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TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

STAGES 1 &2 - COARSE SCREEN ASSESSMENT OF OPTIONS

A1100300

REVISION SCHEDULE

REV. NO.	DATE	DESCRIPTION	PREPARED BY	REVIEWED BY	APPROVED BY
1.0	15 Sep 2008	Draft Report	M Hunting G Samios	S O'Brien	M Hunting
2.0	2 Dec 2008	Final Draft Report	M Hunting G Samios	S O'Brien	M Hunting
4.0	3 Feb 2009	Final Report	M Hunting G Samios	R Siebert, A Burnham, S O'Brien	M Hunting
5.0	16 Feb 2009	Revised Final Report	M Hunting G Samios	R Siebert, A Burnham	M Hunting
6.0	12 March 2009	Revised Final Report	M Hunting G Samios	R Siebert, A Burnham	M Hunting
7.0	6 October 2009	Final Report	M Hunting G Samios	S O'Brien	M Hunting

EXECUTIVE SUMMARY

Introduction

The Tweed District Water Supply Augmentation Options Study is being undertaken to assist Tweed Shire Council in the determination of a preferred option for the augmentation of its water resources.

The study is being undertaken in three stages:

- **Stage 1: Identification of Feasible Options:** This stage involved a review of existing reports and data in relation to Tweed's water supply, including estimates of yield of the existing resources and demand forecasts to identify a list of feasible options;
- **Stage 2: Coarse Screen Assessment of Options:** This stage involved an investigation of the issues and constraints associated with each option against a set of assessment criteria in order to produce a sound basis for selecting a shortlist of three, or four preferred options;
- **Stage 3: Fine Screen Assessment of Options:** This stage will focus on the merits of the shortlisted options to analyse in more detail capital and operating costs, timing and constraints.

This report summarises the Stages 1 and 2 investigations which are aimed at documenting the options available to augment the water source. A long list of options was developed with a high level assessment undertaken to enable each to be scored against triple bottom line (environmental, social and economic) criteria to enable a shortlist to be developed for further, more detailed investigation in Stage 3 of the project.

Forecast Water Demand

The population forecasts show that there will be steady growth of approximately 4 percent per annum to a population of 157,000 persons by the year 2036. The corresponding demand forecasts target an average annual water demand of 19,000 ML/annum by the year 2036.

The existing secure yield of the Bray Park water supply scheme (including the existing Clarrie Hall Dam) is 13,750 ML/annum. Demand for water is expected to increase to exceed this secure yield at either:

- The "baseline forecast" (following present unrestricted trends) by the year 2016, or
- The "BASIX forecast" (following the introduction of demand management efficiencies) by the year 2019.

The preferred option of water resource augmentation will be assessed on its capacity to provide an additional 5,250 ML/annum of secure yield by the year 2036, which is equivalent to the target average annual water demand of 19,000 ML/annum, and includes the BASIX demand management efficiencies.

Options Considered

Nine options were identified as worthy for consideration as part of the options review, and these are grouped as follows:

Options involving Dams:

1. Raising the existing Clarrie Hall Dam
2. New dam on Byrrill Creek
3. New dam on Oxley River, near Tyalgum (Rocky Cutting site).

Options involving Pipelines to the Assets of other Water Utilities:

4. Pipeline link to Rous Water, at Ocean Shores
5. Pipeline link to the South East Queensland Water Grid, near the Tugun desalination facility.

Other Options:

6. Desalination
7. Groundwater supply
8. Indirect potable reuse
9. Direct potable reuse.

Approach to Options Assessment

Options were assessed using a range of data sources including desk-top reviews of existing reports on the water resources of the Tweed Shire, discussions with other water utilities to the north and south of Tweed Shire with a view of ascertaining their potential for cross-boundary capacity sharing and consultation with hydrogeologists in relation to potential groundwater resources.

Ten assessment criteria were used to differentiate the benefits and risks associated with each of the options, and these are summarised in the following table.

Summary of Assessment Criteria

Assessment Criteria	Explanation
Secure Yield	Whether the augmentation option has sufficient capacity to meet the 2036 forecast demand of 19,000 ML/annum for 157,000 population, and to what extent it has excess capacity to meet future demand beyond that date.
Planning Obligations	The number of stakeholders involved in the regulatory framework and the associated timeframe and risks for completion by 2016, when augmentation is required.
Established Technologies and Feasibility	Whether existing technologies and accepted practices are involved, or whether there are risks associated with innovation and emerging technologies.
Environmental	Extent and severity of environmental impacts that are likely to be encountered

Assessment Criteria	Explanation
Constraints	including aquatic, terrestrial and areas of conservation significance.
Social Acceptability	Impact on established developed areas (urban, rural, agricultural, commercial, industrial, etc.) and their associated political interactions.
Legislative Acceptability	The extent to which required legislation is influenced by discretionary powers, which impact upon the augmentation option to increase its uncertainty of delivery.
Cultural Heritage Impacts	Impacts upon areas of historical importance and sites of cultural significance.
Lead Time for Construction & Potential for Escalation of Costs	Where the uncertainties associated with the preliminary phases of project delivery increase the risks of blow-out of the end costs of the project.
Cost – Net Present Value and $/ML	Evaluation of estimated Net Present Value, taking account of the capital and operations costs over 30 years discounted at 7%. This is also expressed as a cost per unit of production ($/ML).
Greenhouse Gas Emissions and Energy Consumption	An assessment of the energy inputs, which are proportional to the direct greenhouse emissions.

A multi criteria analysis was undertaken to identify the risks related to each option. A weighting factor (1 to 5) was applied to the relative risk (high risk rating 1 and low risk rating 5) under each of the assessment criteria. Each of the options was scored and ranked, based on the product of the rating and weighting factor.

Results of Options Assessment

The results of the initial ranking of options using the above process are summarised in the following table, in terms of the assessed score, the Net Present Value and the Annualised Cost (cost per ML produced over a 30 year assessment period).

Initial Ranking of Options

Ranking	Option	NPV ($m)	Annualised Cost	Assessed Score
1	Option 1 - Raising Clarrie Hall Dam	$42 million	$569/ML	151
2	Option 2 - Byrrill Creek Dam Construction	$51 million	$653/ML	117
3	Option 5 - Pipeline to the SEQ Water Grid	$116 million	$1,655/ML	111
4	Option 4 - Pipeline to Rous Water	$51 million	$2,444/ML	109
5	Option 3 - Oxley River Dam Construction	$64 million	$696/ML	102
6	Option 7 - Groundwater Supply	$44 million	$2,535/ML	93
7	Option 6 - Desalination	$194 million	$2,782/ML	81
8	Option 8 - Indirect Potable Reuse	$331 million	$3,579/ML	72
9	Option 9 - Direct Potable Reuse	$307 million	$3,318/ML	65

Conclusions

1. Two mandatory assessment criteria were identified as part of the assessment:
   - Secure yield, for an additional 5,250 ML/annum;
   - Established technologies and feasibility.

   The options which did not meet these minimum requirements and were not considered further as long term supply options were:
   - Option 4 – Pipeline to Rous Water Ranked No. 4
   - Option 7 – Groundwater Supply Ranked No. 6
   - Option 9 – Direct Potable Reuse Ranked No. 9
2. The relatively high risks (rating 1) that were deemed to adversely impact the options are summarised as follows:
   - Options 2 and 3 - Byrrill Creek Dam Construction and the Oxley River Dam Construction – These two options presented the potential for considerable escalation of costs, due to the long lead time envisaged before construction could commence.
   - Option 3 - Oxley River Dam Construction – There is significant habitat for threatened flora and fauna species near the dam site, as well as the social impacts of its proximity to Tyalgum and the likelihood of flooding parts of the village and some rural properties. These issues would contribute to planning process obstacles. There were no criteria where the Oxley River dam out-scored the Byrrill Creek dam.
   - Options 5 and 7 - Pipeline to Rous Water and the Groundwater Option - Did not meet the minimum requirement for an additional 15 ML/day (5,250 ML/annum) of secure yield, and are likely to provide only approximately 5 ML/day (1,825 ML/annum) and 4.3 ML/day (1,470 ML/annum) respectively.
   - Option 5 - Pipeline to SEQ Water Grid – This option has political and legislative difficulties due to interstate transfer of resources. These impacts are not likely to be diminished during periods of prolonged drought, when alternative supplies are needed most.
   - Option 6 - Desalination – This option is expensive and involves significant environmental impacts associated with disposal of the brine wastes.
   - Option 9 - Indirect Potable Reuse and Direct Potable Reuse – These options are expensive and not socially acceptable. These issues would contribute to planning process obstacles.
3. Based on the initial assessment of the options, Option 1 involving the raising of the existing Clarrie Hall Dam ranked the highest by a significant margin. It would therefore appear that this option provides the most secure way forward for augmenting the Tweed district water supply.
4. The investigation and approvals process associated with the raising of Clarrie Hall Dam, coupled with the relatively long phase of project implementation, may put at risk the completion of the project by the year 2016, when the existing secure yield of 13,750 ML/annum could be reached.

5. A contingency plan is required to deliver an emergency supply in the event that augmentation of supply is not completed by the year 2016. The contingency supply should have a short lead time and may be provided through a combination of the options listed in the table below.

Possible Contingency Supply Options

Rank	Option
3	Option 5 - Pipeline to the SEQ Water Grid
4	Option 4 - Pipeline to Rous Water
6	Option 7 - Groundwater Supply

Recommendations

Based on the initial assessment of options it is recommended that:

1. Tweed Shire Council carry out further investigations under the Stage 3 'fine screen' process involving detailed analysis relating to the assessment criteria. Particular attention should be given to the investigations and associated timeframes required to deliver the project. Options to be examined under the Stage 3 process are:
   - Option 1 - Raising of Clarrie Hall Dam;
   - Option 2 – a New Dam on Byrrill Creek; and
   - Option 5 - Link to South East Queensland Water Grid.
2. In addition a contingency plan based on a combination of the following (short delivery time) options should be progressed:
   - Option 4 - Link to Rous Water;
   - Option 5 - Link to South East Queensland Water Grid; and
   - Option 7 – Groundwater Supply.

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1. INTRODUCTION

The Tweed District Water Supply Augmentation Options Study is being undertaken to assist Tweed Shire Council in the determination of a preferred option for the augmentation of its water resources. Currently water demand in the Bray Park scheme, which supplies water to over 75,000 persons, is around 10,500 ML/annum.

The Bray Park scheme involves the Bray Park Water Treatment Plant, which sources water from the Tweed and Oxley Rivers. When natural flows at the Bray Park Weir are insufficient to meet water supply demands, then water is released into the Tweed River from Clarrie Hall Dam, located on Doon Doon Creek, a tributary of the Tweed River.

Based on hydrologic assessment of the existing water resources, the secure yield is 13,750 ML/annum. This is calculated using the desired Level of Service (LOS) under the 5/10/20 rule, which equates to water restrictions being required, on average, no more than 5 % of the time in no more than one year in 10 and at an average of 20% reduction of demand.

1.1 OBJECTIVES

This report is aimed at documenting the options available to augment the water source. A long list of options is developed with a high level assessment undertaken to enable each to be scored against Triple Bottom Line (environmental, social and economic) criteria to enable a short list to be developed for further, more detailed investigation.

1.2 PROJECT STAGES

To identify a preferred option the study is being undertaken in three stages as shown in Table 1. This report addresses the outcomes of Stages 1 and 2. The Stage 3 Fine Screen assessment of shortlisted options will be presented separately.

Table 1 : Stages of the Options Study

Stage	Description
Stage 1: Identification of Feasible Options	This stage involved a review of existing reports and data in relation to Tweed's water supply, including estimates of yield of the existing resources and demand forecasts to identify a list of feasible options. A stakeholder meeting was held on 7 March 2008 at which nine options were identified for further analysis as outlined in this report.
Stage 2: Coarse Screen Assessment of Options	This stage involved an investigation of the issues and constraints associated with each option against a set of assessment criteria in order to produce a sound basis for selecting a shortlist of three or four preferred options, on which Council can focus its strategy. A set of ten assessment criteria, encompassing the various risks and issues, were developed to enable a multi criteria analysis to be applied in order to rank options. This report provides the basis for selection of the shortlisted options through the coarse screening process.
Stage 3: Fine Screen Assessment of Options	This stage will focus on the merits of the shortlisted options to analyse in more detail capital and operating cost, timing and constraints. At this stage a preferred option will be selected for augmenting the Tweed District Water Supply to satisfy demand to 2036.

2. BACKGROUND

2.1 POPULATION PROJECTIONS

The current population in the service area of the Bray Park water supply scheme was estimated to be approximately 78,000 persons in 2008. Future development will bring steady growth, at a rate of approximately 4 percent per annum, increasing the population to around 157,000 persons by the year 2036. A summary of the population growth including the growth in the major developments is shown in Table 2 (*Demand Management Strategy*, MWH 2008).

Table 2: Services (Water) Population Projection for Tweed Shire

Estimated Population	2006	2011	2021	2031	2036	2041 (Ultimate)
Existing Serviced Population	73,185	71,966	69,018	66,044	64,854	64,854
Projected Infill Population	0	6,951	16,402	22,435	25,896	28,461
Major Development Areas						
Bilambil Heights	*0*	*0*	*2,934*	*5,609*	*6,881*	*6,881*
Cobaki Lakes	*0*	*0*	*4,454*	*8,525*	*10,464*	*10,464*
Kings Forest	*0*	*0*	*4,640*	*8,880*	*10,900*	*10,900*
Terranora Area A	*0*	*0*	*1,300*	*2,498*	*3,071*	*3,071*
West Kingscliff	*0*	*0*	*1,158*	*2,197*	*2,687*	*2,687*
Total of Major Development Areas	0	0	14,486	27,709	34,003	34,003
Greenfield outside Major Areas	0	6,182	19,540	27,301	32,295	36,395
Tweed Shire Total	**73,185**	**85,099**	**119,446**	**143,488**	***157,048***	**163,714**

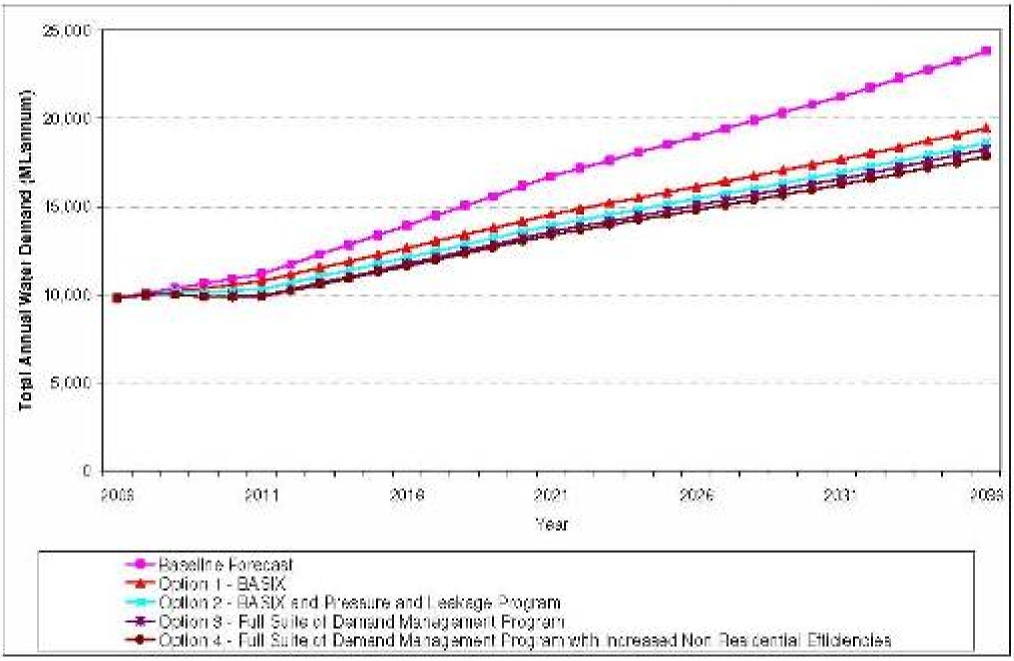
2.2 DEMAND PROJECTIONS

The Demand Management Strategy developed detailed demand forecasts based on sectoral assessment taking account of source substitution (recycled water and rainwater tanks) and improvement to water use efficiency.

Demand forecasts included a baseline case, which assumed that historical demand would continue, as well as a range of managed demand scenarios. The overall range of the forecasts (envelope between baseline and preferred scenario forecast) is shown in Figure 1.

As there is no guarantee that the demand will fall in line with the preferred scenario forecast, it is recommended that this strategy adopt a target average annual water demand of 19,000 ML/annum by 2036. This is the demand achieved by the implementation of statutory elements of the Demand Management Strategy only, i.e. BASIX, as well as the natural progression of water efficient fittings and fixtures such as dual flush toilets and water efficient showerheads and washing machines.

Figure 1: Forecast Water Demand for the Preferred Demand Management Strategy



2.3 EXISTING WATER RESOURCES

The existing secure yield of the Bray Park scheme is 13,750 ML/annum. Based on the demand projections outlined in Figure 1, the system demand will exceed the secure yield by 2016 under the baseline projection, or by 2019 under the adopted demand forecast. If demand reductions of the preferred scenario are fully achieved, this date would be extended to around 2022.

It is forecast that demand will rise to 19,000 ML/annum by the year 2036 under the Option 1 – BASIX demand forecast.

The preferred option of water resource augmentation will be assessed on its capacity to provide an additional 5,250 ML/annum of secure yield, which is a total of 19,000 ML/annum to the year 2036, as shown in Figure 1 (Refer to Figure 7-1 on page 94 of *Demand Management Strategy*, MWH 2008).

3. IDENTIFICATION OF THE OPTIONS

3.1 OPTIONS CONSIDERED

Nine options were identified in the Stage 1 long-list process as worthy for consideration as part of the options review. The nine options can be broadly grouped as follows:

Options involving Dams:

1. Raising the existing Clarrie Hall Dam
2. New dam on Byrill Creek
3. New dam on Oxley River, near Tyalgum (Rocky Cutting site).

Options involving Pipelines to the Assets of other Water Utilities:

4. Pipeline link to Rous Water, at Ocean Shores
5. Pipeline link to the South East Queensland Water Grid, at the Tugun desalination facility.

Other Options:

6. Desalination
7. Groundwater supply
8. Indirect potable reuse
9. Direct potable reuse.

Plans showing the locality of each option are provided in **Appendix F**.

3.2 BRIEF DESCRIPTION OF OPTIONS

The locations of options outlined above are shown in Figure 2. A brief description of each option under consideration is given below.

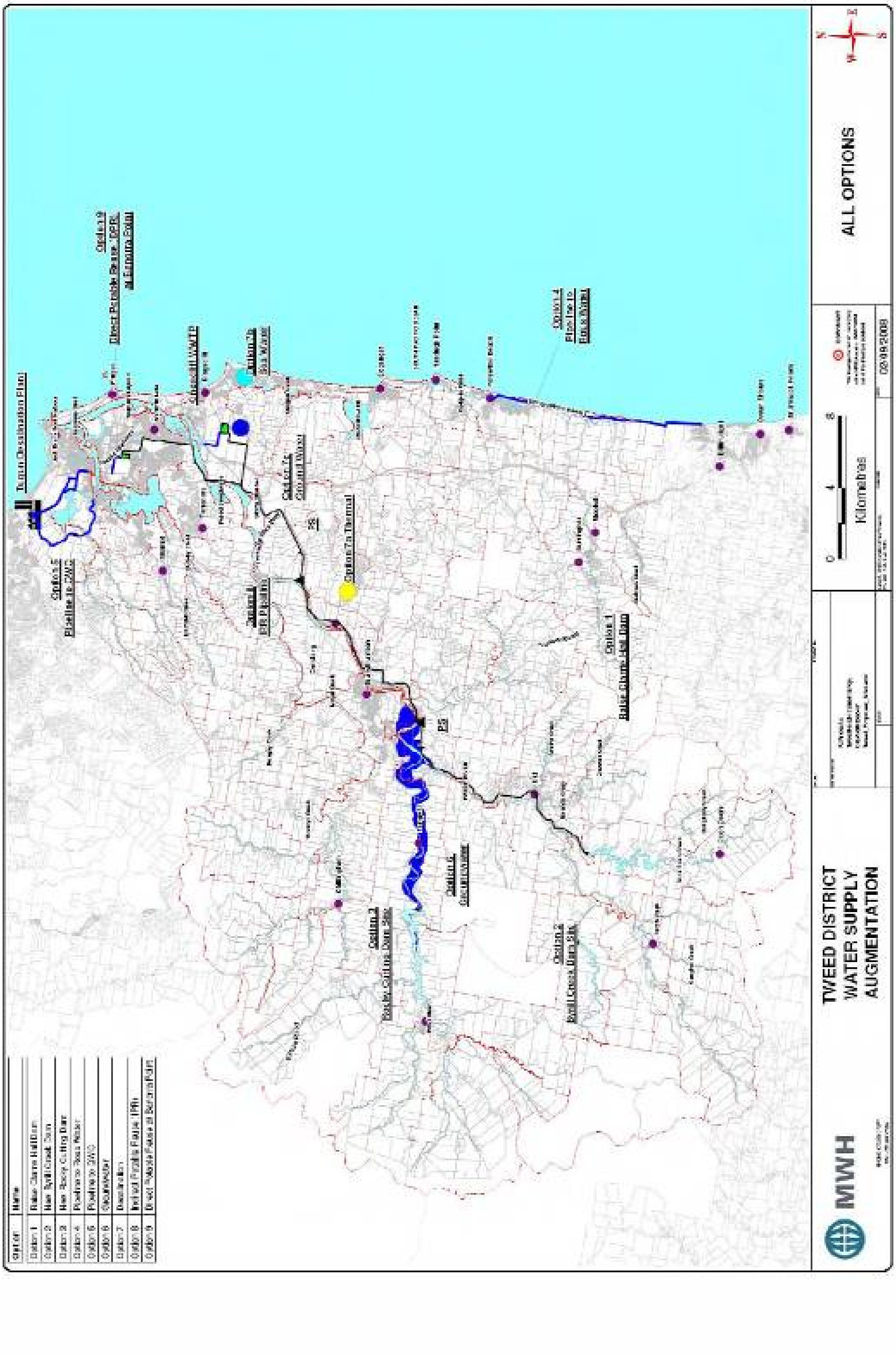
3.2.1 OPTION 1 - RAISING CLARRIE HALL DAM

Clarrie Hall Dam was commissioned in 1983 to provide drought security to the Tweed district water supply and the Bray Park scheme as described in Section 1, whereby water is released from the dam into the Tweed River when natural flows at the Bray Park Weir are insufficient to meet water supply demands.

The dam has a full supply level (FSL) of 61.5 m AHD and storage capacity of 16,000 ML. Council commissioned a study of options to raise the dam to increase the secure yield of the scheme (NSW Commerce, May 2008). This study recommended that the dam should be raised to RL 70.0 m AHD, to increase the storage capacity to 42,300 ML with an overall secure yield of 22,000 ML/annum. The recommendation was based on considerations of engineering, social and environmental factors, as well as efficiency, constructability and economy.

It is proposed to cover the existing spillway by a raised embankment. A new 40 metre wide spillway is proposed to be constructed higher in the left abutment. The new spillway excavation would provide a balanced volume of rockfill for the raised embankment. The existing outlet tower would be raised and strengthened.

Figure 2: Location of Options



3.2.2 OPTION 2 - NEW DAM ON BYRRILL CREEK

Future bulk water needs may be provided by constructing a new earth and rockfill dam on Byrrill Creek, which is also a tributary to the Tweed River west of Uki. The dam analysed in this coarse screening has a full supply level (FSL) of 115.5 m AHD and storage capacity of 16,300 ML with a secure yield of 9,000 ML/annum (Table 1, NSW Commerce, July 2004).

The dam site has previously been investigated since 1977 by:

- Geological Survey of New South Wales "*Tweed Shire Water Supply Augmentation Reconnaissance Engineering Geological Report*," September 1977, and
- Department of Public Works NSW "*Tweed District Water Supply Headworks Augmentation*," October 1977, and
- Geological Survey of New South Wales "*Feasibility Investigations at Byrrill creek and Doon Doon Damsites, Tweed Shire*," August 1978, and
- NSW Department of Commerce "*Construction of Dam on Byrrill Creek, Update of Estimate*," July 2004.

3.2.3 OPTION 3 - NEW DAM ON OXLEY RIVER (ROCKY CUTTING SITE)

The Oxley River Dam was identified on the middle arm of the Tweed River, near Tyalgum at the Rocky Cutting site (GHD, February 1975). The storage capacity of the Oxley River Dam has more recently been quoted as 35,000 ML with a secure yield of 20,000 ML/annum (Table 3.5, SMEC 2007). The FSL for this dam is approximately 56 m AHD (Figure 6, DPW, September 1977).

The dam site has previously been investigated by:

- Gutteridge, Haskins and Davey Pty Ltd "Tweed Shire Council Augmentation of Tweed District Water Supply," February 1975, and
- Geological Survey of New South Wales "Tweed Shire Water Supply Augmentation Reconnaissance Engineering Geological Report," September 1977, and
- Department of Public Works NSW "Tweed District Water Supply Headworks Augmentation," October 1977, and
- SMEC on behalf of the National Water Commission "Integrated Water Supply Options for North East New South Wales and South East Queensland," 2007.

3.2.4 OPTION 4 - PIPELINE LINK TO ROUS WATER AT OCEAN SHORES

Rous Water is the regional authority providing bulk water to the constituent councils of Byron, Ballina, Lismore and Richmond Valley in northern NSW. Its water supply network extends to Ocean Shores in Byron Shire. This option comprises a pipeline link from the northern part of the Rous distribution network at Ocean Shores in Byron Shire. The connection would comprise a pumping station and an 18.3 km, 300 mm diameter pipeline with a capacity of 5 ML/day, linking to the Tweed system at Pottsville. This would initially supplement the water supply to the coastal communities of Tweed Shire.

Preliminary discussions have been held with Rous Water concerning the link. The existing Rous system does not have capacity to provide for both Rous and Tweed, and the timing of Rous's proposed Dunoon Dam would need to be considered in any offer of supply from Rous Water.

3.2.5 OPTION 5 - PIPELINE LINK TO SOUTH EAST QUEENSLAND WATER GRID

The Queensland Water Commission (QWC) was established by the Queensland Government in 2006 with the responsibility to provide a secure water supply to South East Queensland. As part of the planning for the future of water in South East Queensland, the QWC is establishing the South East Queensland Water Grid. The Water Grid will link major sources of bulk water across the region including the raising of Hinze Dam and the Tugun Desalination Plant, currently being constructed in South East Queensland.

This option proposes a pipeline connection comprising a pumping station and 6 km of 500 mm diameter pipeline with a capacity of 20 ML/day between the South East Queensland (Gold Coast) Desalination Facility at Tugun (as part of the South East Queensland Water Grid) and Kennedy Drive, Tweed Heads.

Three pipeline route options were examined for this option:

- Along the Pacific Highway to Kennedy Drive;
- Along the Tugun Bypass, Parkes Drive and Rose Street to Kennedy Drive;
- Via the proposed Cobaki Lakes development to Kennedy Drive (preferred alignment).

Preliminary discussions have been held with Queensland Water Commission concerning the pipeline link.

3.2.6 OPTION 6 - DESALINATION

The assessment of this option is based on the report undertaken by the Department of Energy, Utilities and Sustainability (DEUS) in December 2005. The investigation reviewed the viability of desalination along the north and mid north coast of NSW, including three options within Tweed Shire. These options included:

- Thermal desalination plant at Condong (20 ML/day multiple distillation process). Raw water would be sourced from the Tweed River with delivery into the adjacent distribution system to Terranora and to Duranbah. Brine would be discharged through an 18 km pipeline along Clothiers Creek Road to Norries Head.

- Membrane desalination plant at Kingscliff (2-stage @ 10 ML/day each reverse osmosis process). Raw water would be sourced from the mouth of Cudgen Creek, with delivery to the Kingscliff and Bogangar service reservoirs. Brine would be discharged to the sea at the northern end of Bogangar Beach.
- Membrane desalination plant at Cudgen (2-stage @ 10 ML/day each reverse osmosis process). Raw water would be sourced from brackish groundwater of the Tweed floodplain, with delivery to the Kingscliff and Bogangar service reservoirs. Brine would be discharged to the sea at the northern end of Bogangar Beach.

3.2.7 OPTION 7 – GROUNDWATER SUPPLY

An investigation was undertaken by Environmental Hydrogeology Associates (EHA) as part of this study to review the potential of groundwater resources in the Tweed valley for providing additional water supply. Three sites were identified to have potential for supplying groundwater resources:

- Two sites located upstream of Bray Park in the Tweed valley alluvial aquifers. It was estimated that a borefield comprising up to 7 bores, each 20 m deep may yield around 4.3 ML/day. These sites are in proximity to the Bray Park Water Treatment Plant and reservoirs.
- Dune sand deposits along the coast, between Chinderah and Bogangar were also identified.

