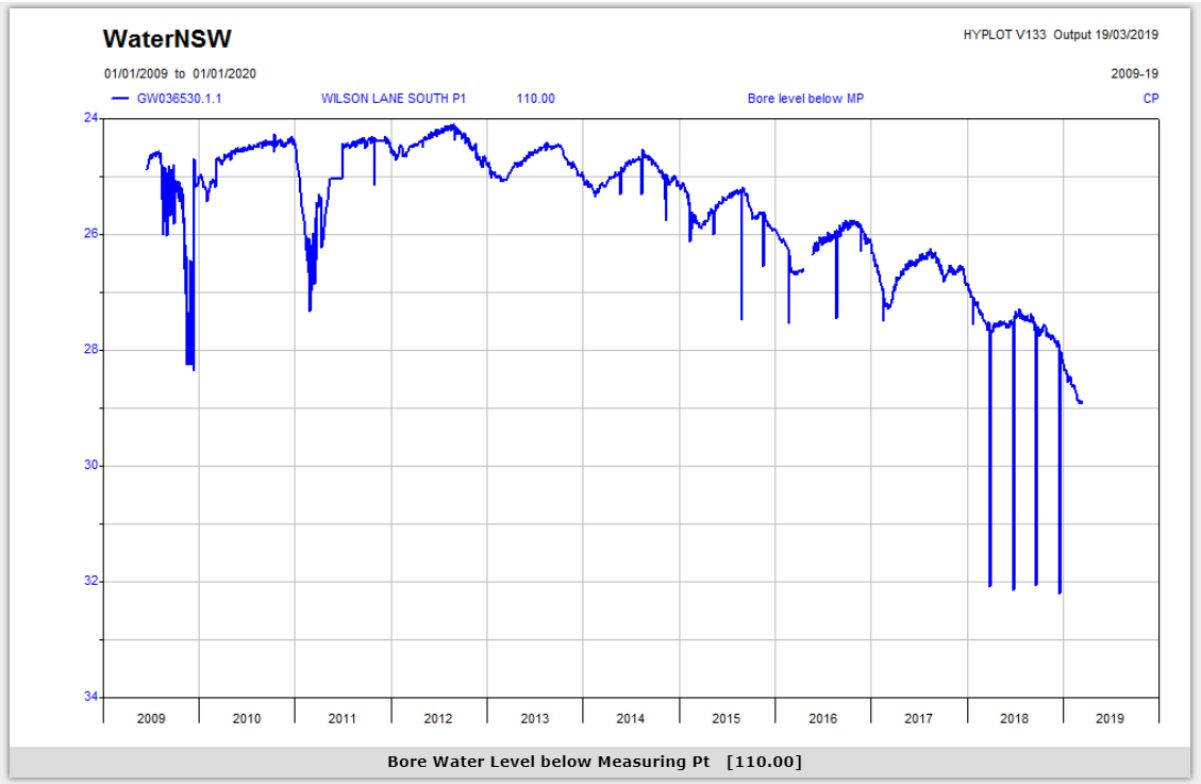


FIGURE 2 NSW Water Monitoring Bore Wilsons Lane Narromine SP1

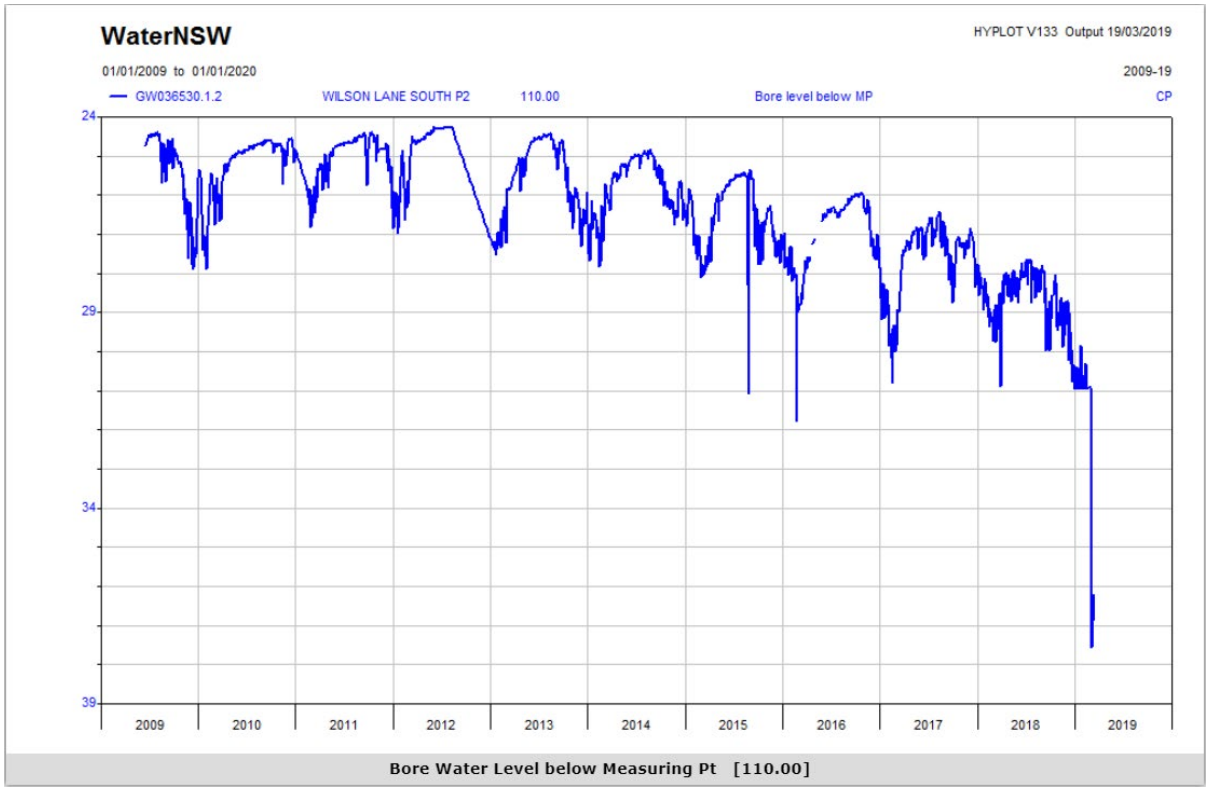


FIGURE 2a NSW Water Monitoring Bore Wilsons Lane Narromine SP2

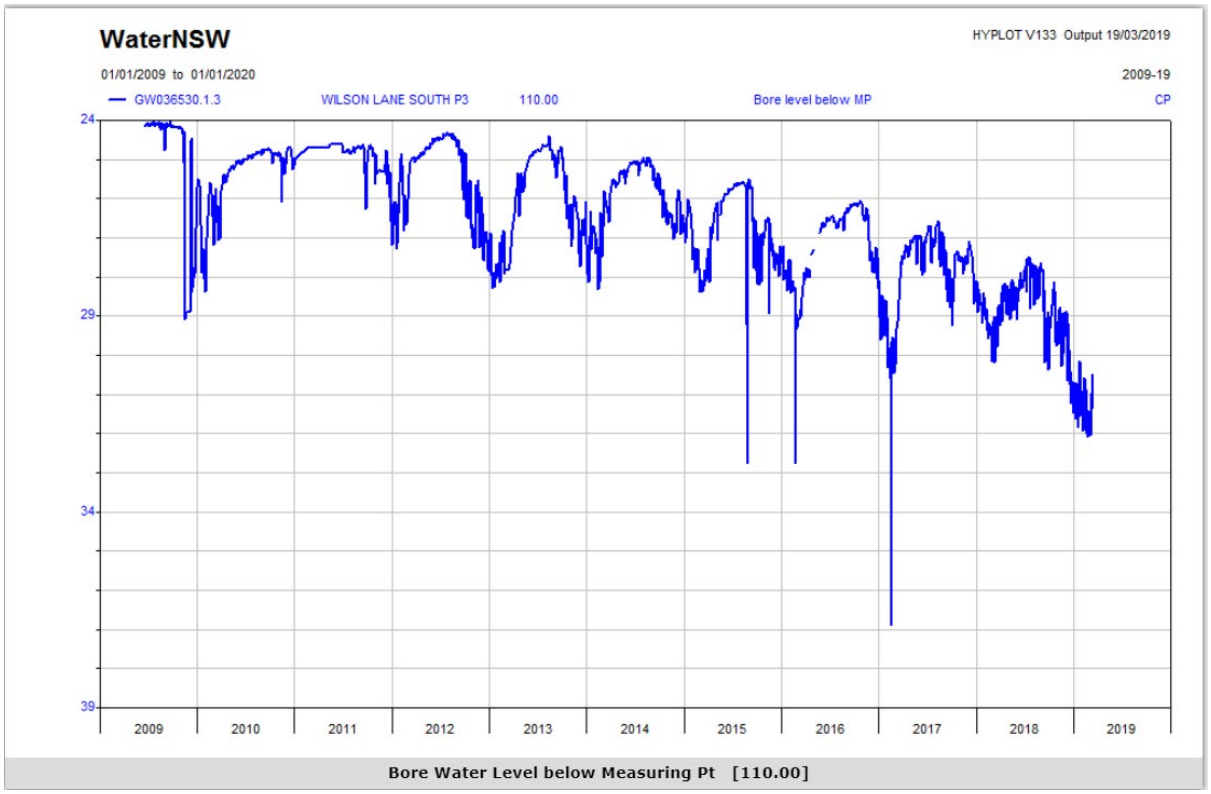


FIGURE 2b NSW Water Monitoring Bore Wilsons Lane Narromine SP3

Narromine Shire Council Infrastructure and Engineering Report (2019)

- As previously identified in the NARROMINE SHIRE COUNCIL DROUGHT SECURITY UPDATE REPORT of APRIL- 2019 the situation in regard to water security in Narromine has continued to deteriorate. There is further evidence that the Standing Water Level (SWL) of the Upper and Lower Quaternary Aquifers in the Lower Macquarie Alluvial System is still under pressure with only minor recovery recorded since the onset of the colder weather. As well a recent pump change at Narromine Bore No 8 due to motor failure revealed evidence of possible aquifer compaction.
- Investigations and requested budget estimates were carried out for a temporary containerised Iron and Manganese removal and filtration system for potential installation at the location of Bore 6D. This intended as a temporary solution to treat water from the deeper bores 6D and 9D when required to the same water quality as the existing bores.]
- OUTCOMES:
    - Following meetings with DOI Water staff and the Premiers Cross Border Commissioner Mr James McTavish it was decided to engage Haldon Industries to carry out further Optimisation testing. The results of this testing are presented in the attached reports along with suggestions on the management of backwash water and sludge.
    - It is therefore recommended that Council proceed forward with the proposals as put forward by Haldon Industries to install and commission a Temporary Treatment system. This being for the removal of Iron and Manganese from Deep Bores 6 and 9 pending receiving concurrence from DOI Water in relation to Section 60.

Narromine Water Treatment Plant options Report, David Swan 2016

Water for the Narromine Township is available from predominately bores; however Council does have access to the Macquarie River for watering some of its recreational areas. While increased water availability is now available through the drilling of new bores, the water quality from these sources requires additional treatment than currently available.

During 2015 and 2016, funds were provided to Council to augment the water supply for Narromine with the aim of improving the Town's drought security. Two new replacement bores were constructed to source water from a deeper, larger aquifer, and an existing bore not in use was equipped and put into service. The bores in question are located along Tullamore Rd to the south of Narromine with the four bores located roughly in a line, parallel to the road extending about 1.8kms from Nellie Vale Rd. These bores are known as Bores 6, 7, 8 and 9 as shown in Figure 3.1. Prior to this augmentation, there were existing bores at each of these sites. Reference to these bores in this paper refer to the new bores, post the completion of the drilling of a new bore at the Bore 6 and Bore 9 sites, and the equipping of the new bore at the Bore 7 site.
At the time of writing this paper, bore 6 and Bore 9 have not been equipped because on completion of the new bores, the quality of the available water does not meet the requirements for drinking water.

Table 3.1: Bore Flow Rates - Bores 6,7,8,9.

Bore Number	Flow rate (L/sec)	Daily flow based on 22. hours pumping (kL)
Bore No 6	35	2,772

Bore No 7	15	1,188
Bore No 8	15	1,188
Bore No 9	50	3,960
Total	**115L/sec**	**9,108 (9.1 ML)**

Table 3.4: Current Peak Day Demand for Narromine

Narromine Consumers	Number per Category	Peak Day Demand L/day	Qty per Category	Peak Day Demand L/day	Total L/day
Permanent houses, water connections	1491	5,000	1491	5,000	7,455,000
Flats/units	16	1,250	16	1,250	20,000
Hotels/motels	7	150/bed	132	150	19,800
Caravan Parks	1	600/site	64	600	38,400
Schools	11	50/pupil	911	50	45,550
Hospital	2	1,000/bed	29	1,000	29,000
Nursing homes	3	300/bed	46	300	13,800
Office/shops/ Industrial Premises	216	500	216	500	108,000
Parks, Ovals, etc.	see attached	62,500/ha	20.9	62,500	1,306,250
TOTAL					**9.04ML**

APPENDIX B

PUMPING TEST DATA

Single Rate Pump Test and Recovery

LICENCE No. 80WA703153 **BORE No.** Trangie TWS Bore

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Sunday 3 May 2015 10:00 **Duration:** 48 **hours**

S.W.L.: 35.71 **metres** **Height reference point above GL:** ..... **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)	Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
1	58.24	22.53	42	23.81	4	54.80	22.63	54.24
15	66.26	30.55	42	23.81	5	54.03	23.40	56.09
20	66.93	31.22	42	23.81	6	53.45	23.98	57.48
25	67.41	31.70	42	23.81	7	53.00	24.43	58.56
30	67.78	32.07	42	23.81	8	52.61	24.82	59.49
45	68.74	33.03	42	23.81	9	52.26	25.17	60.33
50	68.93	33.22	42	23.81	10	51.97	25.46	61.03
60	69.33	33.62	43	23.26	12	51.42	26.01	62.34
75	69.83	34.12	43	23.26	14	51.03	26.40	63.28
105	70.63	34.92	43	23.26	16	50.70	26.73	64.07
120	70.92	35.21	43	23.26	18	50.40	27.03	64.79
140	71.33	35.62	43	23.26	20	50.12	27.31	65.46
160	71.61	35.90	43	23.26	25	49.53	27.90	66.87
180	71.89	36.18	43	23.26	30	49.07	28.36	67.98
210	72.28	36.57	43	23.26	35	48.63	28.80	69.03
240	72.59	36.88	44	22.73	40	48.28	29.15	69.87
300	73.09	37.38	44	22.73	50	47.70	29.73	71.26
360	73.52	37.81	44	22.73	60	47.23	30.20	72.39
480	73.93	38.22	45	22.22	70	46.77	30.66	73.49
600	74.47	38.76	45	22.22	80	46.42	31.01	74.33
720	74.79	39.08	45	22.22	100	45.78	31.65	75.86
960	75.35	39.64	46	21.74	120	45.25	32.18	77.13
1200	75.87	40.16	46	21.74	150	44.66	32.77	78.55
1440	76.23	40.52	46	21.74	180	44.13	33.30	79.82
1560	76.45	40.74	46	21.74	240	43.27	34.16	81.88
1920	76.57	40.86	46	21.74	300	42.69	34.74	83.27
2160	76.93	41.22	47	21.28	360	42.25	35.18	84.32
2520	77.22	41.51	47	21.28	420	42.05	35.38	84.80
2880	77.43	41.72	47	21.28	1680	38.75	38.68	92.71

Single Rate Pump Test and Recovery

LICENCE No. 80WA703153 **BORE No.** Trangie TWS Bore 2 - High School

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Monday 11 May 2015 11:00 **Duration:** 48 **hours**

S.W.L.: 36.36 **metres** **Height reference point above GL:** ..... **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)
1	48.10	11.74	37.0	27.03
3	49.80	13.44	37.0	27.03
5	50.52	14.16	37.0	27.03
10	51.44	15.08	37.0	27.03
15	52.02	15.66	37.0	27.03
20	52.41	16.05	37.0	27.03
30	53.00	16.64	37.0	27.03
45	53.50	17.14	37.0	27.03
60	53.86	17.50	37.0	27.03
90	54.33	17.97	37.0	27.03
120	54.89	18.53	37.0	27.03
180	55.86	19.50	37.0	27.03
240	56.12	19.76	37.0	27.03
360	57.12	20.76	37.5	26.67
480	57.22	20.86	37.5	26.67
660	57.39	21.03	37.5	26.67
840	58.39	22.03	37.5	26.67
1080	58.71	22.35	38.0	26.32
1200	58.93	22.57	38.0	26.32
1380	59.05	22.69	38.0	26.32
1440	59.22	22.86	38.0	26.32
1590	59.43	23.07	38.0	26.32
1800	59.74	23.38	38.5	25.97
1980	60.22	23.86	38.5	25.97
2340	60.35	23.99	38.5	25.97
2580	60.43	24.07	38.5	25.97
2700	60.74	24.38	38.5	25.97
2880	60.91	24.55	38.5	25.97

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
1	48.75	12.16	49.53
3	48.69	12.22	49.78
5	48.03	12.88	52.46
10	47.13	13.78	56.13
15	46.62	14.29	58.21
20	46.28	14.63	59.59
30	45.83	15.08	61.43
45	45.34	15.57	63.42
60	44.86	16.05	65.38
90	43.99	16.92	68.92
120	43.26	17.65	71.89
180	42.35	18.56	75.60
240	42.00	18.91	77.03
360	41.85	19.06	77.64
480	41.10	19.81	80.69
600	40.49	20.42	83.18
780	39.91	21.00	85.54
1260	37.70	23.21	94.54
1800	37.62	23.29	94.87

Single Rate Pump Test and Recovery

LICENCE No. ..... **BORE No.** Trangie TWS Bore

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Sunday 17 July 2016 6:00 **Duration:** 48 **hours**

S.W.L.: 31.72 **metres** **Height reference point above GL:** ..... **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)
1	46.74	15.02		
3	50.52	18.80		
5	51.68	19.96		
10	52.74	21.02		
15	53.22	21.50		
20	53.44	21.72		
30	53.93	22.21		
45	54.32	22.60		
60	54.58	22.86		
90	54.97	23.25		
120	55.30	23.58		
180	55.74	24.02		
240	56.11	24.39		
360	57.43	25.71		
1440	59.10	27.38		
2160	59.44	27.72		
2880	59.69	27.97		

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
5	41.00	19.92	68.21
60	37.90	23.02	78.82
75	37.79	23.13	79.20
105	37.45	23.47	80.36
165	36.72	24.20	82.86
180	36.65	24.27	83.10
240	36.30	24.62	84.30
360	35.81	25.11	85.98
720	34.51	26.41	90.43

LICENCE No. GW021185 / 80BL015961 **BORE No.** Bore 3

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Sunday 20 October 2018 12:00 **Duration:** 48 **hours**

S.W.L.: 22 **metres** **Height reference point above GL:** **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)
1	27.23	5.23		25.00
2	27.33	5.33		25.00
3	27.46	5.46		25.00
4	27.63	5.63		25.00
5	27.69	5.69		25.00
6	27.73	5.73		25.00
7	27.74	5.74		25.00
8	27.79	5.79		25.00
9	27.84	5.84		25.00
11	27.88	5.88		25.00
22	28.10	6.10		25.00
30	28.12	6.12		25.00
35	28.13	6.13		25.00
40	28.17	6.17		25.00
45	28.22	6.22		25.00
60	28.34	6.34		25.00
90	28.47	6.47		25.00
120	28.59	6.59		25.00
300	28.89	6.89		25.00
480	28.96	6.96		25.00
1260	29.17	7.17		25.00
1320	29.24	7.24		25.00
1440	29.26	7.26		25.00
1560	29.29	7.29		25.00
1680	29.31	7.31		25.00
1860	29.34	7.34		25.00
2640	29.44	7.44		25.00
2760	29.45	7.45		25.00
2880	29.46	7.46		25.00

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)

LICENCE No. ..... **BORE No.** Narromine TWS Bore (replacement of Bore 6)

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Sunday 24th November 2016 13:30 **Duration:** 48 **hours**

S.W.L.: 27.45 **metres** **Height reference point above GL:** 1 **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)
1	40.18	12.73		35.00
3	41.57	1.39		35.00
5	41.84	0.27		35.00
7	41.95	0.11		35.00
10	42.02	0.07		35.00
15	42.09	0.07		35.00
20	42.15	0.06		35.00
25	42.17	0.02		35.00
30	42.20	0.03		34.75
40	42.22	0.02		34.75
50	42.22	0.00		34.75
60	42.23	0.01		34.75
75	42.24	0.01		34.50
90	42.24	0.00		34.50
105	42.25	0.01		34.50
120	42.27	0.02		34.50
140	42.28	0.01		34.50
160	42.29	0.01		34.50
180	42.30	0.01		34.50
210	42.31	0.01		34.50
240	42.33	0.02		34.50
300	42.33	0.00		34.50
360	42.33	0.00		34.50
420	42.33	0.00		34.50
480	42.34	0.01		34.50
540	42.33	-0.01		34.50
600	42.33	0.00		34.50
660	42.33	0.00		34.50
720	42.32	-0.01		34.50
780	42.31	-0.01		34.50
840	42.31	0.00		34.50
960	42.30	-0.01		34.50
1080	42.30	0.00		34.50
1200	42.29	-0.01		34.50
1320	42.29	0.00		34.50
1440	42.29	0.00		34.50
1560	42.29	0.00		34.50
1920	42.28	-0.01		34.50
2040	42.28	0.00		34.50
2160	42.28	0.00		34.50
2280	42.28	0.00		34.50
2400	42.28	0.00		34.50
2520	42.27	-0.01		34.50
2640	42.27	0.00		34.50
2880	42.27	0.00		34.50

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
0	42.27		
1	29.86		
2	29.53		
3	29.28		
4	29.19		
5	29.06		
10	28.72		
15	28.53		
20	28.39		
30	28.20		
40	28.09		
45	28.03		
60	27.90		
90		make -up	
105	27.69		
120	27.57		

observation bore) New bore 9

S.W.L.: 30.94 **metres**

Height reference point abov 1 **metres**

Distance from bore pumptest bore : 584.00 **metres**

Time (minutes)	Depth to water (metres)	Draw down (metres)
30	30.94	30.94
60	30.94	0.00
120	30.94	0.00
240	30.94	0.00
300	30.94	0.00
360	30.94	0.00
420	30.94	0.00
480	30.95	0.01
840	**30.96**	0.01
960	**30.97**	0.01
1080	**30.98**	0.01
1200	**31.01**	0.03
1320	**31.01**	0.00
1440	**31.02**	0.01
1560	**31.02**	0.00
1920	**31.03**	0.01
2040	**31.03**	0.00
2160	**31.03**	0.00
2280	**31.03**	0.00
2400	**31.03**	0.00
2520	**31.03**	0.00
2640	**31.03**	0.00
2880	**31.03**	0.00

Single Rate Pump Test and Recovery

LICENCE No. ..... **BORE No.** .....

