Northern Rivers Regional Bulk Water Supply Strategy

Draft

April 2013

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PROJECT 12-025– NOROC REGIONAL BULK WATER SUPPLY STRATEGY					
REV	**DESCRIPTION**	**AUTHORS**	**REVIEW**	**APPROVAL**	**DATE**
0	Issued for Rous Water review	R. Campbell, K. Pratt, U. Makings, M. Howland	R. Campbell, M. Howland	M. Howland	8/3/13
1	Issued for NOROC SWMG review	R. Campbell, K. Pratt,	M. Howland	M. Howland	22/4/13

EXECUTIVE SUMMARY

The Northern Rivers Regional Organisation of Councils (NOROC) has resolved to develop a long-term (50-year) regional water supply strategy in order to evaluate the potential benefits to future water supply security resulting from a regionally integrated system. This report investigates numerous interconnection and supply scenarios that aim to maximise the benefit of a regional approach and presents the key issues for consideration.

E1 EXISTING WATER SUPPLIES

The status of the existing water resources and current demand for water is presented in Interim Report 1 (attached as Appendix 1). The Northern Rivers water supplies currently serve approximately 80,000 residential properties and 7,000 non-residential connections with a regional demand of approximately 23,000 ML/a. The majority of potable town water supply is sourced from surface water resources, whilst groundwater is used on a smaller scale in some areas to supplement local supplies and provide a back-up source during drought.

The major sources of water are Rocky Creek Dam in the Richmond River catchment and Clarrie Hall Dam in the Tweed River catchment providing 48% and 38% of the region's water supply respectively and serving the majority (90%) of the study area population. There are also many smaller water sources serving the towns and villages within the study area.

Based on the current demand and supply estimates presented in Interim Report 1 (Appendix 1), each water supply scheme currently has an acceptable level of water security.

E2 FUTURE WATER SUPPLY SECURITY ISSUES

Interim report 2 (attached as Appendix 2) documents the long-term (50 year) demand forecast for the region. By 2060, the Northern Rivers water supplies are predicted to serve approximately 146,000 residential properties and 14,000 non-residential connections with a regional demand of approximately 40,000 ML/a, an increase of approximately 74%.

Despite this increasing demand, the current secure yield of the region's water resources (approximately 32,000 ML/a) is expected to decrease with the impacts of future climate change by approximately 6,000 ML/a or 26% by 2060. Although there is some uncertainty with these predictions, there is little doubt that additional water supplies will be required due to population growth and the reduction in available water resources.

The expected demand, secure yield and supply deficit at 2060 are summarised in Table E1. The total regional supply deficit by 2060 is expected to be approximately 43% or 14,000 ML/a. Major additional water supplies will be required to meet the growth in demand within the Rous Water bulk supply area and the Tweed Shire Council Bray Park system. Mullumbimby and Kyogle will also require significant additional supply compared to current sources. Smaller increases are also required in Casino, Bonalbo and Nimbin.

The level of accuracy of the analysis was influenced by the data available from each LWU. Whilst the level of accuracy is considered acceptable for this study, there is opportunity to improve the data particularly with respect to the influence of demand hardening and climate change on secure yield. A key component of the strategy implementation involves addressing the data deficiencies.

Table E1: Future Demand, Secure Yield and Supply Deficit (ML/a)

Supply Area	2060 Forecast Demand	2060 Predicted Secure Yield [1]	Year that augmentation may be required	2060 Predicted Supply Deficit	2060 Supply Deficit (% of current supply)
Rous Water bulk supply	15,790	10,695 – 9,160	2022	5,100 – 6,600	37% - 48%
Wardell	200	unknown	unknown	unknown	unknown
Mullumbimby	690	380	2025	310	71%
Kyogle	440	250	2015	190	59%
Bonalbo	47	52	2048	5	10%
Woodenbong and Muli Muli	59	66	Not required within next 50 years		
Nimbin	88	unknown	unknown	unknown	unknown
Casino	2,410	2,020	2025	390	15%
Bray Park (Tweed District and Uki)	19,980	13,750	2030	6,230	45%
Tyalgum	61	96	Not required within next 50 years		
Region	*40,000*	*26,000*		*14,000*	*43%*

1. Secure yield of Rous Water supplies has been determined using the 5/10/10 rule. Secure yield of all other supplies has been determined using the 5/10/20 rule.