The EHA report on the identification of feasible options for groundwater resources in the Shire is provided in **Appendix D**.

3.2.8 OPTION 8 - INDIRECT POTABLE REUSE (IPR)

Indirect Potable Reuse (IPR) is a process that involves the advanced treatment of wastewater effluent and the discharge of this recycled water to the natural water bodies for further extraction and treatment prior to being discharged to the potable water supply system. This option would involve the advanced MF/RO treatment and advanced oxidation of 75% of the available effluent from the Banora Point WWTP and Kingscliff WWTP and pumping of the water through a 50 km pipeline to Clarrie Hall Dam. The volume of water produced under this option is estimated at 28 ML/day.

The IPR process depends upon multiple barriers before reaching the consumer. These would typically include:

1. Catchment controls (trade waste agreements)
2. Water treatment (conventional process at the back-end of the WWTPs)
3. Microfiltration
4. Reverse osmosis
5. Advanced oxidation
6. Disinfection - chlorination
7. Retention in a dam (Clarrie Hall Dam)
8. Water treatment (Bray Park WTP, which repeats barriers 2 and 3)

3.2.9 OPTION 9 - DIRECT POTABLE REUSE (DPR)

Direct Potable Reuse (DPR) is the advanced treatment of wastewater effluent to a point where it can be directly injected into the potable water network. Treatment involves advanced MF/RO processes as well as advanced oxidation. A plant with a capacity of approximately 19.5 ML/day could be constructed at the Banora Point WWTP with a pumped connection to the distribution network at Tweed Heads. Another plant with a capacity of approximately 8.3 ML/day could be constructed at the new Kingscliff WWTP with a pumped connection to the distribution network at Chinderah.

The DPR process is similar to the IPR process, except that barriers / processes 7 and 8 do not apply. These barriers/ processes may be substituted with alternatives, such as:

7. Reverse osmosis – second pass
8. Oxidant – ozone.

4. PRELIMINARY ASSESSMENT OF OPTIONS

The options were assessed using a range of data sources including the following:

- Desk-top reviews of existing reports on the water resources of the Tweed Shire;
- Discussions with other water utilities to the north and south of Tweed Shire with a view of ascertaining their potential for cross-boundary capacity sharing;
- Consultation with hydrogeologists in relation to potential groundwater resources.
- Stakeholder meetings with Council officers who are familiar with the background of previous studies and investigations.

4.1 ASSESSMENT CRITERIA

Options as outlined in Section 3 were assessed on the basis of a range of environmental, social and economic criteria. A description of the criteria adopted is provided in Table 3.

Table 3: Summary of Assessment Criteria

Assessment Criteria	Explanation
Secure Yield	Whether the augmentation option has sufficient capacity to meet the 2036 forecast demand of 19,000 ML/annum for 157,000 population, and to what extent it has excess capacity to meet future demand beyond that date.
Planning Obligations	The number of stakeholders involved in the regulatory framework and the associated timeframe and risks for completion by 2016, when augmentation is required.
Established Technologies & Feasibility	Whether existing technologies and accepted practices are involved, or whether there are risks associated with innovation and emerging technologies.
Environmental Constraints	Extent and severity of environmental impacts that are likely to be encountered including aquatic, terrestrial and areas of conservation significance.
Social Acceptability	Impact on established developed areas (urban, rural, agricultural, commercial, industrial, etc.) and their associated political interactions.
Legislative Acceptability	The extent to which required legislation is influenced by discretionary powers, which impact upon the augmentation option to increase its uncertainty of delivery.
Cultural Heritage Impacts	Impacts upon areas of historical importance and sites of cultural significance.
Lead time for Construction & Potential for Escalation of Costs	Where the uncertainties associated with the preliminary phases of project delivery increase the risks of blow-out of the end costs of the project.
Cost – Net Present Value and $/ML	Evaluation of estimated Net Present Value, taking account of the capital and operations costs over 30 years discounted at 7%. This is also expressed as a cost per unit of production ($/ML).
Greenhouse Gas Emissions and Energy Consumption	An assessment of the energy inputs, which are proportional to the direct greenhouse emissions.

4.2 REVIEW OF RELEVANT LITERATURE AND EXISTING REPORTS

A review of previous reports that were applicable to the project was undertaken. Major sources of information were:

- In respect of the options involving the dams, investigation reports date back to the mid 1970s. The NSW Department of Public Works and the Geological Survey of NSW investigated several dam sites for augmenting the Tweed District Water Supply and these culminated in the construction in 1983 of the Clarrie Hall Dam on Doon Doon Creek.
- In 2005, the Department of Energy, Utilities and Sustainability commissioned the NSW Department of Commerce to investigate the viability of desalination along the north and mid north coast of NSW, including three sites within Tweed Shire Council.
- In 2007, the National Water Commission commissioned SMEC to investigate integrated water supply options in north east NSW and south east Queensland. This study identified the Rocky Cutting Dam as a potential water resource for south east Queensland.

A reference list of the relevant reports used as part of this assessment is included in **Appendix B**.

4.3 DISCUSSIONS WITH NEIGHBOURING WATER UTILITIES

Discussions were held with neighbouring water utilities to the north and south of Tweed Shire to ascertain their willingness to supply into Tweed Shire and to enquire about terms and conditions of supply, the likely point of supply and the tenure of supply (lead time to commencement and duration). Results of these discussions are as follows:

- A meeting was held on 23 April 2008 with the Queensland Water Commission (QWC), as operator of the South East Queensland Water Grid regarding the possibilities of connecting the Tugun Desalination Plant on the Gold Coast, to Kennedy Drive, Tweed Heads.

  The QWC advised that it may have surplus capacity for supply across the border from the desalination plant in the first years after commissioning, but that this was dependent on the prior recovery of the existing water resources from the drought, which has severely depleted the water resources in South East Queensland. Correspondence from the QWC is attached in **Appendix C**.

- Discussions were held with Rous Water as bulk supplier to northern NSW regarding the possibilities of connecting the Rous system at Ocean Shores to Pottsville.

  Rous Water advised that it may have capacity for supply to Pottsville, but that this was limited by the capacity of the existing distribution system from the existing Rocky Creek Dam headworks and its plans to augment supply involving the timing of the future Dunoon Dam project.

4.4 CONSULTATION WITH HYDROGEOLOGISTS

A sub-consultant with expertise in groundwater hydrology was engaged to provide advice and report on the potential of the known aquifers in the region for augmenting the supply.

Mr Peter Evans of Environmental Hydrology Associates Pty Ltd (EHA) drew upon the knowledge from previous relevant reports and identified the issues against which groundwater options could be developed. The report from EHA is attached in **Appendix D**.

4.5 STAKEHOLDER MEETINGS

Meetings with Council officers and study partners from the NSW Department of Commerce were held at various stages of the study.

These meetings were held to confirm the Stage 1 list of options and the extent of previous investigations involving environmental, cultural heritage and economic issues and constraints affecting each option.

A stakeholder meeting was also held to review an initial Stage 2 multi criteria analysis and to provide additional input to the rating and weightings.

4.6 ECONOMIC COMPARISON OF OPTIONS

Comparison of the economics of the options involved a range of approaches. The most universally recognised approach determines the cost effectiveness through a cost per unit water delivered for each option. There are a number of different formulations available for the assessment of cost effectiveness including levelised cost, annualised cost and average incremental cost. In the situation where the characteristics of water delivered by different options are not identical (e.g. timing, yield, cost, demand etc), each of these formulations can generate biases in the results (Beatty and O'Brien 2007). Recent studies of water supply options have generally adopted an Average Incremental Cost (AIC) approach. This approach could be described as the calculation of the revenue (volume based) required to recoup a capital and operational outlay over time, and as such tends to be a practical approach. The AIC approach has been adopted for this study.

The assumptions underlying the economic analysis are as follows:

- All projects were assumed to commence supplying water in the same year (Year 1);
- The net present value (NPV) of capital costs for each project was taken to be the cost in Year 0 – the year before it begins to supply water.
- The volume of water supplied by the option was considered to increase from zero in Year 0 at the same rate of growth in demand in the Shire over the period from 2016 up to the year the capacity of the option in question is reached. Once the capacity has been reached, water is assumed to be delivered at a constant rate until the end of the 30 year planning horizon.
- A discount rate of 7 % was adopted.

Details of the economic assessment are provided in **Appendix A** and summarised in Table 4.

Table 4: Summary of Economic Assessment

Option	Capital Cost	Annual Operating Cost	NPV	Annualised Cost over 30 years
Option 1 - Raising Clarrie Hall Dam	$30 million	$200/ML	$42 million	$569/ML
Option 2 - Byrrill Creek Dam Construction	$38 million	$200/ML	$51 million	$653/ML
Option 3 - Oxley River Dam Construction	$50 million	$200/ML	$64 million	$696/ML
Option 4 - Pipeline to Rous Water	$12 million	$28/ML	$51 million	$2,444/ML
Option 5 - Pipeline to the SEQ Water Grid	$9 million	$2,000/ML	$116 million	$1,655/ML
Option 6 - Desalination	$167 million	$400/ML	$194 million	$2,782/ML
Option 7 - Groundwater Supply	$39 million	$218/ML	$44 million	$2,535/ML
Option 8 - Indirect Potable Reuse	$296 million	$25/ML	$331 million	$3,579/ML
Option 9 - Direct Potable Reuse	$270 million	$12/ML	$307 million	$3,318/ML

References:

Beatty, R., O'Brien, S. and Stewart, B., (2005). *Integrated Water Cycle Management – Getting the Economics Right.* Ozwater Watershed, May 2005.

Beatty, R. and O'Brien, S. (2007), *The Economics of Supply and Demand Options: Problems with Levelised Cost.* Water June 2007.

5. MULTI-CRITERIA ANALYSIS OF OPTIONS

5.1 PROCESS ADOPTED

Each of the nine options was compared against the assessment criteria, which are used to differentiate the benefits and risks associated with each of the options. An assessment matrix, or multi criteria analysis (MCA) was developed, based on the following:

- A **rating** was assigned, based on a qualitative impact on the assessment criteria. The rating is summarised in Table 1 of **Appendix E**, based on a 1 to 5 system, with a 1 indicating a high risk and 5 indicating a low level of risk.
- A **weighting factor** of the relative level of significance was applied to the assessment criteria. The initial weighting factors based on a multiplier of 1 to 5 are shown in Table 5.

Table 5: Initial Weighting Factors

Assessment Criteria	Adopted Weighting Factor
Secure Yield	5
Planning Obligations	4
Established Technologies & Feasibility	4
Environmental Constraints	4
Social Acceptability	3
Legislative Acceptability	4
Cultural Heritage Impacts	4
Lead Time & Potential for Escalation	2
NPV & Costs per kL	4
Greenhouse Gas & Energy Consumption	3

- A **score** was derived based on the product of the rating and the weighting factor to provide a comparison of options.

The resultant scores were then ranked from one to nine to identify the top preferences for further assessment (fine screening).

Where it is difficult to distinguish between the rankings of the options, a *sensitivity analysis* may be applied, by adjustment of the weighting factors to vary the relative level of significance of the assessment criteria.

5.2 RESULTS OF ANALYSIS

A multi-criteria analysis was undertaken by the project team including Council officers. The analysis applied the set of weighting factors to produce the ranking of the options as summarised in Table 6. Details of the multi criteria analysis are presented in Table Table 2 of **Appendix E.**

Table 6: Initial Ranking of Options

Rank	Option	NPV ($m)	Annualised Cost	Assessed Score
1	Option 1 - Raising Clarrie Hall Dam	$42 million	$569/ML	151
2	Option 2 - Byrrill Creek Dam Construction	$51 million	$653/ML	117
3	Option 5 - Pipeline to the SEQ Water Grid	$116 million	$1,655/ML	111
4	Option 4 - Pipeline to Rous Water	$51 million	$2,444/ML	109
5	Option 3 - Oxley River Dam Construction	$64 million	$696/ML	102
6	Option 7 - Groundwater Supply	$44 million	$2,535/ML	93
7	Option 6 - Desalination	$194 million	$2,782/ML	81
8	Option 8 - Indirect Potable Reuse	$331 million	$3,579/ML	72
9	Option 9 - Direct Potable Reuse	$307 million	$3,318/ML	65

5.3 DISCUSSION OF THE OPTIONS

The ten assessment criteria involve some criteria, which are considered mandatory for an option to be considered further. These mandatory assessment criteria are:

1. **Secure Yield** - The water resource augmentation was assessed on its capacity to provide an additional 5,250 ML/annum (15 ML/d) of secure yield to provide a total of 19,000 ML/annum in the year 2036 (as shown in Figure 1). Two options do not meet this minimum requirement:
    - Option 4: Pipeline to Rous Water - Ranked No. 4, will only provide 5 ML/day or 1,825 ML/a
    - Option 7: Groundwater Supply - Ranked No. 6 will only provide 4.3 ML/d or 1,470 ML/a.
2. **Established Technologies and Feasibility** - The augmentation should be delivered using accepted technical practices involving established standards and workable outcomes which are beyond question. One option does not meet this criterion:
    - Option 9 – Direct Potable Reuse - Ranked No. 9

    It is highly unlikely that direct potable reuse would be accepted as the second scheme worldwide, after Windhoek, Namibia – when there are other options available.

The four highest ranked options were selected from the application of the weighting factors and rating of the multi-criteria analysis. As discussed above one of these options, Option 4 involving a pipeline from Rous Water does not meet the minimum yield requirement and is therefore disregarded as a long term supply option. Option 4 could however be considered as a short-term emergency source in the event that the capacity of the Tweed network cannot supply the demands of growth at the southern extremities of the system.

Alternatively Option 4 could be utilised as part of a combined scheme involving various small supply options. One such combined option that may be considered is:

- Option 4 – Pipeline to Rous Water, providing 5 ML/day; plus
- Option 7 – Groundwater Supply, providing 4.3 ML/day; plus
- Option 5 – Pipeline to SEQ Water Grid, providing the balance of water needs up to 20 ML/day.

Removal of Option 4 from the highest ranking options provides a shortlist of three options which singularly meet the requirement of adequate secure yield. The shortlist of options is provided in Table 7.

Table 7: Shortlist of Highest Ranked Options

Rank	Option
1	Option 1 - Raising Clarrie Hall Dam
2	Option 2 - Byrrill Creek Dam Construction
3	Option 5 - Pipeline to the SEQ Water Grid

With respect to Option 5 (ranked 3) involving a pipeline connection to the South East Queensland Water Grid, enquiries have been made with the QWC relating to the terms and conditions, availability and earliest commencement date for such a connection. The QWC responded with an e-mail, which is included in **Appendix C**.

The QWC confirmed that a notional 20 ML/day would be available from the South East Queensland (Gold Coast) Desalination Facility at Tugun. This advanced water treatment plant is part of South East Queensland Water Grid, which comprises several drought-proofing infrastructure components, many of which are still under construction.

QWC confirmed that:

> *"The South East Queensland (Gold Coast) Desalination Facility is now 85 percent complete, including 20 kilometres of the required 25 kilometre pipeline length now constructed to connect to the Southern Region Water Pipeline."* (QWC Water Supply Emergency projects, Monthly Report – July 2008.)

The Queensland Government is however reluctant to commit a definite supply to Tweed Shire at this stage, as the South East Queensland Water Grid is not yet fully commissioned, and the combined water resources in South East Queensland have not yet recovered from the worst drought on record.

Once these conditions are met, if the Tweed Shire Council is interested in purchasing water from the South East Queensland Water Grid, the SEQ Water Grid Manager would potentially be in a position to enter discussions on this supply option.

The response from the QWC highlights the potential risks of this option, in that supply from Queensland into NSW may be refused under circumstances where there are depleted water resources in Queensland due to drought, or other Act of God. This situation may occur irrespective of the fact that the Tugun Desalination Facility having an unlimited water resource and high reliability.

6. CONCLUSIONS

Based on the initial assessment, or coarse screening, of options for the augmentation of the Tweed Water Supply the following conclusions are drawn:

1 Detailed demand forecasting undertaken as part of the Demand Management Strategy (MWH 2008) identified that the demand in the shire is likely to exceed the yield of the Clarrie Hall Dam (13,750 ML/a) by around 2016 or by 2019 assuming that the BASIX program is successfully implemented.

2 Based on the demand assessment a minimum supply augmentation of 5,250 ML/a. was targeted to achieve a forecast demand of 19,000 ML/a (with BASIX) in the year 2036.

3 Two mandatory assessment criteria were identified as part of the assessment:

- Secure yield, for an additional 5,250 ML/annum;
- Established technologies and feasibility.

The options which did not meet these minimum requirements and were not considered further as long term supply options were:

- Option 4 – Pipeline to Rous Water — Ranked No. 4
- Option 7 – Groundwater Supply — Ranked No. 6
- Option 9 – Direct Potable Reuse — Ranked No. 9

4 The highest ranking options have the highest ratings for secure yield and established technologies:

- Option 1 – Raising Clarrie Hall Dam — Ranked No. 1
- Option 2 – New Byrrill Creek Dam — Ranked No. 2
- Option 5 – Pipeline to SEQ Water Grid — Ranked No. 3
- Option 4 – Pipeline to Rous Water — Ranked No. 4
- Option 3 – New Oxley River Dam — Ranked No. 5

5 Options that rated low, i.e. those with relatively high risk in relation to likely cost escalation or long lead time before constriction could commence were:

- Option 2 – New Byrrill Creek Dam — Ranked No. 2
- Option 3 – New Oxley River Dam — Ranked No. 5

6 The option with the most significant environmental concerns (habitat for threatened flora and fauna species near the dam site), as well as social impact (proximity to Tyalgum and the likelihood of flooding parts of the village and some rural properties) was found to be:

- Option 3 – New Oxley River Dam — Ranked No. 5

These issues would contribute to significant planning process obstacles. There were no criteria where the Oxley River dam out-scored the Byrrill Creek dam.

7 The option with the potential for political and legislative difficulties, due to interstate transfer of resources was:

- Option 5 – Pipeline to SEQ Water Grid Ranked No. 3

These issues are not likely to be diminished during periods of prolonged drought, when alternative supplies are needed most.

8 The most expensive options (with NPV of $200 to $300 million) also involve significant environmental impacts associated with disposal of the brine wastes:

- Option 6 – Desalination Ranked No. 7
- Option 8 – Indirect Potable Reuse Ranked No. 8
- Option 9 – Direct Potable Reuse Ranked No. 9

Direct potable reuse is not socially acceptable and would involve significant planning process obstacles.

9 Based on the initial assessment of the options, Option 1 involving the raising of the existing Clarrie Hall Dam ranked the highest by a significant margin. It would therefore appear that this option provides the most secure way forward for augmenting the Tweed district water supply.

10 The investigation and approvals process associated with the raising of Clarrie Hall Dam, coupled with the relatively long phase of project implementation, may put at risk the completion of the project by the year 2016, when the existing secure yield of 13,750 ML/annum could be reached.

A contingency plan is therefore required to deliver an emergency supply in the event that augmentation of supply is not completed by the year 2016. The contingency supply should have a short lead time and may be provided through a combination of the options listed in Table 8.

Table 8: Possible Contingency Supply Options

Rank	Option
3	Option 5 - Pipeline to the SEQ Water Grid
4	Option 4 - Pipeline to Rous Water
6	Option 7 - Groundwater Supply

The advantages of these options are that:

- They depend on well established technologies and are not likely to be exposed to long lead times for construction and significant escalation of costs;
- Their cultural heritage, social and political impacts are relatively low and should be able to be managed expediently;
- The NPV and annualised cost per ML for the options is relatively low.

The disadvantages of these options are that:

- The pipeline to Rous Water and Groundwater Supply do not separately provide sufficient supply to meet demands for the full planning horizon to the year 2036;
- Pipeline options cannot be staged in the short term. However, the supply from the SEQ Water Grid can be downsized.

7. RECOMMENDATIONS

Based on the initial assessment of options it is recommended that:

1. Tweed Shire Council carry out further investigations under the Stage 3 'fine screen' process involving detailed analysis relating to the assessment criteria. Particular attention should be given to the investigations and associated timeframes required to deliver the project. Options to be examined under the Stage 3 process are:
   - Option 1 - Raising of Clarrie Hall Dam;
   - Option 2 – a New Dam on Byrrill Creek; and
   - Option 5 - Link to South East Queensland Water Grid.
2. In addition a contingency plan based on a combination of the following (short delivery time) options should be progressed:
   - Option 4 - Link to Rous Water;
   - Option 5 - Link to South East Queensland Water Grid; and
   - Option 7 – Groundwater Supply.

REFERENCES

See Appendix B

APPENDIX A : SUMMARY OF ASSESSMENT CRITERIA

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

ASSESSMENT OF OPTIONS REV 5

ASSESSMENT CRITERIA	Option 1: Raising Clarrie Hall Dam	Option 2: New Byrrill Creek Dam	Option 3: New Oxley River Dam	Option 4: Pipeline Link to Rous Water
SECURE YIELD	Raising dam to FSL 70 m provides storage of 42,300 ML with an overall secure yield of 22,000 ML/annum, which satisfies the 2036 population of 157,000.	Construction of new dam to FSL 115.5 m provides storage of 18,300 ML, with an additional secure yield of 9,000 ML/annum, which satisfies the 2036 population of 157,000.	Construction of new dam to FSL 56 m provides storage of 35,000 ML, with an additional secure yield of 20,000 ML/annum, which satisfies the 2036 population of 157,000.	Construction of new 18.3 km pipeline (300 mm dia.) provides an additional 1,800 ML/annum (5 ML/day), which is insufficient for the year 2036 planning horizon.
PLANNING OBLIGATIONS	The dam wall is zoned Rural 1(a). Division 24 of State Environmental Planning Policy (Infrastructure) 2007 enables development for the purposes of water storage without development consent. Immediately downstream of the dam wall, the area is zoned 7(l) Environmental Protection (habitat).	The dam wall is zoned Rural 1(a). Division 24 of State Environmental Planning Policy (Infrastructure) 2007 enables development for the purposes of water storage without development consent. Land zoned Rural 1(a) will be inundated.	The river itself is unzoned. The land is zoned 7(l) Environmental Protection (habitat) on the northern side of the river and Rural 1(a) on the southern side of the proposed wall. The following land zonings are likely to be inundated: Rural 1(a), 1(f) Forestry and 7(l) Environmental Protection (habitat).	Due to SEPP Infrastructure 2007, the pipeline is able to be constructed without development consent. Reticulation for water supply can be constructed without consent in any land zoning. It is noted that the road adjoins areas that are zoned: Environmental Protection 7(a) (wetlands and littoral rainforest), Environmental Protection 7(l) (coastal lands) and Zone 8(a) National Park.
ESTABLISHED TECHNOLOGIES & FEASIBILITY	CFRD raising feasible, additional rockfill from new spillway on left abutment, tower raised and strengthened.	Earth & rockfill type dam previously studied is feasible, spillway excavation on right abutment will supply some materials.	Concrete gravity, CFRD, or earth & rockfill is feasible, 60m wide spillway excavation will supply material for embankment.	Pipeline construction feasible adjacent to road, easily accessible for construction trenching and laying pipes. Depending on hydraulics, an associated pumping facility may be required. The pipeline can be designed to flow both ways if required.
ENVIRONMENTAL CONSTRAINTS	Raising existing dam, not new construction site, access and rockfill sources are within site. Archaeological overview done - some significant sites found. Flora & fauna overview done - some significant forest and threatened species found, will need further assessment. EIS to be prepared.	New dam construction, access and works facilities required. Clearing of site is a major issue. Much of land to be inundated is owned by Council. Upper reaches of inundated area encroaches into Mebbin State Forest.	New dam construction access and works facilities required. Clearing of site is a major issue. National park and private land issues, as well as flora & fauna and cultural heritage need to be addressed.	New pipeline construction in already disturbed areas. Possibility that acid sulphate soils will be encountered.
Aquatic	Clarrie Hall Dam is a fish barrier and has impacted the aquatic environment. Upstream inundation of aquatic habitat occurs with the raising.	Creation of a new fish barrier will occur on Byrrill Creek. Inundation of aquatic habitat including pool and riffle sequences for a large stretch of the river will also occur.	Creation of a new fish barrier will occur on the Oxley River. Inundation of aquatic habitat including pool and riffle sequences for a large stretch of the river will also occur.	Minimal impacts. Construction will need to be managed to ensure that adjoining waterways are not impacted.
Terrestrial Ecology	A preliminary ecological investigation has indicated that there would be inundation of some significant vegetation communities and fauna habitats. Two Endangered Ecological Communities could partially be impacted (Lowland Forest on the Floodplain and Coastal Freshwater Wetland on the Floodplain). Several threatened fauna species habitat may be impacted, including the Comb-crested Jacana, which inhabits the shallow wetlands, but new shallow wetlands would establish around the new lake margins.	High potential for impacting threatened flora species and threatened fauna species habitat (records of threatened flora/fauna occur in/or near the dam site. Large portions of the inundation area have been cleared previously. However, riparian vegetation has been retained adjacent to the creek line, which provides a vegetated corridor and contains some rainforest (potentially Lowland Rainforest EEC).	High potential for impacting threatened flora species and threatened fauna species habitat (records of threatened flora/fauna occur in/or near the dam site. Mixture of cleared and vegetated areas will be inundated. Some significant vegetation communities likely to be impacted (potentially Lowland Rainforest EEC).	The pipeline will be constructed within the cleared road reserve of a public road (northern section of the pipeline). There is the potential for minimal clearance of coastal vegetation. Some clearing is likely in the closed road area (southern section of the pipeline) This would need to be minimised due to the location being in the Nature Reserve. There are 5 threatened plant species, which occur in the Billinudgel Nature Reserve (several plants occur less than 1 km from the pipeline corridor) 44 Threatened fauna species have been recorded in the reserve.
Conservation Areas	Part of the eastern side of the inundation area occurs near the boundary of Mount Jerusalem National Park.	The south western end of the inundation area is close to the boundary of Mebbin National Park.	No National Park is impacted. Mount Warning National Park boundary occurs south of the inundation area.	The pipeline route is adjacent to a public road (Coast Road) and a closed road (Old Coast Road), which is now an unsealed track (with the intent to totally close the track in the north of the Billinudgel Nature Reserve. Coastal Road is located in Wooyung Nature Reserve and Old Coast Road is located in Billinudgel Nature Reserve. The Billinudgel Nature Reserve policy states that Non-NPWS infrastructure developments within the Reserve will be prohibited where the proposal may adversely impact on natural and cultural heritage values, conflict with the objectives of the Plan of Management, or are not consistent with the NP&W Act and NPWS policies. Therefore, for the pipeline to be approved, it will be required to meet these conditions.
Services / Roads	Minimal impacts. Road bridge raising may be required.	Byrrill Creek Road will require relocation to the north and will involve short-term disruption to the local community.	The public road will be required to be relocated.	A Telstra cable runs along the Coast and Old Coast Roads.
SOCIAL ACCEPTABILITY	Benefit to community from increase in storage and maintenance of secure yield for future demand. Minor political impact due to Clarrie Hall Dam being an existing dam. Raising the dam to RL 70 m and associated flood surcharge will not inundate private properties.	Additional storage will compliment Clarrie Hall storage to provide secure for many years in the future. New dam site likely to be a major political issue. NSW Weirs Policy discourages construction of new on-river storages. Council owns a large portion of the area. Some land acquisition will be required, including the site of the dam.	Benefit to community from increase in storage and maintenance of secure yield for future demand. New dam site likely to be a major political issue. NSW Weirs Policy discourages construction of new on-river storages. Road relocation is required. Village of Tyalgum impacted by increasing flooding. Future augmentation of the dam would have significant impacts on the village. Land acquisition will be required and several rural residences will be impacted.	Additional security of water, which could delay requirements for new or additional storage. The southern section of the pipeline is in the Nature Reserve. There is potential for opposition to works in a Nature Reserve. The northern section of the pipeline should be able to be contained within the public road reserve. Potential for designing the pipeline to flow both ways, which could benefit both Tweed and Rous communities.
LEGISLATIVE ACCEPTABILITY	Raising on the site of the existing dam wall does not present significant additional legislative hurdles.	NSW Weirs Policy discourages construction of new on-river storages. This, together with the requirement for new acquisitions will require the careful application of legislative procedures.	This site will require the full force of legislation to overcome significant social and environmental concerns.	The proximity of environmentally significant areas is likely to attract opposition to this scheme and require the careful application of legislative procedures.
CULTURAL HERITAGE IMPACTS	Known Aboriginal sites will be inundated, or within the increased flood level (11 sites including shelter sites).	The site requires survey, however it is likely Aboriginal sites will be inundated due to proximity to a water source. It is understood that archaeological sites occur at the western end of the storage.	The site requires survey, however it is likely that Aboriginal sites will be inundated due to their usual proximity to a water source.	The pipeline route requires archaeological survey. The majority of the pipeline would be located in areas previously disturbed for road construction, or previous sand mining. This would minimise the risk of impacting sites. There are at least 16 recorded Aboriginal sites in the Billinudgel Reserve plus a mythological site. The main sites include a scar tree, bora ring, stone artefact scatters and isolated finds which indicate camp sites, hunting and gathering activities and travel routes (NPWS Plan of Management).
LEAD TIME FOR CONSTRUCTION & POTENTIAL FOR ESCALATION OF COSTS	Need to consider the time required to conduct environmental investigations and achieve approvals. 1 to 2 years pre-construction, 1 year construction, potential for cost escalation depends on contractor method. Highest risk in M&E items.	Need to consider the time required to conduct environmental investigations and achieve approvals. 1 to 2 years pre-construction, 1.5 years construction, potential for cost escalation depends on contractor method. Highest risk in M&E items.	Need to consider the time required to conduct environmental investigations and achieve approvals. 2- to 3 years pre-construction, 2 years construction taking into account remoteness of site, high chance of cost escalation. Also high risk in M&E items.	Need to consider the time required to conduct environmental investigations and achieve approvals. 6 months pre-construction, 6 months construction, but high potential for cost escalation due to rapid rise in pipework costs.
CAPITAL, OPERATIONS, NPV & COST / KL	Based on D&C 2007 report, **capital cost** is $30 million to increase storage by 26,300 ML = $1.15/kL. Assume the **annual operating costs** of $200/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2016 is $42.1 million. **Annualised Cost ($/ML)** over 30 years is $569/ML.	Based on D&C 2004 report, **capital cost** is $38 million (2007 prices) for 16,300 ML storage = $2.33/kL. Assume the **annual operating costs** of $200/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $50.8 million. **Annualised Cost ($/ML)** over 30 years is $653/ML.	Based on SMEC 2007 report, **capital cost** is $50 million for 35,000 ML storage. Suggests $1.42/kL. Assume the **annual operating costs** of $295/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $64.4 million. **Annualised Cost ($/ML)** over 30 years is $606/ML.	Based on current costs, **capital cost** for 300-mm steel pipeline = $11.3 million. Plus Billinudgel pump station = Plus Billinudgel pump station = $0.5 million **Total capital cost** of scheme is approx. $11.8 million. Assume bulk cost of water is $2,000/ML. **Operating costs** are approx. $50,000/annum, or $28/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $61.3 million. **Annualised Cost ($/ML)** over 30 years is $2,444/ML.
GREENHOUSE GAS & ENERGY CONSUMPTION	Electricity to power M&E items. No greenhouse gas emission under normal operation. Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions. Unless vegetation in new inundated areas is entirely cleared and mulched for rehabilitation works, GHG emissions is also an issue with decomposition.	Electricity to power M&E items. No greenhouse gas emission under normal operation. Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions. Unless vegetation in new inundated areas is entirely cleared and mulched for rehabilitation works, GHG emissions is also an issue with decomposition.	Electricity to power M&E items. No greenhouse gas emission under normal operation. Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions. Unless vegetation in new inundated areas is entirely cleared and mulched for rehabilitation works, GHG emissions is also an issue with decomposition.	Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions.
ASSESSMENT CRITERIA	**Option 1: Raising Clarrie Hall Dam**	**Option 2: Byrill Creek Dam Construction**	**Option 3: Oxley River Dam Construction**	**Option 4: Pipeline Link to Rous Water**