CLIENT NAME: Narromine Shire Council

S.W.L.: 26.5 **metres** **Height reference point above GL:** 0.3 **metres**

METHOD OF MEASURING DISCHARGE: Flow meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Pumping rate (l/s)	
1	33.61	7.11	30.0	
2	33.99	7.49	30.0	
3	34.16	7.66	30.0	
4	34.27	7.77	30.0	
5	34.35	7.85	30.0	
7	34.45	7.95	30.0	
9	34.51	8.01	30.0	
11	34.58	8.08	30.0	
13	34.61	8.11	30.0	
15	34.64	8.14	30.0	
20	34.72	8.22	30.0	
25	34.78	8.28	30.0	
30	34.83	8.33	30.0	
35	34.87	8.37	30.0	
40	34.90	8.40	30.0	
45	34.97	8.47	30.0	
50	35.02	8.52	30.0	
55	35.03	8.53	30.0	
60	35.05	8.55	30.0	
70	35.13	8.63	30.0	
80	35.17	8.67	30.0	
90	35.21	8.71	30.0	
100	35.25	8.75	30.0	
110	35.25	8.75	30.0	
120	35.33	8.83	30.0	
135	35.35	8.85	30.0	
150	35.38	8.88	30.0	
165	35.42	8.92	30.0	
180	35.45	8.95	30.0	
210	35.50	9.00	30.0	
240	35.55	9.05	30.0	
270	35.58	9.08	30.0	

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
1	27.90	8.22	85.45
1.5	27.74	8.38	87.11
2	27.70	8.42	87.53
2.5	27.69	8.43	87.63
3	27.69	8.43	87.63
4	27.68	8.44	87.73
5	27.65	8.47	88.05
6	27.62	8.50	88.36
7	27.60	8.52	88.57
8	27.58	8.54	88.77
9	27.56	8.56	88.98
10	27.55	8.57	89.09
12	27.52	8.60	89.40
14	27.50	8.62	89.60
16	27.48	8.64	89.81
18	27.46	8.66	90.02
20	27.44	8.68	90.23
25	27.41	8.71	90.54
30	27.39	8.73	90.75
35	27.37	8.75	90.96
40	27.34	8.78	91.27
45	27.32	8.80	91.48
50	27.31	8.81	91.58
55	27.29	8.83	91.79
60	27.28	8.84	91.89
90	27.21	8.91	92.62
150	27.14	8.98	93.35
210	27.06	9.06	94.18
390	26.96	9.16	95.22

Time (minutes)	Depth to water (metres)	Draw down (metres)	Pumping rate (l/s)	
300	35.62	9.12	30.0	
330	35.65	9.15	30.0	
360	35.68	9.18	30.0	
390	35.71	9.21	30.0	
420	35.74	9.24	30.0	
450	35.77	9.27	30.0	
480	35.80	9.30	30.0	
600	35.85	9.35	30.0	
1440	36.08	9.58	30.0	
1500	36.08	9.58	30.0	
1560	36.08	9.58	30.0	
1590	36.08	9.58	30.0	
1620	36.09	9.59	30.0	
1650	36.09	9.59	30.0	
1680	36.10	9.60	30.0	
1710	36.10	9.60	30.0	
1740	36.11	9.61	30.0	
1770	36.11	9.61	30.0	
2160	36.11	9.61	30.0	
2880	36.12	9.62	30.0	

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)

LICENCE No. 80WA703150 **BORE No.** Narromine TWS Bore (replacement of Bore 9)

CLIENT NAME: Narromine Shire Council

DATE/TIME PUMPING COMMENCED: Monday 16th November 2015 13:30 **Duration:** 48 **hours**

S.W.L.: 29.5 **metres** **Height reference point above GL:** 1 **metres**

METHOD OF MEASURING DISCHARGE: Water meter

Time (minutes)	Depth to water (metres)	Draw down (metres)	Time to pump 1000l	Pumping rate (l/s)
1	30.79	1.29		37.00
3	31.55	0.76		37.00
5	32.23	0.68		37.00
7	32.39	0.16		37.00
10	32.49	0.10		37.00
15	32.57	0.08		37.00
20	32.63	0.06		37.00
25	32.69	0.06		37.00
30	32.75	0.06		37.00
40	32.85	0.10		37.00
50	32.92	0.07		37.00
60	32.96	0.04		37.00
75	33.00	0.04		37.00
90	33.05	0.05		37.00
105	33.09	0.04		37.00
120	33.13	0.04		37.00
140	33.15	0.02		37.00
160	33.18	0.03		37.00
180	33.20	0.02		37.00
210	33.24	0.04		37.00
240	33.28	0.04		37.00
300	33.32	0.04		37.00
360	33.36	0.04		37.00
420	33.39	0.03		37.00
480	33.42	0.03		37.00
540	33.44	0.02		37.00
600	33.46	0.02		37.00
660	33.48	0.02		37.00
720	33.50	0.02		37.00
780	33.52	0.02		37.00
840	33.54	0.02		37.00
960	33.56	0.02		37.00
1080	33.58	0.02		37.00
1200	33.60	0.02		37.00
1320	33.62	0.02		37.00
1440	33.64	0.02		37.00
1560	33.66	0.02		37.00
1920	33.68	0.02		37.00
2040	33.70	0.02		37.00
2160	33.72	0.02		37.00
2280	33.74	0.02		37.00
2400	33.76	0.02		37.00
2520	33.78	0.02		37.00
2640	33.80	0.02		37.00
2880	33.83	0.03		37.00

Recovery (minutes)	Depth to Water (meters)	Recovery (metres)	Recovery (%)
0	-33.83		
1			
5			
7			
8			
9			
10			
12			
14			
16			
18			
20			
25			
30			
35			
40			
50			
60			
70			
80			
100			
120			
150			
180			
240			
300			
360			
420			
1680			


HEC
HARWOOD ENVIRONMENTAL CONSULTANTS

Appendix B Detailed costing

PROJECT TITLE: NARROMINE WATER SECURITY OPTIONS ASSESSMENT

PROJECT NO.: NSC2308B

ESTIMATE TYPE: PRELIMINARY

OPTION 2-1 **DATE OF ESTIMATE** 06-Sep-23

DESCRIPTION Macquarie River Route 1

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	SUB-TOTAL (inc CPI)	TOTAL	ASSUMPTIONS	
1	**General - Pipeline**							
1.1	Site establishment	1	ea	$ 85,000	$ 85,000			
1.2	Site disestablsiment	1	ea	$ 85,000	$ 85,000			
1.3	Preliminaries	1	ea	$ 92,708	$ 92,708			
1.4	Other	1	ea	$ 42,110	$ 42,110			
						$ 304,818		
2	**Pipeline**							
2.1	Service Location	1	ea	$ 19,600	$ 19,600			
2.2	Supply all valves and flowmeters	1	ea	$ 133,550	$ 133,550			
2.3	Nominal DN450 DICL pipe	3,920	m	$ 341	$ 1,335,505			
2.4	Nominal DN450 DICL (Trench type B)	3,920	m	$ 165	$ 645,475			
2.5	Supply & installation of Rail Crossing	1	ea	$ 150,000	$ 150,000			
2.6	Supply and Install Road Crossings	14	ea	$ 20,000	$ 280,000			
2.7	Bulkheads and Trenchstops in accordance with WSAA drawing WAT-1209	-	ea	$ 2,500	$ -			
2.8	Supply and Install valve pits excluding cost of valves and fittings	-	ea	$ 5,000	$ -			
2.9	Preparation of Work as Executed	3,920	m	$ 3	$ 11,760			
2.10	Acceptance testing - trunk main	3,920	m	$ 4	$ 15,680			
2.11	Restoration	3,920	m	$ 12	$ 47,040			
						$ 2,638,610		
3	**General - Pump Station**							
3.1	Site establishment	1	ea	$ 20,000	$ 20,000		2 x Skid with three filters and backwash pump	
3.2	Site disestablsiment	1	ea	$ 20,000	$ 20,000			
3.3	Preliminaries	1	ea	$ 25,000	$ 25,000			
3.4	Other	1	ea	$ 40,000	$ 40,000			
						$ 105,000		
4	**Pump Station**							
4.1	Service Location	1	Each	$ 19,600	$ 19,600			
4.2	New Screen Supply	1	Each	$ 60,000	$ 60,000			
4.3	New Screen Install	1	Each	$ 45,000	$ 45,000			
4.4	Inspection and Rectification of Suction Line	1	Each	$ 50,000	$ 50,000			
4.5	Restoration of Wet Well	1	Each	$ 50,000	$ 50,000			
4.6	Supply 2 new pumps	2	Each	$ 45,000	$ 90,000			
4.7	Mechanical Fitout of Wet Well	1	Each	$ 150,000	$ 150,000			
4.8	Building Construction Slab	63	m3	$ 1,000	$ 62,500			
4.9	Building Construction Walls and Roof	250	m2	$ 600	$ 150,000			
4.1	Gantry Crane	1	Each	$ 25,000	$ 25,000			
4.11	Internal Pipework	1	Each	$ 50,000	$ 50,000			
4.12	Gauge Board	1	Each	$ 20,000	$ 20,000			
4.13	Electrical Installation	1	Each	$ 250,000	$ 250,000			
4.14	Transformer	1	Each	$ 40,000	$ 40,000			
4.15	Preparation of Work as Executed	1	Each	$ 20,000	$ 20,000			
4.16	Commissioning	1	Each	$ 10,000	$ 10,000			
4.17	Restoration	1	ea	$ 20,000	$ 20,000			
						$ 1,112,100		
Total Estimated Construction Cost						**$ 4,205,703**		
Design & Management								
	Design			10%	$ 420,570.28			
	Design Project management			16%	$ 67,291.25			
	Construction management			9%	$ 378,513.26			
						$ 866,375		
Total Estimated Design & Construction						**$ 5,072,078**	**$**	-
	Contingency			30%	$ 1,521,623.29			
	Escalation			12%	$ 608,649.32			
						$ 2,130,273	**$**	**2,130,273**
TOTAL ESTIMATED CAPITAL COST						**$ 7,202,350**		

OPERATION & MAINTENANCE COSTS

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	ANNUAL TOTAL	TOTAL	ASSUMPTIONS
1	**Electricity**						
	Pumping @ 7.5ML/d	29	kW	$ 0.22	$ 55,926		
						$ 55,926	
						$ 7,457	/ML
2	**Maintenance**						
	Maintenance	1% of capital			$ 72,024		
						$ 72,024	

PROJECT TITLE: NARROMINE WATER SECURITY OPTIONS ASSESSMENT

PROJECT NO.: NSC2308B

ESTIMATE TYPE: PRELIMINARY

OPTION 2-2 **DATE OF ESTIMATE** 06-Sep-23

DESCRIPTION Macquarie River Route 2

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	SUB-TOTAL (inc CPI)	TOTAL	ASSUMPTIONS
1	**General - Pipeline**						
1.1	Site establishment	1	ea	$ 85,000	$ 85,000		
1.2	Site disestablsiment	1	ea	$ 85,000	$ 85,000		
1.3	Preliminaries	1	ea	$ 94,154	$ 94,154		
1.4	Other	1	ea	$ 42,961	$ 42,961		
						$ 307,115	
2	**Pipeline**						
2.1	Service Location	1	ea	$ 20,000	$ 20,000		
2.2	Supply all valves and flowmeters	1	ea	$ 136,276	$ 136,276		
2.3	Nominal DN450 DICL pipe	4,000	m	$ 341	$ 1,362,760		
2.4	Nominal DN450 DICL (Trench type B)	4,000	m	$ 165	$ 658,648		
2.5	Supply & installation of Rail Crossing	1	ea	$ 150,000	$ 150,000		
2.6	Supply and Install Road Crossings	14	ea	$ 20,000	$ 280,000		
2.7	Bulkheads and Trenchstops in accordance with WSAA drawing WAT-1209	-	ea	$ 2,500	$ -		
2.8	Supply and Install valve pits excluding cost of valves and fittings	-	ea	$ 5,000	$ -		
2.9	Preparation of Work as Executed	4,000	m	$ 3	$ 12,000		
2.10	Acceptance testing - trunk main	4,000	m	$ 4	$ 16,000		
2.11	Restoration	4,000	m	$ 12	$ 48,000		
						$ 2,683,684	
3	**General - Pump Station**						
3.1	Site establishment	1	ea	$ 20,000	$ 20,000		2 x Skid with three filters and backwash pump
3.2	Site disestablsiment	1	ea	$ 20,000	$ 20,000		
3.3	Preliminaries	1	ea	$ 25,000	$ 25,000		
3.4	Other	1	ea	$ 40,000	$ 40,000		
						$ 105,000	
4	**Pump Station**						
4.1	Service Location	1	Each	$ 19,600	$ 19,600		
4.2	New Screen Supply	1	Each	$ 60,000	$ 60,000		
4.3	New Screen Install	1	Each	$ 45,000	$ 45,000		
4.4	Inspection and Rectification of Suction Line	1	Each	$ 50,000	$ 50,000		
4.5	Restoration of Wet Well	1	Each	$ 50,000	$ 50,000		
4.6	Supply 2 new pumps	2	Each	$ 45,000	$ 90,000		
4.7	Mechanical Fitout of Wet Well	1	Each	$ 150,000	$ 150,000		
4.8	Building Construction Slab	63	m3	$ 1,000	$ 62,500		
4.9	Building Construction Walls and Roof	250	m2	$ 600	$ 150,000		
4.1	Gantry Crane	1	Each	$ 25,000	$ 25,000		
4.11	Internal Pipework	1	Each	$ 50,000	$ 50,000		
4.12	Gauge Board	1	Each	$ 20,000	$ 20,000		
4.13	Electrical Installation	1	Each	$ 250,000	$ 250,000		
4.14	Transformer	1	Each	$ 40,000	$ 40,000		
4.15	Preparation of Work as Executed	1	Each	$ 20,000	$ 20,000		
4.16	Commissioning	1	Each	$ 10,000	$ 10,000		
4.17	Restoration	1	ea	$ 20,000	$ 20,000		
						$ 1,112,100	
Total Estimated Construction Cost						**$ 4,253,074**	
Design & Management							
	Design			10%	$ 425,307.40		
	Design Project management			16%	$ 68,049.18		
	Construction management			9%	$ 382,776.66		
						$ 876,133	
Total Estimated Design & Construction						**$ 5,129,207**	**$ -**
	Contingency			30%	$ 1,538,762.17		
	Escalation			12%	$ 615,504.87		
						$ 2,154,267	**$ 2,154,267**
TOTAL ESTIMATED CAPITAL COST						**$ 7,283,474**	

OPERATION & MAINTENANCE COSTS

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	ANNUAL TOTAL	TOTAL	ASSUMPTIONS
1	**Electricity**						
	Pumping @ 7.5ML/d	31	kW	$ 0.22	$ 59,146		
						$ 59,146	
						$ 7,886	/ML
2	**Maintenance**						
	Maintenance	1% of capital			$ 72,835		
						$ 72,835	

PROJECT TITLE: NARROMINE WATER SECURITY OPTIONS ASSESSMENT

PROJECT NO.: NSC2308B

ESTIMATE TYPE: PRELIMINARY

OPTION 2-3 **DATE OF ESTIMATE** 06-Sep-23

DESCRIPTION Macquarie River Route 3

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	SUB-TOTAL (inc CPI)	TOTAL	ASSUMPTIONS
1	**General - Pipeline**						
1.1	Site establishment	1	ea	$ 85,000	$ 85,000		
1.2	Site disestablsiment	1	ea	$ 85,000	$ 85,000		
1.3	Preliminaries	1	ea	$ 115,498	$ 115,498		
1.4	Other	1	ea	$ 55,520	$ 55,520		
						$ 341,018	
2	**Pipeline**						
2.1	Service Location	1	ea	$ 19,600	$ 19,600		
2.2	Supply all valves and flowmeters	1	ea	$ 176,477	$ 176,477		
2.3	Nominal DN450 DICL pipe	5,180	m	$ 341	$ 1,764,774		
2.4	Nominal DN450 DICL (Trench type B)	5,180	m	$ 165	$ 852,949		
2.5	Supply & installation of Rail Crossing	1	ea	$ 150,000	$ 150,000		
2.6	Supply and Install Road Crossings	14	ea	$ 20,000	$ 280,000		
2.7	Bulkheads and Trenchstops in accordance with WSAA drawing WAT-1209	-	ea	$ 2,500	$ -		
2.8	Supply and Install valve pits excluding cost of valves and fittings	-	ea	$ 5,000	$ -		
2.9	Preparation of Work as Executed	5,180	m	$ 3	$ 15,540		
2.10	Acceptance testing - trunk main	5,180	m	$ 4	$ 20,720		
2.11	Restoration	5,180	m	$ 12	$ 62,160		
						$ 3,342,221	
3	**General - Pump Station**						
3.1	Site establishment	1	ea	$ 20,000	$ 20,000		2 x Skid with three filters and backwash pump
3.2	Site disestablsiment	1	ea	$ 20,000	$ 20,000		
3.3	Preliminaries	1	ea	$ 25,000	$ 25,000		
3.4	Other	1	ea	$ 40,000	$ 40,000		
						$ 105,000	
4	**Pump Station**						
4.1	Service Location	1	Each	$ 19,600	$ 19,600		
4.2	New Screen Supply	1	Each	$ 60,000	$ 60,000		
4.3	New Screen Install	1	Each	$ 45,000	$ 45,000		
4.4	Inspection and Rectification of Suction Line	1	Each	$ 50,000	$ 50,000		
4.5	Restoration of Wet Well	1	Each	$ 50,000	$ 50,000		
4.6	Supply 2 new pumps	2	Each	$ 45,000	$ 90,000		
4.7	Mechanical Fitout of Wet Well	1	Each	$ 150,000	$ 150,000		
4.8	Building Construction Slab	63	m3	$ 1,000	$ 62,500		
4.9	Building Construction Walls and Roof	250	m2	$ 600	$ 150,000		
4.1	Gantry Crane	1	Each	$ 25,000	$ 25,000		
4.11	Internal Pipework	1	Each	$ 50,000	$ 50,000		
4.12	Gauge Board	1	Each	$ 20,000	$ 20,000		
4.13	Electrical Installation	1	Each	$ 250,000	$ 250,000		
4.14	Transformer	1	Each	$ 40,000	$ 40,000		
4.15	Preparation of Work as Executed	1	Each	$ 20,000	$ 20,000		
4.16	Commissioning	1	Each	$ 10,000	$ 10,000		
4.17	Restoration	1	ea	$ 20,000	$ 20,000		
						$ 1,112,100	
Total Estimated Construction Cost						**$ 4,945,514**	
Design & Management							
	Design			10%	$ 494,551.38		
	Design Project management			16%	$ 79,128.22		
	Construction management			9%	$ 445,096.24		
						$ 1,018,776	
Total Estimated Design & Construction						**$ 5,964,290**	**$ -**
	Contingency			30%	$ 1,789,286.89		
	Escalation			12%	$ 715,714.75		
						$ 2,505,002	**$ 2,505,002**
TOTAL ESTIMATED CAPITAL COST						**$ 8,469,291**	

OPERATION & MAINTENANCE COSTS

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	ANNUAL TOTAL	TOTAL	ASSUMPTIONS
1	**Electricity**						
	Pumping @ 7.5ML/d	32	kW	$ 0.22	$ 61,113		
						$ 61,113	
						$ 8,148	/ML
2	**Maintenance**						
	Maintenance	1% of capital			$ 84,693		
						$ 84,693	