The key water supply security issues for the region are:

- Current sources are heavily dominated by surface water storages;
- There is increasing uncertainty into the future with climate change, but the consensus is that the yield of surface water sources will decrease;
- Population will continue to grow, particularly within Tweed Shire and Ballina;
- Despite historical reduction in water use per connection, there will be a significant regional supply deficit by 2060; and
- Although demand management and source substitution are likely to result in some benefits into the future, major augmentation of potable water supplies is required throughout the region in the coming decades.

E3 POTENTIAL BENEFITS OF A REGIONAL APPROACH

This study has investigated the possible interconnection of the water supply schemes in the region and the potential benefits to be gained. While local supply options can be implemented separately by each LWU to ensure water supply security, a regional approach can provide improved financial outcomes through economies of scale as well as access to a wider range of options to improve efficiency, system resilience and operational flexibility. By looking at a regional approach with the best solutions drawn from across the region, rather than restricted to supply solutions within LWU boundaries, optimised supply schemes can be developed.

The potential benefits of interconnecting the region's water schemes are:

- Financial: There is potential to provide a lower cost drinking water supply to the region over the long-term when compared to stand-alone schemes. This can be achieved through:
    - Opportunities for staging of water source development – Major capital expenditure can be delayed through staged implementation of sources servicing the region rather than development of multiple local sources in the short-term;
    - Increased flexibility in scheme development – Access to a wider range of water sources provides opportunities to implement lower cost solutions;
    - Reduced duplication of infrastructure – Sharing of major headworks infrastructure such as water sources and treatment facilities is cost-effective; and
    - Sharing of costs over a larger customer base – Regional interconnection provides the opportunity to access a larger customer base and hence reduce customer costs.
- System Resilience and Flexibility: There is potential to reduce the risk of supply shortage in the region through:
    - Supply diversity - A regional scheme with multiple water sources has the potential to be more resilient to drought;
    - Supply redundancy - The impacts of emergency situations (such as the loss of a supply through natural disaster or contamination event or the loss of major infrastructure through fire) can be minimised with the availability of alternative headworks infrastructure;
    - Secure yield - The combined operation of the LWUs existing sources may result in an increase in secure yield from those sources when incorporated in a regional scheme;
    - Climate resilience - The existing water supply schemes feature surface water sources which are vulnerable to future climate change. A regional scheme can cost-effectively incorporate a range of climate resilient supply sources to address risks of reduction in average yield and increased yield variability due to climate change over the long term; and
    - System Flexibility - By virtue of its size and diversity, a regional scheme offers increased flexibility and scalability. It is possible to incorporate future sources in a regional scheme that can be constructed in stages allowing adaption to changing demand growth patterns and the influence of demand side initiatives.
- Environmental and Social Outcomes: The development of significant infrastructure raises extensive planning and approval challenges. A regional approach allows access to a wider range of options to improve environmental and social outcomes.
- Management and Administration: While this study is focussed on regional infrastructure approaches, a regional scheme would also provide opportunities for improved management and administration through:
    - Improved skills - A regional scheme would bring together the current skill groups of the individual LWUs allowing both the sharing of those skills across the region as well as the enhancement of skills that a larger work group can afford through specialisation;
    - Improved resilience to an ageing workforce – A future shortfall in skills in the water industry is predicted due to the ageing workforce and the more volatile nature of the workforce. A regional approach would provide a larger skills base to cover the skills required as well as provide a training area for replacing those skills; and

- Increased efficiency - A regional approach can provide greater efficiency through less duplication of infrastructure and administrative processes.

E4 DEVELOPMENT OF A REGIONAL APPROACH

Each LWU has previously identified future water source options that could potentially meet future shortfalls in supply although none of the LWUs have progressed those potential supply options to a point where the future supply can be considered secure. Some LWUs have investigated options involving water sharing with neighbouring utilities, although this is the first study to consider integrated water supply options on a regional scale.