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

ASSESSMENT OF OPTIONS REV 5

ASSESSMENT CRITERIA	Option 5: Pipeline to S E Queensland Water Grid	Option 6: Desalination	Option 8: Indirect Potable Reuse	Option 9: Direct Potable Reuse
SECURE YIELD	Construction of new 7 km pipeline (500 mm dia.) via the future Cobaki Lakes development provides an additional 7,500 ML/annum (20 ML/day), which is sufficient for the year 2036 planning horizon.	Construction of desalination plants at either Condong (20 ML/d from Tweed River), or Cudgen (two 10 ML/d stages - brackish groundwater), or Kingscliff (two 10 ML/d stages - seawater), by 2012 provides an additional 7,500 ML/annum, which is sufficient for the year 2036 planning horizon.	Construction of 20 ML/d and 5 ML/d MF/RO advanced recycled water treatment plants at Banora Point STP and Kingscliff STP and a 50 km pipeline and 4 pumping stations to Clarrie Hall Dam, by 2012 provides an additional 10,200 ML/annum, which is sufficient for the year 2036 planning horizon.	Construction of 20 ML/d and 5 ML/d MF/RO advanced recycled water treatment plants at Banora Point STP and Kingscliff STP and a 2.8 km pipelines and pumping stations, provides an additional 10,200 ML/annum, which is sufficient for the year 2036 planning horizon.
PLANNING OBLIGATIONS	Need for Federal ***Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*** approval with lead time normally 6 to 12 months (or more). If the alignment is adopted through the future Cobaki Lakes development, then the pipeline will be located in the road reserve when the development proceeds.	This would be a major project under the NSW major projects assessment system of ***Part 3A*** of the ***Environmental Planning and Assessment (EP&A) Act 1979*** and ***State Environmental Planning Policy (Major Projects) 2005.*** Projects that come under this system require Department of Planning assessment and Ministerial approval due to their: Significance to NSW as a whole; Environmental impact; Strategic location; Essential infrastructure; Large water infrastructure projects in excess of $30 million capital value come under the scrutiny of Part 3A of the EP&A Act.	This would be a major project under the NSW major projects assessment system of ***Part 3A*** of the ***Environmental Planning and Assessment (EP&A) Act 1979*** and ***State Environmental Planning Policy (Major Projects) 2005.*** Projects that come under this system require Department of Planning assessment and Ministerial approval due to their: Significance to NSW as a whole; Environmental impact; Strategic location; Essential infrastructure; Large water infrastructure projects in excess of $30 million capital value come under the scrutiny of Part 3A of the EP&A Act.	Renewed water to conform to the **National Recycled Water Guidelines.** State legislative framework not yet developed in NSW. Similar framework in Queensland exists: **Public Health Amendment Regulation No. 1 2008,** Sections 18AD and Schedule 3B **Water Supply (Safety & Reliability) Act 2008,** effective from 1 July 2008. This may also be a major project under the NSW major projects assessment system as per IPR.
ESTABLISHED TECHNOLOGIES & FEASIBILITY	Pipeline construction feasible adjacent to road, easily accessible for construction trenching and laying pipes. A 120 kW pumping station has been allowed in the estimates. Need to under-bore the Tugun By-pass.	Both thermal and membrane desalination for water treatment plants are now recognised technologies - such as plants under construction at Tugun, Qld and in operation in WA.	MF/RO advanced water treatment plants for indirect potable reuse schemes are now recognised technologies - such as part of the SE Qld Water Grid. The pipelines and pumping stations are established technologies.	Same process as IPR with issues of disposal of the toxins in the concentrate, such as ammonia, chloramine, anionic surfactants.
ENVIRONMENTAL CONSTRAINTS	New pipeline construction in already disturbed areas and some parts in sensitive wetlands. Probability that acid sulphate soils will be encountered with risks associated with ASS disposal.	Acquisition of some private lands, as well as flora & fauna and cultural heritage issues need to be addressed. Possibility that acid sulphate soils will be encountered at the Cudgen site with risks associated with ASS disposal. Disposal of the brine by-product to sea (Kingscliff or Bogangar) likely to arouse significant concerns.	Toxicity of waste concentrate is an issue for disposal options. Acquisition of some private lands, as well as flora & fauna and cultural heritage issues need to be addressed. Probability that acid sulphate soils will be encountered with risks associated with ASS disposal.	Toxicity of waste concentrate is an issue for disposal options.
Aquatic	Endangered frogs were an issue with the Tugun By-pass approvals process.	Lowering of the groundwater reserves at Cudgen is an issue with the Cudgen Nature Reserve. Abstraction of 20 ML/d from the Tweed River at Condong will have impacts on fish species.	450 mm underbore of Tweed River expected to be in an environmentally sensitive area.	Minimal impacts.
Terrestrial Ecology	Scheduled plant and animal species were an issue with the Tugun By-pass approvals process.	16 km of brine waste pipeline from Condong, along Clothiers Creek Road to Norries Head will impact significant vegetation communities.	Scheduled plant and animal species are expected to be an issue over the 50 km pipeline to Clarrie Hall Dam. Some significant vegetation communities likely to be impacted (potentially Lowland Rainforest EEC).	Minimal impacts.
Conservation Areas	The pipeline route is adjacent to the Tugun By-pass section of the Pacific Motorway and possibly in a future railway easement.	Lowering of the groundwater reserves at Cudgen is an issue with the Cudgen Nature Reserve.	The pipeline route between Uki and CHD is adjacent to State forests with significant flora, fauna and cultural heritage values.	Minimal impacts.
Services / Roads	Power and Telstra cables are along the Tugun By-pass.	Minimal impacts.	Power, Telstra and other utility services are located in proximity to the pipeline route.	Minimal impacts.
SOCIAL ACCEPTABILITY	Need for cross border approvals coordination. Water transfer from NSW into Queensland has been politicised previously - this scheme sends water in the reverse direction, from the recently commissioned Queensland Water Grid. The Queensland Water Grid has excess capacity from the Tugun Desalination Plant for the foreseeable future. Need to work with community and local conservation groups.	Consultation with local community groups will be required to overcome the issues arising from efficiencies associated with the relatively high energy consumption to support the treatment processes, and also the environmental concerns over disposal of the brine waste stream to either Norries Head, or at the northern end of Bogangar Beach. Land acquisitions will be required for the plant footprint.	Need to work with community and local conservation groups. Land acquisitions will be required and several rural properties will be impacted. Similar IPR schemes have been rejected by communities in Toowoomba and Caboolture, Qld.	Difficulties in convincing the community to accept the second DPR scheme worldwide (after Windhoek, Namibia), when other options exist.
LEGISLATIVE ACCEPTABILITY	Agreement to the transfer of water between the States, particularly when one party is under the influence of a drought is a significant risk to this scheme.	The requirements for disposal of the waste brine will require the careful application of legislative procedures. Ministerial discretionary powers may be required for a project of this nature and size.	The requirements for disposal of the waste brine will require the careful application of legislative procedures. Ministerial discretionary powers may be required for a project of this nature and size.	Legislative framework in NSW is yet untested and this scheme is likely to present significant additional legislative hurdles.
CULTURAL HERITAGE IMPACTS	Archaeological surveys over part of the route have been conducted as part of the EIS for the Tugun By-pass. The majority of the pipeline would be located in areas previously disturbed for road construction. Significant length remains in undisturbed land. Need to allow time to deal with Traditional Owner groups under two State sets of legislation.	Archaeological surveys over the 16 km route of the brine waste pipeline from Condong, along Clothiers Creek Road to Norries Head will be required.	The majority of the pipeline would be located in areas previously disturbed for road construction. Need to allow time to deal with Traditional Owner groups.	Minimal impacts.
LEAD TIME FOR CONSTRUCTION & POTENTIAL FOR ESCALATION OF COSTS	Need to consider the time required to conduct environmental investigations and achieve approvals. 6 months pre-construction, 6 months construction, but high potential for cost escalation due to rapid rise in pipework costs.	Relatively long lead-time required to conduct environmental investigations, community consultation, land acquisitions and achieve approvals under Part 3A of the EP&A Act.	Relatively long lead-time required to conduct environmental investigations, community consultation, land acquisitions and achieve approvals under Part 3A of the EP&A Act. 2- to 3 years pre-construction, 3 years construction with high chance of cost escalation. Also high risk in M&E items.	Need to consider the time required to conduct environmental investigations and achieve approvals. 2- to 3 years pre-construction, 2 years construction with high chance of cost escalation. Also high risk in M&E items.
CAPITAL, OPERATIONS, NPV & COST / KL	7.0 km of 500-mm steel pipes, = $8.3M and 120 kW pumping station = $0.6 million. **Total capital cost** = $9.1 million. Assume bulk cost of water is $2,000/ML. Assume the **operating costs** of $57,000 per annum. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $115.6 million. **Annualised Cost ($/ML)** over 30 years is $1,555/ML.	Based on DEUS 2006 report, **capital costs** are: Condong desal = $167 million = $8.4 million / ML/d. Cudgen desal = $79 million. St 1 = $7.9 million / ML/d. Kingscliff desal = $93 million St 1 = $9.3 million / ML/d. Assume the **annual operating costs** of $400/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $194.2 million. **Annualised Cost ($/ML)** over 30 years is $2,782/ML.	Capital costs of MF/RO WTPs are: Banora Point STP: $8 million / ML/d. Say $150 million. Kingscliff STP: $6 million / ML/d. Say $66 million. Four pumping stations: $3.7 million. 50 km of 300-mm, 450-mm and 490-mm rising mains and discharge structure at CHD: $78.7 million. **Total capital cost** of scheme is approx. $296 million. **Operating costs** are approx. $250,000/annum, or $25/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $331.0 million. **Annualised Cost ($/ML)** over 30 years is $2,579/ML.	Capital costs of MF/RO & advanced oxidation WRP are: Banora Point STP: $9.5 million / ML/d. Say $187 million. Kingscliff STP: $9.5 million / ML/d. Say $79 million. Banora Point & Kingscliff pumping stations: $2.2 million. 1.3 km of 450-mm rising mains from Banora PS to Fraser Drv - $1.5 million. 1.5 km of 375-mm rising mains from Kingscliff PS to Tweed Valley Way - $1.4 million. **Total capital cost** of scheme is approx. $270 million. **Operating costs** are approx. $150,000/annum, or $12/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $306.8 million. **Annualised Cost ($/ML)** over 30 years is $3,316/ML.
GREENHOUSE GAS & ENERGY CONSUMPTION	Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions.	Electricity to power M&E items will contribute significantly to GHG emissions. Construction activities will contribute significantly to GHG emissions.	Electricity to power M&E items will contribute significantly to GHG emissions. Clearing of site, excavation and other construction activities will contribute significantly to GHG emissions.	Electricity to power M&E items will contribute significantly to GHG emissions. Construction activities will contribute significantly to GHG emissions.
ASSESSMENT CRITERIA	Option 5: Pipeline to S E Queensland Water Grid	Option 6: Desalination	Option 8: Indirect Potable Reuse	Option 9: Direct Potable Reuse

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

ASSESSMENT OF OPTIONS REV 5

ASSESSMENT CRITERIA	Option 7: Groundwater		
SECURE YIELD	Construction of new borefield in the vicinity of either Bray Park (20 m deep in alluvium aquifer), or adjacent to existing trunk system along the coast (dune sand aquifer) by 2013, provides an additional 1,470 ML/annum (4.3 ML/day), which is insufficient for the year 2036 planning horizon.		
PLANNING OBLIGATIONS	Development of groundwater resources involves three legislative frameworks administered by the **Department of Water & Energy (DWE)** in NSW. ***(i) Water Act 1912*** - being phased out and replaced by Water Management Act 2000. ***(ii) Water Management Act 2000*** involves 'water sharing plans' for groundwater licences and approvals, which are based on protecting the sustainability of the aquifer and reserving a proportion of the average annual recharge for the environment. ***(iii) National Water Initiative (NWI)***, endorsed by COAG in 2004. The **DWE** would require any groundwater resource for TSC to conform to the above framework AND include an environmental assessment to ensure protection of the groundwater resource against: Seawater intrusion or induced acid sulfate soils (ASS) impacts, Impacts of connected stream flows, wetlands, etc, Abstraction of other users, Well-head contamination. In addition to the above NSW State framework, the **Federal EPA** may intervene where it considers that a groundwater project for urban purposes is of national environmental significance. The provisions of the **Environmental Protection and Biodiversity Conservation (EPBC) Act 1999** would then be invoked.		
ESTABLISHED TECHNOLOGIES & FEASIBILITY	Borefield construction is feasible where the following assumptions are made: Host aquifer is in proximity to existing distribution system; Salinity is < 1,000 mg/L, and preferably < 500 mg/L; Bore yield > 5 L/sec in alluvium systems; Location is accessible as public lands to host borefields and pipelines; No direct conflict with other existing groundwater users.		
ENVIRONMENTAL CONSTRAINTS	Under the provisions of the above-mentioned EPBC Act 1999 the following environmental criteria would need to be upheld: Borefield is > 500 metres from a site of known or potential contamination, Borefield is > 500 metres from a significant wetland.		
Aquatic	***NWI*** to be upheld involving an environmental assessment to ensure protection of the groundwater resource against impacts of connected stream flows, wetlands, seawater intrusion, groundwater level reduction, etc. ***EPBC Act 1999*** would need to be upheld whereby borefield is > 500 metres from a significant wetland.		
Terrestrial Ecology	There is the potential for minimal clearance of coastal vegetation. Groundwater level reduction can adversely affect dependant terrestrial vegetation - Melaleuca and Allocasuarina sp.		
Conservation Areas	**EPBC Act 1999** would need to be upheld whereby borefield is > 500 metres from a significant wetland.		
Services / Roads	Power and road access is required to the borefield site.		
SOCIAL ACCEPTABILITY	Extraction to be within rates that do not harm the environment, whereby concerns are raised over unacceptable environmental impact. The need to impose well-head protection zones through town planning instruments and exclude potentially contaminating activities from the vicinity of the borefield. Proposed borefields to be > 200 m from significant concentrations of existing domestic bores, particularly in the dune sand aquifers along the developed coastal strip. Borefield is > 500 metres from sites of potential contamination, such as municipal landfill sites, septic tanks and agricultural chemicals, etc.		
LEGISLATIVE ACCEPTABILITY	There is an increasing legislative complexity being applied to the harvesting of groundwater resources.		
CULTURAL HERITAGE IMPACTS	Traditional owners generally regard groundwater resources of particular cultural significance. The views of traditional owner groups should be included as part of the overall project impact.		
LEAD TIME FOR CONSTRUCTION & POTENTIAL FOR ESCALATION OF COSTS	Lead time is subject to variables such as: The extent of hydrogeological investigations through modelling, monitoring bores and permitting. Time required to conduct environmental investigations, community consultation and achieve approvals. Allowances for treatment facilities and connecting infrastructure. Time allowed for all investigations through to commissioning is 3.5 years (EHA Table 3-3).		
CAPITAL, OPERATIONS, NPV & COST / KL	Costs are subject to many variables such as: Number of bores to target 50 L/sec (4 ML/d); Proximity of borefield to existing major reticulation; Required spacing between individual bores and monitoring systems to maintain sustainable draw-down; Nature of treatment (potentially for iron, salinity & disinfection). Compare with BCAA on Bribie Island ***with full treatment***: **Capital costs** of a 4.32 ML/d borefield is $39 million, or $9 million / ML/d. **Operating costs** are approximately $320,000/annum, or $218/ML. If the works are constructed in 2014/15, the discount rate of 7 %, the **NPV** over 30 years to 2015 is $49.9 million. **Annualised Cost ($/ML)** over 30 years is $2,535/ML.		
GREENHOUSE GAS & ENERGY CONSUMPTION	Clearing of site and other construction activities will emit some gases. Electricity to power M&E items - bore pumps, water treatment facilities and booster pumps.		
ASSESSMENT CRITERIA	**Option 7: Groundwater**		

APPENDIX B : CHECKLIST OF RELEVANT REPORTS

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

CHECKLIST OF RELEVANT REPORTS

Information relevant to the Tweed district water supply augmentation includes the following reports in chronological order:

No.	Title	Author	Date	Reference
1	Augmentation of Tweed District Water Supply	GHD	February 1975	
2	Tweed Shire Water Supply Augmentation - Reconnaissance Engineering Geological Report.	Geological Survey of NSW	September 1977	GS 1977/194
3	Tweed District Water Supply Headworks Augmentation Final Investigation Part 1 – Project Definition	Dept. of Public Works NSW	October 1977	WS 150-A
4	Feasibility investigations at Byrrill Creek and Doon Doon Damsites, Tweed Shire	Geological Survey of NSW	August 1978	GS 1978/252
5	Tweed District Water Supply Augmentation (Headworks) Clarrie Hall Dam - Site Confirmation and Selection of Dam Type	Dept. of Public Works NSW	September 1979	WS 150-C
6	Tweed District Water Supply Augmentation, Clarrie Hall Dam, Summary of Site Geology	Public Works Dept. of NSW	May 1981	GS1981/253
7	Tweed District Water Supply Augmentation, Clarrie Hall Dam Engineering Geology Report on Construction	Geological Survey of NSW	1983	GS1983/004
8	Clarrie Hall Dam and Bray Park Weir Yield Survey	SunWater	July 2002	E02065-01
9	Construction of Dam on Byrrill Creek, Update of Estimate	NSW Department of Commerce	July 2004	
10	New South Wales North and mid-North Coast Viability and Cost Effectiveness of Desalination	DEUS	December 2005	DC05201
11	Tweed Integrated Water Cycle Management (IWCM) Context Study and Strategy	HWA	March 2006	
12a	Tweed Shire Council Activity Management Plans - Water Supply	MWH	July 2006	A0151601
12b	Tweed Shire Council Activity Management Plans - Wastewater	MWH	July 2006	A0151601

13	Tweed River System Water Supply Security Review	SunWater	November 2006	G-81903-02-03-03
14	Water Supply and Sewerage Development Servicing Plans	Tweed Shire Council	2007	
15	Integrated Water Supply Options of North East NSW and South East Queensland	SMEC	2007	
16	Demand Management Strategy, Stage 1	MWH	February 2008	A1067401
17	Clarrie Hall Dam – Determination of Optimum Size and Dam Raising Options Study, Final Evaluation Report	NSW Department of Commerce	May 2008	DC08060
18	Tweed District Water Supply Augmentation Options Study – Identification of Feasible Options – Groundwater Supply	Environmental Hydrology Associates	22 July 2008	GW-08-02-REP-001 Rev A

APPENDIX C : LETTER FROM QUEENSLAND WATER COMMISSION

"Dennien Barry" <Barry.Dennien@seqwgm.qld.gov.au>

24/09/2008 05:35 PM

To "Mark Hunting" <mark.hunting@au.mwhglobal.com>

cc

bcc

Subject RE: Tweed's Water Supply Augmentation Options Study

Mark

Thankyou for your email and your patience,

See below some revised words we would be comfortable with in your report. We will support our position with a letter to be forwarded through shortly.

"The South East Queensland (Gold Coast) Desalination Facility is now 85 percent complete, including 20 kilometres of the required 25 kilometre pipeline length now constructed to connect to the Southern Region Water Pipeline ." (QWC Water Supply Emergency projects, Monthly Report – July 2008.)

The Queensland Government is reluctant to commit a definitive supply into NSW at this stage, as the South East Queensland Water Grid is not yet fully commissioned, and the combined water resources in South East Queensland have not yet recovered from the worst drought on record. Once these conditions are met, if the Tweed Shire Council is interested in purchasing water from the SEQ Water Grid, the SEQ Water Grid Manager would potentially be in a position to enter discussions on this supply option.

Regards
Barry

From: Mark Hunting [mailto:mark.hunting@au.mwhglobal.com]
Sent: Tuesday, 23 September 2008 4:10 PM
To: Dennien Barry
Cc: Shane F O'Brien
Subject: Tweed's Water Supply Augmentation Options Study

Barry,

We are about to issue our client, Tweed Shire Council with a progress report on the findings of our options analysis for augmenting the water supply to Tweed Shire.
Of the nine options examined, the logistics of supplying water from the South East Queensland Water Grid look quite promising, based on its proximity to Tweed and the preliminary discussions that we held with you on 23 April 2008.

We would like to include some meaningful words around the option of a connection to the South East Queensland Water Grid, and to that end we seek confirmation from QWC of your position in the matter.

We have already drafted some words in anticipation of your position, but would like these to be backed up by your response before we release anything to our client.

The words that we have drafted are as follows:

"QWC confirmed that a notional 20 ML/day would be available from the South East

Queensland (Gold Coast) Desalination Facility at Tugun. This advanced water treatment plant is part of South East Queensland Water Grid, which comprises several drought-proofing infrastructure components, many of which are still under construction.

QWC confirmed that:

"The South East Queensland (Gold Coast) Desalination Facility is now 85 percent complete, including 20 kilometres of the required 25 kilometre pipeline length now constructed to connect to the Southern Region Water Pipeline ." (QWC Water Supply Emergency projects, Monthly Report – July 2008.)

The Queensland Government is reluctant to commit a definitive supply into NSW at this stage, as the South East Queensland Water Grid is not yet commissioned to deliver, and the combined water resources in South East Queensland have not yet recovered from the worst drought on record. The Queensland Government's position in this regard is not to commit to any new and potential consumers, before the combined water resources in South East Queensland have replenished to at least 60 percent capacity. At the present time supply is at 42 percent capacity (22 September 2008).

This highlights the potential risks of this option, in that supply into NSW may be refused under circumstances where there are depleted water resources in Queensland, under the influence of a drought, or other Act of God, irrespective of the South East Queensland (Gold Coast) Desalination Facility being tapped into a relatively infinite resource. It is noted that this water is manufactured water and its capacity is therefore limited to the production capacity of the plant itself and not the size of the raw resource."

Barry, please be assured that we intend to advise our client strictly in accordance with your response to our letter of 8th May 2008.

At this stage the option to connect to QWC would appear to stack-up favourably in comparison to some of the other options, and Tweed may instruct us to take this option forward to greater detail. This reinforces our need to receive your response to our letter, which deals with the necessary issues of:

- Terms and conditions (capacities and bulk costs),
- Point of supply and
- Tenure of supply (commencement and duration) - all of which are over and above the words already drafted.

Please do not hesitate to contact me to discuss the above at your earliest convenience.

Regards Mark

MWH

BUILDING A BETTER WORLD

Mark M. Hunting

Gold Coast Office Manager

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AUSTRALIA

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Web: www.mwhglobal.com.au

APPENDIX D : IDENTIFICATION OF GROUNDWATER RESOURCES

(Environmental Hydrology Associates Pty Ltd, July 2008)

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

INPUT TO STAGE 1 – IDENTIFICATION OF FEASIBLE OPTIONS - GROUNDWATER SUPPLY

Report Prepared by Environmental Hydrology Associates (EHA Pty Ltd)

for

MWH Australia Pty Ltd

22 July 2008

Report Number GW-08-02-REP-001 Rev A

Limitations Statement

The sole purpose of this report and the associated services performed by EHA Pty Ltd (EHA) is to provide a report detailing a groundwater assessment made for input for a process of identification of feasible options for urban water supply for the Tweed District Water Supply Augmentation Options Study in accordance with the scope of services set out in the contract between EHA and MWH Australia Pty Ltd ('the Client'). That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the data sources for the relevant sites.

EHA derived the data in this report primarily from, examination of records in the public domain ands data relevant to the sites provided by the Client and other parties.

The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the sites and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, EHA has relied upon and presumed accurate certain information (or absence thereof) relative to the site including surface geological mapping and publicly available hydrological data. Except as otherwise stated in the report, EHA has not attempted to verify the accuracy or completeness of any such information.

No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings, observations and conclusions are based solely upon site conditions, information, drawings supplied by the Client and others in existence at the time of the investigation.

The cost projections detailed in this report have been provided in good faith based on reasonable costs as reported by relevant reputable contractors. It should be noted that the passage of time may result in cost escalations.

This document has been prepared solely for the benefit of the Client and is issued in confidence for the purpose only for which it is supplied. Unauthorised use of this document in any form whatsoever is prohibited. No liability is accepted by EHA Pty Ltd or any employee, contractor or subconsultant of this company with respect to its use by any other person.

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1 INTRODUCTION

1.1 BACKGROUND

The Tweed Shire Council water supply has an existing secure yield of approximately 13,750 ML/a. The current demand for water is approximately 10,500 ML/a and is rising as development in the Shire accelerates. It is anticipated that an increased secure yield will be required by approximately 2013.

The Tweed Integrated Water Cycle Management Context and Strategy recognised this requirement and identified requirement to identify and assess options for the augmentation of the water supply.

MWH Australia Pty Ltd and NSW Commerce have been engaged to carry out a Tweed District Water Supply Augmentation Options Study and MWH Australia Pty Ltd engaged EHA Pty Ltd to provide specialist input to Stage 1 of this study, being Identification of Feasible Options.

1.2 SCOPE

The project work documented herein covers the following scopes of services:

- Review previous relevant reports and any material considered applicable (obtain relevant previous reports, review previous reports and materials, and summarise key elements of reports);
- Identify and confirm groundwater options available for the augmentation of the Tweed Shire Council Water Supply;
- Identify and list the criteria by which the relevant groundwater options can be assessed;
- Undertake a coarse review of legislative and planning issues including:
  - Review the adequacy of the criteria to fulfil requirements & potential EIS
  - Review the adequacy of the criteria to fulfil requirements of relevant agencies in assessment of preferred the option;
  - Review planning and legislative issues to be addressed and risks that the project will not be able to adequately address those issues;
  - Provide an overview for the location and operation of borefields;
  - Identify potential social factors associated with groundwater options;
  - Identify potential environmental factors associated with groundwater options including sustainability;
    - Identify potential cost and yield factors associated with groundwater options including security of yield; and
  - Identification of reasonable implementation timeframe

- Documentation of the initial groundwater investigations.