PROJECT TITLE: NARROMINE WATER SECURITY OPTIONS ASSESSMENT

PROJECT NO.: NSC2308B

ESTIMATE TYPE: PRELIMINARY

OPTION 3-1 **DATE OF ESTIMATE** 06-Sep-23

DESCRIPTION Dubbo Route 1

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	SUB-TOTAL (inc CPI)	TOTAL	ASSUMPTIONS
1	**General - Pipeline**						
1.1	Site establishment	1	ea	$ 85,000	$ 85,000		
1.2	Site disestablsiment	1	ea	$ 85,000	$ 85,000		
1.3	Preliminaries	1	ea	$ 1,210,661	$ 1,210,661		
1.4	Other	1	ea	$ 689,830	$ 689,830		
						$ 2,070,491	
2	**Pipeline**						
2.1	Service Location	1	ea	$ 144,400	$ 144,400		
2.2	Supply all valves and flowmeters	1	ea	$ 582,580	$ 582,580		
2.3	Nominal DN450 DICL pipe	34,200	m	$ 341	$ 11,651,598		
2.4	Nominal DN450 DICL (Trench type B)	34,200	m	$ 114	$ 3,898,800		
2.9	Preparation of Work as Executed	34,200	m	$ 1	$ 39,672		
2.10	Acceptance testing - trunk main	34,200	m	$ 4	$ 136,800		
2.11	Restoration	34,200	m	$ 12	$ 410,400		
						$ 16,864,250	
3	**General - Pump Station**						
3.1	Site establishment	1	ea	$ 20,000	$ 20,000		2 x Skid with three filters and backwash pump
3.2	Site disestablsiment	1	ea	$ 20,000	$ 20,000		
3.3	Preliminaries	1	ea	$ 25,000	$ 25,000		
3.4	Other	1	ea	$ 40,000	$ 40,000		
						$ 105,000	
4	**Pump Station**						
4.1	Service Location	1	Each	$ 19,600	$ 19,600		
4.2	New Screen Supply	1	Each	$ 60,000	$ 60,000		
4.3	New Screen Install	1	Each	$ 45,000	$ 45,000		
4.4	Inspection and Rectification of Suction Line	1	Each	$ 50,000	$ 50,000		
4.5	Restoration of Wet Well	1	Each	$ 50,000	$ 50,000		
4.6	Supply 2 new pumps	2	Each	$ 45,000	$ 90,000		
4.7	Mechanical Fitout of Wet Well	1	Each	$ 150,000	$ 150,000		
4.8	Building Construction Slab	63	m3	$ 1,000	$ 62,500		
4.9	Building Construction Walls and Roof	250	m2	$ 600	$ 150,000		
4.1	Gantry Crane	1	Each	$ 25,000	$ 25,000		
4.11	Internal Pipework	1	Each	$ 50,000	$ 50,000		
4.12	Gauge Board	1	Each	$ 20,000	$ 20,000		
4.13	Electrical Installation	1	Each	$ 250,000	$ 250,000		
4.14	Transformer	1	Each	$ 40,000	$ 40,000		
4.15	Preparation of Work as Executed	1	Each	$ 20,000	$ 20,000		
4.16	Commissioning	1	Each	$ 10,000	$ 10,000		
4.17	Restoration	1	ea	$ 20,000	$ 20,000		
						$ 1,112,100	
Total Estimated Construction Cost						**$ 20,197,016**	
Design & Management							
	Design			8%	$ 1,615,761.27		
	Design Project management			10%	$ 161,576.13		
	Construction management			9%	$ 1,817,731.43		
						$ 3,595,069	
Total Estimated Design & Construction						**$ 23,792,085**	**$ -**
	Contingency			30%	$ 7,137,625.42		
	Escalation			12%	$ 2,855,050.17		
						$ 9,992,676	**$ 9,992,676**
TOTAL ESTIMATED CAPITAL COST						**$ 33,784,760**	

OPERATION & MAINTENANCE COSTS

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	ANNUAL TOTAL	TOTAL	ASSUMPTIONS
1	**Electricity**						
	Pumping @ 7.5ML/d	-	kW	$ 0.22	$ -		
						$ -	
						$ -	/ML
2	**Maintenance**						
	Maintenance	1%	of capital		$ 337,848		
						$ 337,848	

PROJECT TITLE: NARROMINE WATER SECURITY OPTIONS ASSESSMENT

PROJECT NO.: NSC2308B

ESTIMATE TYPE: PRELIMINARY

OPTION 3-2 **DATE OF ESTIMATE** 06-Sep-23

DESCRIPTION Dubbo Route 2

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	SUB-TOTAL (inc CPI)	TOTAL	ASSUMPTIONS
1	**General - Pipeline**						
1.1	Site establishment	1	ea	$ 85,000	$ 85,000		
1.2	Site disestablsiment	1	ea	$ 85,000	$ 85,000		
1.3	Preliminaries	1	ea	$ 1,210,661	$ 1,210,661		
1.4	Other	1	ea	$ 689,830	$ 689,830		
						$ 2,070,491	
2	**Pipeline**						
2.1	Service Location	1	ea	$ 144,400	$ 144,400		
2.2	Supply all valves and flowmeters	1	ea	$ 685,311	$ 685,311		
2.3	Nominal DN450 DICL pipe	38,000	m	$ 361	$ 13,706,220		
2.4	Nominal DN450 DICL (Trench type B)	38,000	m	$ 114	$ 4,332,000		
2.9	Preparation of Work as Executed	38,000	m	$ 1	$ 44,080		
2.10	Acceptance testing - trunk main	38,000	m	$ 4	$ 152,000		
2.11	Restoration	38,000	m	$ 12	$ 456,000		
						$ 19,520,011	
3	**General - Pump Station**						
3.1	Site establishment	1	ea	$ 20,000	$ 20,000		2 x Skid with three filters and backwash pump
3.2	Site disestablsiment	1	ea	$ 20,000	$ 20,000		
3.3	Preliminaries	1	ea	$ 25,000	$ 25,000		
3.4	Other	1	ea	$ 40,000	$ 40,000		
						$ 105,000	
4	**Pump Station**						
4.1	Service Location	1	Each	$ 19,600	$ 19,600		
4.2	New Screen Supply	1	Each	$ 60,000	$ 60,000		
4.3	New Screen Install	1	Each	$ 45,000	$ 45,000		
4.4	Inspection and Rectification of Suction Line	1	Each	$ 50,000	$ 50,000		
4.5	Restoration of Wet Well	1	Each	$ 50,000	$ 50,000		
4.6	Supply 2 new pumps	2	Each	$ 45,000	$ 90,000		
4.7	Mechanical Fitout of Wet Well	1	Each	$ 150,000	$ 150,000		
4.8	Building Construction Slab	63	m3	$ 1,000	$ 62,500		
4.9	Building Construction Walls and Roof	250	m2	$ 600	$ 150,000		
4.1	Gantry Crane	1	Each	$ 25,000	$ 25,000		
4.11	Internal Pipework	1	Each	$ 50,000	$ 50,000		
4.12	Gauge Board	1	Each	$ 20,000	$ 20,000		
4.13	Electrical Installation	1	Each	$ 250,000	$ 250,000		
4.14	Transformer	1	Each	$ 40,000	$ 40,000		
4.15	Preparation of Work as Executed	1	Each	$ 20,000	$ 20,000		
4.16	Commissioning	1	Each	$ 10,000	$ 10,000		
4.17	Restoration	1	ea	$ 20,000	$ 20,000		
						$ 1,112,100	
Total Estimated Construction Cost						**$ 22,852,777**	
Design & Management							
	Design			8%	$ 1,828,222.16		
	Design Project management			10%	$ 182,822.22		
	Construction management			9%	$ 2,056,749.93		
						$ 4,067,794	
Total Estimated Design & Construction						**$ 26,920,571**	**$ -**
	Contingency			30%	$ 8,076,171.39		
	Escalation			12%	$ 3,230,468.56		
						$ 11,306,640	**$ 11,306,640**
TOTAL ESTIMATED CAPITAL COST						**$ 38,227,211**	

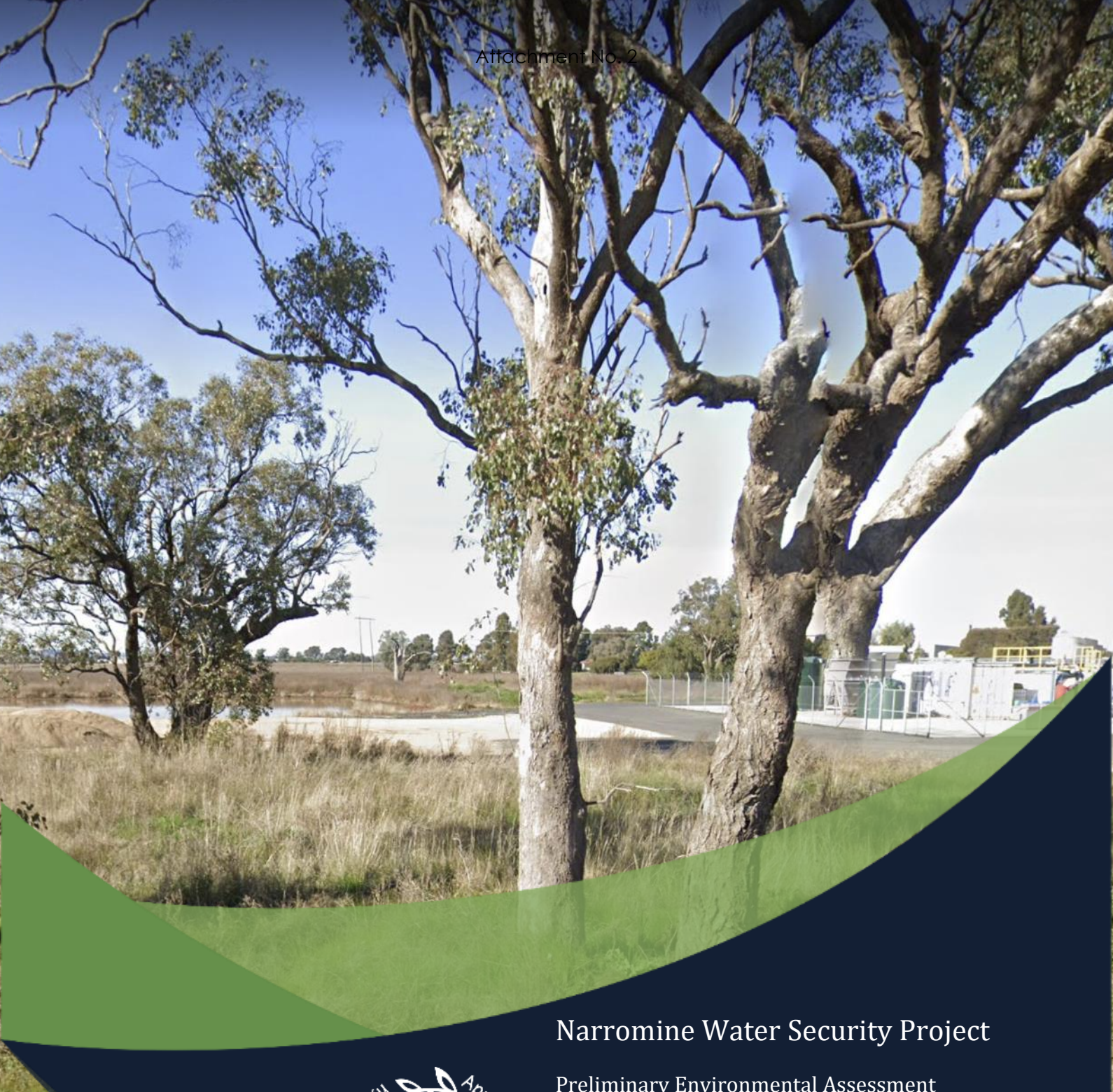
OPERATION & MAINTENANCE COSTS

NOTES:

ITEM	DESCRIPTION	QTY	UNIT	RATE	ANNUAL TOTAL	TOTAL	ASSUMPTIONS
1	**Electricity**						
	Pumping @ 7.5ML/d	-	kW	$ 0.22	$ -		
						$ -	
						$ -	/ML
2	**Maintenance**						
	Maintenance	1%	of capital		$ 382,272		
						$ 382,272	

Discount rate	7% pa			Option 2-1				Option 2-2				Option 2-3				Option 3-1				Option 3-2			
Year	Production (ML)		Shortfall	Capital cost	Fixed operating	Variable operating	Present cost	Capital cost	Fixed operating	Variable operating	Present cost	Capital cost	Fixed operating	Variable operating	Present cost	Capital cost	Fixed operating	Variable operating	Present cost	Capital cost	Fixed operating	Variable operating	Present cost
2022	**662.0**		66.2																				
2023	674.8		67.5																				
2024	687.6		68.8																				
2025	700.4	0	70.0	$ 7,202,350			$ 7,202,350	$ 7,283,474			$ 7,283,474	$ 8,469,291			$ 8,469,291	$ 33,784,760			$ 33,784,760	$ 38,227,211			$ 38,227,211
2026	713.2	1	71.3		$ 72,024	$ 531,815	$ 7,766,685		$ 72,835	$ 562,440	$ 7,877,189		$ 84,693	$ 581,145	$ 9,091,570		$ 337,848	$ -	$ 34,100,506		$ 382,272	$ -	$ 38,584,475
2027	**726.0**	2	72.6		$ 72,024	$ 541,359	$ 8,302,437		$ 72,835	$ 572,534	$ 8,440,879		$ 84,693	$ 591,575	$ 9,682,248		$ 337,848	$ -	$ 34,395,595		$ 382,272	$ -	$ 38,918,366
2028	734.8	3	73.5		$ 72,024	$ 547,921	$ 8,808,497		$ 72,835	$ 579,474	$ 8,973,357		$ 84,693	$ 598,746	$ 10,240,138		$ 337,848	$ -	$ 34,671,379		$ 382,272	$ -	$ 39,230,414
2029	743.6	4	74.4		$ 72,024	$ 554,483	$ 9,286,456		$ 72,835	$ 586,414	$ 9,476,295		$ 84,693	$ 605,916	$ 10,767,000		$ 337,848	$ -	$ 34,929,122		$ 382,272	$ -	$ 39,522,048
2030	752.4	5	75.2		$ 72,024	$ 561,045	$ 9,737,825		$ 72,835	$ 593,354	$ 9,951,278		$ 84,693	$ 613,087	$ 11,264,508		$ 337,848	$ -	$ 35,170,002		$ 382,272	$ -	$ 39,794,602
2031	761.2	6	76.1		$ 72,024	$ 567,607	$ 10,164,038		$ 72,835	$ 600,293	$ 10,399,812		$ 84,693	$ 620,257	$ 11,734,246		$ 337,848	$ -	$ 35,395,124		$ 382,272	$ -	$ 40,049,326
2032	**770.0**	7	77.0		$ 72,024	$ 574,169	$ 10,566,454		$ 72,835	$ 607,233	$ 10,823,324		$ 84,693	$ 627,428	$ 12,177,719		$ 337,848	$ -	$ 35,605,519		$ 382,272	$ -	$ 40,287,386
2033	778.8	8	77.9		$ 72,024	$ 580,731	$ 10,946,363		$ 72,835	$ 614,173	$ 11,223,168		$ 84,693	$ 634,599	$ 12,596,353		$ 337,848	$ -	$ 35,802,149		$ 382,272	$ -	$ 40,509,872
2034	787.6	9	78.8		$ 72,024	$ 587,293	$ 11,304,987		$ 72,835	$ 621,113	$ 11,600,630		$ 84,693	$ 641,769	$ 12,991,501		$ 337,848	$ -	$ 35,985,916		$ 382,272	$ -	$ 40,717,803
2035	796.4	10	79.6		$ 72,024	$ 593,855	$ 11,643,486		$ 72,835	$ 628,053	$ 11,956,925		$ 84,693	$ 648,940	$ 13,364,442		$ 337,848	$ -	$ 36,157,661		$ 382,272	$ -	$ 40,912,131
2036	805.2	11	80.5		$ 72,024	$ 600,417	$ 11,962,958		$ 72,835	$ 634,992	$ 12,293,209		$ 84,693	$ 656,111	$ 13,716,393		$ 337,848	$ -	$ 36,318,169		$ 382,272	$ -	$ 41,093,745
2037	**814.0**	12	81.4		$ 72,024	$ 606,979	$ 12,264,443		$ 72,835	$ 641,932	$ 12,610,574		$ 84,693	$ 663,281	$ 14,048,502		$ 337,848	$ -	$ 36,468,178		$ 382,272	$ -	$ 41,263,479
2038	816.2	13	81.6		$ 72,024	$ 608,619	$ 12,546,885		$ 72,835	$ 643,667	$ 12,907,897		$ 84,693	$ 665,074	$ 14,359,629		$ 337,848	$ -	$ 36,608,373		$ 382,272	$ -	$ 41,422,108
2039	818.4	14	81.8		$ 72,024	$ 610,260	$ 12,811,486		$ 72,835	$ 645,402	$ 13,186,442		$ 84,693	$ 666,866	$ 14,651,096		$ 337,848	$ -	$ 36,739,396		$ 382,272	$ -	$ 41,570,360
2040	820.6	15	82.1		$ 72,024	$ 611,900	$ 13,059,372		$ 72,835	$ 647,137	$ 13,447,393		$ 84,693	$ 668,659	$ 14,924,146		$ 337,848	$ -	$ 36,861,847		$ 382,272	$ -	$ 41,708,913
2041	822.8	16	82.3		$ 72,024	$ 613,541	$ 13,291,596		$ 72,835	$ 648,872	$ 13,691,860		$ 84,693	$ 670,452	$ 15,179,939		$ 337,848	$ -	$ 36,976,288		$ 382,272	$ -	$ 41,838,402
2042	**825.0**	17	82.5		$ 72,024	$ 615,181	$ 13,509,147		$ 72,835	$ 650,607	$ 13,920,883		$ 84,693	$ 672,244	$ 15,419,566		$ 337,848	$ -	$ 37,083,242		$ 382,272	$ -	$ 41,959,419
2043	825.0	18	82.5		$ 72,024	$ 615,181	$ 13,712,466		$ 72,835	$ 650,607	$ 14,134,923		$ 84,693	$ 672,244	$ 15,643,517		$ 337,848	$ -	$ 37,183,199		$ 382,272	$ -	$ 42,072,520
2044	825.0	19	82.5		$ 72,024	$ 615,181	$ 13,902,484		$ 72,835	$ 650,607	$ 14,334,961		$ 84,693	$ 672,244	$ 15,852,816		$ 337,848	$ -	$ 37,276,616		$ 382,272	$ -	$ 42,178,221
2045	825.0	20	82.5		$ 72,024	$ 615,181	$ 14,080,071		$ 72,835	$ 650,607	$ 14,521,912		$ 84,693	$ 672,244	$ 16,048,423		$ 337,848	$ -	$ 37,363,923		$ 382,272	$ -	$ 42,277,007
2046	825.0	21	82.5		$ 72,024	$ 615,181	$ 14,246,040		$ 72,835	$ 650,607	$ 14,696,632		$ 84,693	$ 672,244	$ 16,231,233		$ 337,848	$ -	$ 37,445,517		$ 382,272	$ -	$ 42,369,331
2047	825.0	22	82.5		$ 72,024	$ 615,181	$ 14,401,151		$ 72,835	$ 650,607	$ 14,859,923		$ 84,693	$ 672,244	$ 16,402,084		$ 337,848	$ -	$ 37,521,774		$ 382,272	$ -	$ 42,455,615
2048	825.0	23	82.5		$ 72,024	$ 615,181	$ 14,546,115		$ 72,835	$ 650,607	$ 15,012,530		$ 84,693	$ 672,244	$ 16,561,758		$ 337,848	$ -	$ 37,593,042		$ 382,272	$ -	$ 42,536,254
2049	825.0	24	82.5		$ 72,024	$ 615,181	$ 14,681,595		$ 72,835	$ 650,607	$ 15,155,155		$ 84,693	$ 672,244	$ 16,710,985		$ 337,848	$ -	$ 37,659,647		$ 382,272	$ -	$ 42,611,618
2050	825.0	25	82.5		$ 72,024	$ 615,181	$ 14,808,211		$ 72,835	$ 650,607	$ 15,288,448		$ 84,693	$ 672,244	$ 16,850,450		$ 337,848	$ -	$ 37,721,895		$ 382,272	$ -	$ 42,682,051
2051	825.0	26	82.5		$ 72,024	$ 615,181	$ 14,926,545		$ 72,835	$ 650,607	$ 15,413,022		$ 84,693	$ 672,244	$ 16,980,792		$ 337,848	$ -	$ 37,780,071		$ 382,272	$ -	$ 42,747,877
2052	825.0	27	82.5		$ 72,024	$ 615,181	$ 15,037,137		$ 72,835	$ 650,607	$ 15,529,445		$ 84,693	$ 672,244	$ 17,102,606		$ 337,848	$ -	$ 37,834,441		$ 382,272	$ -	$ 42,809,396
2053	825.0	28	82.5		$ 72,024	$ 615,181	$ 15,140,494		$ 72,835	$ 650,607	$ 15,638,253		$ 84,693	$ 672,244	$ 17,216,451		$ 337,848	$ -	$ 37,885,254		$ 382,272	$ -	$ 42,866,890
2054	825.0	29	82.5		$ 72,024	$ 615,181	$ 15,237,090		$ 72,835	$ 650,607	$ 15,739,942		$ 84,693	$ 672,244	$ 17,322,848		$ 337,848	$ -	$ 37,932,743		$ 382,272	$ -	$ 42,920,624
2055	825.0	30	82.5		$ 72,024	$ 615,181	$ 15,327,366		$ 72,835	$ 650,607	$ 15,834,978		$ 84,693	$ 672,244	$ 17,422,285		$ 337,848	$ -	$ 37,977,125		$ 382,272	$ -	$ 42,970,842

Appendix C Environmental report



Narromine Water Security Project

Preliminary Environmental Assessment

November 2023

Prepared for Atom Consulting on behalf of Narromine Shire Council

Preliminary Environmental Assessment – Narromine Water Security Project

Document Verification

Revision	Author/s	Internal review	Date submitted	Client Review and Approval	
				Name	Date
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This Report has been prepared by The Environmental Factor (TEF) at the request of Atom Consulting (AC) on behalf of Narromine Shire Council (NSC) to identify the potential environmental impacts and any additional approvals required, arising from the proposed Water Security Project in Narromine, NSW. This document is not intended to be utilised or relied upon by any persons other than NSC, nor to be used for any purpose other than that articulated above. Accordingly, TEF accepts no responsibility in any way whatsoever for the use of this report by any other persons or for any other purpose.