Potential supply scenarios have been developed focussing on strategies to resolve the predicted 2060 water supply deficit for the region as a whole. The scenarios are influenced by two key attributes:

- Physical interconnections: The degree to which the water supply system is connected within the region will determine what ultimately is considered to be part of the regional scheme and consequently, the population that is to be served by the scheme and the likely future water demand to be met by the scheme; and
- Water supplies: The potential new or augmented sources that can be utilised to provide the required secure yield.

Physical Interconnections

The viability of the interconnection options will depend on:

- The supply augmentation options included in the regional scheme – for example inclusion of Kyogle water supply would be more attractive if augmentation options in the western parts of the region (e.g. Toonumbar Dam) were included;
- The need for augmentation of local supplies (i.e. due to future yield deficit or emergency source requirements) and the benefits that would be derived locally from being connected to the regional network; and
- The opportunities for sharing the costs of major infrastructure and whether the additional costs of connecting an area to the regional network are justifiable from an absolute cost as well as an overall cost sharing perspective.

The large future yield deficit likely to be experienced by Rous Water and Tweed Shire Council and the predicted timing of required augmentation (2022 and 2030 respectively) suggest that a substantial benefit may be achieved from interconnection of these supplies through water sharing and cost sharing opportunities. The interconnection of these two systems is considered critical in achieving a true regional approach for the NOROC study area. The outer limits of these two systems are in close proximity to each other, potentially minimising costs associated with the connection pipeline. While this option has not been investigated in any detail, there are no known technical barriers.

In addition to this major connection to the Tweed system, Rous Water's current bulk supply network could also be extended to include Casino, Mullumbimby and Nimbin or Kyogle. The interconnection of these smaller water supply systems does not significantly alter the predicted yield deficit of a scenario involving connection of the Bray Park system and the Rous Water system. These options could be implemented either as part of the overall regional scheme or could be implemented purely to resolve local supply issues at these centres.

Not all of the individual LWU water supplies would be connected to a regional scheme. While opportunities to connect will depend on the future needs and proximity of infrastructure, the current information suggests that:

- Water supplies are adequate to serve future demand in Tyalgum, Woodenbong and Muli Muli for the next 50 years;
- Water supplies are adequate to serve future demand in Bonalbo for the next 35 years; and
- While data on secure yield are currently not available, a future supply deficit has not been identified for Wardell. Future connection to the regional scheme is considered to be relatively simple due to its proximity to the Rous Water distribution network.

Water Source Options

There is a wide range of primary source options and it is necessary to consider their viability as part of a regional supply approach. The scale of the long-term yield deficit necessitates a primary source option that can address a significant component of the yield deficit either alone or in combination with other options. It is mandatory that any potential scheme is able to provide secure yield to satisfy the future (2060) demand within the connected network. However, it is acknowledged that there are significant uncertainties regarding the yield of potential surface water options and therefore it is not appropriate to limit the scenarios to particular local solutions. The timing of the need for augmentation also suggests that a major source would need to be implemented within ten years. The schemes must also be able to supply water meeting the Australian Drinking Water Guidelines or the Recycled Water Guidelines as applicable. Public health considerations would be addressed in future design stages of the scheme.

A wide range of supply options were considered including surface water, groundwater, desalination, supply from neighbouring utilities and potable reuse of wastewater and stormwater. Potable substitution options cannot be considered a regional solution as they are likely to be only implemented on a local scale where the opportunity exists to resolve multiple wastewater and water supply issues. Similarly, groundwater supplies would be developed on a decentralised basis and therefore are not considered to meet the criteria for a regional scheme. These decentralised sources have not been further considered in the development of the regional schemes, however, they could be utilised to augment parts of a regional scheme as appropriate.