This report provides documentation of this scope of works.

2 RELEVANT INFORMATION SOURCES

2.1 RELEVANT AVAILABLE GEOLOGICAL AND HYDROGEOLOGICAL MAPS

The most relevant available geological maps are:

- Brown R.E., 2001, Warwick-Tweed Heads 1:250,000 Metallogenic Map, Preliminary edition, Geological Survey of New South Wales, Sydney; and
- Geological Survey of Queensland 1978 Murwillumbah, Queensland, 1:100 000 geological series map. Sheet 9541, 1st edition. Geological Survey of Queensland 1v

The 1:250,000 scale metallogenic map provided in the Geological Survey of NSW, Warwick-Tweed Heads 1:250 000 Sheet Area (New South Wales Portion) Exploration Data Package is the most recent an relevant of this mapping and has been largely adopted herein as the geological base for figures and hydrogeological calculations.

In addition to Brown's geological mapping, additional mapping of New South Wales coastal Quaternary age geology (Troedson et al, 2004) is available from Geological Survey of New South Wales, and this has been drawn upon to better define key geological units such as dune sand deposits which may host significant useful groundwater supplies.

The most relevant hydrogeological maps for the Tweed Shire are:

- NSW Dept of Land and Water Conservation 1997 Tweed-Brunswick Catchment Groundwater Availability Map, DLWC Hydrogeology Unit, March 1997; and
- NSW Dept of Land and Water Conservation 1997 Groundwater Vulnerability - Tweed-Brunswick Catchments, DLWC Hydrogeology Unit, March 1997

2.2 RELEVANT AVAILABLE REPORTS

The key relevant reports for the geology of the Tweed Shire are:

- Brown, R.E., Henley, H.F. and Stroud, W.J. 2001 Warwick-Tweed Heads 1:250 000 Sheet Area (New South Wales Portion) Exploration Data Package, Geological Survey of New South Wales, Volume 1 Geology, Mineral Occurrences, Exploration and Geochemistry, 12 December 2001; and
- Troedson, A., Hashimoto, T.R., Jaworska, J., Malloch, K., Cain, L., 2004. New South Wales Coastal Quaternary Geology, 108pp. In NSW Coastal Quaternary Geology Data Package (on CD-ROM), Troedson, A., Hashimoto, T.R. (eds), New South Wales Department of Primary Industries, Mineral Resources, Geological Survey of New South Wales, Maitland.

The key relevant reports for the groundwater resources of the Tweed District are:

- McKibbin, D. 1995 Upper North Coast Groundwater Resource Study, NSW Department of Land and Water Conservation (Water Resources), Technical Services Division, August 1995;

- NSW Dept of Land and Water Conservation 1997 Tweed-Brunswick Catchment Groundwater Availability Map – Explanatory Notes, DLWC Hydrogeology Unit, March 1997;
- NSW Dept of Land and Water Conservation 1997 Tweed-Brunswick Catchment Groundwater Vulnerability Map – Explanatory Notes, DLWC Hydrogeology Unit, March 1997;
- NSW Department of Natural Resources 2006a Macro Water Sharing Plans - Coastal Alluvial Groundwater Sources - June 2006 - Tweed River Alluvium Groundwater Source - Report Card;
- NSW Department of Natural Resources 2006b Macro Water Sharing Plans - Coastal Groundwater Sources - June 2006 - Tweed Coastal Sands Groundwater Source - Report Card;
- Ross, J.B. and McKibbin D. 1992 North Coast Sustainable Strategy Groundwater Aspects. Department of Water Resources Technical Services Division. Report No. TS.024;
- Water Conservation and Irrigation Commission, 1968 Water Resources of the Tweed and Brunswick Valleys, Survey of thirty New South Wales River Valleys, Report No. 9; and
- Water Resources Commission 1984, Groundwater in New South Wales.

In addition to this report, some commentary pertaining to the hydrogeology and groundwater resources of geological units that extend from the adjoining Gold Coast City to Tweed Shire is provided by:

- Parsons Brinkerhoff 2005 Gold Coast Water Future Project – Groundwater Investigation, report to Gold Coast Water, report number 2138163A-001-RPT001, January

2.3 NSW DEPARTMENT OF WATER AND ENERGY DATABASE - NSW GROUNDWATER WORKS

In addition to available NSW Government mapping and reporting the NSW Government maintains a database on groundwater works including bores, well and excavations. This site presents information approximately 90,000 works constructed for obtaining water across NSW as Groundwater Summary Reports.

While scrutiny of this detailed groundwater information is beyond the scope of this report, some references have been made to this material and specific comments are made to data drawn from this source in the following report sections.

2.4 SUMMARY OF KEY ELEMENTS OF REPORTS & MAPS

Figure 1 presents the surface geology of the study area based on the geological mapping of Brown (2001). Figure 2 presents the surface geology of the study area based on the geological mapping of Brown (2001) with modifications for the distribution of dune sand deposits drawn from mapping provided by Troedson et al (2004). Appendix A provides a geological key for Figures 1 & 2.

Figure 3 presents groundwater availability mapping for the study area after DLWC (1997a) and Figure 4 presents groundwater vulnerability mapping for the study area after DLWC (1997c).

The following section provides commentary regarding potential groundwater sources that have been identified within the Tweed Shire Boundary.

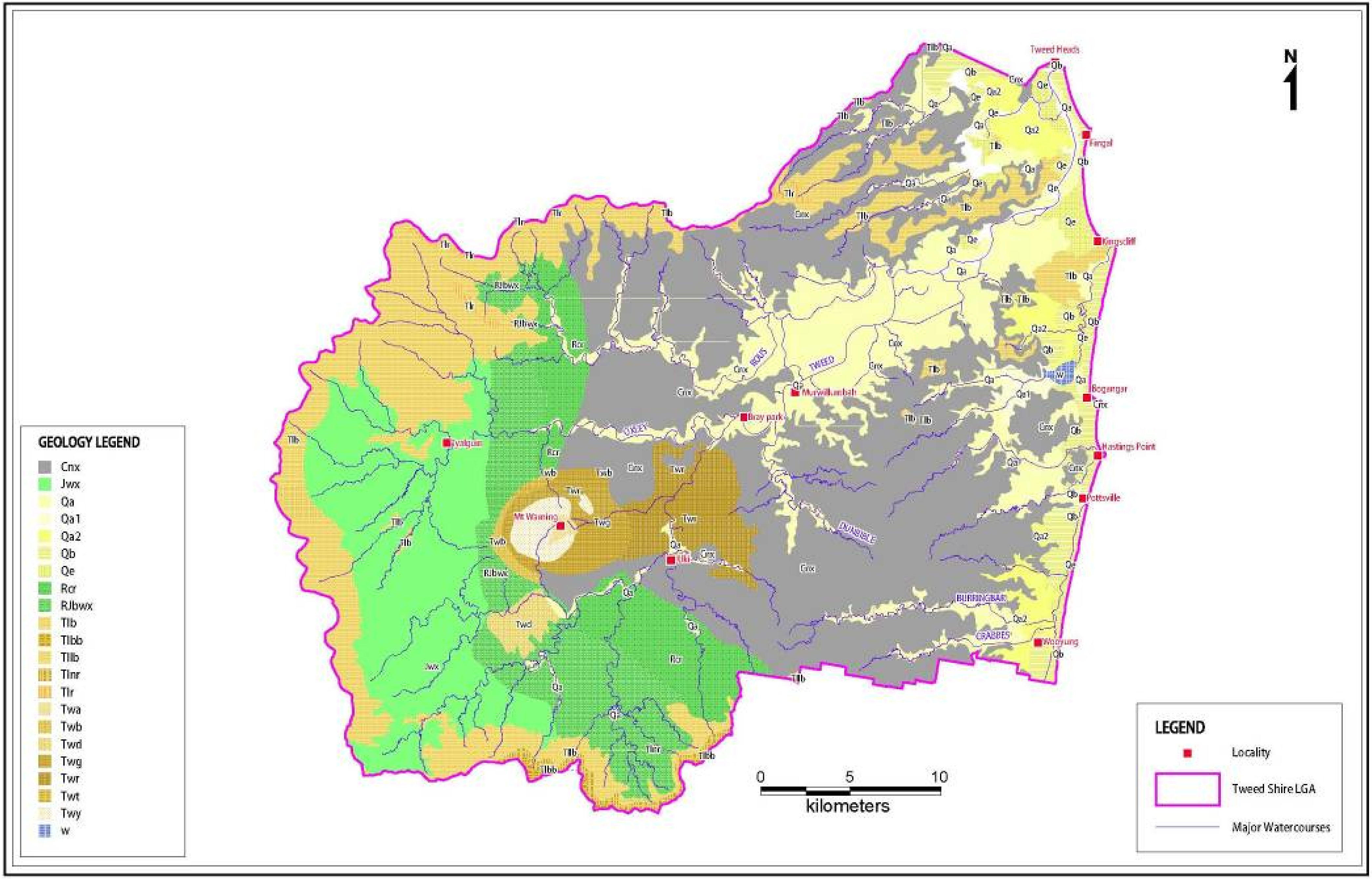

Figure 1
SURFACE GEOLOGY OF THE STUDY AREA BASED ON GEOLOGICAL MAPPING OF BROWN (2001)

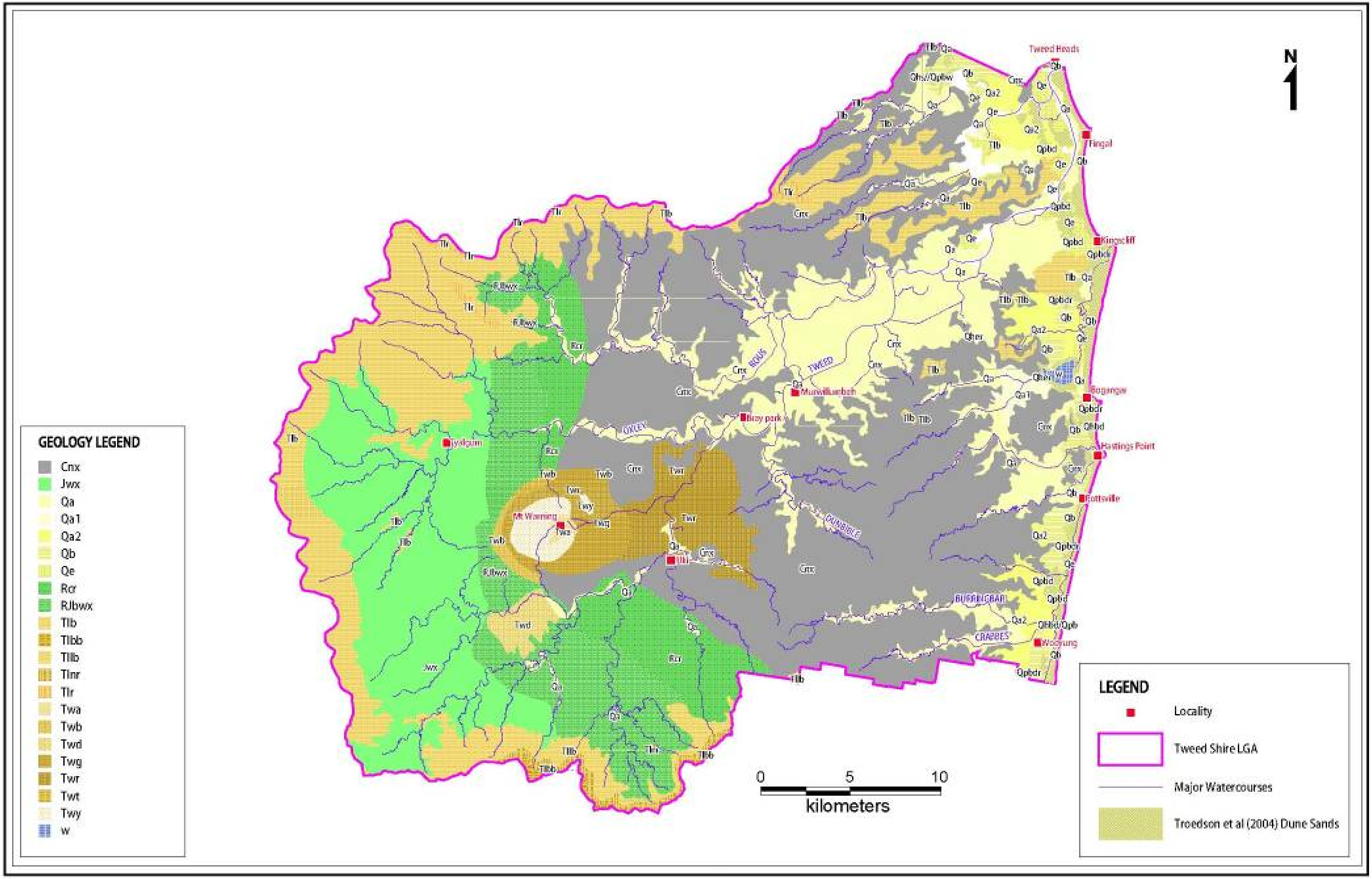

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Figure 2
SURFACE GEOLOGY OF THE STUDY AREA BASED ON GEOLOGICAL MAPPING OF BROWN (2001) WITH MODIFICATIONS FOR THE DISTRIBUTION OF DUNE SAND DEPOSITS FROM MAPPING PROVIDED BY TROEDSON ET AL (2004)

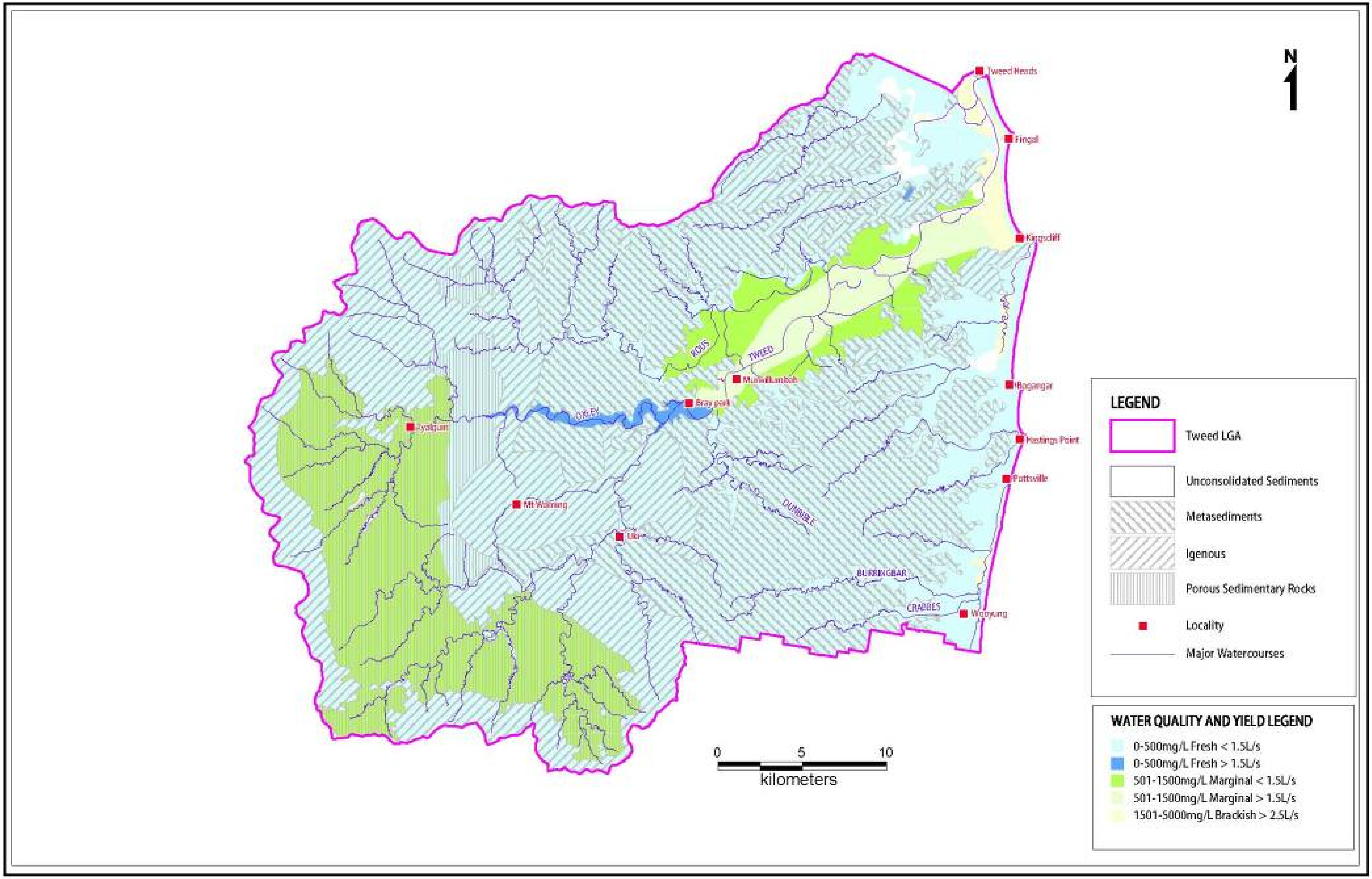

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Figure 3
GROUNDWATER AVAILABILITY MAPPING FOR STUDY AREA (AFTER DWLC 1997a)

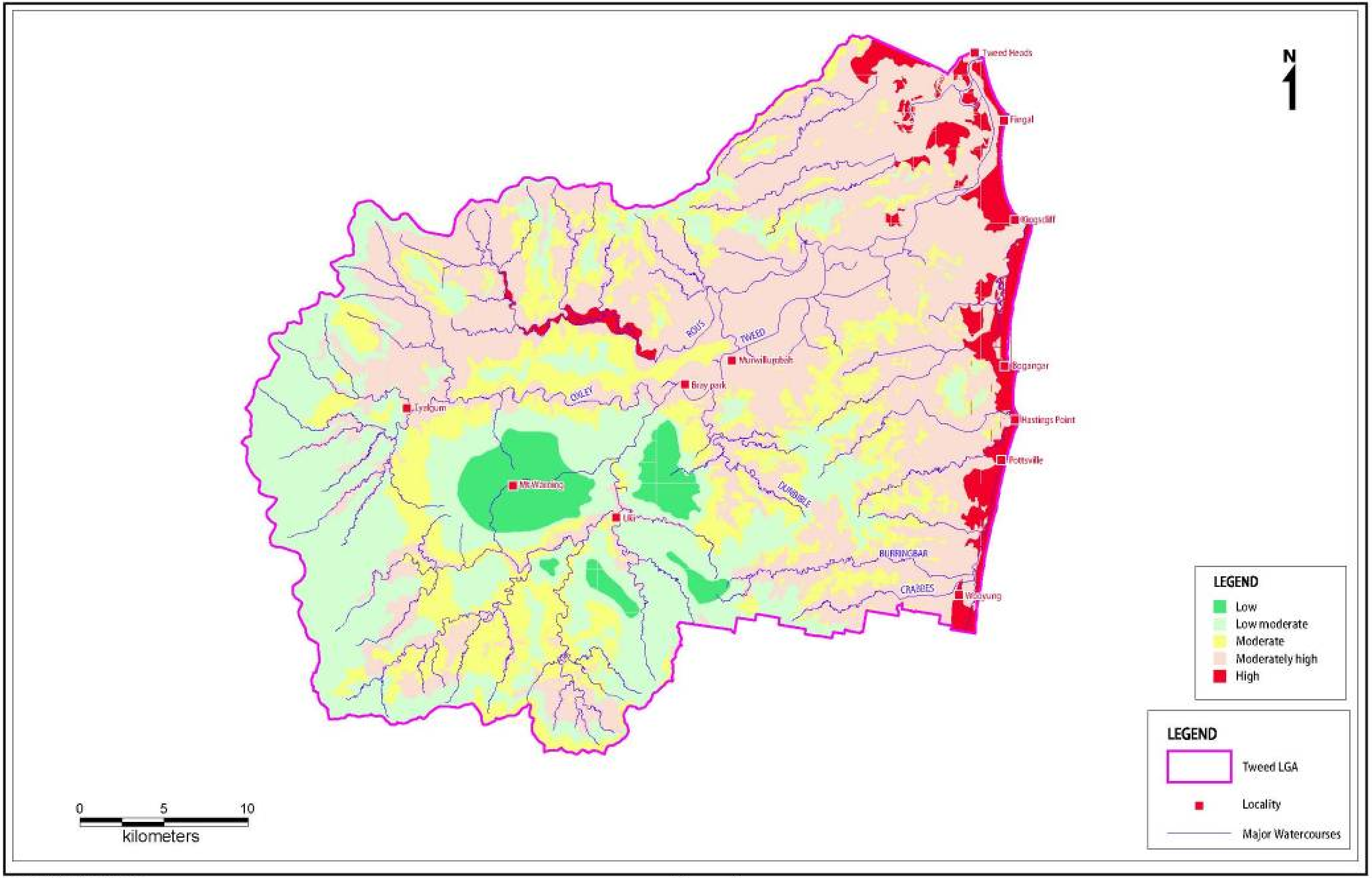

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Figure 4
GROUNDWATER VULNERABILITY MAPPING FOR STUDY AREA (AFTER DLWC 1997a)

2.4.1 Palaeozoic age metasedimentary rocks of the Neranleigh Fernvale Beds

Palaeozoic age metasedimentary rocks of the Beenleigh Block form effective geological basement to the Tweed Shire. The Neranleigh Fernvale Beds of this structural unit outcrop over 429.4 km^2 in Tweed Shire in a broad band of outcrop that extends well to the north and south of the Shire.

This unit will largely be present at depth beneath the entire Shire, sub-cropping beneath younger Mesozoic age sediments of the Clarence Moreton Basin, Mesozoic age volcanics correlated with the Ipswich Basin, Tertiary age volcanics of the Mt Warning system and younger Quaternary age alluvium, dune sand and other coastal / estuarine deposits.

McKibbon (1995) indicated that the Neranleigh Fernvale Beds in the Upper North Coast area consist of strongly folded and structurally deformed greywacke, slate, phyllite and quartzite. He indicated that within this unit groundwater occurs associated with secondary porosity such joints, fractures, fissures and weathered zones along such features. Although McKibbon indicated that this unit has generally low permeability with individual bore yields generally in the order of 0.5 L/s, occasional supplies to 5 L/s are recorded. He noted that this formation hosts unconfined to semi-confined aquifers.

Notwithstanding McKibbon's assessment it should be noted that elsewhere across the extensive outcrop area of the Neranleigh Fernvale Beds in southern Queensland some appreciable individual bore supplies are obtained from this unit. For example a contingency urban water supply borefield of four production bores has been established at Chandler in the southern outskirts of Brisbane that is delivering a contingency groundwater supply of 54 L/s with an overall salinity of less than 700 mg/L total dissolved solids.

EHA (2006) noted that in contrast with much of the Brisbane area, in the Gold Coast area the Neranleigh Fernvale Beds appear to support a few larger groundwater supplies, although more broadly it is a relatively poor water source. EHA noted advice from water bore drilling contractor Graeme Hoffman who has significant experience in the construction of water bores in this formation. EHA noted that Hoffman had advised that the Neranleigh Fernvale Beds are generally poor groundwater producers however in some areas of the Gold Coast, some large supplies are drawn from them such as the Southport Australian Rules Ground that has a bore that produces approximately 11.36 L/s, the Parkwoods Golf Course that has a bore that produces approximately 11.36 to 16.41 L/s from weathered greywacke and the Gold Coast University site that has a bore that produces approximately 4 L/s. Mr Hoffman indicated that successful bores in the Neranleigh Fernvale Beds are usually located in low-lying, swampy areas.

McKibbon (1995) quoted an estimate of 64 production bores tapping the Beenleigh Block metasedimentary rocks in an Upper North Coast study area extending from Coffs Harbour in the south, Tenterfield and Glen Innes in the west and the Queensland border in the north. He estimated the total yield for these rocks over this larger study area to be 10,000 ML/a and total groundwater extraction from the bores tapping these rocks to be 700 ML/a.

As previously indicated the outcrop area of the Neranleigh Fernvale Beds present within Tweed Shire totals 429.4 km^2. Adopting a mean annual rainfall of 1,576.9 mm/a (ie. mean rainfall at Murwillumbah) and the unit rainfall recharge value of 1% quoted by McKibbon, an overall groundwater recharge of 6,771 ML/a is projected for this aquifer within Tweed Shire. Adopting McKibbon's assumption of 50 m mean saturated thickness and mean porosity of 1% a storage value of 214,695 ML is projected for these rocks beneath their outcrop area. Table 2.1 provides a summary of the projected storage for the key geological units of Tweed Shire including the Neranleigh Fernvale Beds.

DLWC (1997c&d) rated the vast majority of outcrop area of the Neranleigh Fernvale Beds to be of "Moderately High" aquifer vulnerability, although some areas of this aquifer were rated to be of "Low Moderate" vulnerability. DLWC (1997c&d) indicated that "Moderately High" vulnerability ranked groundwater resources for the Tweed and Brunswick area included shallow aquifers associated with moderate slopes, higher rainfall and higher recharge with soils often moderately to highly permeable, with a moderate to high cation exchange capacity and a depth to water of less than 10 metres.

Notwithstanding the observations made by EHA (2006) regarding potential high yielding bores in this formation in the southern suburbs of Brisbane and in some areas of the Gold Coast, groundwater extraction from the Neranleigh Fernvale Beds at consistently high capacities has not been established in northern NSW. It should however be noted that some higher capacity water bores tapping this formation have been recorded by DWE in their database of groundwater works reports. For example the Murwillumbah Golf course has a 40 m deep bore tapping the Neranleigh Fernvale Beds that is reported by DWE as yielding 4 L/s of good quality (with respect to salinity) groundwater from a waterbed from 6 to 20 m bGL. At least four bores in the greater Murwillumbah area are recorded in the DWE database as having supplies drawn from the Neranleigh Fernvale Beds greater than 3 L/s with at least one bore reported as having an individual yield of 5.5 L/s.

While it is not possible currently to reliably assess the potential for the development of borefields for Tweed Shire such as is operating at Chandler in Brisbane it is noted that the bores recording in the Murwillumbah area as hosting larger supplies (ie. > 3 L/s) are not deeper than 40 m. It is noted that the experience in the Brisbane area with this formation has been that the larger supplies won from this unit have been at significantly greater depth (ie. 70 – 150 m) than typical drilling depths for most domestic and farming applications (ie. 30 – 50 m).

Deep test drilling of structural targets in areas of low-lying, swampy terrain on the outcrop of this unit would be required to better understand the potential for urban groundwater supply development within this unit.