The information, statements, recommendations, and commentary (together the "Information") contained in this review have been prepared by TEF from material provided by AC and NSC and from material provided by the NSW Department of Planning and the Environment (DPE) and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) and through the assessment process.

This report has been developed with consideration to the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act), the *NSW Environmental Planning and Assessment Regulation 2021* (EP&A Regulation) and the Department of Planning and Environment's (DPE) Guidelines for Division 5.1 assessments (DPE Guidelines). TEF has not sought any independent confirmation of the reliability, accuracy, or completeness of this information. It should not be construed that TEF has carried out any form of audit of the information which has been relied upon.

Accordingly, whilst the statements made in this report are given in good faith, TEF accepts no responsibility for any errors in the information provided by AC or NSC nor the effect of any such errors on the analysis undertaken, suggestions provided, or this report. Site conditions may change after the date of this report. TEF does not accept responsibility arising from, or in connection with, any change to the site conditions. TEF is also not responsible for updating this report if site conditions change.

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ABBREVIATIONS

Abbreviation	Description
AC	Atom Consulting
ACHA	Aboriginal Cultural Heritage Assessment
AHIMS	Aboriginal Heritage Information Management System
BAM	Biodiversity Assessment Method
BDAR	Biodiversity Development Assessment Report
BC Act	*Biodiversity Conservation Act 2016*
BC Regulatory Act	*Biodiversity Conservation Regulatory Act 2017*
Biosecurity Act	*NSW Biosecurity Act 2015*
BOM	Bureau of Meteorology
BOS	Biodiversity Offset Scheme
BVM	Biodiversity Values Map
CEMP	Construction Environmental Management Plan
CLM Act	*Crown Land Management Act 2016*
DAWE	Department of Agriculture Water and the Environment
DECC	Department of Energy and Climate Change
DEE	Department of Environment and Energy
DEEC	Department of Energy and Climate Change NSW
DEWHA	Department of the Environment, Water, Heritage and the Arts
DPI	Department of Primary Industries
DPE	Department of Planning and Environment (formerly DPIE & OEH)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2021*
ERSED	Erosion and Sediment
ESD	Ecologically Sustainable Development
FM Act	*Fisheries Management Act 1994*
GBD	General Biosecurity Duty
GHG	Greenhouse Gasses
ha	Hectare
Heritage Act	*Heritage Act 1997*
IBRA	Interim Biogeographic Region of Australia
KFH	Key Fish Habitat
LALC	Local Aboriginal Land Council

Abbreviation	Description
AC	Atom Consulting
LEP	Local Environmental Plan
LGA	Local Government Area
LLS	Local Land Services
LOO	Likelihood of Occurrence
MNES	Matters of National Environmental Significance
NPW Act	*National Parks and Wildlife Act 1974*
NPWS	National Parks and Wildlife Service
NSC	Narromine Shire Council
NSW	New South Wales
NVR	Transitional Native Vegetation Regulatory Map
OEH	Office of Environment and Heritage (now DPE)
PEA	Preliminary Environmental Assessment
POEO Act	*Protection of the Environment Operations Act 1997*
RF Act	*Rural Fires Act 1997*
RFS	Rural Fire Service
SAII	Serious and Irreversible Impacts
SEPP	State Environmental Planning Policy
SIC	Significant Impact Criteria
SIS	Species Impact Statement
TBC	To be confirmed
TEC	Threatened Ecological Community
TEF	The Environmental Factor
WM Act	Water Management Act 2000
WoNS	Weed of National Significance
WQO	Water Quality Objectives

EXECUTIVE SUMMARY

This Preliminary Environmental Assessment (PEA) has been prepared by The Environmental Factor (TEF) at the request of Atom Consulting (Atom) on behalf of Narromine Shire Council (NSC or Council) to identify the potential environmental impacts and any additional approvals required, arising from the proposed Water Security Project in Narromine, NSW. The assessment presents findings of investigations undertaken into the anticipated environmental impacts and constraints that may arise from the proposed options presented as part of the Narromine Water Security project.

Council is currently considering four (4) Options as part of the current assessment, as follows:

- Option 1 – Current Groundwater Source
- Option 2 – Current Bores and Macquarie River
- Option 3 – Drinking Water from Dubbo
- Option 4 – Demand reduction schemes

The first Option would look to continue with the current sole water source – groundwater – by utilizing the existing borefield (specifically the current active Bores 3, 8, 6 and 9) and construction of an additional bore, most likely in management Zone 4 or 5 of the Lower Macquarie Aquifer that is farther afield near Trangie; the second Option supplements the existing bore water supply with water pumped directly from the Macquarie River; and the third Option would see supply of all treated water into Narromine from the Water Treatment Plant (WTP) in Dubbo; however, for Option 3 the current borefield would not be decommissioned, as a secondary source of water is required as a failsafe for the town's water security, and the Narromine WTP will need to remain operational.

The fourth Option is considered complementary to all other Options, and includes stakeholder and community engagement, water saving initiatives and onsite water collection; this Option is recommended to be implemented alongside and complementary to the Option that is ultimately selected.

Option 1, Option 2 and Option 3 were weighed against a range of relevant environmental and socio-economic factors in accordance with the 'Evaluation of integrated water cycle management scenarios' Guideline (the IWCM Evaluation Guidelines; NSW DOI, 2019) to assist Council's decision-making process through consideration of environmental and social factors. Economic considerations have not been completed herein as these are being considered in a separate report.

Based on the outcome of this evaluation, Option 2 arose as the preferred Option. Option 2 poses the least likely impacts to biodiversity, and Aboriginal and non-Aboriginal heritage overall. Risk of impacts arising from pollution events is slightly higher than for Option 1, with the potential for incidences to occur within both surface and groundwater sources. Conversely, wastes and resource use are likely to be lower than for Option 1 as the longest pipeline from the Macquarie River Pump Station (PS) is ~5.2 km. This assumes the additional Bore would need to be constructed closer to the township of Trangie approximately 35 km to the northwest of Narromine.

The anticipated assessment and approval requirements for progressing Option 2 have also been provided.

1 INTRODUCTION

This Preliminary Environmental Assessment (PEA) has been prepared by The Environmental Factor (TEF) at the request of Atom Consulting (Atom) on behalf of Narromine Shire Council (NSC or Council) to identify the potential environmental impacts and any additional approvals required, arising from the proposed Water Security Project in Narromine, NSW. The assessment presents findings of investigations undertaken into the anticipated environmental impacts and constraints that may arise from the proposed options presented as part of the Narromine Water Security project.

1.1 Background

The NSC Local Government Area (LGA) covers an area of 5,224 km^2 with a population of approximately 6,500 people (ABS, 2023). Prior to the drought of 2017-2020, Narromine drew all its potable water supply from a series of bores between Dubbo and Narromine. All bores except one (1) failed during the drought due to a continued fall in the aquifer level, with little to no recharge occurring since 2012. Efforts made since this time have provided little to no positive outcome for immediate water security for the township. Additionally, there has been significant demand increases over the last 10 years due to agricultural irrigation, including the introduction of cotton irrigation circa 2010, and projected future demand is set to increase due to economic and population growth over the next few years.

Consequently, Council is seeking a PEA and constraints and opportunities report, to support the Water Security Options Study for the township of Narromine, NSW. The study will be in-line with the Program Guidelines - Safe & Secure Water Program (NSW DoI, 2019) and will include treatment investigations, water quality information, site selection, procurement options analyses and strategy, project cost estimates, community & stakeholder consultation, and development of an approvals register. The data collected will then be used to further develop various project options to improve the town's water security. As part of this options assessment, Council requested that a PEA be completed to investigate potential constraints and opportunities as well as potential impacts from program delivery.

The water security aspects of the above assessment have been completed herein. The water quality assessment has been completed separately.

1.2 Narromine water supply system

Narromine Shire sits within the Macquarie – Bogan River Catchment, which covers an area of 74,800 km^2. This catchment provides water to around 180,000 people, and includes a number of major cities and towns, including Dubbo and Nyngan. This catchment also provides water to some smaller towns, including Warren and the focus of this assessment – Narromine (Figure 1). The Macquarie-Bogan catchment supports a range of water users including local councils, water utilities, dryland agriculture, livestock grazing and some irrigated agriculture, such as cotton.

Drinking water in Narromine is currently extracted from Bores 6, 8 and 9 and is processed through the temporary iron and manganese removal plant. This treated water is then combined with water from Bore 3 and chlorinated and distributed to customers.

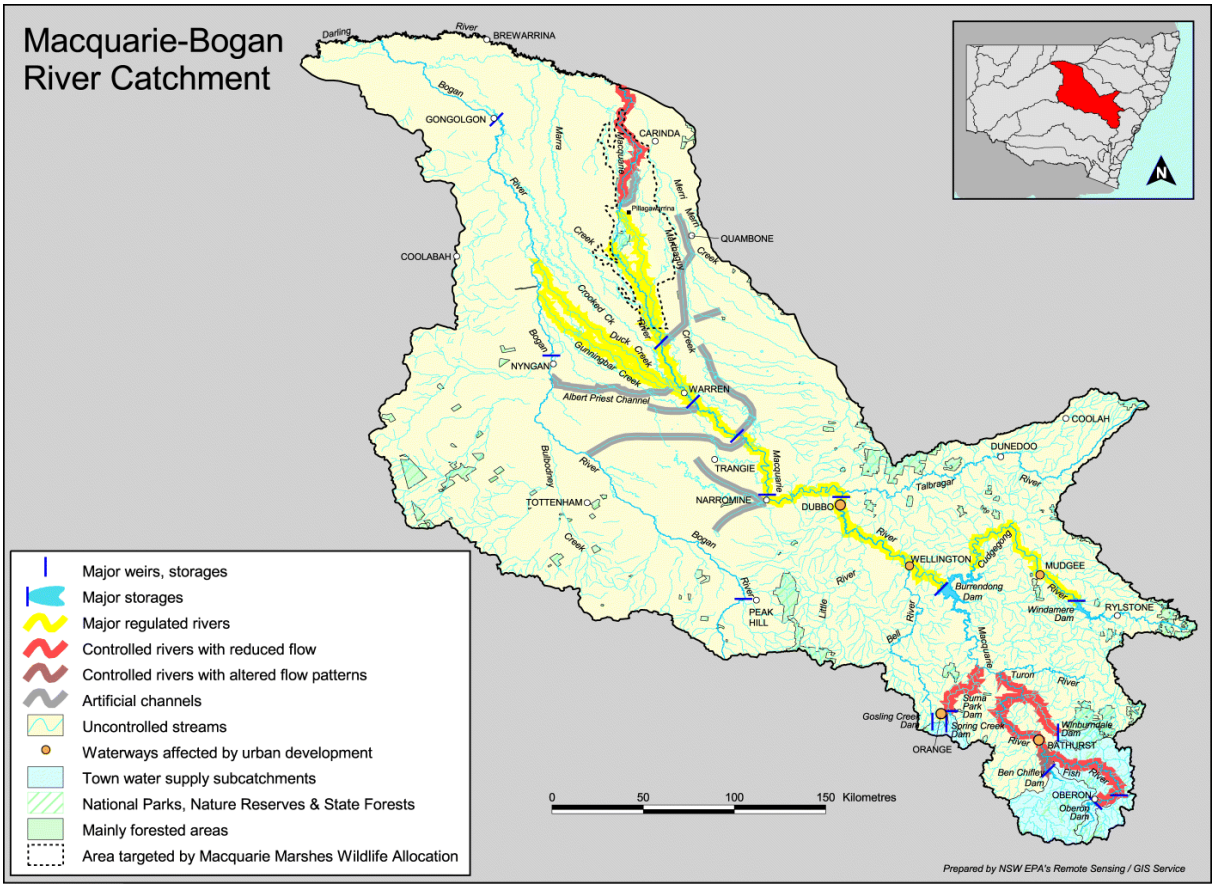


Figure 1 Macquarie-Bogan River Catchment

1.2.1 Issues identified

Water security

Narromine gets its water from bores that are drilled along the Lower Macquarie Alluvium sediments, associated with the ancient channels of the Macquarie River, downstream of Narromine. Water in the aquifer is in part replenished by water that seeps from the river or is pumped from the river and then seeps into the aquifer from irrigation channels and irrigated fields (Narromine DWMS, 2018). CSIRO (2008) indicates that the current total entitlement for the Upper Macquarie Aquifer is 38.4 gigalitres per year (GL/yr), and that extraction in 2004 – 2005 was 37 GL. It was also estimated by CSIRO that long term average rainfall recharge to the aquifer is 7.1 GL/yr; this is well below the amount required to recharge the aquifer based on current usage and system pressure.

Despite wet conditions and flooding of the Macquarie River since 2020, there has not been any recovery in the standing water level of the aquifer (NSC, 2022). Water NSW Monitoring Bore GW0365301.1 and GW0365301.2 show the downward trend in water levels which has persisted since 2011, with the only recovery being marginal due to seasonal decreases in irrigation demand due to periods of wet weather. The irrigation demand on the aquifer has increased significantly in the last 10 years due to the introduction of irrigated cotton crops.

It is anticipated that increased demand will occur in future due to population growth predicted for Narromine. While NSC has sufficient allocation under its Water Access Licence (WAL) to service the town into the future, it has not been able to achieve the yield allocation from the existing bores. Under

current licensing arrangements, it is understood that NSC has a limited opportunity to apply for additional bores, and consequently the Shire is experiencing compromised water security.

Water quality

The raw water characteristics of Narromine water supply vary depending on which bore is being used. Typical characteristics include:

- Neutral pH
- Variable turbidity, and
- High iron and manganese.

Variable turbidity, coupled with high iron and manganese would contribute to discolouration of the water, which can impact community wellbeing through discoloured clothes, towels, dishes and bathtubs / sinks, and reduced water pressure from residue buildup in pipes.

The Integrated Water Cycle Management (IWCM) Issues Paper (PWA, 2022) identified that water from the current supply system has a very high risk from chlorine-resistant and chlorine sensitive pathogens.

Water extracted from the borefield is processed through a temporary Water Treatment Plant (WTP) which is owned and operated by an external contractor.

1.3 Current and predicted climate scenarios

With the range of pressures on the current system, Narromine is facing both water shortages and water quality issues, in both the current climate and predicted future climate change scenarios.

With recharge of the aquifer not occurring reliably to satisfy drawdown since 2010, if usage does not slow and alternative water sources are not sought, Narromine could face the very real threat of running out of water. The long-term sustainability of groundwater abstraction from the Macquarie alluvium will be highly dependent upon the extent to which surface water flows can, in future, be maintained by release from Lake Burrendong, or the implementation of alternative means to supplement aquifer recharge (HEC, 2023).

Climate change predictions for the region include hotter days, reduced rainfall and increase in stochastic events that can result in flooding; further detail on this is provided in Section 1.3 below. These changes would exacerbate an already tenuous position for the Shire if changes to the overall system, and more broadly regional usage and water allocations, are not made.

CSIRO (2008) indicates that under the best-estimate 2030 climate there would be an overall 8% reduction in water availability in the Macquarie and a 9% reduction in end-of-system flows. Under the dry extreme for 2030 there would be a 25% reduction in overall water availability and a 28% reduction in end-of-system flows, whilst the wet extreme indicates corresponding increases of 25% and 41%. These scenarios present very different outcomes for the region.

1.3.1 Current climate

The Dubbo Airport Automated Weather Station (AWS), which is the nearest AWS for Narromine, has been collecting meteorological data since 1993 and has recorded observations of several meteorological data including temperature, humidity, rainfall and wind speed. Data recorded over the

past 30 years indicates that, on average, January is the hottest month of the year, with a mean daily maximum temperature of 33.6°C. July is the coolest month with a mean daily maximum temperature of 15.7°C. Rainfall data indicates that March is recorded as the wettest month with an average rainfall of 66.3 mm falling, with August the driest month at 36.2 mm. The yearly average rainfall stands at 586.5.

Table 1 Long term climate averages for the Dubbo Airport AWS (065070)

Observation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean observations													
Mean maximum temperature (°C)	33.6	32.0	29.1	24.9	20.0	16.4	15.7	12.0	17.6	21.5	25.1	28.6	**24.7**
Mean minimum temperature (°C)	18.4	17.6	14.8	10.3	6.4	4.4	3.1	3.3	6.1	9.5	13.4	15.9	**10.3**
Rainfall (mm)	94.3	83.8	83.9	62.7	63.0	67.6	67.6	63.4	58.9	67.7	70.0	76.1	**858.5**

1.3.2 Climate Change Predictions

The AdaptNSW division 'Climate Change snapshot' for the Central West and Orana (OEH, 2014), states that the region is projected to continue to warm during the near future (2020 – 2039) and far future (2060 – 2079), compared to recent years (1990 – 2009). There is very high confidence that the average temperatures will increase across seasons.

The snapshot outlines the following projections for Dubbo:

- Maximum temperatures are projected to increase in the near future by 0.4°C – 1.0°C, increasing to 1.8°C – 2.7°C in the far future.
- Minimum temperatures are projected to increase in the near future by 0.5°C – 0.9°C, increasing to 1.5°C – 2.6°C in the far future.
- The number of hot days is projected to increase and the number of cold nights is projected to decrease.
- Rainfall is projected to decrease in spring and increase in autumn.
- Both average and severe fire weather is projected to increase in summer, spring and winter.

Climate change projections are presented for emission scenarios that will impact the degree to which the climate is altered in the future; each of these is referred to as a 'representative concentration pathway' (RCP) and is representative of the concentration of global Green House Gas (GHG) emissions in the atmosphere under different emissions scenarios. For example, if GHG emissions are mitigated and reduced, the scenario is for 'low emissions' and is referred to as RCP 2.6; conversely, if little effort is made to reduce emissions and the current scenario is continued globally, a 'high emissions' concentration is referred to as RCP 8.5, indicating a high concentration of GHG emissions in the atmosphere moving forward, with potentially devastating impacts by the year 2100.

Under a high emissions scenario (RCP 8.5), NSW and the ACT can expect an average annual temperature increase of around 1.4 - 2.3 °C, whereas large and sustained reductions in global GHG emissions (RCP 2.6) reduce projected warming to around 0.7 - 1.4 °C. Specifically for Dubbo as the closest analogue to Narromine, under emissions scenario RCP 8.5 for the projected time period of 2090, an increase in temperature of between 3.0 °C to 4.5 °C is expected, combined with a change of average rainfall of between -25 % to -7 % (Climate Change in Australia, Analogues Explorer, 2023).

The Central West and Orana region is predicted to experience an increase in rainfall in Autumn and a decrease in Spring. Rainfall changes are associated with changes in extremes, such as floods and droughts. The changes to water quality, potential for erosion and sediment migration, damage to infrastructure and localised flooding complications are associated with these sudden or extreme changes. In addition, much of the assessment area (particularly pipeline routes from Dubbo to Narromine) occurs within a designated bushfire prone area (NSW Rural Fire Service, 2023). With a harsher fire-weather climate predicted in the future (high confidence), there is an increased risk of damage to water supply infrastructure and a strain on capacity of water treatment facilities.

Potential impacts regarding climate change

Throughout the construction phase of any of the proposed Options there will be use of in-demand materials. Use of these materials diminishes the availability of some resources for future use and contributes to pollution and GHG emissions through both direct use of fuels and the embodied energy used in the production of construction materials, and in association with the disposal of related waste products. The use of fossil fuels would also contribute to impacts on climate and air quality. While these impacts would be negligible on global or national scales, efficient resource use should be adopted as a general operating principle, including use of locally sourced materials and locally based construction crews to reduce 'carbon miles' and increase efficiencies.

Overall, the operation of the Proposal once constructed is anticipated to provide positive support to the community through improved water supply infrastructure and is considered a responsible long-term decision for Narromine in the face of predicted climate change impacts, to make the upgrade to a long-term solution to infrastructure. Operation of the newly installed water infrastructure will require consumption of electricity and will therefore contribute to generation of GHG emissions assuming the power is derived from a non-renewable source.

1.4 Aims of the assessment

The aim of the Preliminary Environmental Assessment is to determine at a strategic level the potential suite of environmental impacts arising from each Option considered. And, in completing this assessment and assigning each Option a 'score' against the relevant assessment criteria, assist Council in determining the most appropriate Option for increasing water security for Narromine Shire from an environmental perspective.

Assessment of the financial and engineering aspects of each Option will be completed separately, to ensure transparency and accountability in the selection process.

2 OPTIONS CONSIDERED

The following chapter contain descriptions of the various Options being considered to bring additional water resources to the township of Narromine, in order to meet the current and future demand and increase water security for the LGA.

2.1 Option 1 – Current Groundwater Source

This Option assumes that Council will continue to utilise the existing four (4) bores, and locate and construct additional bores within the locality, to meet the future demand.

Based on the aquifer modelling undertaken as part of Narromine Groundwater Project Report (HEC, 2023), this option has a high risk of not being able to meet the levels of service required, due to the frequency and duration of restrictions on this water source.