A preliminary evaluation of the individual water source options was undertaken to document the attractiveness and issues related to primary source options in the region. The following are considered to have the most potential:

- Large-scale centralised desalination is an attractive option in terms of yield, climate independence and scalability. Potential risks factors are energy requirements and brine disposal although acceptable solutions have been developed elsewhere and there is no reason why the same level of acceptability will not apply locally. The greatest unknown with desalination is cost;
- The surface water options could be either single large storages meeting the full deficit or a combination of storages to achieve the same outcome. The options involving new surface water storages do not provide climate independence but storages on the coast are likely to be more resilient to climate change. There are significant risks with approval of surface water options related to legislative acceptability, environmental and cultural heritage impacts. Whilst there is significant community opposition to the construction of new dams, raising of existing dams is likely to be less controversial. The cost of these options is likely to be influenced by the measures required to reduce these risks and impacts;
- The most attractive Tweed River surface water option is the raising of Clarrie Hall Dam. The potential yield realised from raising the FSL to 70m (maximum size) is 8,250 ML/a;

- The most attractive option for a new storage on the Richmond River is Dunoon Dam. A 50,000ML storage is predicted to yield 6,100 ML/a with an additional 6,000 ML/a potentially available from a 85,000 ML storage; and
- Raising Toonumbar Dam and creating town water supply licences could yield 10,000 ML/a with a 10m raising. A 20m raising is also potentially feasible but the additional yield is unknown.

Potential Regional Scenarios

Potential regional water supply schemes have been developed that maximise the benefits of interconnection and optimise the utilisation of water resources in the region. While multiple variations on interconnection and supply options could be considered to satisfy the supply deficit and these each have intrinsic positive and negative aspects, a range of regional scenarios has been considered to meet the objectives of the study:

- Scenario 1 - Desalination;
- Scenario 2 - Dunoon Dam (Richmond River, 50,000 ML) and raise Clarrie Hall Dam (Tweed River);
- Scenario 3 - Dunoon Dam (Richmond River, 85,000 ML);
- Scenario 4 - Use of Toonumbar Dam (with 20 m raising); and
- Scenario 5 – Use of Toonumbar Dam (with 10m raising) and raise Clarrie Hall Dam.

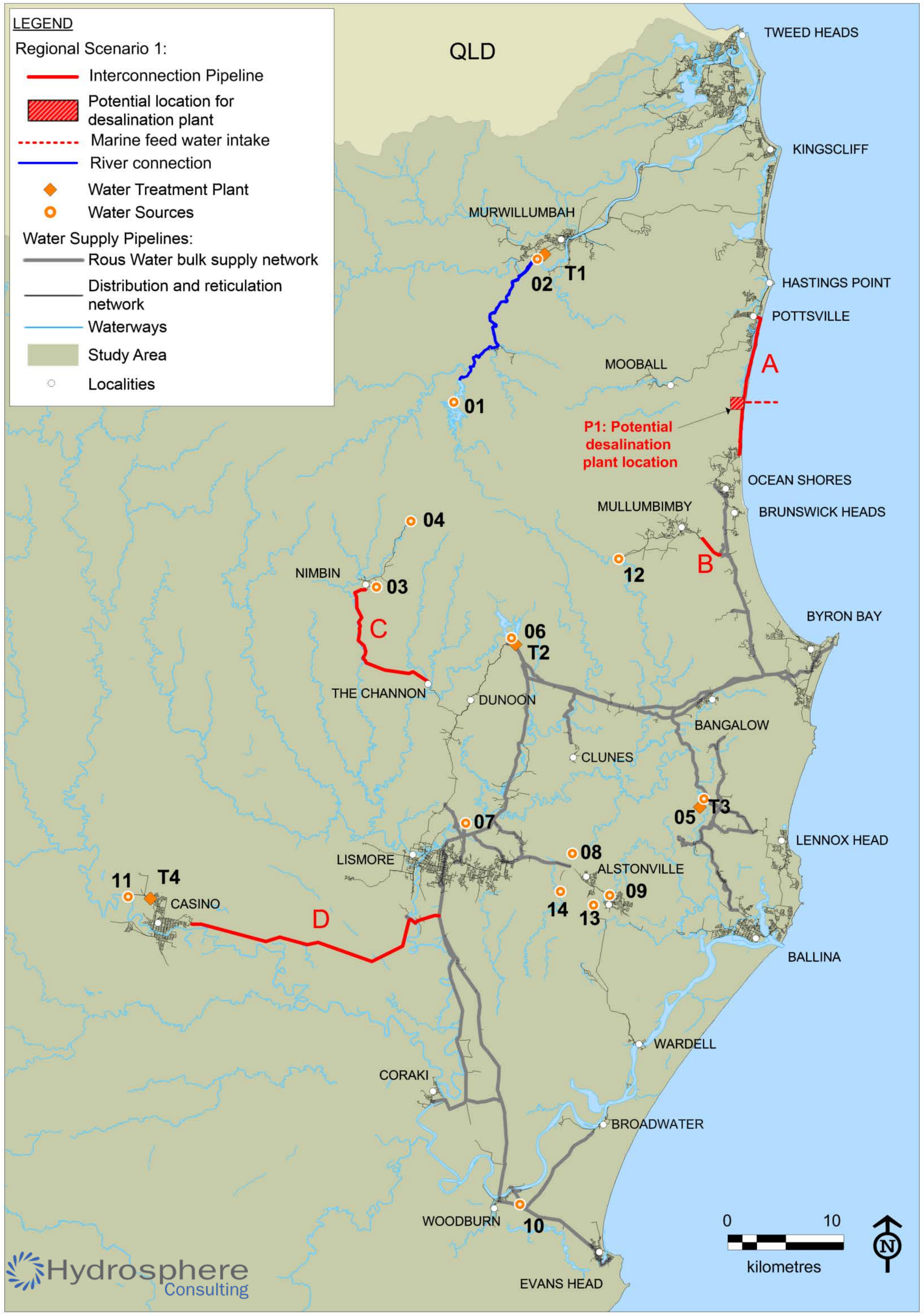
All scenarios require interconnection of the Rous Water and Bray Park systems. Casino, Mullumbimby and Nimbin may also be connected to the regional scheme although this does not significantly alter the demand or yield of the scheme. Connection of these smaller supplies would address local supply issues but would introduce additional costs as well as cost-sharing opportunities.