Table 2.1 Summary of projected groundwater storage, recharge and indicative yields for key geological units of Tweed Shire

Era	Period	Structural element	Geological unit	Geological map symbol for unit (see Figure 1)	(km2)	Mean adopted saturated thickness (m)	Mean adopted effective porosity (%)	Projected total storage (ML)	Adopted mean rainfall (mm/a)	Adopted mean recharge rate (% annual rainfall)	Projected unit recharge rate (mm/a)	Projected total recharge (ML/a)	Adopted proportion of total recharge that could be recoverable (%)	Projected recoverable groundwater yield (ML/a)	Comment
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (Tweed Heads to Fingal)	Qa2, Qb	14.28	15	30	64,260	1,463.7	20	292.7	4,180	30	1,254	
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (Fingal to Kingscliff)	Qa2, Qb	5.82	15	30	26,190	1,463.7	20	292.7	1,704	30	511	
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (Kingscliff to Bogangar)	Qa2, Qb	15.46	15	30	69,570	1,463.7	20	292.7	4,526	30	1,358	
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (Bogangar to Hastings Point)	Qa2, Qb	3.92	15	30	17,640	1,463.7	20	292.7	1,148	30	344	
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (Hastings Point to southern coast boundary of Tweed Shire)	Qa2, Qb	25.49	15	30	114,705	1,463.7	20	292.7	7,462	30	2,239	
Cainozoic	Quaternary (Holocene)	Recent coastal sediments	Dune sand deposits (all Tweed Shire)	Qa2, Qb	64.97	15	30	292,365	1,463.7	20	292.7	19,019	30	5,706	
Cainozoic	Quaternary	Recent alluvium	Tweed River alluvial system - Middle Arm / Oxley River freshwater	Qa2, Qb	8.87	15	10	13,305	1,726.4	2	34.5	306	15	46	
Cainozoic	Quaternary	Recent alluvium	Tweed River alluvial system	Qa		15	10		1,570.9		0.0	0	15	0	
Cainozoic	Tertiary	Lamington Volcanics	Lamington Volcanics - sub-alkali basalt	Tlb	171.8	60	3	309,240	1,555.4	10	155.5	26,722	15	4,008	
Cainozoic	Tertiary	Lamington Volcanics	Lamington Volcanics - Blue Knob Basalt & Andesite	Tlbb	2.57	60	3	4,626	1,555.4	10	155.5	400	15	60	
Cainozoic	Tertiary	Mt Warning Complex	Mt Warning Central Complex - unnamed basalt	Twb	3.3	60	3	5,940	1,555.4	10	155.5	513	15	77	
Cainozoic	Tertiary	Mt Warning Complex	Mt Warning Central Complex - unnamed dolerite & basalt	Twd	8.01	60	3	14,418	1,555.4	10	155.5	1,246	15	187	
Cainozoic	Tertiary	Tertiary age volcanics	Mt Warning Complex & Lamington Volcanics (all Tweed Shire)	Tlb, Tlbb, Twb, Twd	185.7	60	3	334,224	1,555.4	10	155.5	28,881	15	4,332	
Mesozoic	Jurassic	Clarence - Moreton Basin	Walloon Coal Measures	Jwa	156.24	100	2	312,480	1,555.4	0.5	7.8	1,215	0	0	Unit hosts poor groundwater quality
Mesozoic	Jurassic - Triassic	Clarence - Moreton Basin	Woogaroo Sub-Group	Rbw	93.7	100	5	468,500	1,555.4	5	77.8	7,287	10	729	Unit has groundwater of variable salinity
Mesozoic	Triassic	Clarence - Moreton Basin	Chillingham Volcanics	Rzr	61.2	60	1	36,720	1,555.4	3	46.7	2,856	10	286	
Palaeozoic	Devonian - Carboniferous	Beenleigh Block	Neranleigh Fernvale Beds	Cna	429.39	50	1	214,695	1,576.9	1	15.0	6,771	10	677	Unit has highly variable salinity and individual bore yields

2.4.2 Mesozoic age volcanics of the Clarence Moreton Basin

The Chillingham Volcanics which are of Triassic age form the basal unit of the Clarence Moreton Basin in the Tweed Shire. This unit extends north into Queensland and is correlated with the lower section of the Ispwich Basin. The Chillingham Volcanics outcrop in a relatively narrow and arcuate band that trends broadly north – south, from near Chillingam in the north to near Mt Jerusalem in the south of the Shire. The rocks of this unit include rhyolite, lithic rhyolitic tuff, shale, and basal cobble conglomerate. Brown et al (2001) have indicated that the Chillingham Volcanics have a maximum thickness possibly reaching 1,500 m.

EHA (2006) noted that little is known of the hydrology of this formation, however it would be expected to host minor aquifers developed in weathered and fractured rock. This formation is unlikely to host groundwater resources of great significance except for small-scale individual domestic use.

The outcrop area of the Chillingham Volcanics present within Tweed Shire totals 61.2km^2. Adopting a mean annual rainfall of 1,555 mm/a (ie. mean rainfall at Tyalgum) and a unit rainfall recharge value of 3%, an overall groundwater recharge of 2,856 ML/a is projected for this aquifer within Tweed Shire. Adopting an assumption of 50 m mean saturated thickness and mean porosity of 1% a storage value of 36,720 ML is projected for these rocks beneath their outcrop area. Table 2.1 provides a summary of the projected storage for the key geological units of Tweed Shire including the Chillingham Volcanics.

It should be noted that the total recharge estimate presented in Table 2.1 does not equate to an available groundwater yield for this aquifer. This is because in a relatively undeveloped state, the recharge into the aquifer system will be balanced by discharge from the system in the form of wetlands and the baseflow of streams that drain such areas. Increased groundwater pumping from the Chillingham Volcanics would result in some reduction to stream flow as less recharge would be rejected, however the associated reduction in the more critical groundwater baseflow during the drier months of the year may be proportionally less. This is because when an aquifer is effectively full or close to full there is no working storage to buffer recharge and discharge. When some working storage is created through groundwater pumping the effective recharge potential increases.

In order to account for the need to preserve some stream baseflow during periods of low rainfall, the overall aquifer recharge figure projected for the Chillingham Volcanics as presented in Table 2.1 should be reduced. In Table 2.1 a factor of 10% has been adopted for recoverable recharge reflecting both the need to maintain stream base flow and the likely relative difficulty in establishing borefields within this geological unit.

This rock unit underlies the small community of Chillingham in outcrop and at depth beneath the small community of Numinbah. Accordingly it may be able to be drawn on to provide small domestic supplies or even perhaps small community water supply schemes, however further investigation to clarify the potential of this unit is beyond the scope of this project. Notwithstanding this, it would be expected that the Chillingham Volcanics are unlikely to be able to provide or to contribute to significant large-scale urban water supply schemes for Tweed Shire.

2.4.3 Mesozoic age sedimentary rocks of the Clarence Moreton Basin

The sedimentary rocks of the Clarence Moreton Basin directly overlie the Chillingham Volcanics in Tweed Shire and outcrop in a broad band of 250 km^2 between the Chillingham Volcanics and the basalts of the Lamington - Mt Warning complex. Within Tweed Shire the sedimentary units of the Clarence Moreton Basin include the following units:

- Bundamba Group (Woogaroo Sub-Group); and
- Walloon Coal Measures.

McKibbon (1995) indicated that within the Clarence Moreton Basin sediments groundwater occurs in porous horizons as well as in joints and bedding plane fractures with most of the waterbeds being confined. He also indicated that groundwater associated with the rock formations of the Clarence Moreton Basin is characterised by small individual bore yields (most commonly 0.3 L/s but up to 1.5 L/s) and rather variable quality. McKibbon also indicated that at 1995, the total groundwater usage from the porous rock aquifers of the Clarence Moreton Basin did not exceed 2,000 ML/a over a broad area of the Upper North Coast of NSW that included but was not restricted to Tweed Shire.

McKibbon (1995) quoted an estimate of 104 production bores tapping the Clarence Moreton Basin rocks in an Upper North Coast study area extending from Coffs Harbour in the south, Tenterfield and Glen Innes in the west and the Queensland border in the north. He estimated the total yield for these rocks over this larger study area to be 28,100 ML/a and total groundwater extraction from the bores tapping these rocks to be 1,000 ML/a.

Walloon Coal Measures

McKibbon (1995) indicated typical individual bore yields from the Walloon Coal Measures to be less than 0.5 L/s with some supplies up to 5 L/s. However he also indicated that although bores in Walloon Coal Measures generally obtain water within 30 m of the surface, it is usually brackish. McKibbon's assessment of the Walloon Coal Measures is consistent with other assessments of the groundwater prospectivity of this formation (eg. EHA, 2006), however it should be noted that some isolated incidences of low salinity groundwater have been reported from the Walloon Coal Measures.

It is noted that this formation underlies Tyalgum, however at this location it is only approximately 2 km to its mapped lower boundary with the underlying Woogaroo Sub-Group. Accordingly the mapping suggests that at Tyalgum only part of the lower section of the Walloon Coal Measures is present.

The outcrop area of the Walloon Coal Measures occupies 156.2 km^2 within Tweed Shire. Adopting a mean annual rainfall of 1,555 mm/a (ie. mean rainfall at Tyalgum) and the unit rainfall recharge value of 0.5% quoted by McKibbon, an overall groundwater recharge of 1,215 ML/a is projected for this aquifer within Tweed Shire. Adopting McKibbon's assumption of 100 m mean saturated thickness and mean porosity of 2% a storage value of 312,480 ML is projected for these rocks beneath their outcrop area. Table 2.1 provides a summary of the projected storage for the key geological units of Tweed Shire including the Walloon Coal Measures.

Notwithstanding the relatively large projected storage for this unit, because of relatively poor water quality hosted by this formation it would be expected that the Walloon Coal Measures are unlikely to be able to provide or to contribute to significant large-scale urban water supply schemes for Tweed Shire.

Bundamba Group / Woogaroo Sub-Group

McKibbon (1995) indicated that the Bundamba Group consists of early to mid Jurassic sandstones, siltstones and pebble conglomerates. He described the Bundamba Group rocks as forming a low yielding, low salinity aquifer system. McKibbon (1995) indicated typical individual bore yields from the Bundamba Group rocks to be less than 0.5 L/s with some supplies up to 2.5 L/s.

Brown (2001) mapped an outcrop area of 93.7 km^2 of undifferentiated Woogaroo Sub-Group rocks to the immediate east of the Walloon Coal Measures in Tweed Shire and Brown et al (2001) described these rocks as comprising

- Ripley Road Sandstone consisting of thick-bedded, coarse grained, crossbedded, quartz arenite and conglomerate; and
- Raceview Formation consisting of thinly-interbedded, fine-grained lithic to quartz arenite, siltstone and claystone, minor pebble conglomerate; and minor coal.

McKibbon did not specifically make comment regarding the sub-units of the Bundamba Group and it should be noted that production bore yields from the member Ripley Road Sandstone have been know to be as high at 15 L/s elsewhere where associated with significant jointing / fracturing. For example the Brisbane Aquifer Project currently draws a contingency urban town water supply of 20 L/s from two production bores to 150 m deep.

The Woogaroo Sub-Group outcrop occupies 93.7 km^2 within Tweed Shire. Adopting a mean annual rainfall of 1,555 mm/a (ie. mean rainfall at Tyalgum) and the unit rainfall recharge value of 5% quoted by McKibbon, an overall groundwater recharge of 7,287 ML/a is projected for this aquifer within Tweed Shire. Adopting McKibbon's assumption of 100 m mean saturated thickness and mean porosity of 5% a storage value of 468,500 ML is projected for these rocks in the area beneath their outcrop. Table 2.1 provides a summary of the projected storage for the key geological units of Tweed Shire including the Walloon Coal Measures.

The small village of Numinbah lies on the outcrop of the Woogaroo Sub-Group rocks, but close to its outcrop boundary with the underlying Chillingham Volcanics. As previously indicated at Tyalgum, the Walloon Coal Measures outcrop but only the lower section of this unit is present overlying the Woogaroo Sub-Group. It should be noted that there is some potential for the development of small-scale groundwater supplies from this unit.

2.4.4 Tertiary age basalts of the Mt Warning Complex

McKibbon (1995) noted that the Lamington Volcanics which consist mainly of basalt and rhyolite, have very extensive flows and extend from Ballina – Byron Bay on the eastern seaboard through to the McPherson Range along the Queensland border in the north. Within Tweed Shire the surface geological mapping of

Brown (2001) indicates that in total, 185.7 km^2 of the Shire is occupied by surface outcrop of these Tertiary age volcanic rocks.

Brown et al (2001) indicated that the Late Oligocene – Early Miocene age Tweed Volcano covers an area approximately 100 km by 80 km and is still recognisable as a shield volcano with an eroded central caldera with slope angles of the shield low, between 1 and 3°. Brown et al indicated that the maximum thickness of the volcanics associated with the Tweed Volcano is approximately 1,000 m, however erosion has removed the eastern coastal portion. Brown et al noted that Mount Warning, a prominent peak (to elevation 1,156 m) is composed of trachyandesites surrounded by plutonic rocks, has usually been described as the feeder in the centre of the eroded caldera, although isotopic dating suggests that these rocks are older than the shield volcanics. Brown et al have suggested that the feeder for the Tweed volcanics may have been the Mount Nullum igneous complex immediately to the east of the Mount Warning Central Complex.

The key geological units of these Tertiary age volcanics within Tweed Shire include:

- Lamington Volcanics - sub-alkali basalt (comprising sub-alkali basalt with members of rhyolite, trachyte, tuff, agglomerate, and conglomerate);
- Lamington Volcanics - Blue Knob Basalt (comprising both basalt and andesite);
- Mt Warning Central Complex – basalt (comprising basalt, typically extensively recrystallised, ring-dyke); and
- Mt Warning Central Complex - dolerite & basalt (comprising intrusive dolerite and basalt).

McKibbon (1995) indicated that the Tertiary age volcanics form one of, if not the most important aquifer systems in the North Coast area of NSW. He noted that these rocks provide a very reliable system for bore water supplies containing low salinity groundwater that is suitable for most urban and rural purposes. McKibbon noted that individual bores have yields that commonly range from 0.5 to 15 L/s from average depths of 30 m.

McKibbon noted that the permeability of the volcanics is generally high due to consistent secondary porosity features such as joints and fractures as well as some primary features such as vesicular zones.

It is of some significance that McKibbon has also noted that groundwater discharging from the basalt terrains feeds numerous springs and substantially maintains some wetlands and the baseflow of streams that drain such areas.

McKibbon indicated that the groundwater hosted by the volcanics is usually of excellent quality with low total salt content although it is often found to have appreciable hardness.

McKibbon indicated that the basalts are relatively poorly developed for groundwater supplies within the study area with the exception of the Cudgen plateau to the south of Kingscliff. He noted that the Cudgen plateau is important locally because it has very fertile basaltic soils within a few kilometres of the coast and hosts a small but important groundwater system to provide domestic and irrigation supplies. McKibbon noted that on the Cudgen plateau at 1995, 15 bores had been constructed in the area and irrigation entitlements at that time had reached more than 20 ML/a.

McKibbon (1995) indicated a mean recharge rate for the basalts of the north coast of NSW in the order of 10% of a mean annual rainfall of 1,876 mm. He also indicated mean saturated thicknesses of 60 m and a mean porosity of 3%.

McKibbon (1995) quoted an estimate of 724 production bores tapping the Tertiary age volcanics rocks in an Upper North Coast study area extending from Coffs Harbour in the south, Tenterfield and Glen Innes in the west and the Queensland border in the north. He estimated the total yield from these rocks over his larger study area to be 797,000 ML/a and total groundwater extraction from the bores tapping this unit to be 8,800 ML/a.

The outcrop area of Tertiary age volcanics present within Tweed Shire totals 185.68 km^2. Adopting a mean annual rainfall of 1,555 mm/a (ie. mean rainfall at Tyalgum) and the unit rainfall recharge value of 10% quoted by McKibbon, an overall groundwater recharge of 28,880 ML/a is projected for this aquifers within Tweed Shire. Adopting McKibbon's assumption of 60 m mean saturated thickness and mean porosity of 3% a storage value of 334,200 ML is projected for these rocks. Table 2.1 provides a summary of the projected storage for the key geological units of Tweed Shire including the Tertiary age volcanics.

It should be noted that the total recharge estimate does not equal an available groundwater yield for these aquifers. This is because in a relatively undeveloped state, the recharge into the aquifer system will be balanced by discharge from the system in the form of wetlands and the baseflow of streams that drain such areas. Increased groundwater pumping from the volcanics would result in some reduction to stream flow as less recharge would be rejected, however the associated reduction in the more critical groundwater baseflow during the drier months of the year may be proportionally less. This is because when an aquifer is effectively full or close to full there is no working storage to buffer recharge and discharge. When some working storage is created through groundwater pumping the effective recharge potential increases.

2.4.5 Quaternary age alluvium of the Tweed River

Brown et al (2001) has indicated that gravels, sand and mud have accumulated as alluvial deposits along most streams in the Warwick – Tweed Heads Geology Sheet area and that the Tweed and Richmond Rivers are dominated by floodplain sediments with lesser levee and channel deposits. Brown et al have noted that the floodplain deposits are mainly muds with sandy and lesser gravelly sediments in crevasse splays, and peaty accumulations in backswamps and abandoned channels. They have also indicated that the lower reaches of both the Tweed River and Richmond River are incised into Pleistocene age estuarine muds.

McKibbon (1995) indicated that prior to 1995 the groundwater resources of the Tweed River valley were not well known and he documented investigations of these sediments undertaken by the Department of Water Resources. This investigation work involved geophysical survey work and the construction of two groundwater monitoring bores.

McKibbon (1995) indicated that the maximum thickness of the unconsolidated sediments of the Tweed River alluvium was approximately 35 m. He also concluded that no significant low salinity groundwater resources where found on any of the survey lines downstream of Murwillumbah and he attributed this to a predominantly estuarine nature of the sediments over much of the valley. Quaternary age coastal dune sands

McKibbon (1995) indicated that upstream of Murwillumbah the groundwater potential in the Tweed River alluvium is much better with alluvium thicknesses to 20 m on the river. McKibbon indicated that individual bore yields to 15 L/s were judged to be available and that salinity, based on a single test bore result of 427 mg/L total dissolved solids was low.

McKibbon (1995) also indicated that there was likely to be moderate yields of low salinity water available from both the tributary Rous River and Oxley River alluvial systems.

McKibbon (1995) indicated that the total area covered by the alluvium of the Tweed River covered 147 km^2 and that adopting a porosity of 10% and an estimated saturated thickness of 15 m the alluvium held a total storage of 222,000 ML. Of this total figure McKibbon indicated at only 44,000 ML was low salinity groundwater with the remainder being high salinity groundwater. Further to this McKibbon projected recharge to the Tweed River alluvium of 4,960 ML/a based on 2% of a mean annual rainfall figure of 1,687 mm becoming effective recharge.

McKibbon (1995) indicated that water use from the Tweed River alluvium at 1995 was 108 ML/a from a total of 12 water supply bores. This equates to a mean individual pumping rate of 0.285 L/s.

McKibbon also noted that that at 1995 the total area of public lands overlying the groundwater resource of the Tweed River alluvium was 6.6 km^2 representing 4.5% of the surface extent of the aquifer.

Groundwater availability mapping DLWC (1997a) indicates that much of the lower Tweed River alluvium to the east of Bray Park hosts groundwater of marginal quality from the perspective of salinity with marginal quality defined by DLWC as a total dissolved solids content between 501 and 1,500 mg/L with higher yielding individual supplies (defined as > 1.5 L/s) located closer to the Tweed River (See Figure 3).

The DLWC mapping also indicates that upstream of the Bray Park area, that the alluvium along the middle arm of the Tweed River / Oxley River hosts groundwater of fresh quality with fresh quality defined by DLWC as a total dissolved solids content less than 500 mg/L with higher yielding individual supplies (ie. > 1.5 L/s) located closer to the Tweed River (See Figure 3). The DLWC mapping indicates that although the alluvium of the tributaries of the Rous River and Dunbible Creek hosts low salinity groundwater, the yields from individual water bores in these areas is likely to be less than 1.5 L/s.

A preliminary review of DWE database information provides relatively little data regarding the alluvium in the Bray Park area, suffice to note that the data available suggests that immediately upstream of Bray Park the alluvium thins markedly away from the course of the middle arm of the Tweed River although one well (GW012644) constructed approximately 1 km east of the weir and 300 m from the river on its left bank penetrated to a total depth of 4.9 m and drew a supply reported to be 2.53 L/s from a depth of 2.7 m and a standing groundwater level of 1.2 m bGL.

The area of alluvium upstream of the Bray Park area along the middle arm of the Tweed River / Oxley River that hosts groundwater of fresh quality covers 8.87 km^2. Adopting McKibbon's recharge estimate of 2% of mean rainfall and applying this to the mean annual rainfall for Murwillumbah of 1,576.9 mm, a total recharge to this section of alluvium of 306 ML/a is projected. This figure is very much only a preliminary projection as it is likely that the stream has some connection with the groundwater system and stream recharge would form a component of the overall recharge to the system. Adopting McKibbon's saturated thickness assumption of 15 m and effective porosity of 10%, a total groundwater storage of 13,305 ML is projected.

Under the NSW Department of Natural Resources (2006a) Macro Water Sharing Plans process a report card document has been provided for the Tweed River Alluvium Groundwater Source which is categorised to consist of floodplain sand and gravel deposits in the Tweed valley. In the report card for this source it is indicated that typical bore depths range from 5 - 20 metres, usually underlain by the metamorphosed rocks of the New England Fold Belt and older sediments of the Tweed River Alluvium.

The report card document indicates that the alluvium of the Tweed River covers of 127 km^2 and receives recharge at a rate of 22861 ML/a (effectively 226 mm/a or 11% of mean annual rainfall at Murwillumbah). The document indicates that at June 2006 the existing licensed entitlement for this unit was 555 ML/a of which 37% is general purpose, 34% stock and domestic, and 23% other purposes.

The report card proposes that the volume available for licensed and approved extraction (based on sustainability factor of 60% of recharge) is 13,716 ML/a. This suggests that in the area underlain by the alluvium of the Tweed River system at June 2006 potentially, groundwater supplies of 13,161 ML/a remained unassigned.

DLWC (1997c&d) rated the vast majority of outcrop area of the Tweed River alluvium to be of "Moderately High" vulnerability although the alluvium of the Rous River was rated to be of "High Vulnerability". DLWC (1997c&d) indicated that "Moderately High" vulnerability ranked groundwater resources for the Tweed and Brunswick area included shallow aquifers associated with moderate slopes, higher rainfall and higher recharge with soils often moderately to highly permeable, with a moderate to high cation exchange capacity and a depth to water of less than 10 metres.

2.4.6 Quaternary age coastal dune sand deposits

McKibbon (1995) has indicated that interspersed between rocky headlands, coastal sand masses extend almost the entire seaboard length of the upper north coast of NSW. McKibbon noted that the NSW Department of Water Resources had undertaken geophysical surveys (electromagnetics and conventional resistivity soundings) to investigate these sediments at Chinderah and at Cudgen – Bogangar Beach within Tweed Shire and found that there was potential for low salinity groundwater to be present.

McKibbon noted that generally the beach and dune sands are of fine to medium grain size (ie. 0.12 – 0.5 mm diameter). He also noted that within the sands a dark carbonaceous cemented sand layer (up to 14 m in thickness) is often found, particularly in heathland areas. McKibbin noted that the coastal sand beds are an important aquifer system because they catch and store a significant proportion of the rain that falls on them and because their permeability is generally high. He noted that with proper bore design, yields of up to 40 L/s can be drawn from some bores, however because of their connection with bodies of saline water great care is necessary to avoid saline intrusion.

McKibbon (1995) has noted that watertables within the sands are often shallow and consequently freshwater lagoons, lakes and freshwater wetland habitats within the sand beds are common and represent windows in the watertable. He also noted that whilst groundwater salinity within these sediments is generally low, some water quality issues exist in some areas associated with the presence of hydrogen sulphide, iron or excessive colour.

McKibbon (1995) noted that large numbers of spear points and bores are used to draw groundwater from these sediments on the upper north coast of NSW and he noted the presence of 177 such facilities. He noted that such sediments have significant potential to provide reticulated urban supplies and noted that within the upper north coast area town water supply bores had been constructed in them at Woodburn to supply Evans Head and Woodburn well to the south of Tweed Shire.

Although relatively recent surface geological mapping is available for the Quaternary age sequences (Troedson et al, 2004) for the purposes of this report the geological mapping of Brown (2001) has been used to project the area of dune sand sediments to support preliminary yield projections. This mapping was used to summarise the areas covered by dune sand sediments along the coastal section of Tweed Shire. Table 2.2 provides a summary of these areas.

Table 2.2 Summary of areas covered by dune sand sediments in Tweed Shire

Locality	Area covered by mapped dune sediments (km^2)
Tweed Heads to Fingal	14.28
Fingal to Kingscliff	5.82
Kingscliff to Bogangar	15.46
Bogangar to Hastings Point	3.92
Hastings Point to southern coast boundary of Tweed Shire	25.49
Total for Tweed Shire	64.97

Table 2.2 indicates that the dune sands of Tweed Shire occupy .approximately 65 km^2. Adopting a mean annual rainfall of 1,463.7mm/a (ie. mean rainfall at Coolangatta) and the unit rainfall recharge value of 20% quoted by McKibbon, an overall groundwater recharge of approximately 19,000 ML/a is projected for this aquifer within Tweed Shire. Adopting McKibbon's assumption of 15 m mean saturated thickness and mean porosity of 30% a storage value of 292,365 ML is projected for these sediments. Table 2.1 provides a summary of the projected storage and recharge for the key geological units of Tweed Shire including these sands.

It should be recognised that not all of the recharge projected for this unit is effectively available for extraction as some positive groundwater outflow is required at the coastline to maintain the hydrodynamic balance that prevents unacceptable seawater intrusion and some of the groundwater will provide environmental support for associated freshwater wetlands, streams and lakes. If 30% of the recharge is effectively recoverable then the total dune sand systems could provide supplies of approximately 5,700 ML/a.

It should be noted that a significant number of small-scale groundwater extraction facilities already tap these sands, hence a portion of the 5,700 ML/a is already being utilised.

Under the NSW Department of Natural Resources (2006b) Macro Water Sharing Plans process a report card document has been provided for the Tweed Coastal Sands Groundwater Source which is categorised to consist of coastal dunes and sand plains from Tweed Heads to Pottsville. In the report card for this source it is indicated that typical bore depths range from 5 - 20 metres, usually underlain by the metamorphosed rocks of the New England Fold Belt and older sediments of the Tweed River Alluvium.

The report card document indicates that the coastal dunes and sand plains from Tweed Heads to Pottsville cover an area of 77 km^2 and receive recharge at a rate of 17,430 ML/a (effectively 226 mm/a or 15% of mean annual rainfall at Coolangatta). This figure is at variance with that derived herein through analysis of the mapping of Brown (2001). The report card document indicates that the existing licensed entitlement for this unit is 778 ML/a of which 74% is general purpose, 15% stock and domestic, and 11% other purposes.

The report card proposes that the volume available for licensed and approved extraction (based on sustainability factor of 50% of recharge) is 8,168 ML/a. This suggests that in the area from Tweed Heads to Pottsville at June 2006 potentially groundwater supplies 7,390 ML/a remained unassigned.

This suggests that if the Macro Water Sharing Plans were formally introduced, they would not significantly constrain the development of the dune sands and associated aquifers.

DLWC (1997c&d) rated the vast majority of outcrop area of the coastal sand units to be of "High" aquifer vulnerability. DLWC (1997c&d) indicated that "High" vulnerability ranked groundwater resources for the Tweed and Brunswick area usually included unconfined, shallow, highly permeable, aquifers such as dune sand with minimal soil coverage and low slope with water tables less than 5 metres deep, combined with shallow soil depth, low slope, high to very high permeability, and low CEC.

3 IDENTIFICATION & CONFIRMATION OF GROUNDWATER OPTIONS AVAILABLE FOR AUGMENTATION OF TWEED SHIRE COUNCIL WATER SUPPLY

3.1 IDENTIFICATION OF CRITERIA BY WHICH RELEVANT GROUNDWATER OPTIONS CAN BE ASSESSED

The criteria by which the relevant groundwater options can be assessed include the following:

- Legislative and planning issues;
- Technical factors;
- Social factors
- Environmental factors
- Cost and yield; and
- Implementation timeframe.

3.1.1 Legislative and planning issues

The key legislative and planning issues relevant to the development of groundwater options revolve around the existing relevant NSW water resource management framework.

The NSW Department of Water and Energy (DWE) website (http://www.naturalresources.nsw.gov.au/water/legislation.shtml) provides succinct guidance regarding the water management regime that is relevant to groundwater development within NSW. This website indicates that the key parts of the water management framework in NSW that are relevant to Tweed Shire are:

- *Water Act 1912:* this Act came into force at the turn of the century and represented a different era in water management in NSW. This Act is being progressively phased out and replaced by the *Water Management Act 2000* but some provisions are still in force;
- *Water Management Act 2000*: this is the main piece of water legislation for NSW ensuring that water is provided for the environment and more secure access to water users. The provisions of the Act are being progressively implemented in NSW. In the water sharing plan areas licences and approvals are administered under the *Water Management Act*. Across the entire State, works within 40 metres of a river, lake or estuary require a controlled activity approval under this Act; and
- National Water Initiative: The NSW Government is a partner in the National Water Initiative (NWI) endorsed by the Council of Australian Governments in June 2004. The NSW Government prepared its NSW NWI Implementation Plan in 2005 containing specific actions for implementing the eight key elements of the NWI. The Plan was accredited by the National Water Commission on 18 August 2006.

The NSW government is undertaking a process of developing water sharing plans under the *Water Management Act 2000*. These plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water users such as town supply, rural domestic supply, stock watering, industry and irrigation.

For groundwater systems the environmental provisions in groundwater sharing plans are based on:

- protecting the long-term storage component of the aquifer; and
- reserving a proportion of the average annual recharge for the environment.

In addition the plans set local restrictions on pumping at certain times if water level drawdowns below a specified level are occurring or water quality is declining. Distance limits may also be set between bores or from groundwater dependent ecosystems.

To date no water sharing plan has been implemented for the Tweed Valley or for associated coastal groundwater systems within Tweed Shire. It would, however, be expected that such a plan/s will ultimately be formulated and that future significant groundwater development would be controlled by them.

In the absence of a water sharing plan for the Tweed Valley and associated coastal groundwater systems within Tweed Shire, bore licensing provisions of the *Water Act 1912* still prevail and currently all water bores in NSW are required to be licensed.