Additionally, this Option is solely reliant on one (1) water source being the Upper Macquarie Aquifer, and therefore does not 'spread the load' for water demand across multiple sources. Raw water quality incidents in this source, as well as significant draw down and lack of water availability could therefore reduce the capacity of the WTP, or treated water would not meet the levels of service required for Narromine.

2.2 Option 2 – Current Bores and Macquarie River

This Option supplements the existing bores with water pumped directly from the Macquarie River, and is intended to reduce pumping and treatment costs through use of a diversified water source. To reduce treatment costs, only the volume of water that cannot be supplied by the borefield will be pumped from the river. River water can also be used when bore water quality is unsuitable due to presence of pathogens, when bores are temporarily unavailable, such as for maintenance or when demand is high.

Water from the Macquarie River was previously extracted to the north of Narromine via the redundant WTP river pump station off Warren Road. The original concrete pump well appeared to be in a relatively good condition during a site inspection completed in 2022; however, no formal inspection of the wet well has been undertaken and the condition of the well internally and at depth is unknown.

As part of this Option, it is proposed to utilise this existing pump well to install new pumps, a new suction pipeline and replace the building and ancillary infrastructure. There are four (4) possible pipeline routes from the River pump station to the treatment plant site, which are shown in Figure 6, Figure 7 and Figure 8.

The sizes of the pump station and length of individual pipeline routes are shown in Table 2 below.

Table 2 Macquarie River pump station and pipeline routes

Component	Description			
	Route 1	Route 2	Route 3	Route 4
Pump station	Duty/standby pumps with capacity 102 L/s (7.5 ML/day in 20 hours) at 30 m head			
Pipe material/size	DN450 DICL			

Component	Description			
	Route 1	Route 2	Route 3	Route 4
Pipeline length	3,920 m	4,000 m	5,180 m	5,500 m

2.3 Option 3 – Drinking Water from Dubbo

This option supplies all treated water into the Nymangee Street Reservoir from the John Gilbert WTP in Dubbo; the current borefield would not be decommissioned, as a secondary source of water is required as a failsafe for the town's water security. As discussed in Section 5.3.1 of the Options Assessment Report (Atom, 2023), during peak demand, the John Gilbert WTP is currently operating near capacity – consequently, the Dubbo WTP would also require upgrades to enable this Option to progress. To ensure a secure and diverse water source, NSC would also need to continue to operate the bores and existing treatment plant during these peak times.

As the pipeline will run downhill, it has been assumed there is sufficient head in Dubbo's drinking water supply system, and as such construction of a new pump station would not be required. There are two (2) possible pipeline routes from the Dubbo WTP to the treatment plant site, which are shown in Figure 9, Figure 10 and Figure 11.

The length of individual pipeline routes are shown in Table 3 below.

Table 3 Dubbo pipeline routes

Component	Description	
	Route 1	Route 2
Pipe material/size	DN450 DICL	
Pipeline length	34.2 km	38 km

2.4 Option 4 – Demand reduction schemes

This Option is considered complementary to any / all of the other three (3) Options being considered, and includes:

- Community and stakeholder engagement and education on water saving – techniques and reasoning. Ensuring people understand why water saving is important and is fundamental to success of community engagement.
- Review of current Council water consumption, particularly for irrigation of green spaces and sporting facilities. Implementation of Water Sensitive Urban Design (WSUD) program and consideration of water security in strategic planning and development.
- Broad community and stakeholder engagement and education on water sources – stressors, recharge rates, alternatives.
- Review of primary agricultural usage of water in Narromine Shire, including but not limited to
    - Timing of irrigation events
    - Extraction limits and
    - Climate appropriate crops and land uses.
- Subsidies/incentives and grant funding for onsite water collection facilities at private residences, e.g. water tanks.
- Subsidies/incentives and grant funding for agricultural irrigation and stock-watering innovations.

Generally, water saving initiatives and awareness programs are essential to sustainable management of water resources and water usage in regional areas of Australia that are prone to drought; predictions for changes to climate variables for Narromine include increased hot days and decreased rainfall, coupled with increased risk of stochastic events such as isolated heavy rainfall and flood risk (BOM, 2023). Community engagement is accepted as a critical component of action to reduce disaster risk and strengthen resilience, and subsequently emergency management.

The amount of water currently being used throughout the Shire exceeds the amount of water recharging the aquifer threefold. This is not sustainable, and if not addressed may result in the region running out of water.

3 LEGISLATIVE CONTEXT AND STAKEHOLDER CONSULTATION

The following is a summary of the relevant legislation and policies applicable to the NSC water security Options.

Indication of whether further action is required has also been made in Table 4 below.

Table 4 Legislation checklist

Legislation	Anticipated Implications	Action Required	
Commonwealth			
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	For all Options, potential impacts on relevant MNES must be subject to Assessments of Significance pursuant to the EPBC Act Significant Impact Guidelines (DEWHA 2009). If a significant impact is considered likely, a referral under the EPBC Act must be submitted to the Commonwealth Minister for Environment. MNES can also include world heritage properties, national heritage places and wetlands of international importance.	Yes ☑ No ☐	All Options will require preparation of an REF and the completion of an assessment to assess the potential for impacts on MNES.
NSW / State Legislation, Policies and Guidelines			
State Environmental Planning Policy (Transport and Infrastructure) (Transport and Infrastructure SEPP) 2021	As per Division 24, Section 2.159 (1) Development for the purpose of water reticulation systems may be carried out on or behalf of a public authority without consent on any land. As the proposed works are appropriately characterised as development under the Transport and Infrastructure SEPP, the provisions of the Transport and Infrastructure SEPP apply.	Yes ☐ No ☒	All of the proposed options can be carried out as activities under Division 5.1 of the EP&A Act. Development consent from Council is not required. All options will require preparation of an REF. In addition, there are statutory consultation requirements outlined in Division 1 that will also need to be considered.
Environmental Planning and Assessment Act 1979 (EP&A Act)	Proposed works would require the preparation of a Review of Environmental Factors (REF) to determine if the proposal	Yes ☑ No ☐	All Options will require preparation of an REF, which must consider to the fullest extent

Legislation	Anticipated Implications	Action Required	
and the Environmental Planning and Assessment Regulation 2021 (EP&A Regulation 2021).	would be likely to significantly affect the environment.		possible matters affecting or likely to affect the environment in accordance with s5.5 of the EP&A Act and cl 171(2) of the EP&A Regulation.
Protection of the Environment and Operations Act 1997 (POEO Act)	The POEO Act regulates and requires licensing for environmental protection, including for waste generation and disposal, and for water, air, land and noise pollution. It is anticipated that all options are unlikely to generate significant pollution or result in discharge of waste products as a result of ongoing operations.	Yes ☐ No ☒	None of the options are anticipated to require a license from the Environmental Protection Authority (EPA); however, prevention of pollution of soils, water and air is a factor in consideration for construction and operation of all options.
Biodiversity Conservation Act 2016 (BC Act)	Section 7.3 of the BC Act sets out the tests for determining whether a proposed activity is, or is likely to significantly affect threatened species or ecological communities, or their habitats. Ecological assessment of site to support the preparation of an REF likely required for all options.	Yes ☑ No ☐	Site assessment and preparation of an REF is likely required to consider potential impacts to threatened species or ecological communities, or their habitats in accordance with s7.8 of the BC Act.
Biodiversity Conservation Regulatory Act 2017 (BC Regulatory Act)	Section 6.2(e) of the BC Act provides that the proponent of an activity that is assessed under Division 5.1, Part 5 of the EP&A Act can voluntarily opt out of the Biodiversity Offset Scheme (BOS). However, if any significant impacts to biodiversity are identified through the assessment process, participation in the BOS and the preparation of a Biodiversity Development Assessment Report (BDAR) may be required.	Yes ☐ No ☒	As all options are likely to be assessed under Division 5.1 of the EP&A Act, and Council is the proponent, Council will have the option to elect out of the BOS if it so chooses.
National Parks and Wildlife Act 1974 (NPW Act)	The NPW Act provides for the statutory protection of Aboriginal cultural heritage places, objects and features. To address the requirements of Step 4 of the 'Due Diligence code of practise', a site inspection by a qualified archaeologist and preparation of an Aboriginal Due Diligence (ADD) assessment is likely required for all	Yes ☑ No ☐	Aboriginal Due Diligence (ADD) assessment will be required as part of the preparation of the REF for all of the proposed Options.

Legislation	Anticipated Implications	Action Required	
	options. Should any Aboriginal archaeological material be identified during the site inspection and council is unable to avoid impacting on the area, consultation and engagement with the relevant Aboriginal community will be required to support a more detailed Aboriginal Cultural Heritage Assessment (ACHA) and, potentially, an application for an Aboriginal Heritage Impact Permit (AHIP).		
Heritage Act 1997 (Heritage Act)	Excavation of land on which it is known or where there is reasonable cause to suspect that 'relics' will be exposed, moved, destroyed, discovered or damaged is prohibited unless ordered under an excavation permit (section 139 *Heritage Act*). Assessment will be required to determine if any local, State or National heritage listed items are within the proposed works area. If so, they may require assessment by a qualified heritage officer and the preparation of a Statement of Heritage Impact (SoHI) to determine potential impacts and the necessary mitigation measures that must be implemented.	Yes ☑ No ☐	All options will require preparation of an REF. Confirmation via desktop assessment as to whether the work will require preparation of a Statement of Heritage Impact (SoHI) by a qualified archaeologist.
Fisheries Management Act 1994 (FM Act)	The FM Act aims to conserve threatened species, populations and ecological communities of fish and marine vegetation native to NSW. Permits are required for works within a third order (or higher) streams (based on the Strahler system of stream order classification), and first and second order streams that are known or likely to be habitat for listed threatened species, populations or communities. A permit under the FM Act is required for any work that involves activities involving dredging and reclamation work, activities temporarily or permanently obstructing fish passage, using explosives, electrical devices or other dangerous substances in a waterway and harming marine vegetation.	Yes ☑ No ☐	For all options, a site assessment and preparation of an REF is likely required to consider potential impacts to threatened species, populations and ecological communities covered under the FM Act and whether a permit under the FM Act is required for any proposed works.

Legislation	Anticipated Implications	Action Required	
Water Management Act 2000 (WM Act)	The WM Act Part 2 requires a Water Access Licence (WAL) be issued and complied with when extracting water from a water source including aquifers and rivers (regulated or unregulated). NSC currently has a WAL to extract bore water in Narromine to supply drinking water. The Act also defines the requirements for Water Sharing Plans (WSP) which are used to define how WALs will be issued and rules for extraction under these licences. The following WSPs are currently in place for water that is accessible within NSC's local government area. • Macquarie-Castlereagh Groundwater Sources 2020 • Macquarie and Cudgegong Regulators Rivers Water Source 2016 • Macquarie Bogan Unregulated Rivers Water Sources 2012 Under the WM Act, it is an offence for a person to construct or use a 'water supply work' if they do not hold a water supply work approval (s 91B(1)). However, it is also a defence to a prosecution under that Act if the person can establish that their work is an excluded work or otherwise exempt under the WM Act or the *Water Management (General) Regulation 2018* (**WM Regulation**) from the requirement to have an approval.	Yes ☑ No ☐	Assessment and approval of additional water sources under the WM Act will be required for all of the proposed Options to determine the requirement for a Water access Licence and Water Supply Works Approval.
NSW Biosecurity Act 2015 (Biosecurity Act)	The Biosecurity Act introduces the legally enforceable concept of a General Biosecurity Duty (GBD) (Part 3 of the Biosecurity Act). Priority weeds are listed within Regional Strategic Weed Management Plans, however the GBD is not restricted to listed weeds. Council has biosecurity duties under the Biosecurity Act; namely, to be aware of surroundings and take action to prevent the introduction and spread of pests, diseases, weeds and contaminants.	Yes ☑ No ☐	Council will need to carry out any relevant biosecurity duties, including weed management as applicable for the construction and operation of the selected Option.
Roads Act 1993	The *Roads Act 1993* regulates the use and management of public roads. Section 138	Yes ☑ No ☐	Council are required to complete a Section 138

Legislation	Anticipated Implications	Action Required	
	of the Roads Act requires that consent of the appropriate Roads Authority is obtained for certain work undertaken in, on or over a public road. For any works requiring interaction with a classified State Road or rail corridor, consultation with TfNSW will be required prior to works commencing.		application and concurrence must be sought with TfNSW for all pipeline route options that intersect TfNSW managed roads and / or the rail corridor.
Crown Land Management Act 2016 (CLM Act)	Where work is proposed on Crown land, the proponent of the proposed activity, must, obtain a right of access to the Crown land in accordance with the CLM Act.	Yes ☑ No ☐	A Crown Land Licence is required for work completed on Crown Land
State Environmental Planning Policy (Biodiversity and Conservation) 2021	Site assessment and preparation of REF would need to determine the likelihood of occurrence of the Koala (*Phascolarctos cinereus*) in the area and assess risk of impact to the species.	Yes ☑ No ☐	Preparation of an REF and determination of the Likelihood of Occurrence of Koala for all options.

Further to the above, per the EP&A Regulations, determining authorities must keep the REF documentation including any appendices or addenda and make available for public access once a determination has been made. The EP&A Regulation Clause 171(4) requires the REF to be published on the determining authority's website or the NSW Planning Portal for an activity with:

- A capital investment value of more than $5 million or,
- An approval or permit for activity that requires approval under:
    - FM Act sections 144, 201, 205 or 219, or
    - *Heritage Act 1977* section 57, or
    - *National Parks and Wildlife Act 1974* section 90 or
    - *Protection of the Environment operations Act 1997* sections 47-49 or 122, or
- If the determining authority considers it to be in the public interest.

There are allowances for exceptional circumstances where publication is not required; this is at the Planning Secretary's discretion. If the REF is to be published, the determining authority must place all relevant information on the determining authority's website or the NSW Planning Portal prior to the commencement of works.

Certain parts of the REF document may be sensitive, such as sensitive cultural information requested to be redacted by Aboriginal parties or cyber security impacts and mitigation measures. In these instances, the REF document content can be redacted where required. The REF document (excluding sensitive information) needs to be available online.

4 ASSESSMENT

The following chapters outline the preliminary assessment completed against key environmental aspects for each of the presented Options to increase water security for NSC. Also provided is a score for each Option against a series of relevant criteria, in accordance with the evaluation of integrated water cycle management scenarios guideline (NSW Government, 2019)

4.1 Option 1 – Current Groundwater Source

This first Option would look to continue with the current sole water source – groundwater – by utilizing the existing borefield (specifically the current active Bores 3, 8, 6 and 9) and construction of an additional bore.

While the location of the additional bore has not yet been determined, the additional bore would need to be within the same aquifer as the current borefield. Generally, this is not considered sustainable, given the historic and current pressures on this water source. To mitigate this, the additional bore would likely need to be constructed further away, but still within the Lower Macquarie Alluvial Aquifer. As shown on Figure 2, the town is located in the centre of Zones 6, 1 and 3, and bordered to the north by the Macquarie River which marks the boundary of the Upper Macquarie Groundwater Source.

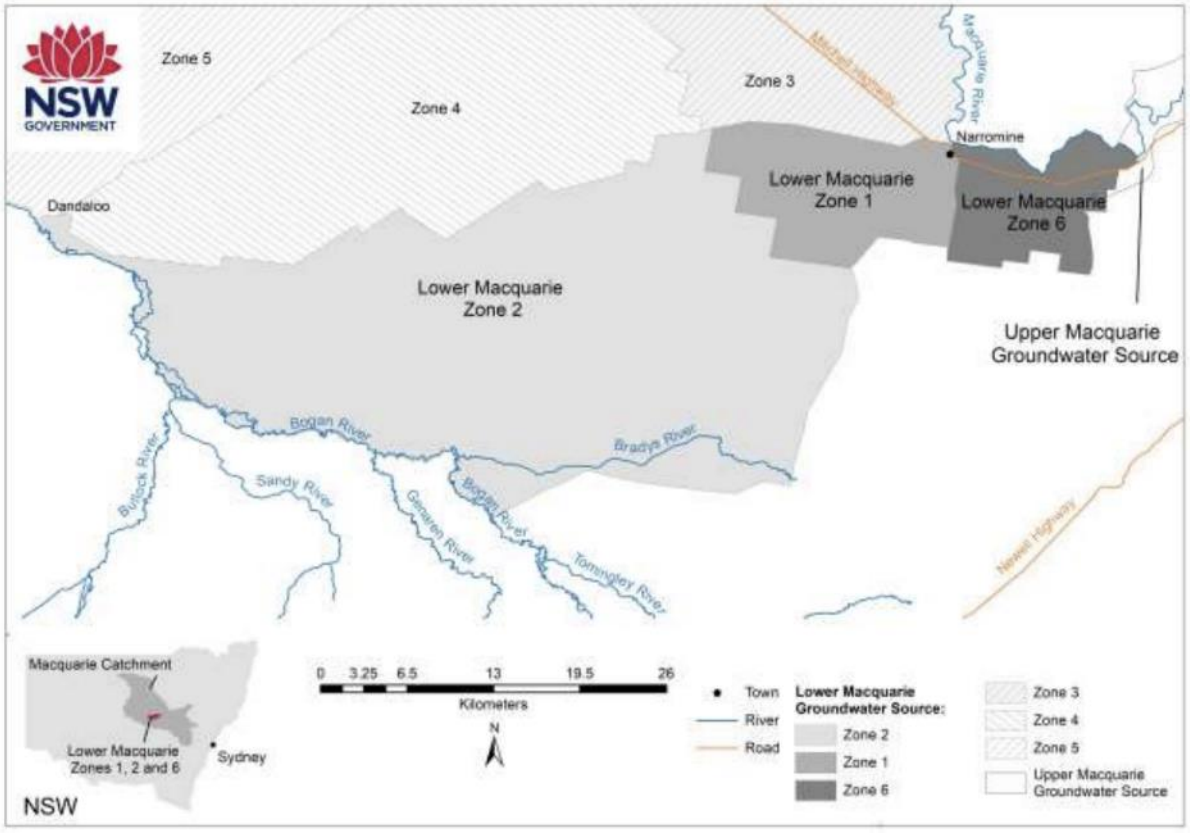


Figure 2 Lower Macquarie Groundwater Source Zones (source: NSW DPIE, 2021)

Council have attempted to find a location within the existing aquifer using test bores but have not been able to locate water. It is therefore likely that the bore(s) would need to be located a long distance from Narromine. The closest deep (150 m +) section of the aquifer is farther afield near the township of Trangie, within Zone 5 of the aquifer, which is a considerable distance at approximately

35 km from Narromine. The deep aquifer near Trangie also has a high sodium content which may increase treatment costs. Consequently, this has the potential to be an extensive and costly undertaking as a pipeline would need to be constructed to transfer water to the WTP from the new bore.

Consideration of relevant environmental aspects of Option 1 is provided below.

4.1.1 Biodiversity – terrestrial and aquatic

It is difficult to quantify the impacts arising from the construction of an additional bore, as the location of said bore has not been determined.

Regardless, any new bore would require a pipeline to transfer water back to the Narromine WTP, which would be at a minimum several kilometers away if within the current Zone of the groundwater source, or a maximum ~35 km if the new bore was in the locality of Trangie in a separate groundwater source Zone.

Terrestrial ecology

The area surrounding the Borefield and the WTP is predominantly cleared agricultural land, with patches of remnant native vegetation occurring along road reserves and waterways in the locality. Bore and pipeline placement could be kept to cleared areas, to avoid and minimize impacts to biodiversity. However, placement of pipelines and easements in private land can be difficult, typically resulting in infrastructure being aligned within road reserves or rail corridors.

As such, the potential for impacts to native vegetation is typically increased and may result in removal of or impacts to mature and remnant native vegetation, and / or impacts to threatened species, populations, ecological communities and / or their habitats as listed under the NSW BC Act and / or the Commonwealth EPBC Act.

Aquatic ecology

Impacts to aquatic ecology associated with Option 1 cannot currently be quantified for surface water ecological systems as a new bore and associated pipeline/s have not been identified; however, further drawdown on the existing groundwater source is documented to have flow on effects to Groundwater Dependent Ecosystems (GDE) present in the vicinity, which may include wetlands, streams, lakes, swamps, aquifers, springs, caves and some vegetation communities. GDEs are important habitats for native fauna such as fish, frogs and waterbirds.

CSIRO (2008) indicates that the current total entitlement for the Upper Macquarie Aquifer is 38.4 gigalitres per year (GL/yr), and that the 2004/05 abstraction was 37 GL. CSIRO estimated that long term average rainfall recharge to the aquifer is 7.1 GL/yr. As such, additional pressure on this water source, without diversifying, would likely further deplete groundwater in the locality and increase pressure/impacts on GDEs.

4.1.2 Heritage – Aboriginal and non-Aboriginal

Impacts to heritage items from development of deeper bores or new bore locations is anticipated to be low, as the footprint of replacement or new bores is relatively small (typically <1 ha in area).

However, if a pipeline would need to be constructed connecting a bore to Narromine that is situated further afield, potential for impacts to heritage items, both Aboriginal and non-Aboriginal, increases.

Aboriginal heritage records within the region are numerous (refer Figure **5** and Figure 8).

4.1.3 Receiving environment – pollution risk

Given the groundwater vulnerability across much of the locality (refer Figure 3) risk of pollution of groundwater is considered moderate to high where upgrades to Bores or establishment of pipelines to connect new Bores is required.