The scenarios are described in the following figures.

Demand Reduction Initiatives

Whilst this study has identified a number of potential supply options that can meet the 2060 secure yield requirements, there are a number of demand reduction initiatives that should be evaluated and potentially pursued in parallel to ensure best-practice is achieved. They are:

- Water loss reduction: The information available on water loss reduction indicates that there is a substantial reduction in demand for water that could be achieved through water loss reduction. Success in this area will reduce the required 2060 secure yield and therefore reduce the supply side capital works requirements and also defer the need for capital works;
- Further demand management initiatives: While the existing demand management programs have been successful in reducing per connection demand, it is unlikely that the demand has been reduced to the lowest level possible. Each LWU demand management program should be evaluated to determine if further reduction in demand is feasible.



SCENARIO 1: DESALINATION

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below) and will be supplemented by treated water from a new 70 ML/day marine desalination facility (P1), potentially located between Ocean Shores and Pottsville. The desalination facility will include a marine feedwater pipeline, a major energy source, brine disposal pipeline and transfer to the regional supply network. Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

1. Peak day demand assumes daily average demand and peaking factor of 2.0.

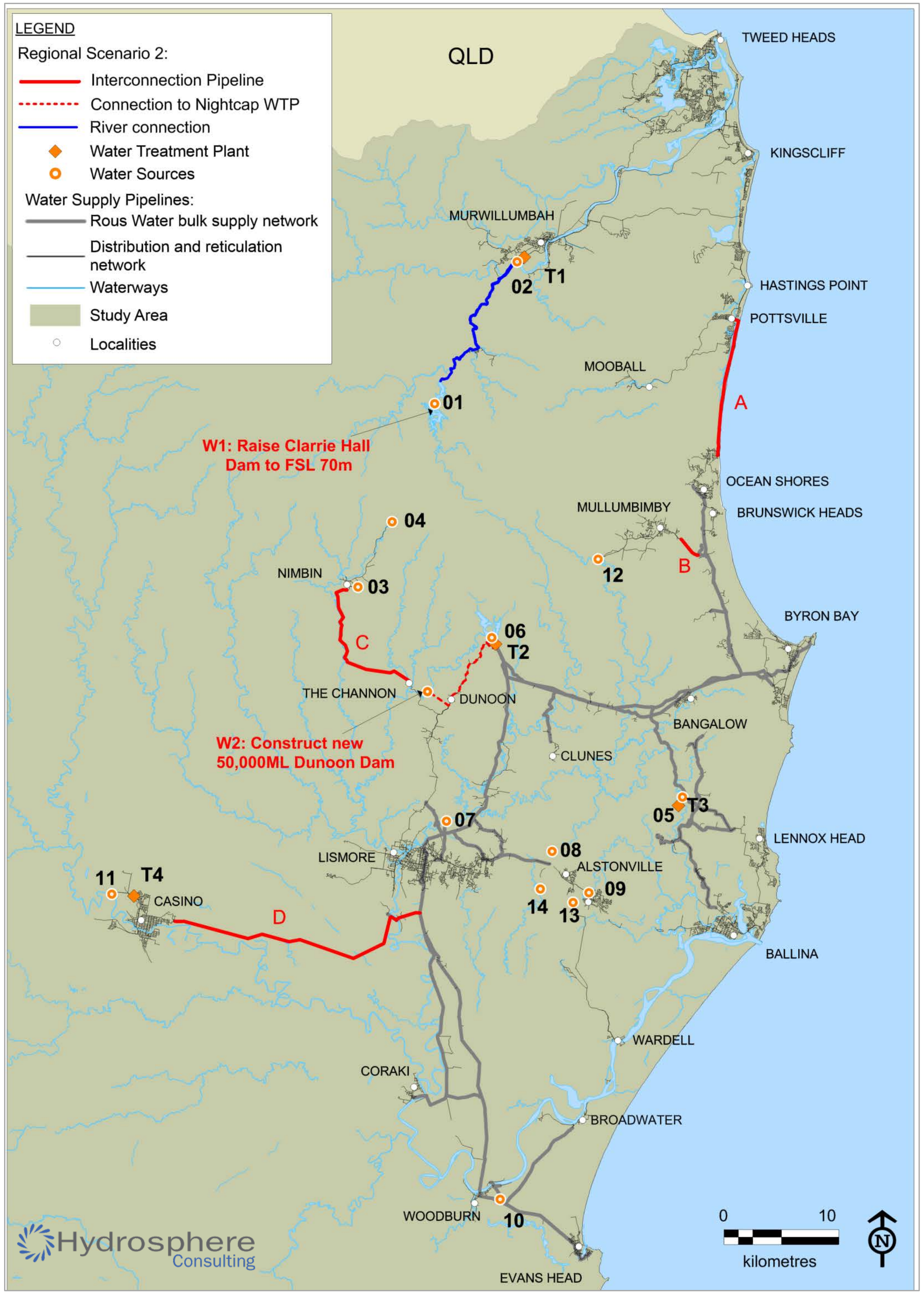
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP	Rous Water	70
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure E2: Regional Water Supply Scenario 1 – Desalination



SCENARIO 2: DUNOON DAM (RICHMOND RIVER, 50,000 ML) AND RAISE CLARRIE HALL DAM (TWEED RIVER)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising Clarrie Hall Dam to FSL 70m (W1) and construction of a new 50,000 ML dam on the Richmond River at Dunoon (W2). Raw water from Dunoon Dam would be treated at the existing Nightcap WTP (T2) which would be augmented by approximately 15 ML/d. Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	**Peak Day (ML/d)** [1]	**Annual Average (ML/a)**	**Peak Day (ML/d)** [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