NSW has a well developed and documented framework for groundwater management that includes:

- a published NSW State Groundwater Policy Framework Document (DLWC, 1997e);
- a published NSW State Groundwater Quality Protection Policy (DLWC, 1998); and
- a published NSW State Groundwater Dependent Ecosystems Policy (DLWC, 2000).

It would be expected that DWE would expect any proposal for licenses to develop bores for town water supply for Tweed Shire to conform to the aforementioned framework for groundwater management and include an environmental assessment that would necessarily have to consider key matters such as:

- Protection of the groundwater resource from seawater intrusion due to over-abstraction;
- Protection of the environment due to impact on connected stream flows and / or impact on groundwater dependent ecosystems (eg. wetlands, springs, vegetation systems that draw on groundwater); and
- Protection of existing groundwater and surface water users

Under the NSW Government "Achieving Sustainable Groundwater Entitlements Program" the NSW Government embarked on a series of water reforms and has moved towards managing its groundwater systems with a focus on long-term sustainability. DWE define the sustainable yield of a groundwater system is that proportion of the aquifer recharge that can be extracted without compromising the integrity of the water source and the ecosystems and communities that depend on it.

It would be reasonable to expect that where groundwater extraction involved a net increase in water extraction from a water system, some refined estimate of overall groundwater system yield would be required.

As previously indicated there has been Macro Water Sharing Plan documents produced for the Tweed River Alluvium Groundwater Source and the Tweed Coastal Sands Groundwater Source - Report Card. It appears likely that DWE will move forward to formalise and implement these plans in the near future. These plans will place significant overall caps on groundwater take from the aforementioned two systems.

Considering the aforementioned framework, the key criteria based on the existing NSW water resource management framework will be:

- Proposal compliance with relevant Water Sharing Plans as they become available;
- Extraction of groundwater not so great as to cause unacceptable seawater intrusion;
- Extraction of groundwater not so great as to cause unacceptable diminution of groundwater levels beneath groundwater dependent ecosystems;
- Extraction of groundwater not so great as to cause unacceptable diminution of groundwater levels beneath linked-groundwater-dependent perennial streams;
- Extraction of groundwater not so great as to cause unacceptable diminution of groundwater levels inducing acid sulphate soil impacts to water quality; and
- Borefield locations should be remote from potentially contaminating activities (ie. adequate setbacks available to provide well-head protection zones).

3.1.2 Technical factors

The key technical factors relevant to the development of groundwater options revolve the following:

- Availability of host aquifers within reasonable distances from existing key population centres;
- Acceptable groundwater quality within host aquifers;
- Acceptable individual bore yields within host aquifers;
- Adequacy of recharge to aquifer systems (ie. balancing recharge against water currently extracted and proposed to be extracted and environmental needs);
- Access to suitable land to host borefields and pipelines;
- The pattern of existing groundwater use.

- Proposed groundwater extraction from system not greater than recoverable percentage listed in Table 2.1
- Suitable locations are accessible as public land to host borefields and pipelines (road reserves if public land not available); and
- Borefield not to be located in direct conflict with pattern of existing groundwater use.

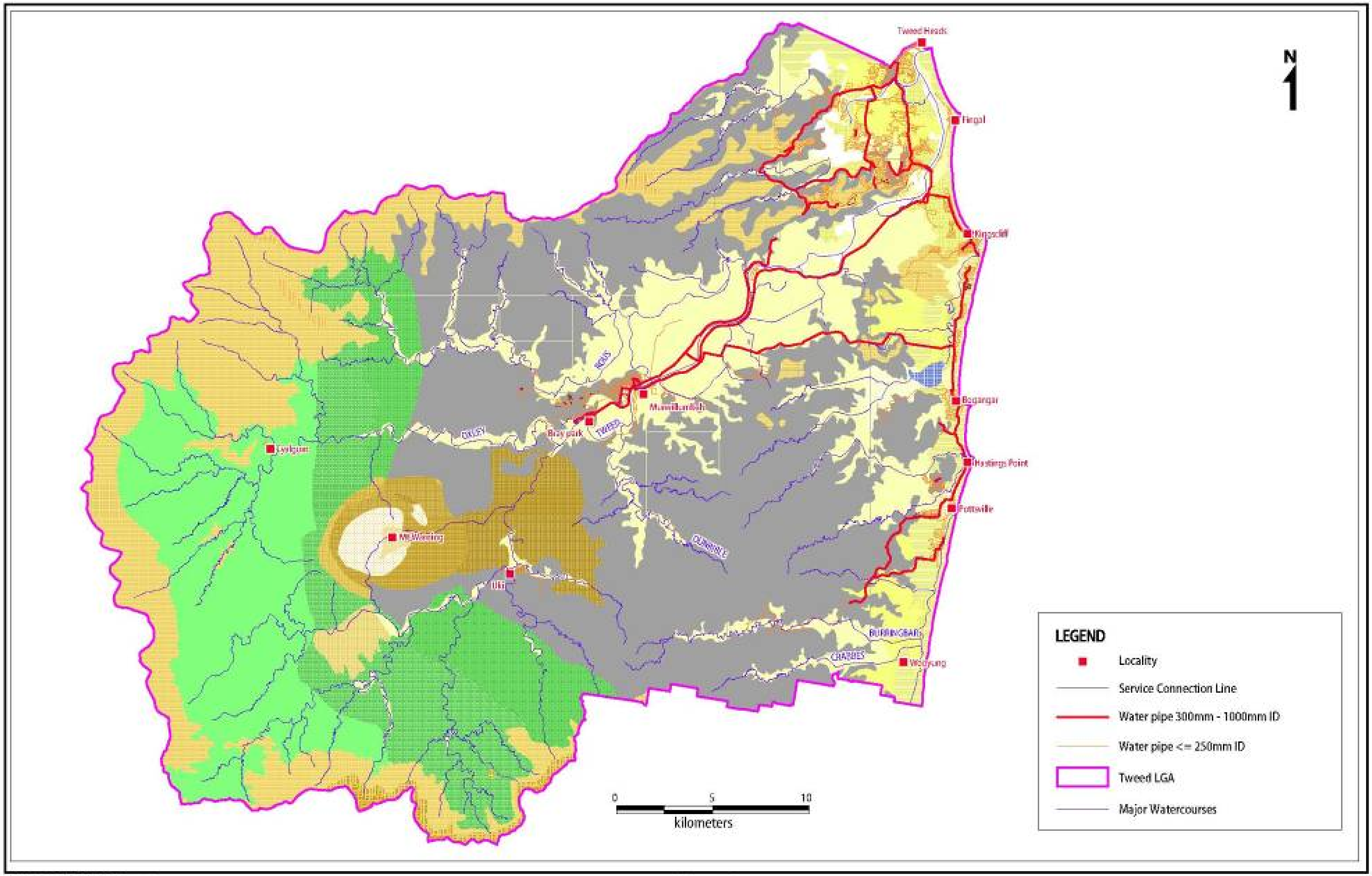

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Figure 5
SURFACE GEOLOGY OF STUDY AREA WITH EXISTING MAIN WATER RETICULATION

3.1.3 Social factors

The key social factors relevant to the development of groundwater options revolve the following:

- The need to maintain acceptable ongoing access to existing groundwater sources in terms of groundwater quality and yield;
- The need to restrict groundwater extraction to within rates that do not harm the environment and in so doing raise concerns regarding unacceptable environmental impact; and
- The need to impose well-head protection zones to exclude the development of potentially contaminating activities from the vicinity of bore fields through town planning instruments.

It should be noted that traditional landholders generally hold that water resources have a particular cultural significance and consideration of the views of traditional landholder groups should always form part of the overall assessment of project criteria.

Considering the aforementioned framework, the key proposed criteria will be:

- Proposed borefields to be greater than 200 m from significant concentrations of existing domestic bores.

3.1.4 Environmental factors

The key environmental factors relevant to the development of groundwater options revolve around the following:

- Avoidance of areas known to be subject to or actually hosting land and water contamination; and
- Recognition of the interconnectivity of groundwater systems with perennial streams, springs, lakes and wetland features of the landscape and the need to manage groundwater extraction within limits to avoid unacceptable impact to such features.

It should be noted than in addition to the relevant NSW State planning and environmental legislation, the Commonwealth environmental protection framework may potentially pose a significant challenge to the development of groundwater resources for urban purposes within Tweed Shire.

There are recent precedents for groundwater projects for town water supply projects being subject to the influence of the Commonwealth Environmental Protection and Biodiversity Protection Act 1999 where it has been determined that the groundwater project might potentially impact on a matter of national environmental significance. As an example of this the Bribie Island Borefield project in Queensland was deemed to be a controlled action under the EPBC Act by virtue of the presence of Ramsar Listed wetlands fringing Bribie Island even though the actual proposed borefield was remote from these wetlands.

Considering the aforementioned framework, the key proposed criteria will be:

- No borefield to be located within 500 m of a site of known or potential land contamination; and
- No borefield to be located within 500 m of a significant wetland.

3.1.5 Cost and yield

The key cost elements that need to be considered are:

- The groundwater supplies must have a reasonable yield to warrant construction;
- The proximity of potential groundwater sources to existing reticulation and treatment infrastructure;
- The required number of bores and required separation distances;
- The nature of treatment required for groundwater supplies;
- The required supporting hydrogeological studies for planning, feasibility and permitting purposes;
- The required groundwater monitoring systems to support operation of the borefields.

Clearly it is difficult to provide cost guidance that can be broadly applicable for all potential urban groundwater supply schemes because the viability of each scheme will be dependant on the individual circumstances of the borefield. However the following general criteria are suggested for the review:

- Supplementary groundwater supplies for small schemes should yield not less than 7.5 L/s (0.65 ML/d) and should consist of no more than 7 bores; and
- Supplementary groundwater supplies to augment major existing systems should target not less than 50 L/s (4.32 ML/d) and should consist of no more than 7 bores;
- Borefield locations should be within 3 km of existing or proposed major reticulation;
- Individual bores should be spaced not more broadly than 750 m;
- Groundwater salinity shall be less than 1,000 mg/L and ideally < 500 mg/L;

3.1.6 Implementation timeframe

The key implementation timeframe issues that need to be considered for groundwater sources are:

- Allowances for iterative rounds of hydrogeological investigation to transition the project/s from concept through feasibility and permitting (ie. including far more detailed studies than documented herein, test drilling, test pumping, and groundwater modelling and allowances for the collection of time-series groundwater level and quality data);
- Allowances for activities associated with permitting including community consultation where relevant;
- Allowances to construct production bores and associated monitoring bores; and
- Allowances to construct reticulation from borefields to suitable treatment / trunk main infrastructure (including permitting).

No specific criteria are proposed for the assessment of these considerations at this time.

3.2 COARSE-SCALE REVIEW OF LEGISLATIVE & PLANNING ISSUES RELEVANT TO GROUNDWATER OPTIONS

3.2.1 Review of adequacy of identified criteria to fulfil requirements for potential EIS

The criteria discussed in section 3.1 have been reviewed against the two main identified options. Table 3.1 provides comparison of the criteria for the Tweed River alluvium option against potential EIS requirements. Table 3.2 provides comparison of the criteria for the Tweed coastal sands option against potential EIS requirements.

3.2.2 Review of adequacy of identified criteria to fulfil requirements of relevant agencies in assessment of preferred option

The criteria discussed in section 3.1 have been reviewed against the two main identified options. Table 3.2 provides comparison of the criteria for the Tweed River alluvium option against potential requirements of regulatory agencies. Table 3.2 provides comparison of the criteria for the Tweed coastal sands option against potential requirements of regulatory agencies.

3.2.3 Review of planning & legislative issues to be addressed & risks that project will not be able to adequately address those issues

The project as currently scoped cannot fully address the investigations that would be required for an EIS on the two major identified options for groundwater development as it is apparent that in additional to significant additional desktop groundwater assessment, an appreciable amount of intrusive investigation work would be required (eg. geophysical investigations, construction of investigation / monitoring bores, construction and test pumping of trial production bores, numerical groundwater modelling etc.).

Further to this point, it is not possible to clearly delineate the best potential locations to host dune sand borefields at the stage of this investigation as a review of available reporting and mapping has borne out that additional more intensive desktop review work is required to identify locations of significant concentrations of existing bores and locations of wetland areas of conservation significance. Accordingly only very general indications can be made regarding the potential sites to host urban groundwater supplies.

3.2.4 Overview of location and operation of borefields

Given the current key population centres, existing major trunk water main locations and the location of a possible additional trunk water main to Ocean Shores, the key potential groundwater development options that could be envisaged for augmentation of town water supply are as follows:

- Development of a small borefield tapping the alluvium of the Middle arm of the Tweed River alluvium adjacent to Bray Park to provide an alternative and "cleaner" source of water for the Bray Park water treatment plant during times when surface water quality is particularly poor. Such a system would involved no net increase in water extraction from that section of the Tweed River; and
- Small-scale coastal dune sand supplies that occur on the coastal section of the Shire within reasonable proximity of the existing trunk water main system.

Table 3.1 Tweed River alluvium option against potential EIS & regulatory agency requirements

Issue category	Issue	Criteria	Criteria compliance	EIS requirement comment	Likely regulatory agency requirement
Legislative & planning issues	Proposal should comply with NSW DWE water sharing plans	Compliance with water sharing plans	Plans not yet in place, proposed yield within plan yield at June 2008		DWE will require compliance with Water Sharing Plans
	Proposal must not cause unacceptable seawater intrusion	Extraction sufficiently low to avoid seawater intrusion	Proposal involves periodic operation of borefield; additional studies required to confirm compliance	EIS will require groundwater modelling	DWE will require groundwater modelling
	Proposal should not result in damage to groundwater dependent ecosystems	Extraction sufficiently low to avoid unacceptable lowering of groundwater levels below GDE's (eg. riparian vegetation)	Should substantially comply. Proposal involves zero-sum offset of groundwater for surface water during periods of poor stream quality	EIS may require groundwater modelling to confirm temporal shifting between groundwater & surface water to be acceptable	
	Proposal should not result in ASS impacts	Extraction sufficiently low to avoid unacceptable lowering of groundwater levels inducing ASS impacts	Proposal involves periodic operation of borefield; additional studies required to confirm compliance	EIS may require groundwater modelling to confirm temporal shifting between groundwater & surface water to be acceptable	
	Proposal should not result in damage to groundwater dependent ecosystems	Extraction sufficiently low to avoid unacceptable reduction in flow of linked groundwater dependent streams	Should substantially comply. Proposal involves zero-sum offset of groundwater for surface water during periods of poor stream quality	EIS may require groundwater modelling to confirm temporal shifting between groundwater & surface water to be acceptable	
	Proposal needs to take into account water quality protection requirements	Site remote from potentially contaminating activities	Insufficient information at this stage of investigation, additional desktop investigations warranted - currently not possible to confirm well head protection needs	Desktop study of location of site contamination required	DWE will require demonstration of compliance with well head protection zone requirements
Technical factors	Availability of host aquifers within reasonable distances from existing key population centres	Aquifers are present within 3 km of existing or proposed major reticulation	Complies. DLWC Water availability mapping suggests that location of supplies meet criteria (preliminary review of DWE bore database suggests that major alluvial waterbodies are likely to be discrete)	Firm location and array of borefield will be required, additional review & intrusive investigation required	
	Acceptable groundwater quality within host aquifers	Groundwater salinity shall be less than 1,000 mg/L and ideally ≤ 500 mg/L	Likely to comply. DLWC Water availability mapping suggests that location of supplies meet criteria (Some construction of bores S/S of Bray Park might be required to achieve full yield)		DWE will require test drilling to confirm quality in area downstream of Bray Park because of potential issues with saline / brackish water
	Acceptable individual bore yields within host aquifers	Individual bore yields for appropriately constructed bores not less than 5 L/s of major alluvium and 1 L/s for dune sand systems	Likely to comply. If basal alluvial sands and gravels can be tapped with appropriately constructed bores significant individual yields should be possible (appreciable risk, test drilling required)		
	Adequacy of recharge to aquifer systems (ie. balancing recharge against water currently extracted and proposed to be extracted and environmental needs)	Proposed groundwater extraction from system not greater than recoverable percentage listed in Table 4	Should comply subject to additional assessment of seawater intrusion risk		DWE will require groundwater modelling
	Access to suitable land to host borefields and pipelines	Suitable locations are accessible as public land to host borefields and pipelines (road reserves if public land not available)	Should largely comply, bores may have to be constructed on road reserves if easements not available over private land		
	Pattern of existing groundwater use	Borefield not to be located in direct conflict with pattern of existing groundwater use	Should largely comply, however additional assessment of existing local bores required	EIS will require assessment of impact to existing users (groundwater modelling requirement)	DWE will require assessment of impact on existing users
Social factors	Need to maintain acceptable ongoing access to existing groundwater sources in terms of groundwater quality and yield Need to restrict groundwater extraction to within rates that do not harm the environment and in so doing raise concerns regarding an acceptable environmental impact Need to impose well-head protection zones to exclude the development of potentially contaminating activities from the vicinity of bore fields through town planning instruments	Proposed borefields to be greater than 500 m from significant concentrations of existing domestic bores	Should largely comply	EIS will require assessment of impact to existing users (groundwater modelling requirement)	DWE will require assessment of impact to existing users (groundwater modelling requirement)
Environmental factors	Avoidance of areas known to be subject to or actually hosting land and water contamination	No borefield to be located within 500 m of a site of known or potential land contamination	Not possible to confirm at this stage of study	EIS will require assessment of potential and actual land contamination status within well head protection zones	DWE will require demonstration of well head protection zones
	Recognition of interconnectivity of groundwater systems with perennial streams, springs, lakes & wetland features of landscape and need to manage groundwater extraction within limits to avoid unacceptable impact	No borefield to be located within 500 m of a significant wetland	Not possible to confirm at this stage of study	EIS will require assessment of potential impact to groundwater dependent features	DWE will require assessment of potential impact to groundwater dependent features
Cost and yield factors	The groundwater supplies must have a reasonable yield to warrant construction	Supplementary groundwater supplies for small schemes should yield not less than 7.5 L/s (0.65 ML/d) and should consist of no more than 7 bores. Supplementary groundwater supplies to augment major existing systems should target not less than 50 L/s (4.32 ML/d) and should consist of no more than 7 bores	Likely compliance	Test drilling & test pumping will be required	Test drilling & test pumping will be required
	Proximity of potential groundwater sources to existing reticulation and treatment infrastructure must be reasonable	Borefield locations within 3 km of existing or proposed major reticulation	Complies. DLWC Water availability mapping suggests that location of supplies meet criteria		
	The required number of bores and required separation distances must be reasonable	Individual bores should be spaced not more broadly than 750 m	Likely to comply	Test drilling will be required	Test drilling will be required
	Treatment processes for groundwater supplies should not extend to reverse osmosis (eg. only aeration, Fe / Mn removal, minor colour removal and disinfection processes)	Groundwater salinity shall be less than 1,000 mg/L and ideally ≤ 500 mg/L	Likely to comply. DLWC Water availability mapping suggests that location of supplies meet salinity criteria	Test drilling & sampling required to confirm treatment requirements	Test drilling & sampling required to confirm treatment requirements
	Supporting hydrogeological studies for planning, feasibility and permitting purposes must be reasonable & able to be achieved within reasonable time frames	No particular criteria proposed	NA	NA	NA

Table 3.2 Tweed River coastal sand option against potential EIS & regulatory agency requirements

Issue category	Issue	Criteria	Criteria compliance	EIS requirement comment	Likely regulatory agency requirement
Legislative & planning issues	Proposal should comply with NSW DWE water sharing plans	Compliance with water sharing plans	Plans not yet in place, proposed yield within plan yield at June 2008		DWE will require compliance with Water Sharing Plans
	Proposal must not cause unacceptable seawater intrusion	Extraction sufficiently low to avoid seawater intrusion	Proposal involves periodic operation of borefield; additional studies required to confirm compliance	EIS will require groundwater modelling	DWE will require groundwater modelling
	Proposal should not result in damage to groundwater dependent ecosystems	Extraction sufficiently low to avoid unacceptable lowering of groundwater levels below GDE's (eg. riparian vegetation)	Depends on specific locations chosen, further study required to refine locations of proposed borefields	EIS may require groundwater modelling to confirm acceptable impact to GDE's	DWE will require groundwater modelling
	Proposal should not result in ASS impacts	Extraction sufficiently low to avoid unacceptable lowering of groundwater levels inducing ASS impacts	Additional ASS & groundwater studies required to confirm compliance	Likely EIS requirement for ASS impact assessment	DWE will require groundwater modelling
	Proposal should not result in damage to groundwater dependent ecosystems	Extraction sufficiently low to avoid unacceptable reduction in flow of linked groundwater dependent streams	Depends on specific locations chosen, further study required to refine locations of proposed borefields	EIS may require groundwater modelling to confirm acceptable impact to local streams	DWE will require groundwater modelling
	Proposal needs to take into account water quality protection requirements	Site remote from potentially contaminating activities	Depends on specific sites adopted, insufficient information at this stage of investigation, additional desktop investigations warranted - currently not possible to confirm well head protection needs	Further refinement of location of borefields needed, Desktop study of location of site contamination required	DWE will require demonstration of compliance with well head protection zone requirements
Technical factors	Availability of host aquifers within reasonable distances from existing key population centres	Aquifers are present within 3 km of existing or proposed major reticulation	Depends on final locations selected but would be expected to achieve compliance based on DLWC Water availability mapping	Firm location and array of borefield will be required, additional review & intrusive investigation required	DWE will have to issue licences for both test drilling & production drilling
	Acceptable groundwater quality within host aquifers	Groundwater salinity shall be less than 1,000 mg/L and ideally ≤ 500 mg/L	Likely to comply. DLWC Water availability mapping suggests that location of supplies will generally meet criteria		DWE will require test drilling to confirm quality
	Acceptable individual bore yields within host aquifers	Individual bore yields for appropriately constructed bores not less than 5 L/s of major alluvium and 1 L/s for dune sand systems	Likely to comply, sufficient depths of dune sands with appropriately constructed bores should yield significant individual supplies (1 - 5 L/s) (Moderate risk, test drilling required)		
	Adequacy of recharge to aquifer systems (ie. balancing recharge against water currently extracted and proposed to be extracted and environmental needs)	Proposed groundwater extraction from system not greater than recoverable percentage listed in Table 4	Should comply subject to additional assessment of seawater intrusion risk	EIS will require groundwater modelling	DWE will require groundwater modelling
	Access to suitable land to host borefields and pipelines	Depends on final locations identified, suitable locations are accessible as public land to host borefields and pipelines (road reserves if public land not available)	Should largely comply, bores may have to be constructed on road reserves if easements not available over private land		
	Pattern of existing groundwater use	Borefield not to be located in direct conflict with pattern of existing groundwater use	Depends on final locations that will require additional investigation to ensure compliance	EIS will require assessment of impact to existing users (groundwater modelling requirement)	DWE will require assessment of impact on existing users
Social factors	Need to maintain acceptable ongoing access to existing groundwater sources in terms of groundwater quality and yield Need to restrict groundwater extraction to within rates that do not harm the environment and in so doing raise concerns regarding unacceptable environmental impact Need to impose well-head protection zones to exclude the development of potentially contaminating activities from the vicinity of bore fields through town planning instruments	Proposed borefields to be greater than 500 m from significant concentrations of existing domestic bores	Depends on final locations that will require additional investigation to ensure compliance	EIS will require assessment of impact to existing users (groundwater modelling requirement)	DWE will require assessment of impact to existing users (groundwater modelling requirement)
Environmental factors	Avoidance of areas known to be subject to or actually hosting land and water contamination	No borefield to be located within 500 m of a site of known or potential land contamination	Not possible to confirm at this stage of study	EIS will require assessment of potential and actual land contamination status within well head protection zones	DWE will require demonstration of well head protection zones
	Recognition of interconnectivity of groundwater systems with perennial streams, springs, lakes & wetland features of landscape and need to manage groundwater extraction within limits to avoid unacceptable impact	No borefield to be located within 400 m of a significant wetland	Not possible to confirm at this stage of study however this is a key development constraint	EIS will require assessment of potential impact to groundwater dependent features	DWE will require assessment of potential impact to groundwater dependent features
Cost and yield factors	The groundwater supplies must have a reasonable yield to warrant construction	Supplementary groundwater supplies for small schemes should yield not less than 7.5 L/s (0.65 ML/d) and should consist of no more than 7 bores. Supplementary groundwater supplies to augment major existing systems should target not less than 50 L/s (4.32 ML/d) and should consist of no more than 7 bores	Likely compliance	Test drilling & test pumping will be required	Test drilling & test pumping will be required
	Proximity of potential groundwater sources to existing reticulation and treatment infrastructure must be reasonable	Borefield locations within 3 km of existing or proposed major reticulation	Should largely comply subject to further work to delineate targets. DLWC Water availability mapping suggests that most of the units meet criteria. Smaller decentralised treatment would be required prior to injection into mains or local use		
	The required number of bores and required separation distances must be reasonable	Individual bores should be spaced not more broadly than 750 m	Likely to comply	Test drilling will be required	Test drilling will be required
	Treatment processes for groundwater supplies should not extend to reverse osmosis (eg. only aeration, Fe / Mn removal, minor colour removal and disinfection processes)	Groundwater salinity shall be less than 1,000 mg/L and ideally ≤ 500 mg/L	Likely to comply for salinity in most areas based on DLWC Water availability mapping, however potential issues exist regarding dissolved iron, manganese and organic colour (tannin)	Test drilling & sampling required to confirm treatment requirements	Test drilling & sampling required to confirm treatment requirements
	Supporting hydrogeological studies for planning, feasibility and permitting purposes must be reasonable & able to be achieved within reasonable time frames	No particular criteria proposed	NA	NA	NA

It should be noted that McKibbon (1995) documented specific investigations by DLWC in Chinderah and Cudgen – Bodanger Beach areas within Tweed Shire and found that there was potential for low salinity groundwater to be present. There are significant dune sand sediments present in the area to the north and north west of Cudgen Lake and notwithstanding the DLWC Water Availability mapping that indicates the presence of some relatively saline groundwater associated with the course of Cudgen Creek to the direct north and north north east of the lake review of the potential of the dune sands in this general area appears to be warranted.

A further and more detailed assessment of the potential dune sand water sources appears to be warranted with such work including a detailed review of DWE water bore database records.

3.2.5 Potential social factors associated with groundwater options

The greatest potential social factors associated with any proposed additional groundwater extraction will be:

- Potential adverse impacts to existing users in terms of quantitative diminution of access to water resources; and if the additional extraction is inappropriately managed
- Potential adverse impacts to users in terms of diminution of the quality of water available in the relevant water resources.

There is potential for both of the main identified opportunities to impact on existing users, however it would be expected that the greatest groundwater stress would be found in areas of the dune sands where there is existing residential or resort development.

Often community groups have strong awareness of the environmental significance of groundwater systems and in some circumstances, strong and vocal community opposition to groundwater extraction occurs (eg. Bribie Island Town Water Supply Project in Queensland).

3.2.6 Potential environmental factors associated with groundwater options including sustainability

As discussed elsewhere in this report the NSW Department of Water and Energy has a groundwater management framework that explicitly acknowledges that groundwater can play an important role in the maintenance of groundwater dependent ecosystems and hydrological features (eg. springs, wetlands, lakes, perennial streams).

For the identified opportunity for development in the Tweed River alluvium upstream, the key environmental factors would be:

- Management of the risk of potential upstream migration of poorer quality (brackish to saline) groundwater through the alluvium from downstream of Bray Park in response to excessive groundwater pumping;
- Potential diminution of stream flow associated with extraction from the alluvium; and
- Possible acid sulphate soil mechanisms associated with changes to groundwater levels.

Additional environmental factors may ultimately be associated with these key factors (eg. impact on aquatic flora, fauna or riparian vegetation associated with the middle arm of the Tweed River).

For the identified opportunity for development in the small-scale coastal dune sand supplies, the key environmental factors would be:

- Management of the risk of potential seawater intrusion (brackish to saline) groundwater through the sands from the coastline in response to excessive groundwater pumping; and
- Potential groundwater level reduction beneath local groundwater dependent wetlands that are often associated / juxtaposed with dune sand deposits;
- Potential groundwater level reduction beneath local groundwater dependent terrestrial vegetation that is often associated with dune sand deposits (eg. *Allocasuarina* sp. trees);
- Potential groundwater contamination from local surface sources such as municipal solid waste landfill facilities, septic tanks, fuel storage and household application of agricultural chemicals; and
- Possible acid sulphate soil mechanisms associated with changes to groundwater levels.