4.1.4 Waste and resource use

The resources used to establish the new bore, replacement bores or connecting pipelines have not been quantified, however it is assumed the new bore would require the following:

- Pump testing including up to 72 hours of water pumping to test flows, and disposal of associated sludge and water
- Bore infrastructure, including:
    - Casing
    - Pump house
    - Drill pad
    - Power connections
    - Telemetry and
    - Access roads
- Connecting pipelines, pump / lift stations.

Where bores are replaced / made deeper into the aquifer, as opposed to establishing a new bore or bores farther afield, the quantities of resources required to proceed with Option 1 are anticipated to be lower.

4.1.5 Socio-economic considerations

According to the Narromine Groundwater Project Report (HEC, 2023) some of the current Narromine bores have been in commission for over 35 years, and in this time have not undergone any major upgrades. Consequently, these bores are nearing the end of their service life.

Additionally, under current licensing arrangements NSC has a limited opportunity to apply for additional bores, meaning this Option carries risk of not gaining approval.

Alternatively, there is an opportunity to increase the town water supply by constructing deeper bores as replacements for the current bores. Since 2012, NSC has drilled three (3) deeper replacement bores on the same sites as the current shallow bores (Bores 6, 7 and 9) in the hopes that a sufficient and reliable water source could be found. HEC considered that based on historical and classical pumping test analysis, the current replacement bores will meet the peak daily demand for NSC in terms of volume. However, the water from this deeper aquifer requires significant water treatment due to poorer quality (HEC, 2023).

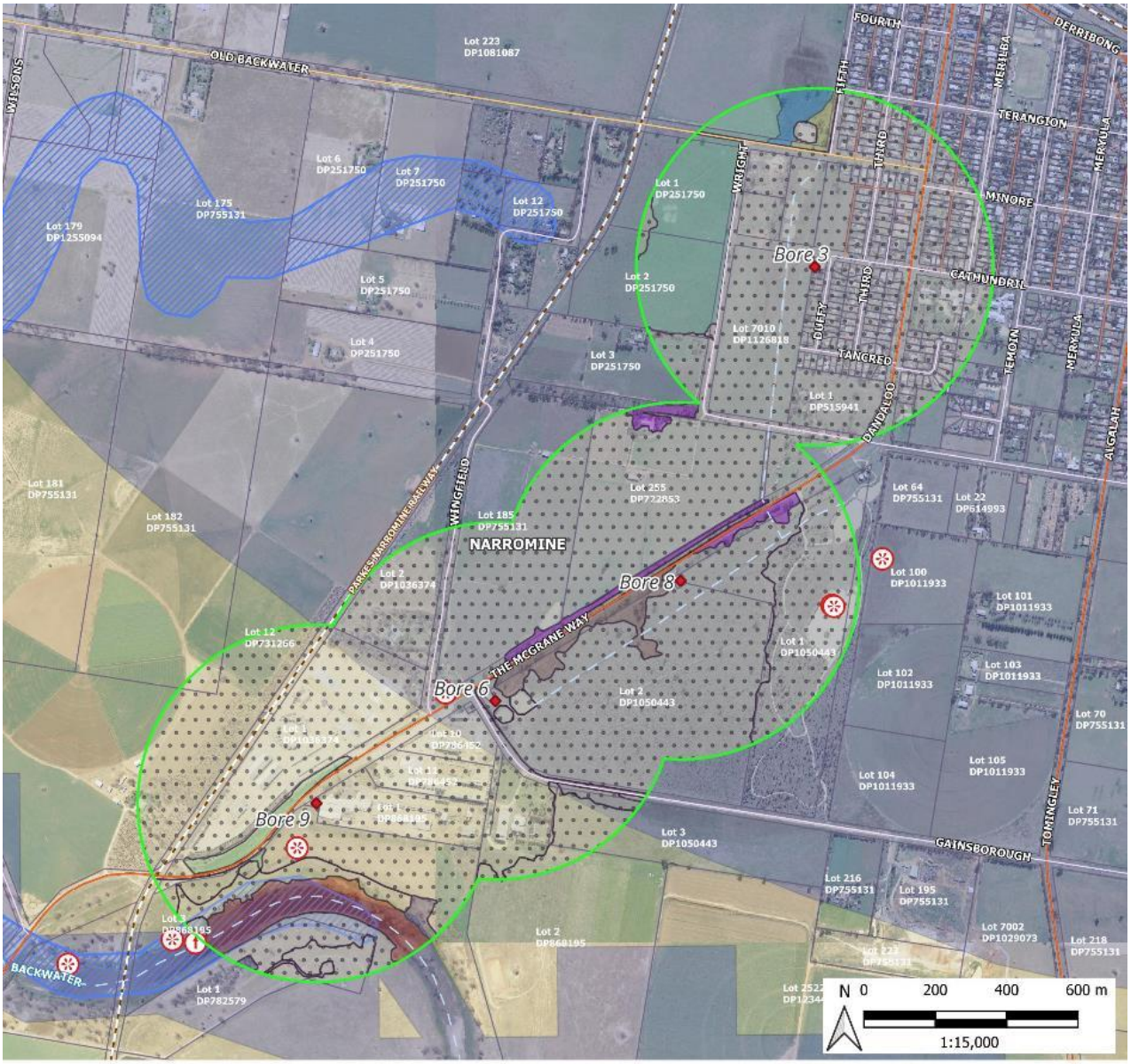
Consequently, if Council were to proceed with Option 1, it would carry financial and community health risks associated with necessary bore replacement, development of new bore/s and pipeline

connections, and concerns regarding the quality of the groundwater which would carry potentially significant cost to bring water to potable quality, or risk to human health.

Table 5 Option 1 assessment

Water Security Option 1

Criterion	Description of Option 1	Score
Environmental Group		
Impact on terrestrial and aquatic biodiversity	Assumed 35 km of potential impact to connect new Bore near Trangie	3/10
Environmental pollution risk (i.e POEO Act)	Construction of a new Bore and associated pipelines and infrastructure carries a risk for pollution incidents to groundwater, surface water and land. Risk is moderate to high.	3/10
Impact on heritage – Aboriginal and non-Aboriginal	Unknown – up to 35 km of pipe alignment results in moderate to high risk.	3/10
Waste and resource use	Use of existing infrastructure + some new infrastructure – 35 km of pipeline	3/10
	(1) Total weighted environmental	**3**
Social Group		
Risk of not meeting LOS (adequate water sources, water strategies)	Uncertainty, as same groundwater source; dependent upon whether additional bore possible	1/10
Impact on land – use and area (ha)/disruption to community	Relatively large impact footprint, long pipe alignment = high number of properties impacted, road use and community impacts exacerbated	3/10
Planned for future changes in development (right sizing)	Does not provide adequate security for future water demand	2/10
Community attraction / liveability	Likely to encounter further water quality concerns in Trangie, compounding current issues; no increased water for community spaces, likely to require current or additional water restrictions	3/10
	(2) Total weighted social	**2**
	(3) Environmental and social score (ESS) (3) = (1) + (2)	**5**



Water and Biodiversity features within 500m of Water Security Option 1

Legend

- Assessment Area
- Bores
- Suburb boundary
- Lot boundary

Roads

- Arterial Road
- Local Road
- Primary Road
- Sub Arterial Road
- Railway

Waterways

- 1st & 2nd order; unnamed waterways
- Key Fish Habitat
- Mapped Groundwater Vulnerability

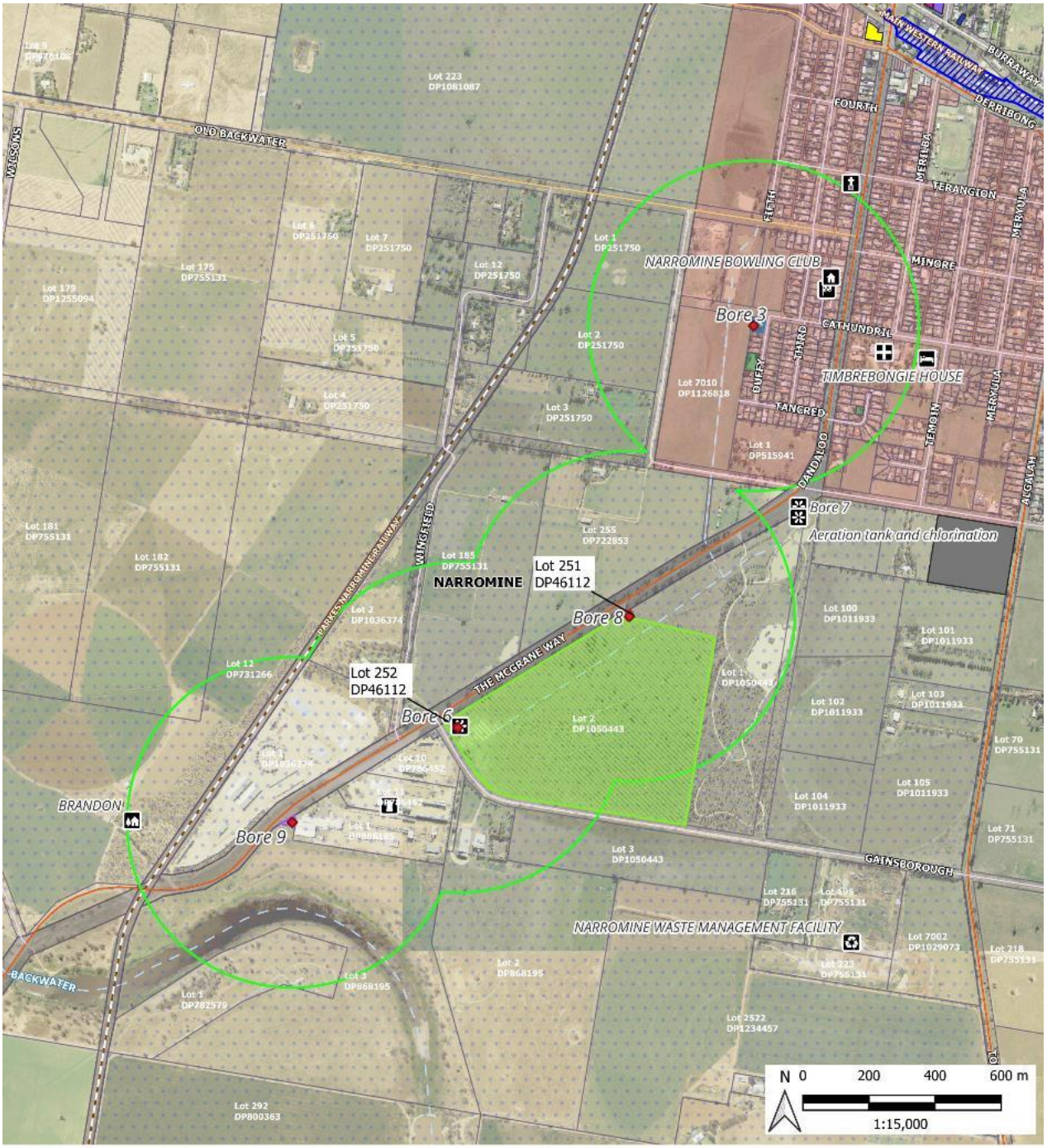
Threatened Species

- Latham's Snipe
- Magpie Goose

Option 1 Plant Community Types

- PCTID: 0 - Not native vegetation
- PCTID: 244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).
- PCTID: 36 - River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion
- PCTID: 45 - Plains Grass grassland on alluvial mainly clay soils in the Riverina Bioregion and NSW South Western Slopes Bioregion
- PCTID: 53 - Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains
- PCTID: 70 - White Cypress Pine woodland on sandy loams in central NSW wheatbelt
- PCTID: 82 - Western Grey Box - Poplar Box - White Cypress Pine tall woodland on red loams mainly of the eastern Cobar Peneplain Bioregion
- PCTID: 83 - Yellow Box woodland on sandy loam soils on alluvial plains mainly in the upper Darling Riverine Plain Bioregion

Figure 3 Option 1 - Water and biodiversity features within the assessment area (500 m radius)



Landuse and sensitive receivers within 500m of Water Security Option 1

Legend

- Assessment area
- Bore
- Suburb boundary
- Lot boundary
- Local Road
- Primary Road
- Sub Arterial Road
- Railway

Roads

- Arterial Road

Waterways

- 1st & 2nd order; unnamed waterways

Directly Impacted Lots

- Lot 241 DP755131
- Lot 251 DP46112
- Lot 252 DP46112
- Lot 236 DP629623
- Lot 2 DP1050443

Sensitive Receivers

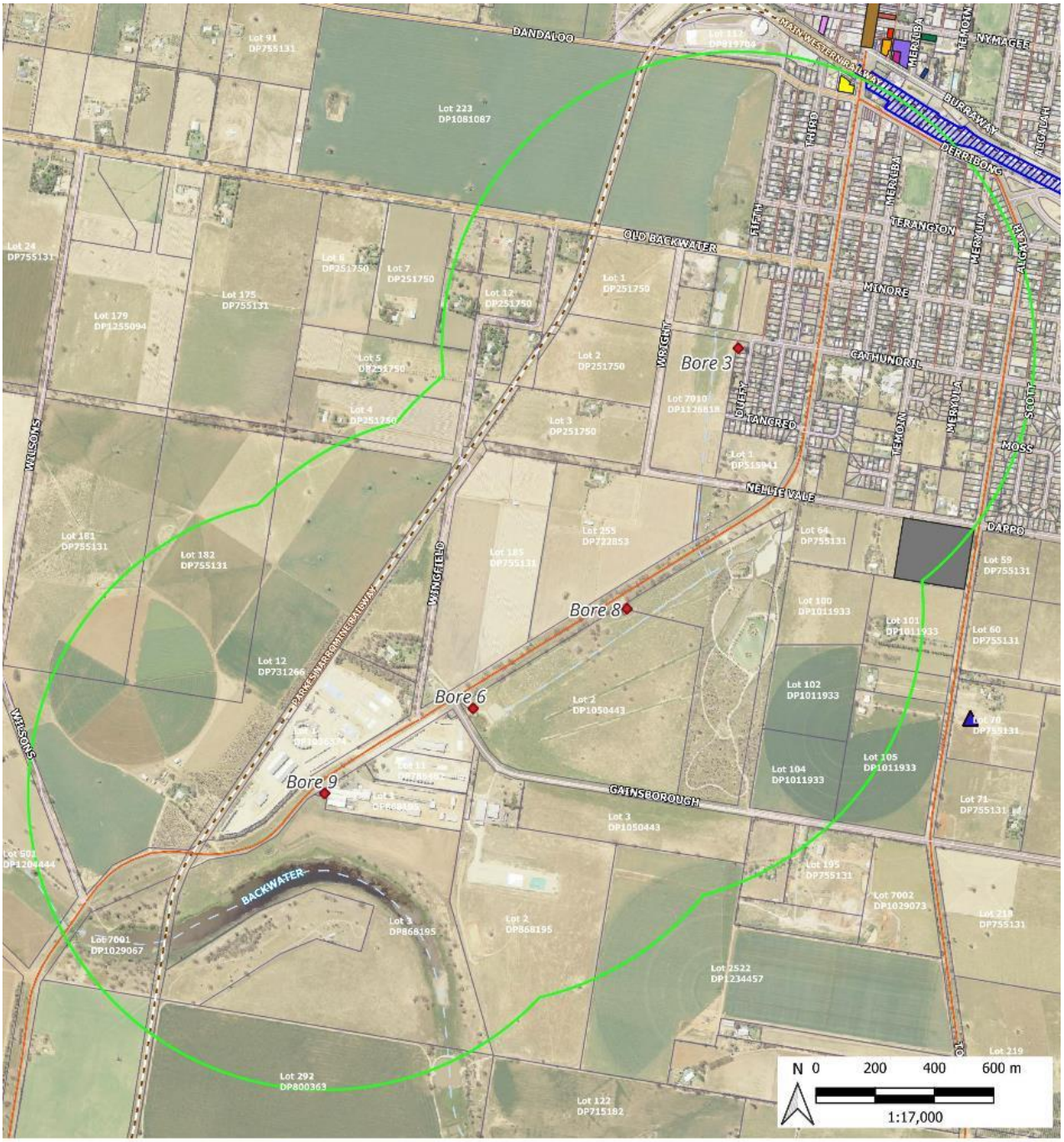
- Club
- General Hospital
- Homestead
- Nursing Home
- Place Of Worship

- Rubbish Depot
- Silo - Commercial
- Sports Field
- Water feature

Land Zoning

- R1
- RE1
- RU1
- SP2

Figure 4 Option 1 – Landuse and Sensitive Receivers within the assessment area (500 m radius)



Aboriginal and Non-Aboriginal Heritage items within 1km of Water Security Option 1

Legend

- 1km Radius
- Bores
- Suburb boundary
- Lot boundary

Roads

- Arterial Road
- Local Road
- Primary Road
- Sub Arterial Road
- Urban Service Lane
- Railway

Waterways

- 1st & 2nd order; unnamed waterways

Heritage Items

- Butchers shop
- CBC Bank
- Cemetery
- Courthouse (former)
- Courthouse Hotel
- Hotel Narromine
- House
- House and bakery
- Imperial Hotel
- Median strip garden
- Narromine Railway Station
- Shops
- The Masonic Lodge
- AHIMS Aboriginal Heritage Item

Figure 5 Option 1 – Aboriginal and non-Aboriginal Heritage items within 1 km

4.2 Option 2 – Current Bores and Macquarie River

Option 2 includes supplementation of the existing bores with water pumped from the Macquarie River, and is intended to reduce pumping and treatment costs, and spread the load for a more sustainable and secure water supply scheme, through use of a diversified water source.

4.2.1 Biodiversity – terrestrial and aquatic

Biodiversity in proximity to the proposed Macquarie River offtake and pipe alignments is limited to patches of native vegetation along road reserves, the rail corridor and in private land, as well as associated with the narrow strip of riparian vegetation along the Macquarie River Vegetated Riparian Zone (VRZ) (refer Figure 6).

The river itself is mapped as supporting Plant Community Type (PCT) PCTID 36 *River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion* in the vicinity of the proposed offtake and pump station location, with PCTID 244 *Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of NSW (wheatbelt)* and PCT ID 82 *Western Grey Box – Poplar Box – White Cypress Pine tall woodland on red loams mainly of the eastern Cobar peneplain Bioregion* occurring within the assessment area, amongst others. These PCTs are analogous to Threatened Ecological Communities (TEC) and are thus afforded protection under legislation.

Terrestrial ecology

All of the proposed pipe alignments share the same River offtake and pump station location and terminate along the same stretch of road on The McGrane Way, where the WTP is located at the intersection with Gainsborough Road.

If the pipeline is located within the road reserve, Option 2 has the potential to impact upon the areas of remnant woodland present there, including large mature and hollow-bearing trees, that occur along The McGrane Way.

Each of the different routes through the township traverse predominantly urban areas, which are largely developed, and now support private gardens, lawns and non-native street trees. The majority of this area is mapped as 'non native vegetation', per the NSW State Vegetation Type Map (SVTM).

Three (3) species of threatened waterbirds, namely Australian Bustard (*Ardeotis australis*), Latham's Snipe (*Gallinago hardwickii*) and Magpie Goose (*Anseranas semipalmata*) have been recorded within the assessment area (500 m buffer from the proposed alignments); Bluegrass (*Dichanthium setosum*) has also been recorded to the southeast of the assessment area and care should be taken to ensure this threatened plant is avoided prior to any of the alignments being selected.

Aquatic ecology

As there is currently limited drawdown on the Macquarie River in the vicinity of Narromine, the River is likely to experience minor changes in hydrological flows downstream of the proposed river offtake. These changes may impact on the aquatic environment through changes to water levels and temporary (and subsequent) changes in water quality through reduced water levels downstream of the extraction point. As the river water volume to be extracted will be to supplement the existing groundwater source as supplied by the bores, and will not become the primary source of water for the

Narromine water supply system, impacts to aquatic ecology and downstream ecosystems are anticipated to be minor and manageable.

As this Option still relies upon the existing groundwater source, which is being extracted from at a rate 5 times higher than it is being replenished, risks to GDEs and wetlands in the area also exist for this scenario. However this risk is lessened through diversification of the water source, meaning that river water can be relied upon if draw down on the bores is too great, water quality is too low, or the township otherwise needs to extract water from the River.

4.2.2 Heritage – Aboriginal and non-Aboriginal

Narromine is rich in non-Aboriginal heritage, with a series of State and locally significant buildings recorded within the assessment area. These include the following historical heritage items:

- Butchers shop
- CBC Bank
- Cemetery
- Courthouse (former)
- Courthouse Hotel
- Hotel Narromine
- House
- House and bakery
- Imperial Hotel
- Median strip garden
- Narromine Aerodrome
- Narromine Railway Station
- Shops
- The Abbey, and
- The Masonic Lodge.

Route 1 via Dandaloo Street passes the highest number of heritage items, passing through the centre of town. Consideration for impacts to heritage items from vibration and damage during construction as well as during operational maintenance should be given when selecting the final alignment.

No items of Aboriginal heritage significance are recorded in the assessment area for Option 2.

4.2.3 Receiving environment – pollution risk

Impacts to air quality and land have the potential to occur during the construction phase of Option 2, for all alignments.

Particularly, risk of reportable incidents under the POEO Act for impacts to sensitive receivers (refer Figure 7) are moderate to high for any construction activities passing through the urban area.

4.2.4 Waste and resource use

Materials, including up to 5.2 km of concrete pipeline and ancillary infrastructure will be required to construct and operate Option 2.

4.2.5 Socio-economic considerations

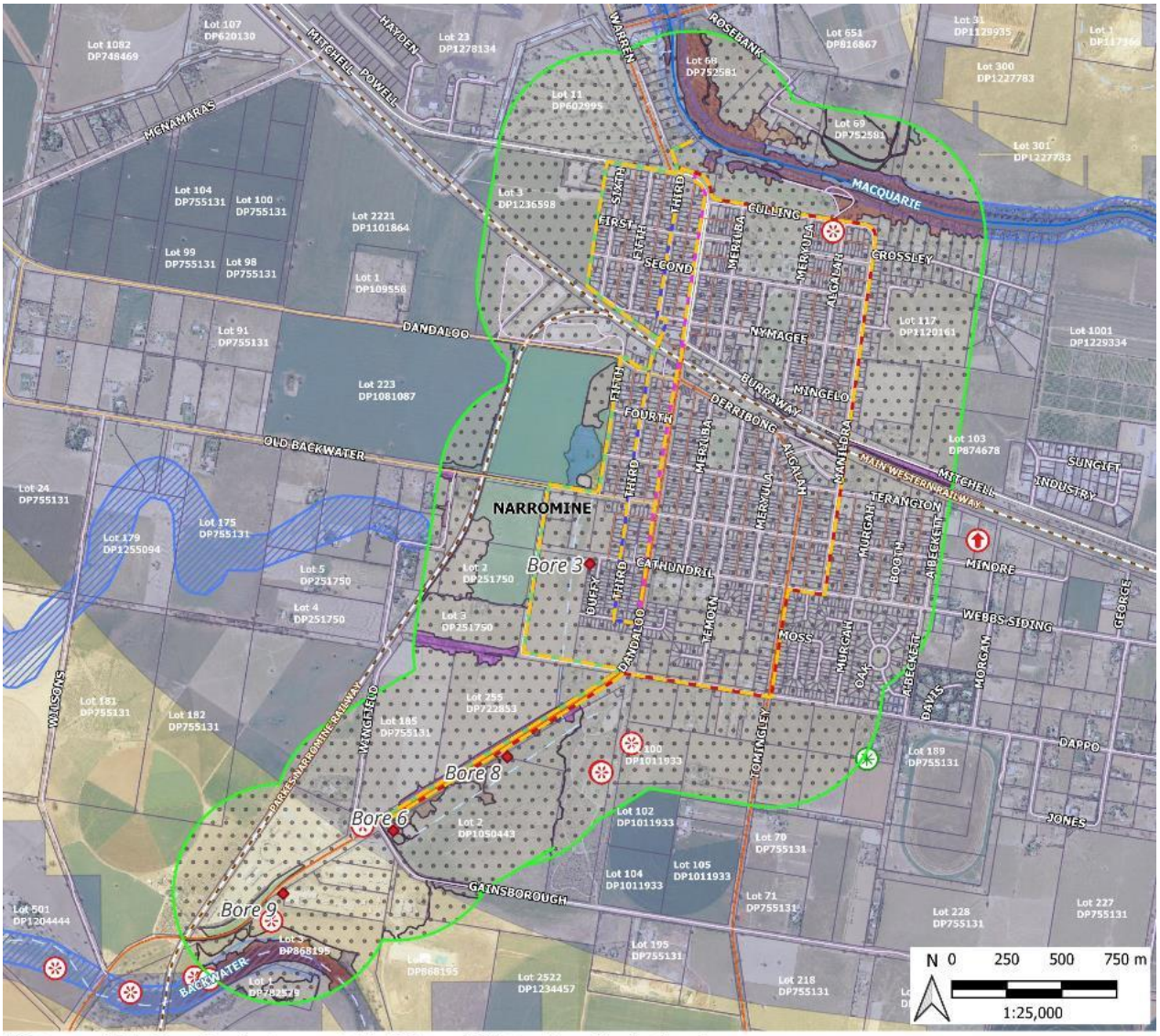
This Option seeks to diversify the water source for the Narromine water supply system, which is more resilient and sustainable than relying solely on groundwater.

Option 2 creates greater certainty for Narromine's water security and alleviates pressure on the existing groundwater source which currently supports the extensive agricultural area surrounding the township, and throughout the Shire.

Table 6 Option 2 assessment

Water Security Option 2

Criterion	Description of Option 2	Score
Environmental Group		
Impact on terrestrial and aquatic biodiversity	Construction of a river offtake and pipeline through an urban area. Potential for downstream aquatic impacts within Macquarie River	6/10
Environmental pollution risk (i.e POEO Act)	Potential for pollution of river. Moderate to high risk for any construction activities passing through the urban area	5/10
Impact on heritage – Aboriginal and non-Aboriginal	No previous records of Aboriginal heritage. Several non-Aboriginal heritage items in proximity	8/10
Waste and resource use	Use of existing infrastructure – no new bore; up to 6 km of new pipeline; use of existing pump well, new pumps & ancillary infrastructure	7/10
	(1) Total weighted environmental	**6.3**
Social Group		
Risk of not meeting LOS (adequate water sources, water strategies)	Increased certainly, as multiple water sources	8/10
Impact on land – use and area (ha)/disruption to community	Relatively small impact footprint, short pipe alignment through an urban area = high number of properties impacted, road use and community impacts. Three pipeline routes under consideration (scored separately).	Route 1 = 3 /10
		Route 2 = 8 /10
		Route 3 = 4 /10
Planned for future changes in development (right sizing)	Provides greater security for future growth due to diversified water source	8/10
Community attraction / liveability	River water quality same risk in terms of health and the borefield; fewer water restrictions on community – more water for community spaces	7/10
	(2) Total weighted social	**Route 1 = 6.8**
		Route 2 = 7.8
		Route 3 = 7
(3) Environmental and social score (ESS) (3) = (1) + (2) (with route 2 as the preferred option)		**Route 2 = 14.1**



Water and Biodiversity features within 500m of Water Security Option 2

Legend

- Assessment area
- Bores
- Sub Arterial Road
- Urban Service Lane

Rivermains Route Options

- Route 1 via Dandaloo St
- Route 2 via Third Ave
- Route 3 via Manildra St
- Route 4 via Wright Rd
- Suburb boundary
- Lot boundary

Waterway

- River
- 1st & 2nd order; unnamed waterways
- Key Fish Habitat
- Mapped Groundwater Vulnerability
- railway

Roads

- Arterial Road
- Local Road
- Primary Road

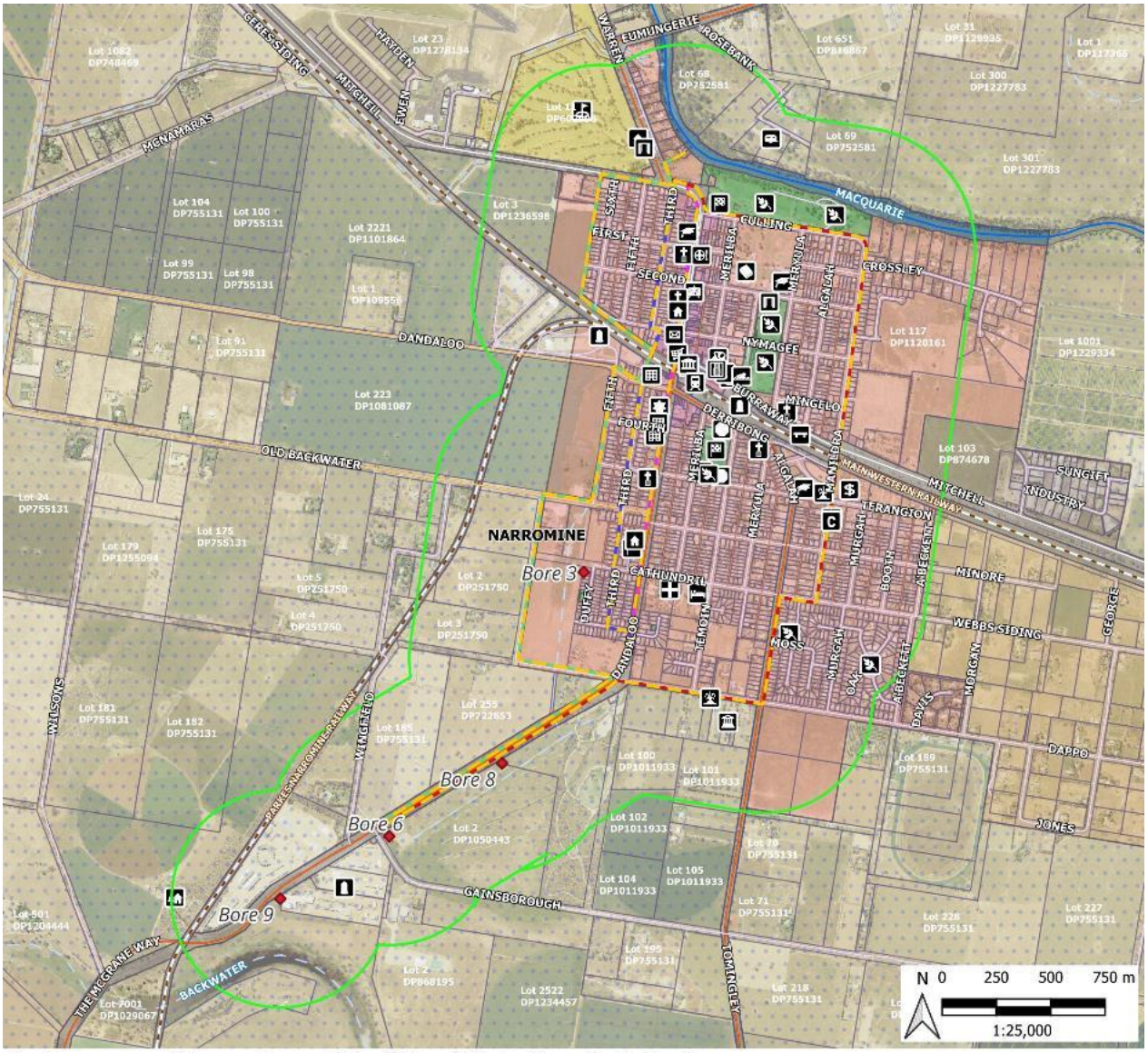
Threatened Species

- Australian Bustard
- Bluegrass
- Latham's Snipe
- Magpie Goose

Plant Community Type

- PCTID: 0 - Not native vegetation
- PCTID: 244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).
- PCTID: 248 - Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW
- PCTID: 36 - River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion
- PCTID: 45 - Plains Grass grassland on alluvial mainly clay soils in the Riverina Bioregion and NSW South Western Slopes Bioregion
- PCTID: 53 - Shallow freshwater wetland sedgeland in depressions on floodplains on inland alluvial plains and floodplains
- PCTID: 70 - White Cypress Pine woodland on sandy loams in central NSW wheatbelt
- PCTID: 82 - Western Grey Box - Poplar Box - White Cypress Pine tall woodland on red loams mainly of the eastern Cobar Peneplain Bioregion
- PCTID: 83 - Yellow Box woodland on sandy loam soils on alluvial plains mainly in the upper Darling Riverine Plain Bioregion

Figure 6 Option 2 – Water and biodiversity features within the assessment area (500 m radius)



Land use an sensitive receivers within 500m of Water Security Option 2

Legend

- Assessment area
- Bore
- Sub Arterial Road
- Railway

Rivermains Route Options

- Route 1 via Dandaloo St
- Route 2 via Third Ave
- Route 3 via Manildra St
- Route 4 via Wright Rd
- Suburb boundary
- Lot boundary

Roads

- Arterial Road
- Local Road
- Primary Road

Waterways

- River
- 1st & 2nd order; unnamed waterways

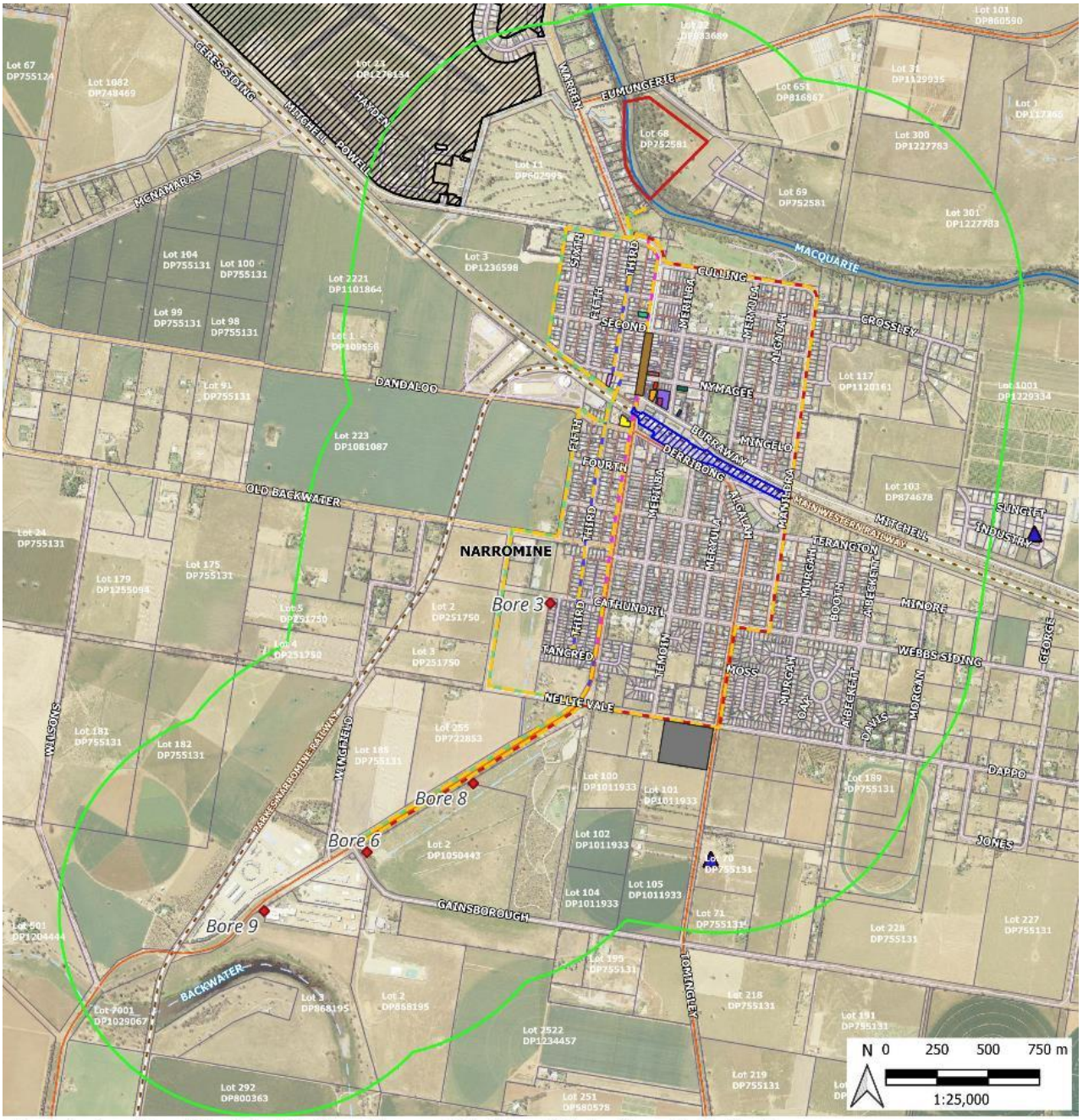
Land zoning

- B2
- IN1
- R1
- R5
- RE1
- RE2
- RU1
- SP2
- W2

Sensitive Receivers

- Ambulance Station
- Cemetery
- Club
- Community Facility
- Court House
- Fire Station
- Firestation - Bush
- General Hospital
- Golf Course
- High School
- Homestead
- Library
- Local Government Chambers
- Monument
- Nursing Home
- Park
- Place Of Worship
- Police Station
- Post Office
- Primary School
- Pumping Station
- Railway Station
- Retirement Village
- Roadside Rest Area
- SES Facility
- Silo - Commercial
- Sports Centre
- Sports Court
- Sports Field
- Stock Sale Yard
- Swimming Pool Facility
- Tourist Information Centre
- Tourist Park / Home Village
- Town

Figure 7 Option 2 – Landuse and Sensitive Receivers within the assessment area (500 m radius)



Aboriginal and Non-Aboriginal Heritage items within 1km of Water Security Option 2

Legend

- 1km Radius
- Bore
- Suburb boundary
- Lot boundary

Rivermains Route Options

- Route 1 via Dandaloo St
- Route 2 via Third Ave
- Route 3 via Manildra St
- Route 4 via Wright Rd

Roads

- Arterial Road
- Local Road
- Primary Road
- Sub Arterial Road
- Railway

Waterways

- River
- 1st & 2nd order; unnamed waterways

- AHIMS Aboriginal Heritage Item
- Aboriginal Place

Heritage Items

- Butchers shop
- CBC Bank
- Cemetery
- Courthouse (former)
- Courthouse Hotel
- Hotel Narromine
- House
- House and bakery
- Imperial Hotel
- Median strip garden
- Narromine Aerodrome
- Narromine Railway Station
- Shops
- The Abbey
- The Masonic Lodge

Figure 8 Option 2 – Aboriginal and non-Aboriginal Heritage items within 1 km

4.3 Option 3 – Drinking Water from Dubbo

Option 3 looks at obtaining the entire drinking water supply for Narromine from Dubbo, a major regional city located approximately 35 km to the east. The two (2) pipe alignments currently proposed are 34.2 km or 38 km in length.

34.5 km of Ductile Iron Concrete Lined (DICL) pipe would need to be installed to transfer the treated water from the potable water reservoir to the Narromine township. Construction of this pipeline has the potential to result in a suite of impacts including but not limited to:

- Up to 38 km of open trenching and horizontal directional drilling to allow the installation of pipeline.
- Impacts to up to 30 individual lots using the Minore Road alignment option, including sensitive receivers, or 18 individual lots using the Mitchell Highway alignment option, including sensitive receivers (Figure 10).
- Potential for impacts to up to 142 objects or places of Aboriginal Heritage significance (Figure 11).
- Potential for impacts to up to 23 non-Aboriginal Heritage items or places (identified as items within 500 m of the alignment) (Figure 11).
- Up to 380 ha of impacts to areas of mapped native and non-native vegetation, including potential for impacts to threatened species, populations, ecological communities and their habitats.
- Use of finite resources in the form of up to 38 km of DICL pipe, pump stations, construction fleet including large plant, and personnel vehicles.

While the above collectively are not necessarily barriers to the selection of this Option, they are considered further below for their comparative environmental and socio-economic sustainability and feasibility for the purposes of improving water security as per the objectives of the Narromine Water Security Project.

4.3.1 Biodiversity – terrestrial and aquatic

The two (2) proposed pipelines for this Option each traverse up to 38 km of land, including areas mapped as supporting TEC and threatened species (refer Figure 9).

Potential direct and indirect impacts to up to 380 ha of native and non-native vegetation, and habitat for 440 threatened species records within a 10km locality, associated with either of the proposed routes.

4.3.2 Heritage – Aboriginal and non-Aboriginal

Across the broad assessment area, which incorporates both pipeline options, there are 142 objects or places of Aboriginal heritage significance. This is a significant number of recorded sites, and poses a constraint to the development of either alternatives associated with this Option.

Advice received from Heritage NSW in obtaining this information, is that any project that returns this number of records from the Aboriginal Heritage Information Management System (AHIMS) requires Aboriginal community consultation. As such, further development of this Option would potentially require an Aboriginal Cultural Heritage Assessment (ACHA), and may require an Aboriginal Heritage Impact Permit (AHIP) for destruction or removal of artefacts. Alternatively, the project may be deemed

too great an impact to cultural heritage, and may be rejected by Heritage NSW if impacts could not be avoided or mitigated.

4.3.3 Receiving environment – pollution risk

The Option isn't anticipated to include activities that are likely to generate significant pollution as part of construction activities or operations, however, the following should be considered:

- Due to the requirement for the removal of vegetation, as well as the need for soil disturbance and trenching works using heavy machinery in proximity to drainage lines and creeks, careful management is required to ensure waterways are not negatively impacted during the construction phase of the project.
- Use of heavy machinery and lubricants required for horizontal drilling has the potential for spills of fuels and other contaminants during construction which could pollute soil and waterways.
- All chemical usage and storage during construction will need to be in line with legislated requirements, to prevent Pollution of Land, which is prohibited under Section 142 A of the POEO Act.

4.3.4 Waste and resource use

Materials, including up to 38 km of concrete pipeline and ancillary infrastructure will be required to construct and operate Option 3. In addition, likely waste products from the construction phase include, but are not limited to: excess soil and spoil and civil construction materials, cleared vegetation and packaging and general waste.