3.2.7 Potential cost & yield factors associated with groundwater options including security of yield

Notwithstanding this cost build up, a fast-tracked project recently completed on Bribie Island to establish a 4.32 ML/d borefield has had a capital cost of approximately $39 million inclusive of bore construction (20 production bores), monitoring bores, pumps, reticulation, power and a full treatment plant. Of this total amount the bore construction and associated clearing cost approximately $2 million. Initial indicative unit operating costs for this plant are approximately $320,000/a which equates to approximately $200/ML/a. It should be noted that this figure excludes costs associated with environmental monitoring and reporting required under the approval for this project.

The recent Brisbane aquifer project, fast-tracked contingency groundwater supply project included five treatment plants and approximately 40 production bores together with monitoring bores and has had a capital cost in the order of $120 million. These two recent projects have suggested capital costs for small-scale urban groundwater supplies with full treatment in the order of $6 – 9 million/ML/d of supply.

These are reasonable figures to adopt for the opportunities identified herein if significant treatment is required for the Tweed River alluvium near Bray Park to address iron / manganese. Accordingly a capital cost in the order of $40 million for the opportunity identified at Bray Park for intermittent access to better quality groundwater.

The key to projecting associated costs with coastal sands groundwater sources is water quality as often these groundwaters have low pH, elevated iron and elevated colour. Where water quality is poorer, full treatment trains are required, however it should be noted that some coastal sand masses host groundwater of very good quality requiring very little treatment other than aeration and disinfection. If a high quality groundwater source can be located, then the overall capital costs for a small system are likely to be less than $5 million whilst costs for a small source with poorer water quality are likely to be prohibitive. For larger coastal sand systems with moderate water quality the capital cost of the Bribie Island plant should provide a good contemporary analogy.

It should be noted that the provision of treatment is the major cost associated with the identified groundwater options and if high quality raw groundwater can be produced, treatment requirements can be reduced with very significant cost savings.

3.2.8 Initial projection of reasonable implementation timeframes

Table 3.3 provides a preliminary projection of scheduling associated with the development of development of a small borefield tapping the alluvium of the Middle arm of the Tweed River alluvium adjacent to Bray Park to provide an alternative and "cleaner" source of water for the Bray Park water treatment plant during times when surface water quality is particularly poor. It should be noted that the schedule indicated in Table 3.3 does not include an allowance for reticulation, procurement and installation of final production pumps or treatment facilities. If the groundwater in the alluvium has negligible iron and manganese, it may be the case that with the Tweed River alluvium opportunity that the raw groundwater may be able to be introduced directly into the treatment train (or a sub-stream thereof) at the Bray Park facility. If there is appreciable iron or manganese present then the raw water would require some additional treatment train and an additional allowance would need to be made for the provision of this.

Table 3.3 Preliminary projection of scheduling associated with development of small borefield tapping alluvium of the Middle arm of Tweed River alluvium

Project task	Required time (months)
Additional desktop-based groundwater investigations	0.5
Pre-feasibility engineering & environmental assessment & review	3
Lag to allow for permitting processes for test drilling	2
Investigation drilling & construction of groundwater monitoring bores (assume 15 bores)	2
Construction and test pumping of 2 x initial pilot production bores	1
Lag to allow collection of temporal groundwater level data	3
Preparation of groundwater model for planning and permitting purposes	4
Environmental studies associated with permitting	6
Lag to allow for permitting processes	12
Construction & testing of residual production bores (assume 5 bores)	4
Construction of reticulation	4
Total	41.5

Table 3.4 provides a preliminary projection of scheduling associated with the development of small-scale coastal dune sand supplies that occur on the coastal section of the Shire within reasonable proximity of the existing trunk water main system. It should be noted that the schedule indicated in Table 3.4 does not include an allowance for reticulation, procurement and installation of final production pumps or treatment facilities.

Table 3.4 Preliminary projection of scheduling associated with development of small-scale coastal dune sand supplies that occur on coastal section of Tweed Shire

Project task	Required time (months)
Additional desktop-based groundwater investigations - detailed refinement of locations to host borefields	2
Pre-feasibility engineering & environmental assessment & review	4
Lag to allow for permitting processes for test drilling	2
Investigation drilling & construction of groundwater monitoring bores (assume 15 bores)	2
Construction and test pumping of 2 x initial pilot production bores	1
Lag to allow collection of temporal groundwater level data	3
Preparation of groundwater model for planning and permitting purposes	4
Environmental studies associated with permitting	6
Lag to allow for permitting processes	12
Construction & testing of residual production bores (assume 5 bores)	4
Construction of reticulation	4
Total	44

4 CONCLUSIONS

The key conclusions of this assessment are that the best options for groundwater development to provide augmentation to Tweed Shire town water supplies are:

- Alluvial aquifers associated with middle arm of the Tweed River system upstream of Bray Park to the west south west of Murwillumbah upstream of the saline groundwater influence where a borefield might be able to be constructed to opportunistically harvest high quality groundwater during periods of time when the river water quality is particularly poor, without substantially expanding the overall take of water from the stream / aquifer system. A likely short-term yield in the order of 50 L/s (4.32 ML/d) could potentially be exploited to improve the raw water feed quality to the Bray Park treatment plant from up to 7 bore constructed to tap basal alluvium from bores to 20 m deep;
- Small-scale coastal dune sand supplies that occur on the coastal section of the Shire within reasonable proximity of the existing trunk water main system. At the current level of this study it is not possible to delineate specific locations for borefields, however specific investigations by DLWC in Chinderah and Cudgen – Bodanger Beach areas within Tweed Shire and found that there was potential for low salinity groundwater to be present. There are significant dune sand sediments present in the area to the north and north west of Cudgen Lake and notwithstanding the DLWC Water Availability mapping that indicates the presence of some relatively saline groundwater associated with the course of Cudgen Creek to the direct north and north north east of the lake review of the potential of the dune sands in this general area appears to be warranted. A further and more detailed assessment of the potential dune sand water sources appears to be warranted with such work including a detailed review of DWE water bore database records.
- The key cost elements associated with the identified groundwater options involve treatment of the raw groundwater. At this point in the study it is not possible to be definitive regarding the likely quality in either the Tweed river alluvium or the Tweed coastal sands save to note that low salinity groundwater is likely. If significant treatment of the raw groundwater is required to address parameters such as iron, manganese or colour, then the costs of the options will be very high. For small scale groundwater supplies requiring appreciable treatment, capital costs in the order of $6 – 9 million/ML/d of supply are indicated by recent analogous projects in Queensland with indicative operating costs in the order of $200/ML/a. For small scale projects with high quality groundwater requiring limited treatment, significantly lower costs would be applicable.

5 RECOMMENDATIONS

The following key recommendations are made:

- The Tweed District Water Supply Augmentation Options Study should consider the groundwater options identified herein;
- If additional clarification is required for the study regarding potential options to develop the Tweed coastal sands, a further and more detailed assessment of the potential dune sand water sources should be undertaken with such work including a detailed review of DWE water bore database records.

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APPENDIX A

GEOLOGICAL MAP KEY

Appendix A - Geological key (after Brown, 2001 & Troedson et al, 2004)

Era	Period / Epoch	Geological symbol	Formation Name	Group or key association	Structural Element	Lithological Description
Cainozoic	Quaternary / undifferentiated	Qb	Unnamed marine barrier sediments	Coastal sediments	Recent cover	Sand
Cainozoic	Quaternary / undifferentiated	Qa2	Alluvial deposits overlying marine barrier sediments	Valley & floodplain sediments	Recent cover	Sand, silt, clay & gravel
Cainozoic	Quaternary / undifferentiated	Qa	Alluvial deposits	Valley & floodplain sediments	Recent cover	Sand, silt, clay & gravel
Cainozoic	Quaternary / undifferentiated	Qrs	Residual soils, colluvium & alluvium	Regolith	Recent cover	
Cainozoic	Quaternary / Holocene	Qhbw	Beach-ridge swale and dune-deflation hollow	Coastal Barrier	Recent cover	Marine sand, organic mud, peat
Cainozoic	Quaternary / Holocene	Qhbd	Dune	Coastal Barrier	Recent cover	Fine to very fine quartzose sand; low shell and heavy mineral content; well-sorted; low to moderate degree of pedogenesis and chemical weathering
Cainozoic	Quaternary / Holocene	Qher	Estuarine shoreline ridge and dune	Estuarine plain	Recent cover	Fine to coarse sand, clayey and / or silty sand, gravelly sand, gravel, sandy silt or clay; moderately to poorly sorted; may contain shell
Cainozoic	Quaternary / Pleistocene	Qpbd	Dune	Coastal Barrier	Recent cover	Fine to very fine quartzose sand; low to moderate heavy mineral content; no shell; well-sorted; high degree of chemical weathering, pedogenesis; often leached near surface, humate-impregnated in subsurface to form dark indurated sand ('coffee rock')
Cainozoic	Quaternary / Pleistocene	Qpbdr	Bedrock mantling dune	Coastal Barrier	Recent cover	Fine to very fine quartzose sand; low to moderate heavy mineral content; no shell; well to moderately sorted; highly chemically weathered; often leached near surface, humate-impregnated in subsurface to form dark indurated sand ('coffee rock')
Cainozoic	Tertiary	Tlbb	Lamington Volcanics - Blue Knob Basalt & Andesite	Lamington Volcanics	Tertiary volcanics	Basalt & andesite
Cainozoic	Tertiary	Tlb	Lamington Volcanics - sub-alkali basalt	Lamington Volcanics	Tertiary volcanics	Sub-alkali basalt

Era	Period / Epoch	Geological symbol	Formation Name	Group or key association	Structural Element	Lithological Description
Cainozoic	Tertiary	Twb	Mt Warning Central Complex - unnamed basalt	Mt Warning Complex	Tertiary volcanics	Basalt
Cainozoic	Tertiary	Twd	Mt Warning Central Complex - unnamed dolerite & basalt	Mt Warning Complex	Tertiary volcanics	Dolerite & basalt
Mesozoic	Jurassic	Jwx	Walloon Coal Measures		Moreton Basin	Shale, siltstone, sandstone, coal seams
Mesozoic	Triassic - Jurassic	RJbwx	Woogaroo Subgroup	Bundamba Group	Moreton Basin	Polymictic conglomerate, quartzose sandstone, siltstone, shale and coal weathered
Mesozoic	Triassic	Rcr	Chillingham Volcanics		Ipswich Basin	Rhyolite, tuff, shale
Palaeozoic	Devonian Carboniferous	Cnx	Neranleigh Fernvale Beds		South D'Aguilar & Beenleigh Blocks	Mudstone, shale, arenite, chert, jasper, basic metavolcanics, pillow lava, conglomerate

APPENDIX E : MULTI CRITERIA ANALYSIS (MCA) MATRIX

TWEED SHIRE COUNCIL

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

TABLE 1: DETERMINATION OF COARSE SCREEN RATINGS

MULTI CRITERIA ANALYSIS FOR ASSESSMENT OF OPTIONS

ASSESSMENT CRITERIA

No.	Option	Secure Yield – Rating	Secure Yield – Description	Planning Obligations – Rating	Planning Obligations – Description	Established Technologies & Feasibility – Rating	Established Technologies & Feasibility – Description	Environmental Constraints – Rating	Environmental Constraints – Description	Social Acceptability – Rating	Social Acceptability – Description
1	Raising Clarrie Hall Dam	5	Previous studies show this option will provide an additional 8,260 ML/annum, which is in excess of the required additional secure yield of 5,260 ML/annum over the planning horizon.	4	The existing dam area is zoned for a dam. Council owns most of the new inundation area with the remainder being zoned rural land.	5	Foundation conditions and potential materials areas are well understood at this site.	3	Some significant forest and threatened species have been identified in the area to be inundated. Preliminary investigations completed.	3	Some land acquisition will be required and small deviation of local roads. Social impacts considered relatively minor since raising is on the site of an existing dam.
2	Byrrill Creek Dam Construction	5	Previous studies show this option will provide an additional 9,000 ML/annum, which is in excess of the required additional secure yield of 4,260 ML/annum over the planning horizon.	3	Council owns part of the inundated area. The majority of the area is zoned for a dam with some land zoned rural.	5	Foundation conditions are expected to be similar to the Clarrie Hall Dam with few potential unknowns.	2	Higher potential than CHD for impacting upon significant flora and threatened species in the inundated area and near the dam site.	2	Some land acquisition will be required and probable closure, or deviation of Byrrill Creek Road.
3	Oxley River Dam Construction	5	Previous studies show this option will provide an additional 20,000 ML/annum, which is well in excess of the required additional secure yield of 5,260 ML/annum over the planning horizon.	2	Land that will be inundated is zoned Rural 1(a), Forestry 8(a) and Environmental Habitat 7(l).	5	Foundation conditions are not expected to raise serious concerns from the potential unknowns.	1	Actual effects are unknown, but given dense vegetation and other land uses, there are likely to be significant effects to flora and fauna, cultural heritage and private landowners.	1	Significant land acquisition will be required. Closure of Tyalgum Road and significant potential for flooding of Tyalgum village.
4	Pipeline to Rous Water	1	The estimated additional supply of 1,800 ML/annum is insufficient as a stand-alone solution.	4	Pipelines for water supply may be constructed without development consent.	5	No insurmountable issues envisaged with pipeline construction technologies.	4	Pipeline route is along the Old Coast Road, which has already been disturbed, but is in proximity to the Billinudgel Nature Reserve.	3	Potential for water to flow in either direction, enhancing water security to both Tweed and Byron communities. However, inter-valley water transfers have previously been politically problematic.
5	Pipeline to SEQ Water Grid	3	Although this option may provide an additional 7,300 ML/annum, there is a risk that it may not be available when required.	2	Needs Federal EPBC Act approval and pipeline will be in future road reserve of Cobaki Lakes development.	5	No insurmountable issues envisaged with pipeline construction technologies in road reserves.	5	Pipeline route is adjacent to the Tugun By-pass and along a future road reserve as part of Cobaki Lakes development.	3	Potential for water to flow in either direction. However, cross-border water transfers have previously been politically problematic.
6	Desalination	4	Depending on further investigation and the final receiving network configuration, this option may provide an additional 7,500 ML/annum.	3	Development consent is likely to include onerous requirements for brine disposal and siting of plant and pipelines. However, precedents do exist in NSW.	2	Thermal and membrane desalination technologies for public water supplies are still developing and highly specialised, but are now recognised in Australia.	1	Disposal of brine by-products is a significant concern. Potential for impacts along the 10 km pipeline, including at coastal headlands and for acid sulphate soils. High chemical and energy use during operation.	2	Social concerns are expected to be raised over disposal of the brine wastes to either Norries Head, or near Bogangar Beach.
7	Groundwater	1	The estimated additional supply of 1,470 ML/annum is insufficient as a stand-alone solution.	2	Development of groundwater resources requires conformance with two State and one Federal legislative frameworks.	4	Whilst borefield technologies are well understood, the outcomes can be uncertain.	2	Borefields to be regulated for set-back distances from wetlands and for adverse effects upon terrestrial vegetation.	3	Concerns may be raised over unacceptable environmental impact.
8	Indirect Potable Reuse	3	This option may provide an additional 10,200 ML/annum, depending on further investigation, the final site configuration and possible staging.	1	Development consent is likely to include onerous requirements from a broader range of agencies for siting of pipelines and disposal of treatment process by-products and toxins.	3	MF / RO advanced water treatment technologies for public water supplies are still developing and highly specialised, but are now recognised in Australia.	2	Disposal of treatment process by-products and toxins is a concern. Potential for impacts along the 80 km pipeline including acid sulphate soils. High chemical and energy use during operation.	2	Social concerns are expected to be raised regarding assurance of public health and disposal of the brine wastes.
9	Direct Potable Reuse	3	This option may provide an additional 10,200 ML/annum, depending on further investigation, possible staging and the final site and receiving network configurations.	1	NSW legislative framework not yet developed for this option. Development consent is likely to include onerous requirements from a broad range of agencies for brine disposal and siting of pipeline.	1	Advanced water treatment multi-barrier technologies for public water supplies for direct potable reuse are untested in Australia.	2	Disposal of treatment process by-products and toxins is a concern. Potential for acid sulphate soil impacts during construction. High chemical and energy use during operation.	1	Significant social concern is expected regarding assurance of public health where DPR has not been implemented in Australia - and other options exist.

No.	Option	Legislative Acceptability – Rating	Legislative Acceptability – Description	Cultural Heritage Impacts – Rating	Cultural Heritage Impacts – Description	Lead Time for Construction & Potential for Escalation of Costs – Rating	Lead Time for Construction & Potential for Escalation of Costs – Description	Capital, Operations, NPV & Annualised Cost per ML – Rating	Capital, Operations, NPV & Annualised Cost per ML – Description	Greenhouse Gas & Energy Consumption – Rating	Greenhouse Gas & Energy Consumption – Description
1	Raising Clarrie Hall Dam	4	No significant legislative hurdles for raising on the site of an existing dam.	3	Sites of known Aboriginal significance will be inundated. Preliminary investigations completed.	3	Environmental investigations and approvals processes, together with dam raising period require significant lead times.	5	Annualised cost over 30 years is very favourable as $800 / ML.	5	GHG emissions are high initially during the construction phase, but thereafter are negligible under normal operations.
2	Byrrill Creek Dam Construction	2	NSW Weirs Policy discourages the construction of new on-stream storages. This, together with new acquisitions poses legislative difficulty.	1	Several sites of known Aboriginal significance will be inundated.	1	Environmental investigations and approvals processes, together with dam raising period require significant lead times, and more so than for CHD Raising.	4	Annualised cost over 30 years is favourable as $[illegible] / ML.	4	GHG emissions are higher than for CHD raising during the construction phase, but thereafter are negligible under normal operations.
3	Oxley River Dam Construction	1	NSW Weirs Policy discourages the construction of new on-stream storages. This, together with significant acquisitions poses legislative difficulty.	2	Sites of Aboriginal significance are yet to be documented, but are likely to be significant.	1	Environmental investigations and approvals processes, together with dam raising period require significant lead times, and more so than for CHD Raising.	4	Annualised cost over 30 years is favourable as $[illegible] / ML.	4	GHG emissions are higher than for CHD raising during the construction phase, but thereafter are negligible under normal operations.
4	Pipeline to Rous Water	3	Inter-valley transfers and the proximity of environmentally significant areas will require careful application of legislative procedures.	3	The majority of the pipeline would be constructed in areas previously disturbed, but no investigations have been carried out and an Archaeological Survey would be required.	3	Environmental approvals still required, but construction period longer than that for the pipeline to SEQ Water Grid.	1	Annualised cost over 30 years is unfavourable at $2,444 / ML.	3	GHG emissions will be relatively moderate during the construction phase. Emissions during operations will be linked to mechanical and electrical plant for pumping.
5	Pipeline to SEQ Water Grid	1	Agreement for transfer of water between the States is likely to be a protracted process.	4	Areas were previously identified under the Tugun By-pass EIS, but the majority of construction will be in areas previously disturbed.	4	Environmental approvals still required, but construction period is less than that for dams.	2	Annualised cost over 30 years is unfavourable at $1,655 / ML.	1	GHG emissions will be relatively moderate during the construction phase. GHG emissions during the operating phase will be very high where purchased water is produced by the Tugun Desalination Facility.
6	Desalination	1	The requirements for the disposal of the brine wastes and water extraction (among others) are likely to involve Ministerial discretionary powers.	2	Archaeological surveys will be required over the 10 km brine waste pipeline and the plant site.	2	Relatively long lead time required for approvals process under Part 3A of EP&A Act.	1	Annualised cost over 30 years is unfavourable at $2,752 / ML.	1	Both the construction phase and the operating costs will contribute significantly to GHG emissions.
7	Groundwater	3	There is an increasing legislative complexity being applied to the development of groundwater resources.	4	Traditional Owner groups regard groundwater resources as of particular cultural significance.	3	Lead time can be significant for environmental investigations, community consultation and approvals.	1	Annualised cost over 30 years is unfavourable at $2,535 / ML.	3	GHG emissions will be relatively moderate during the construction phase. Emissions during operations will be linked to the mechanical and electrical plant for pumping and water treatment.
8	Indirect Potable Reuse	2	The requirements for public health assurances and the disposal of the brine wastes (among others) are likely to involve Ministerial discretionary powers.	2	Archaeological surveys will be required over the 80 km of pipelines. Much of this is in previously disturbed road reserves.	2	Relatively long lead time required for approvals process under Part 3A of EP&A Act.	1	Annualised cost over 30 years is very unfavourable at $3,579 / ML.	1	Both the construction phase and the operating costs will contribute significantly to GHG emissions.
9	Direct Potable Reuse	1	Legislative framework is not yet tested and significant legislative hurdles are envisaged.	4	Minimal impacts as the 2.8 km pipeline is in previously disturbed road reserves.	2	Relatively long lead time required for approvals process under Part 3A of EP&A Act.	1	Annualised cost over 30 years is very unfavourable at $3,518 / ML.	1	Both the construction phase and the operating costs will contribute significantly to GHG emissions.

Notes: Rating is the impact upon the Assessment Criteria, which may be a risk, difficulty, etc. (The Rating is used in Table 2 to determine the Score for each option.)

Rating	Meaning
1	High negative risk, impact, difficulty
2	Difficulties encountered, which can be managed with special treatment
3	Moderately straightforward with a low degree of difficulty
4	Low negative impact
5	Very low negative impact / excellent

TWEED SHIRE COUNCIL APPENDIX E

TWEED DISTRICT WATER SUPPLY AUGMENTATION OPTIONS STUDY

TABLE 2: DETERMINATION OF COARSE SCREEN SCORES AND RANKINGS

MULTI CRITERIA ANALYSIS FOR ASSESSMENT OF OPTIONS

Option		ASSESSMENT CRITERIA: Secure Yield			Planning Obligations			Established Technologies & Feasibility			Environmental Constraints			Social Acceptability		
No.	Description	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score
1	Raising Clarrie Hall Dam	5	5	25	4	4	16	5	4	20	3	4	12	3	3	9
2	New Byrrill Creek Dam	5	5	25	3	4	12	5	4	20	2	4	8	2	3	6
3	New Oxley River Dam	5	5	25	2	4	8	5	4	20	1	4	4	1	3	3
4	Pipeline to Rous Water	1	5	5	4	4	16	5	4	20	4	4	16	3	3	9
5	Pipeline to SEQ Water Grid	3	5	15	2	4	8	5	4	20	5	4	20	3	3	9
6	Desalination	4	5	20	3	4	12	3	4	12	1	4	4	2	3	6
7	Groundwater	1	5	5	2	4	8	4	4	16	2	4	8	3	3	9
8	Indirect Potable Reuse	3	5	15	1	4	4	3	4	12	2	4	8	2	3	6
9	Direct Potable Reuse	3	5	15	1	4	4	1	4	4	2	4	8	1	3	3

Option		Legislative Acceptability			Cultural Heritage Impacts			Lead Time for Construction & Potential for Escalation of Costs			Capital, Operations, NPV & Annualised Cost per ML			Greenhouse Gas & Energy Consumption			Total Score	Rank
No.	Description	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score	Rating	WF	Score	Out of 250	1 to 9
1	Raising Clarrie Hall Dam	4	4	16	3	4	12	3	2	6	5	4	20	5	3	15	151	1
2	New Byrrill Creek Dam	2	4	8	2	4	8	1	2	2	4	4	16	4	3	12	117	2
3	New Oxley River Dam	1	4	4	2	4	8	1	2	2	4	4	16	4	3	12	102	5
4	Pipeline to Rous Water	3	4	12	3	4	12	3	2	6	1	4	4	3	3	9	109	4
5	Pipeline to SEQ Water Grid	1	4	4	4	4	16	4	2	8	2	4	8	1	3	3	111	3
6	Desalination	1	4	4	3	4	12	2	2	4	1	4	4	1	3	3	81	7
7	Groundwater	3	4	12	4	4	16	3	2	6	1	4	4	3	3	9	93	6
8	Indirect Potable Reuse	2	4	8	2	4	8	2	2	4	1	4	4	1	3	3	72	8
9	Direct Potable Reuse	1	4	4	4	4	16	2	2	4	1	4	4	1	3	3	65	9

Notes: **Rating** is the impact upon the Assessment Criteria, which may be a risk, difficulty, etc:

- **1 =** High negative risk, impact, difficulty
- **2 =** Difficulties encountered, which can be managed with special treatment
- **3 =** Moderately straightforward with a low degree of difficulty
- **4 =** Low negative impact
- **5 =** Very low negative impact / excellent

WF is the weighting factor, which is the relative level of significance placed on the Assessment Criteria as follows:

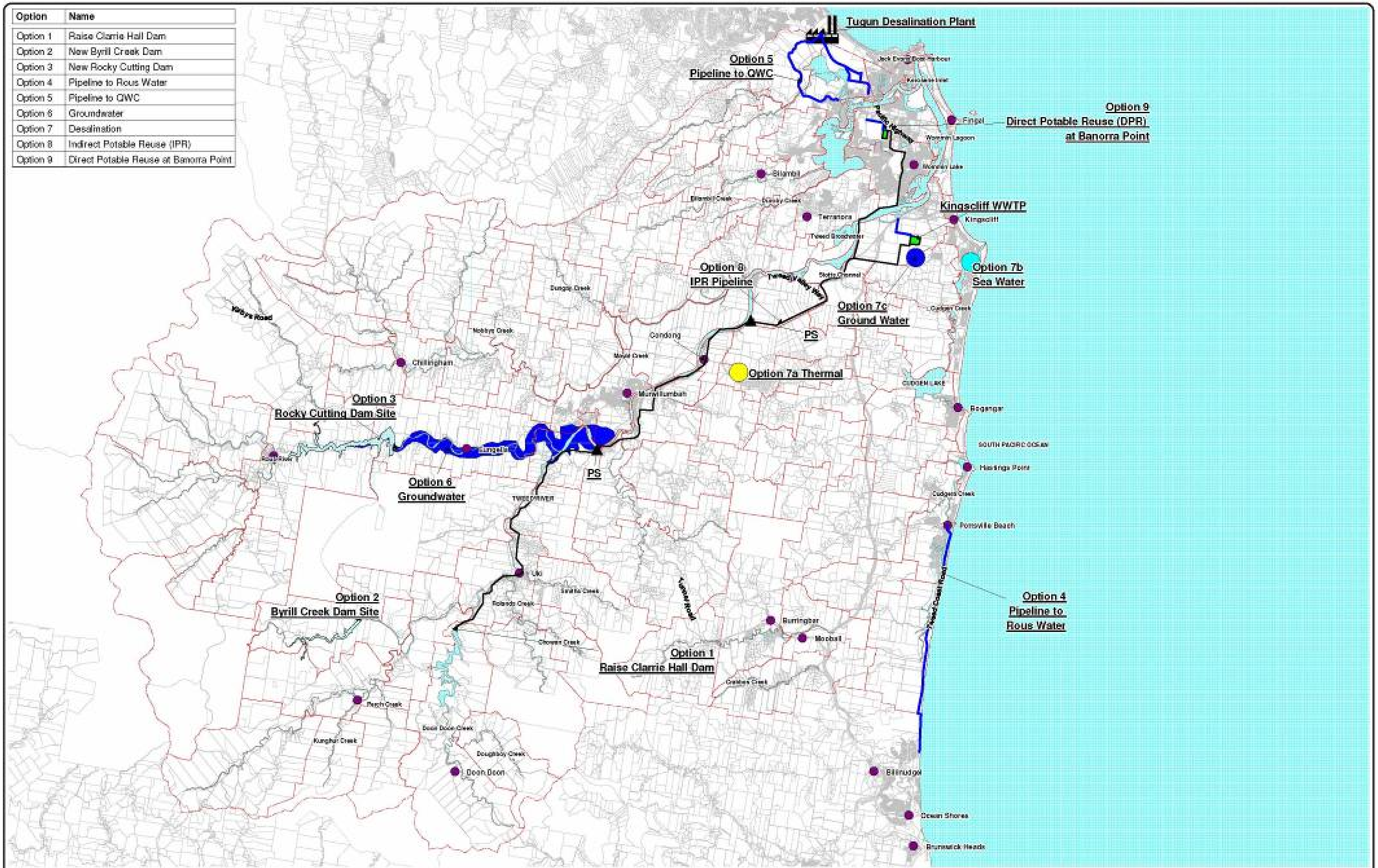
- **1 =** Very Low
- **2 =** Low
- **3 =** Moderate
- **4 =** High
- **5 =** Very High

Score is the product of the Rating and Weighting Factor to identify the preferred options for the Fine Screen

Rank is the relative preference from most preferred (ranked 1) to least preferred (ranked 9), based on the comparison of scores from all assessment criteria.