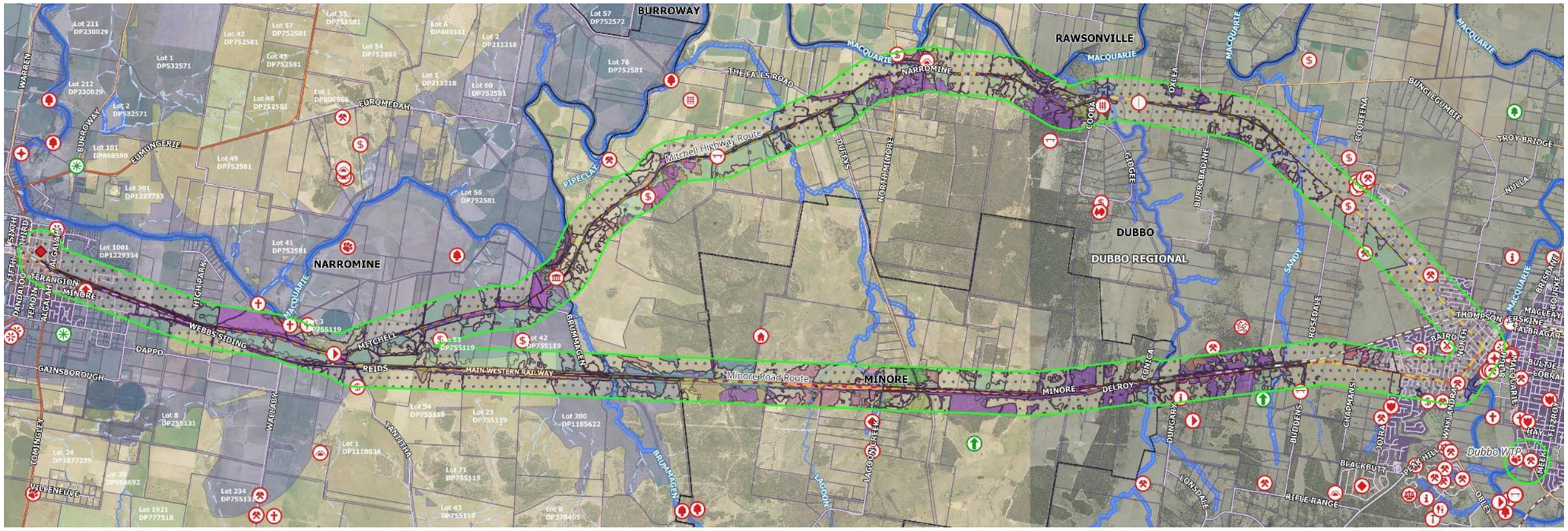
Table 7 Option 3 assessment

Water Security Option 3

Criterion	Description of Option 3	Score
Environmental Group		
Impact on terrestrial and aquatic biodiversity	Up to 38 km of open trenching and horizontal directional drilling to allow the installation of pipeline from Dubbo to Narromine; impacts to a range of TEC and recorded threatened species. Greater drawdown on the bores and Macquarie River in Dubbo with potential for aquatic impacts	2/10
Environmental pollution risk (i.e POEO Act)	Construction of pipeline and associated infrastructure carries a risk for pollution incidents to groundwater, surface water and land. Risk is moderate to high; traverse up to 4 waterways, wetland areas and impacts to GDEs	1/10
Impact on heritage – Aboriginal and non-Aboriginal	Across the broad assessment area, which incorporates both pipeline options, there are 142 objects or places of Aboriginal heritage significance.	1/10
Waste and resource use	Materials, including up to 38 km of concrete pipeline and ancillary infrastructure will be required	3/10
	(1) Total weighted environmental	**1.7**

Water Security Option 3

Criterion	Description of Option 3	Score
Social Group		
Risk of not meeting LOS (adequate water sources, water strategies)	Uncertainty, as supply from Dubbo may not be sufficient during peak demand periods. Places pressure on Dubbo	2/10
Impact on land – use and area (ha)/disruption to community	Relatively large impact footprint, long pipe alignment = high number of properties impacted, road use and community impacts exacerbated	1/10
Planned for future changes in development (right sizing)	Does not provide adequate security for future water demand; additional security from Dubbo water, however impacts / potential for decreased security for Dubbo	3/10
Community attraction/liveability	Greater security, however higher potential for future water restrictions during peak demand periods.	4/10
	(2) Total weighted social	**2.4**
	(3) Environmental and social score (ESS) (3) = (1) + (2)	**4.1**



Water and Biodiversity features within 500m of Water Security Option 3

Legend

- Assessment area
- Suburb boundary
- Lot boundary
- LGA boundary
- Option 3 POIs

Option 3 pipeline options

- Minore Road Route
- Mitchell Highway Route

Roads

- Arterial Road
- Local Road
- Primary Road
- Sub Arterial Road
- Railway

Waterway

- Creek
- River
- 1st & 2nd order; unnamed waterways
- Key Fish Habitat
- Mapped Groundwater Vulnerability

Threatened Species

- Australian Bustard
- Barking Owl
- Black Falcon
- Black-chinned Honeyeater (eastern subspecies)
- Bluegrass
- Brown Treecreeper (eastern subspecies)
- Bush Stone-curlew
- Corben's Long-eared Bat
- Diamond Firetail
- Dusky Woodswallow
- Flame Robin
- Fork-tailed Swift
- Grey-crowned Babbler (eastern subspecies)
- Grey-headed Flying-fox
- Koala
- Large Bent-winged Bat
- Large-eared Pied Bat
- Leafless Indigo
- Little Eagle
- Little Lorikeet
- Little Pied Bat
- Magpie Goose
- Major Mitchell's Cockatoo
- Pine Donkey Orchid
- Powerful Owl
- Red-tailed Tropicbird
- South-eastern Glossy Black-Cockatoo
- Speckled Warbler
- Spotted Harrier
- Spotted-tailed Quoll
- Square-tailed Kite
- Superb Parrot
- Swift Parrot
- Turquoise Parrot
- White-throated Needletail
- Yellow-bellied Sheathtail-bat

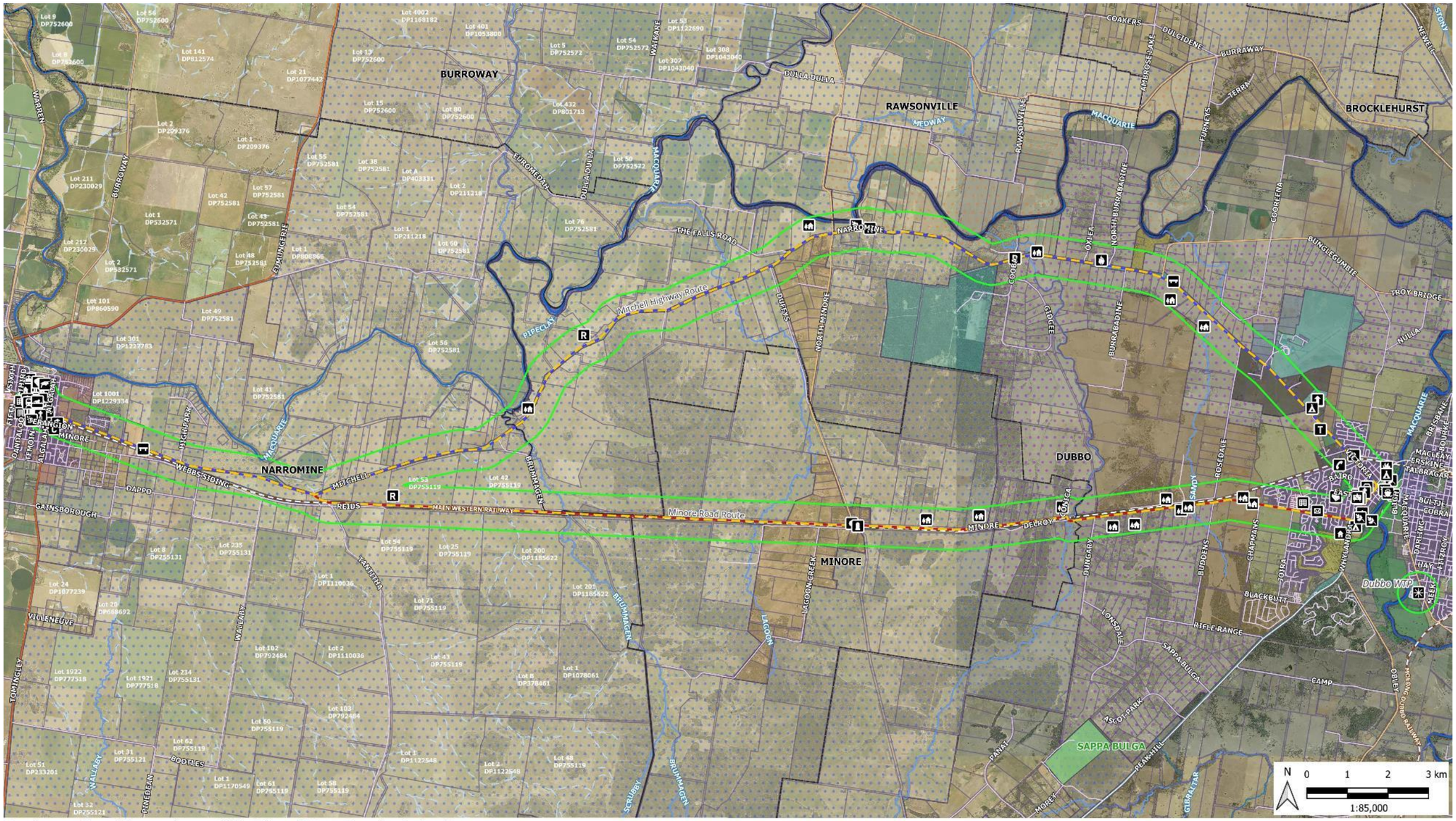
Plant Community Type

- PCTID: 0 - Not native vegetation
- PCTID: 141 - Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions Brigalow Belt South Bioregion
- PCTID: 185 - Dwyers Red Gum - White Cypress Pine - Currawang shrubby woodland mainly in the NSW South Western Slopes Bioregion
- PCTID: 201 - Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South Western Slopes Bioregion
- PCTID: 217 - Mugga Ironbark - Western Grey Box - cypress pine tall woodland on footslopes of low hills in the NSW South Western Slopes Bioregion
- PCTID: 243 - Mugga Ironbark - White Cypress Pine woodland on low rises mainly in the Cobar Peneplain Bioregion
- PCTID: 244 - Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt).
- PCTID: 248 - Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW
- PCTID: 267 - White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion
- PCTID: 357 - Beyeria - Mintbush - Tumbledown Red Gum shrubland - low woodland on conglomerate outcrops in the Wellington region NSW central western slopes
- PCTID: 36 - River Red Gum tall to very tall open forest / woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion
- PCTID: 439 - Mock Olive - Tumbledown Red Gum - Red Ash - Wilga siliceous rocky hill low woodland / shrubland in the Gunnedah - Tambar Springs region Brigalow Belt South Bioregion
- PCTID: 45 - Plains Grass grassland on alluvial mainly clay soils in the Riverina Bioregion and NSW South Western Slopes Bioregion
- PCTID: 461 - Tumbledown Gum woodland on hills in the northern NSW South Western Slopes Bioregion and southern Brigalow Belt South Bioregion
- PCTID: 467 - Blue-leaved Ironbark - Black Cypress Pine shrubby sandstone open forest in the southern Brigalow Belt South Bioregion (including Goonoo)
- PCTID: 469 - White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region southern Brigalow Belt South Bioregion
- PCTID: 511 - Queensland Bluegrass - Redleg Grass - Rats Tail Grass - spear grass - panic grass derived grassland of the Nandewar Bioregion and Brigalow Belt South Bioregion
- PCTID: 54 - Buloke - White Cypress Pine woodland in the NSW South Western Slopes Bioregion
- PCTID: 70 - White Cypress Pine woodland on sandy loams in central NSW wheatbelt
- PCTID: 74 - Yellow Box - River Red Gum tall grassy riverine woodland of NSW South Western Slopes Bioregion and Riverina Bioregion
- PCTID: 76 - Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions
- PCTID: 78 - River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion
- PCTID: 81 - Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion
- PCTID: 82 - Western Grey Box - Poplar Box - White Cypress Pine tall woodland on red loams mainly of the eastern Cobar Peneplain Bioregion
- PCTID: 88 - Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion

N 0 1.5 3 4.5 km

1:85,000

Figure 9 Option 3 – Water and biodiversity features within the assessment area (500 m radius)



Land use and sensitive receivers within 500m of Water Security Option 3

Legend

- Assessment area
- Suburb boundary
- Lot boundary
- Primary Road
- Sub Arterial Road
- Railway
- 1st & 2nd order; unnamed waterways

Roads

- Arterial Road
- Local Road

Waterways

- Creek
- River

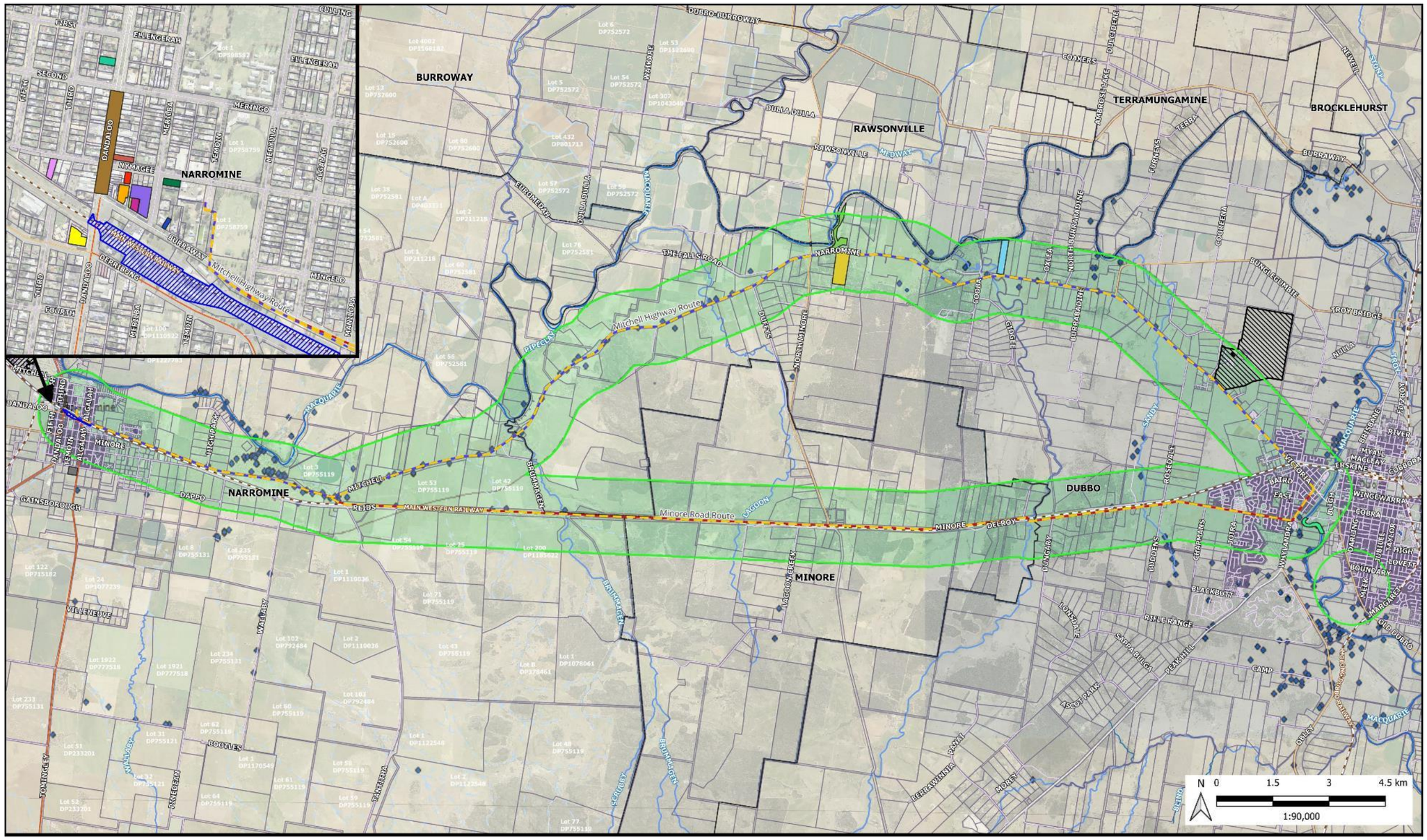
Land zoning

- B1
- B2
- B3
- B5
- B6
- E3
- IN1
- IN2
- IN3
- R1
- R2
- R5
- RE1
- RE2
- RU1
- RU2
- RU4
- SP2
- SP3
- W2

Sensitive receivers

- Ambulance Station
- Club
- Community Facility
- Court House
- Fire Station
- Firestation - Bush
- High School
- Library
- Local Government Chambers
- Monument
- Park
- Place Of Worship
- Police Station
- Post Office
- Primary School
- Pumping Station
- Railway Station
- Retirement Village
- Roadside Rest Area
- Rural Place
- SES Facility
- Silo - Commercial
- Sports Centre
- Sports Court
- Sports Field
- Stock Sale Yard
- Swimming Pool Facility
- Tourist Information Centre
- Town
- Boat Ramp
- Filtration Plant
- Gaol
- Homestead
- Locality
- Preschool
- Special School
- TAFE College
- Tourist Park / Home Village
- Urban Place

Figure 10 Option 3 – Landuse and Sensitive Receivers within the assessment area (500 m radius)



Aboriginal and Non-Aboriginal Heritage items within 1km of Water Security Option 3

Legend

- 1km Radius
- Lot boundary
- Suburb boundary

Roads

- Arterial Road
- Local Road
- Primary Road
- Sub Arterial Road
- Railway

Waterway

- 1st & 2nd order; unnamed waterways
- Creek
- River

Heritage Items

- `Oxlea'
- Butchers shop
- CBC Bank
- Cemetery
- Courthouse (former)
- Courthouse Hotel
- Dickygundi Inn
- Dubbo City Airport
- Early Macquarie River Crossing
- Hotel Narromine
- House
- House and bakery
- Imperial Hotel
- Median strip garden
- Minore Falls
- Narromine Aerodrome
- Narromine Railway Station
- Rawsonville Bridge
- Shops
- Stone house
- The Abbey
- The Masonic Lodge
- Aboriginal Heritage Item

Figure 11 Option 3 – Aboriginal and non-Aboriginal Heritage items within 1 km

5 PREFERRED OPTION

Given the environmental considerations, in concert with the need to secure a reliable water supply for Narromine, the preferred Option from an environmental and socioeconomic standpoint is Option 2 – Current Bores and Macquarie River, in conjunction with Option 4 – Demand reduction schemes.

Of the Options proposed, Option 2 poses the least likely impacts to biodiversity, and Aboriginal and non-Aboriginal heritage. Risk of impacts arising from pollution events is slightly higher than Option 1, with the potential for incidences to occur within both surface and groundwater sources. Wastes and resource use are also likely to be lower than for Option 1 assuming the additional Bore would need to be constructed closer to the township of Trangie approximately 35 km to the northwest, however this has not been fully quantified as a new Bore location has not been selected.

Of the Options put forward, Option 3 is the least sustainable, and poses the highest impact from both an environmental, heritage and a socioeconomic viewpoint, given the potential for impacts to up to 142 Aboriginal heritage objects or places of significance, numerous privately owned Lots, multiple land uses, and a large area of land mapped as supporting native vegetation.

Table 8 below includes a comparison of the environmental criteria considered within this report.

Table 8 Options assessment summary

Water Quality

Criterion	Weighting* (%)	Option 1	Option 2	Option 3
Environmental Group				
Impact on terrestrial and aquatic biodiversity	30	3	6	2
Environmental pollution risk (i.e POEO Act)	30	3	5	1
Impact on heritage – Aboriginal and non-Aboriginal	20	3	8	1
Waste and resource use	20	3	7	1
(1) Total weighted environmental	**10**	**3**	**6.3**	**1.7**
Social Group				
Risk of not meeting LOS (adequate water sources, water strategies)	40	1	8	2
Impact on land – use and area (ha)/disruption to community	20	3	8	1
Not planned for future changes in development (right sizing)	20	2	8	3
Community attraction/liveability	20	3	7	4
(2) Total weighted social	**100**	**2**	**7.8**	**2.4**
(3) Environmental and social score (ESS) (3) = (1) + (2)	10	**5**	**14.1 (Route 2)**	**4.1**

*Weighting is based on low = poor environmental outcome, high = good / better environmental outcome

6 CONCLUSION AND RECOMMENDATIONS

Option 2, as the preferred option, has the least potential for impacts to the environment and the highest potential for security of water for Narromine, given the proposal to diversify the water sources through extraction from both surface and groundwater within the locality, and comparatively the shortest required additional pipeline length. As noted, it is recommended that this Option be in conjunction with Option 4 – Demand reduction schemes.

In order to proceed with Option 2, the following is recommended:

- A detailed constraints assessment be undertaken for each of the proposed pipeline alignments from the Macquarie River PS to the WTP to determine the best route and future assessment and likely approval requirements.
- Detailed design

The following investigations and approvals will be required to progress this proposal:

- Ecological assessment of the preferred route, including targeted surveys for threatened species and assessment of the significance of these impacts under both the BC Act and EPBC Act (if required).
- Aboriginal Due Diligence assessment to be completed as a minimum. Aboriginal Cultural Heritage Assessment will need to be completed if there is potential for impacts to objects or places of Aboriginal heritage significance that cannot be avoided.
- Statement of Heritage Impact (SoHI) will be required if impacts to any non-Aboriginal heritage items are identified and cannot be avoided.
- Preparation of a comprehensive Review of Environmental Factors (REF) needs to be undertaken.
- Third party approvals need to be obtained, including the following as applicable:
    - Water Supply Works Approval (NSW DPE Water)
    - Water Access License (NSW DPE Water)
    - Aboriginal Heritage Impact Permit (AHIP) to permit harm to Aboriginal objects or places – to be avoided where possible. (Heritage NSW).
    - Section 60 works application for any works or activities that may impact heritage listed items – to be avoided where possible (Heritage NSW).
    - Fisheries Permit for any works in a waterway identified as supporting Key Fish Habitat (DPI Fisheries).
    - Section 138 application for any works that intersect TfNSW managed roads and/or the rail corridor (Transport for NSW).

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