APPENDIX F : LOCALITY PLANS OF EACH OPTION

Option	Name
Option 1	Raise Clarrie Hall Dam
Option 2	New Byrill Creek Dam
Option 3	New Rocky Cutting Dam
Option 4	Pipeline to Rous Water
Option 5	Pipeline to QWC
Option 6	Groundwater
Option 7	Desalination
Option 8	Indirect Potable Reuse (IPR)
Option 9	Direct Potable Reuse at Banorra Point



MWH

TWEED DISTRICT WATER SUPPLY AUGMENTATION

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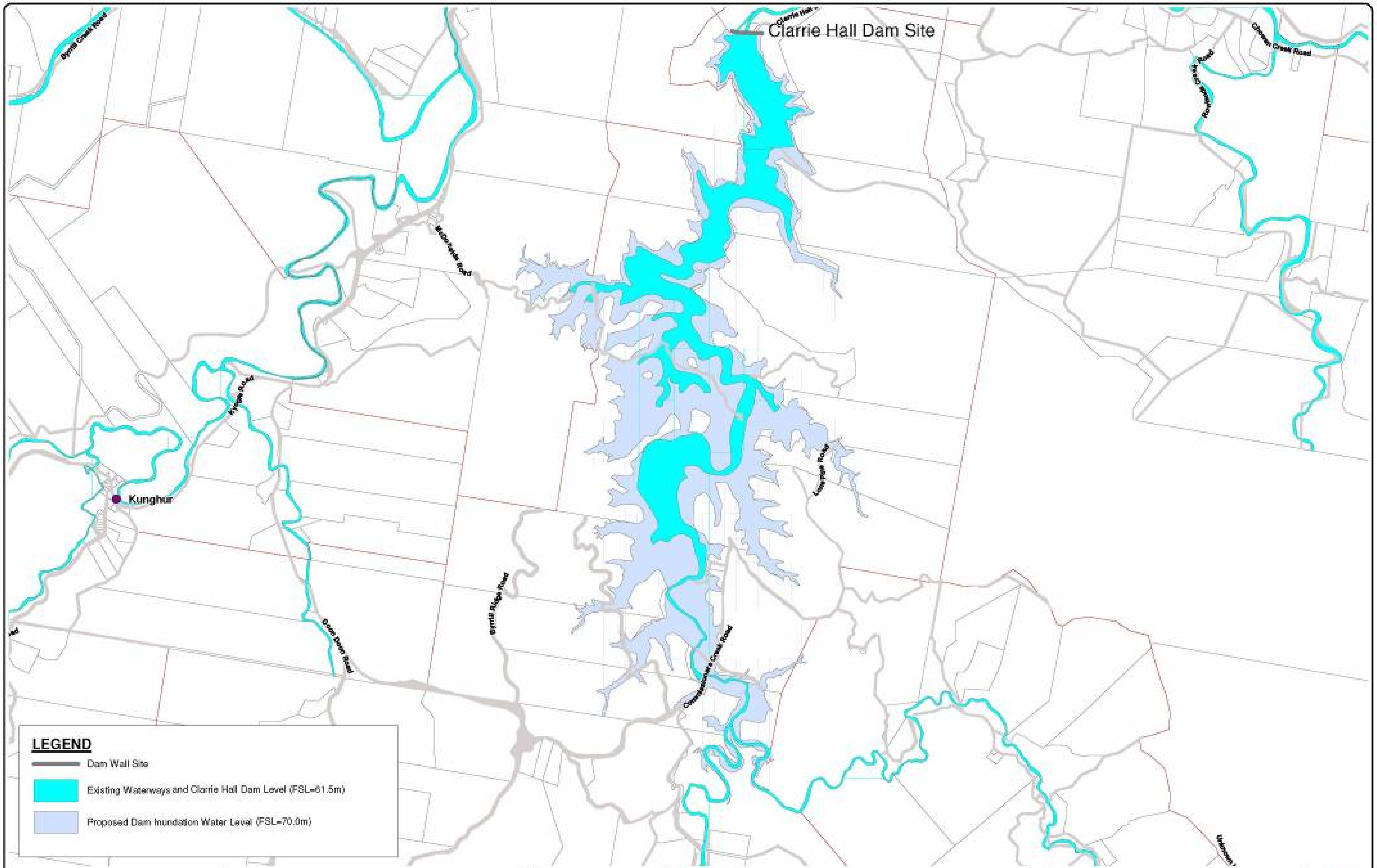
0 4 8
Kilometres

ALL OPTIONS

02/09/2008

N W E S



MWH

TWEED DISTRICT WATER SUPPLY AUGMENTATION

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Augmentation Options Study\
Stage 1 and Stage 2 Coarse Screen\
GIS\GIS\Workspaces\
Tweed_Proposed_Sites_rev1.wor

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kilometres

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OPTION 1 RAISING OF CLARRIE HALL DAM

N W E S

MWH

TWEED DISTRICT WATER SUPPLY AUGMENTATION

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A1108200 - TSC Water Supply Augmentation Options Study\
Stage 1 and Stage 2 Coarse Screen\
GIS\GIS Workspaces\
Tweed_Proposed_Sites_rev1.wor

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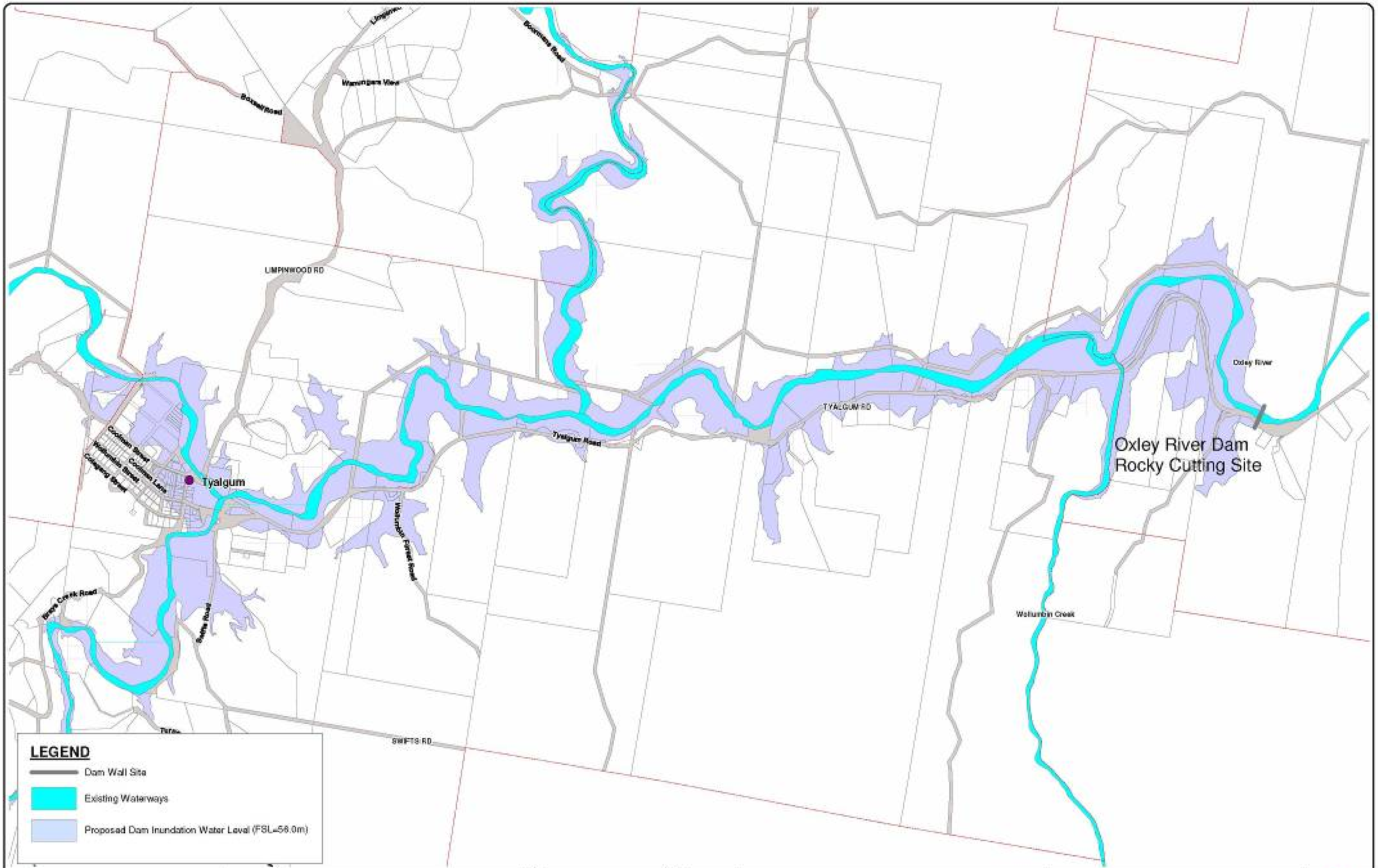
OPTION 2
BYRRILL CREEK DAM

N W E S



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TWEED DISTRICT WATER SUPPLY AUGMENTATION

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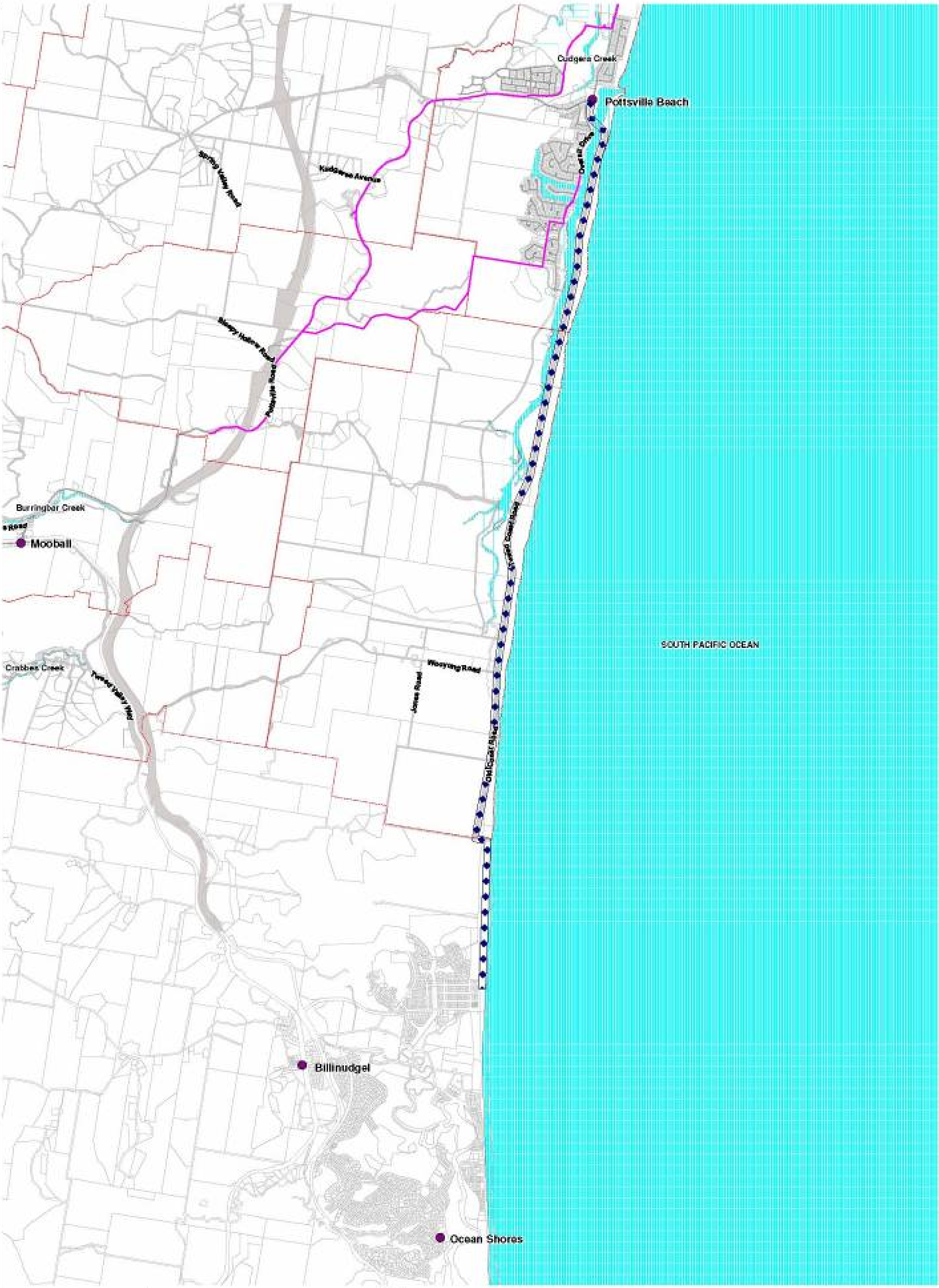
08/10/2009

OPTION 3
OXLEY RIVER DAM

N W E S



MWH

TWEED DISTRICT WATER SUPPLY AUGMENTATION

DATUM:

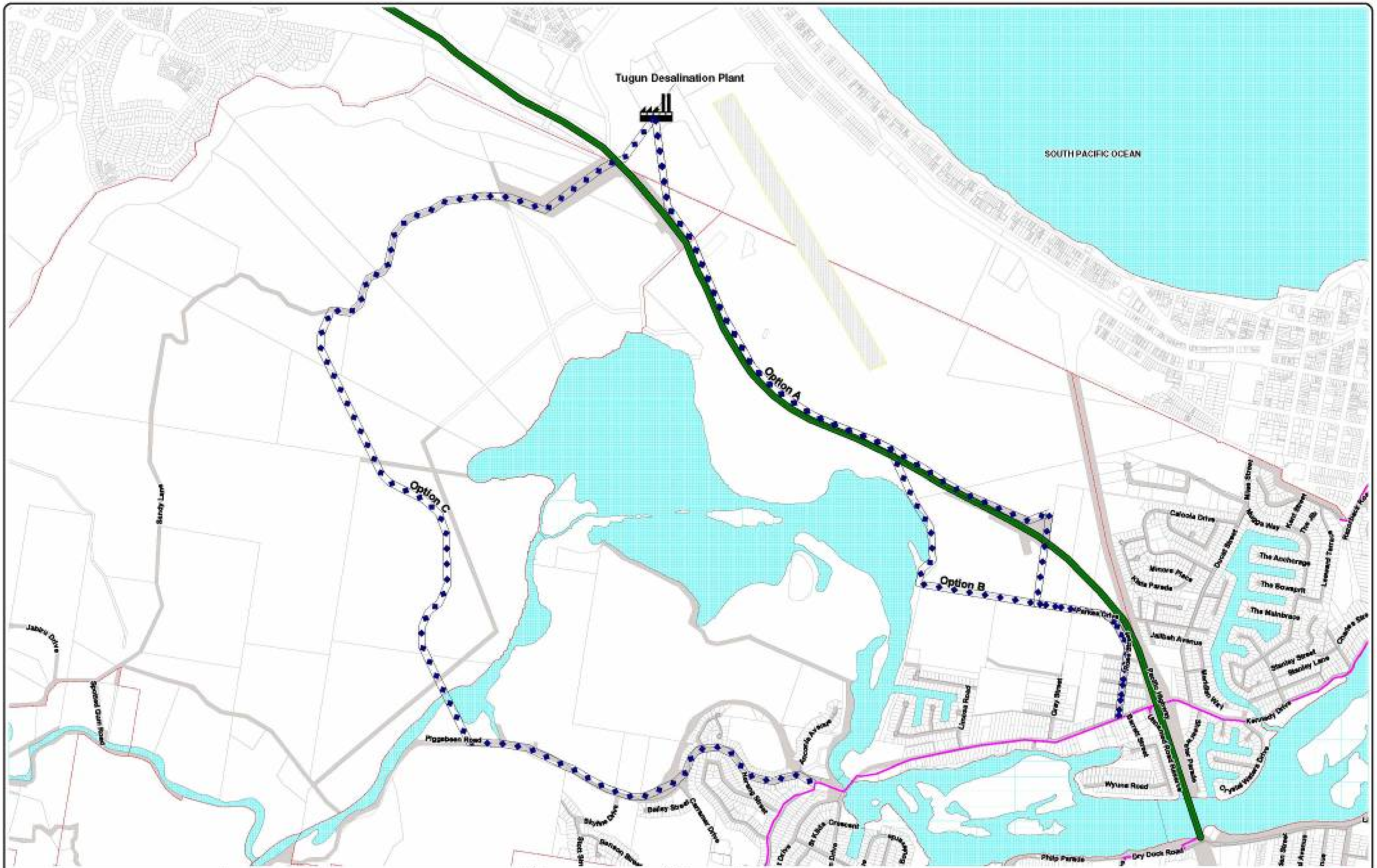
PROJECTION:

SCALE:

OPTION 4
PIPELINE TO
ROUS

DATE: 19/08/2008

N E S W



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TWEED DISTRICT WATER SUPPLY AUGMENTATION

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OPTION 5 PIPELINE TO GOLD COAST

21/08/2008

N
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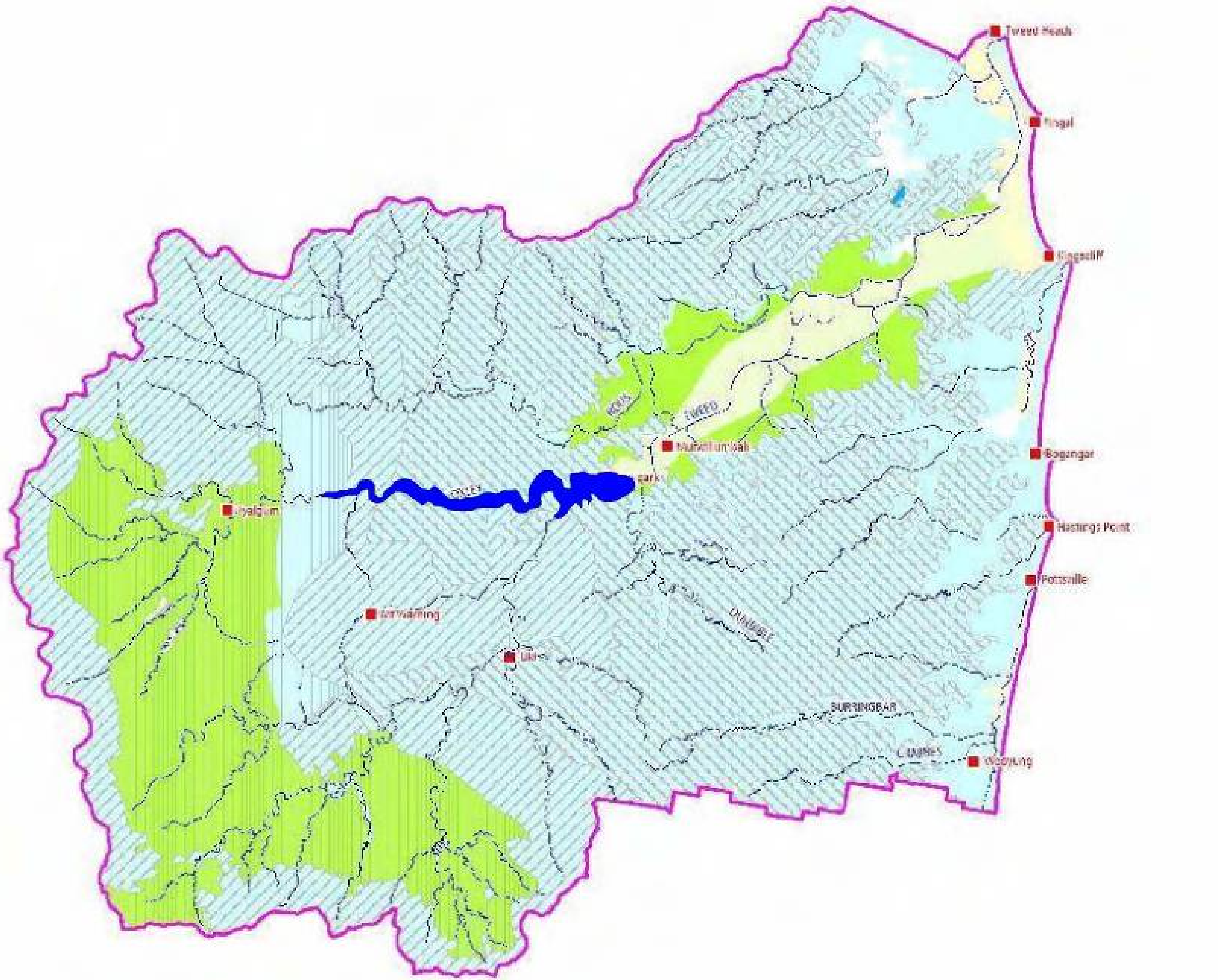

LEGEND

- Tweed LGA
- Unconsolidated Sediments
- Metasediments
- Igenous
- Porous Sedimentary Rocks
- Locality
- Major Watercourses

WATER QUALITY AND YIELD LEGEND

- 0-500mg/L Fresh <1.5L/s
- 0-500mg/L Fresh >1.5L/s
- 501 - 1500 mg/L Fresh <1.5L/s
- 501 - 1500 mg/L Fresh >1.5L/s
- 1501 - 5000 mg/L Fresh > 2.5L/s

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TWEED DISTRICT WATER SUPPLY AUGMENTATION

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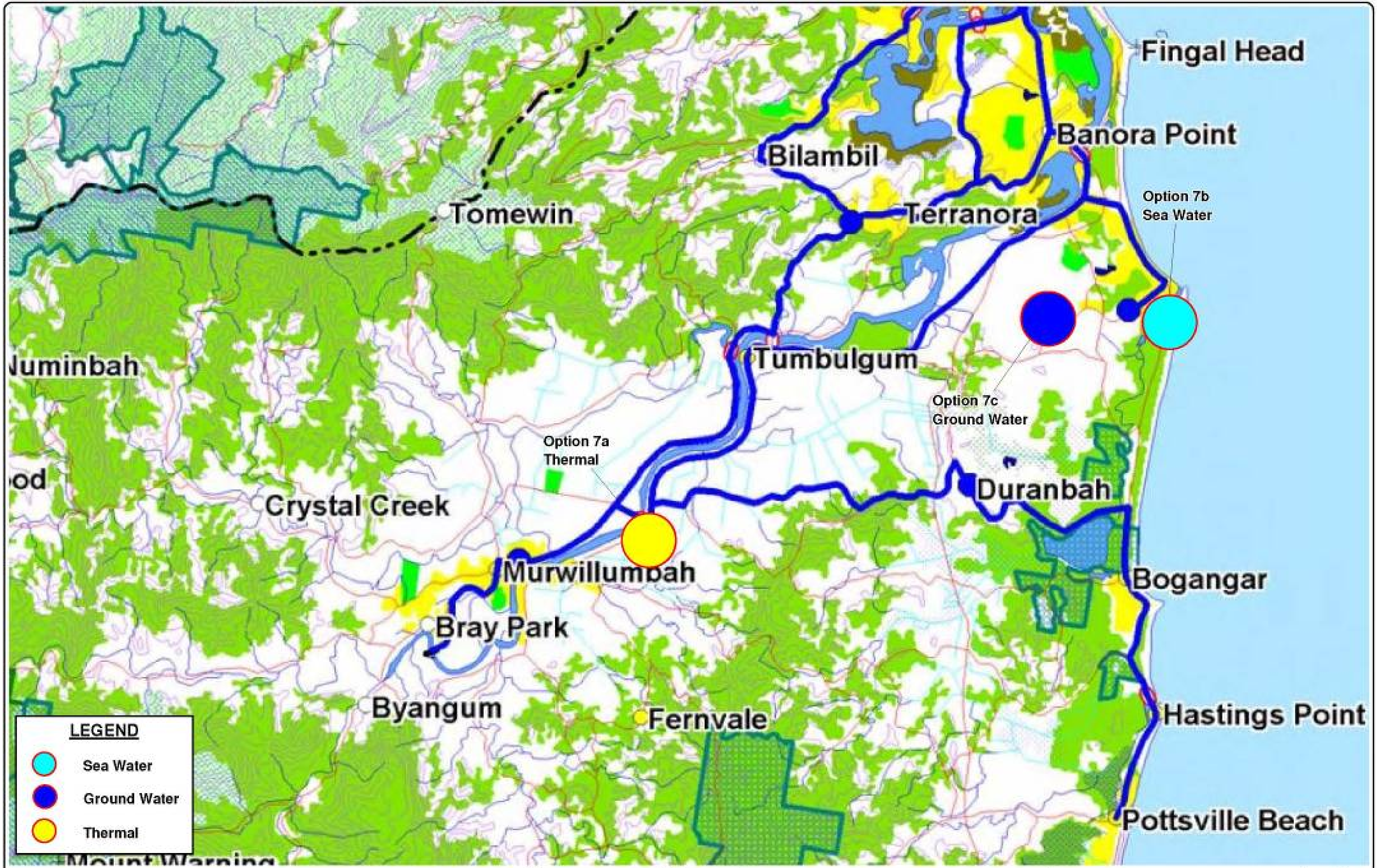
OPTION 6 GROUNDWATER OXLEY RIVER



MWH

TWEED DISTRICT
WATER SUPPLY
AUGMENTATION

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OPTION 7
DESALINATION

02/09/2008

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TWEED DISTRICT WATER SUPPLY AUGMENTATION

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Gis/Workspaces
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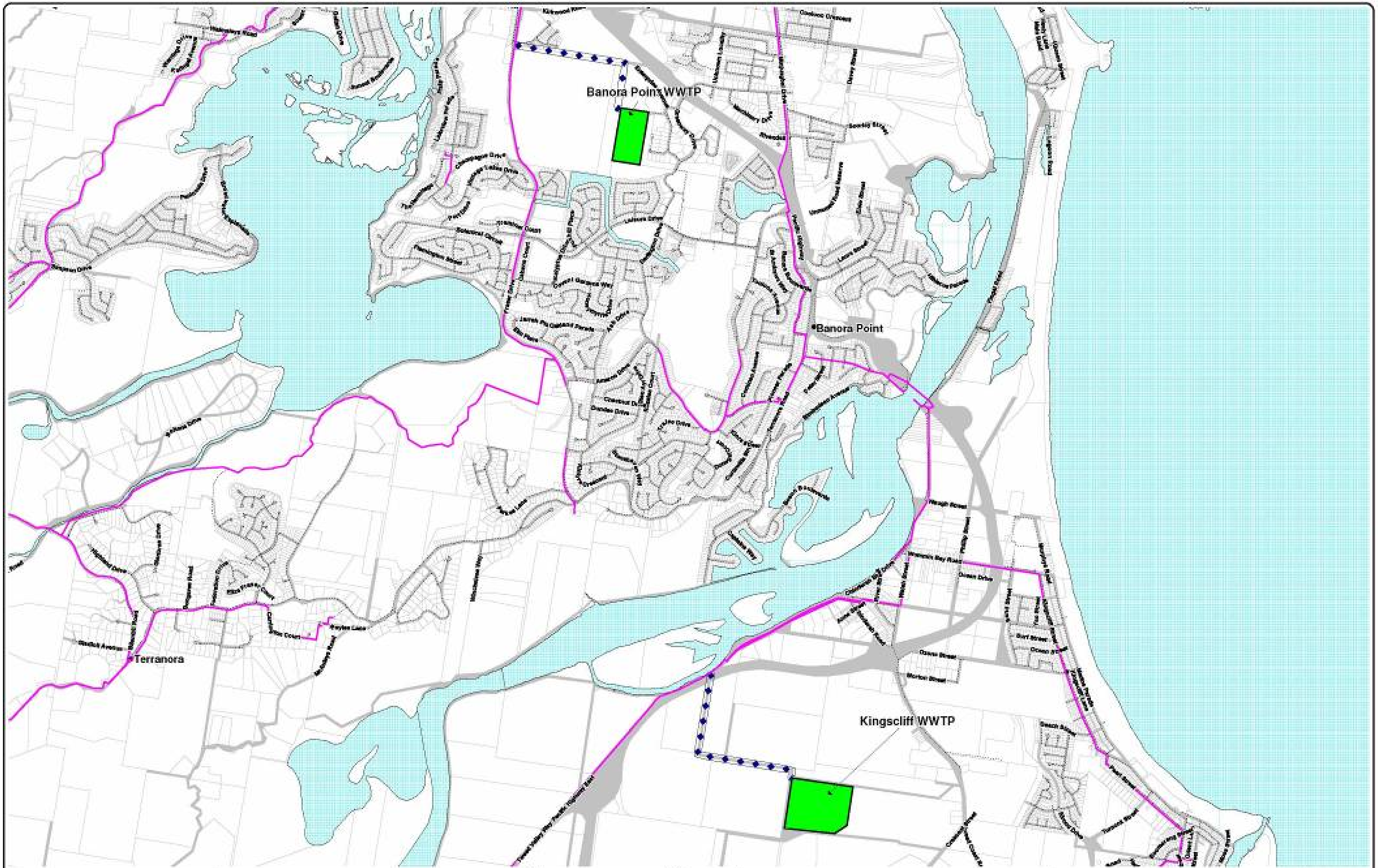
01/09/2008

OPTION 8 INDIRECT POTABLE REUSE



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WATER SUPPLY
AUGMENTATION

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OPTION 9
DIRECT POTABLE
REUSE

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