1. Peak day demand assumes daily average demand and peaking factor of 2.0.

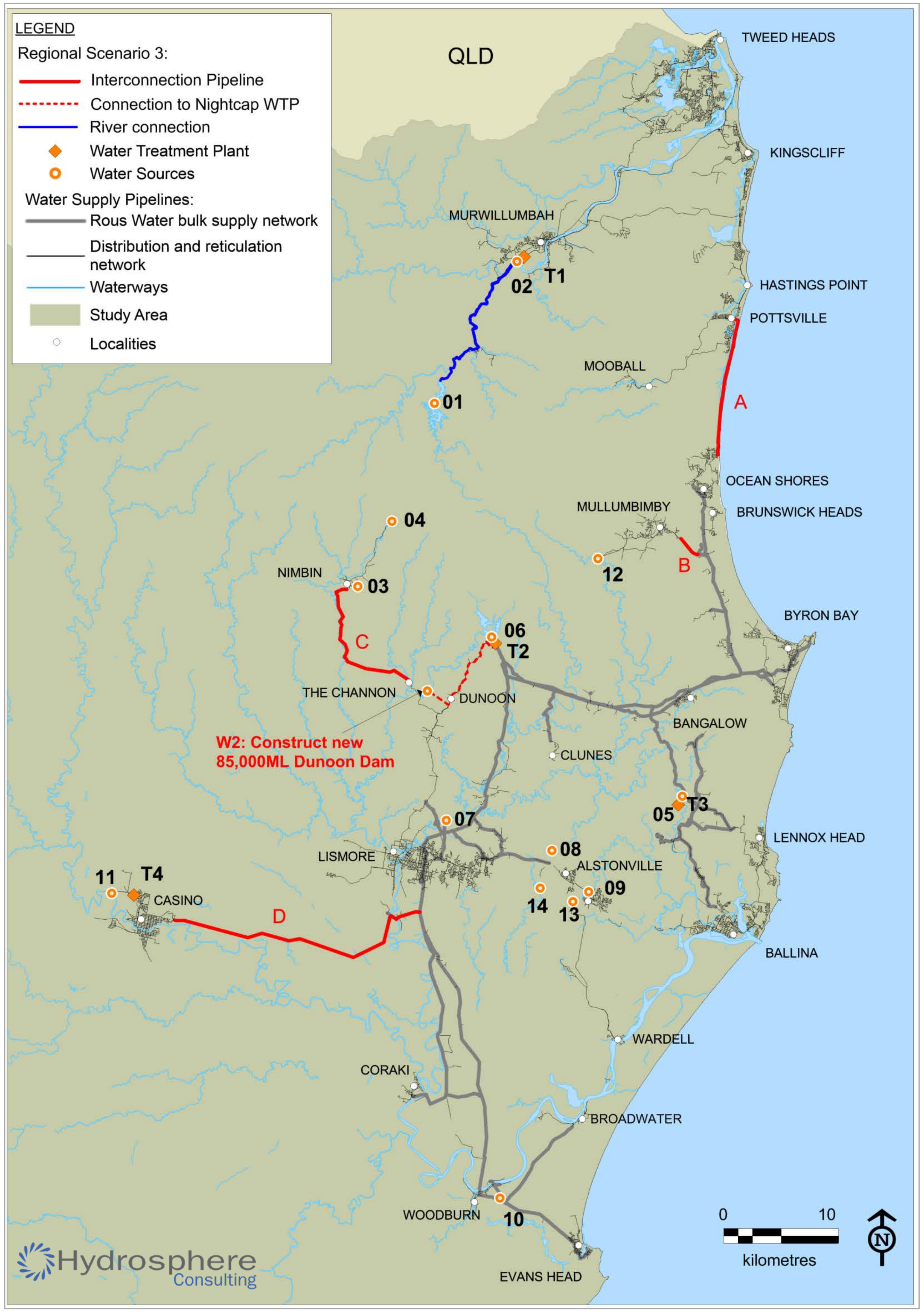
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure E3: Regional Water Supply Scenario 2 – 50,000 ML Dunoon Dam and Raise Clarrie Hall Dam



SCENARIO 3: DUNOON DAM (RICHMOND RIVER, 85,000 ML)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by construction of a new 85,000 ML dam on the Richmond River at Dunoon (W2, potentially constructed in stages). Raw water from Dunoon Dam would be treated at the existing Nightcap WTP (T2) which would be augmented by approximately 55 ML/d (potentially in stages). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

1. Peak day demand assumes daily average demand and peaking factor of 2.0.

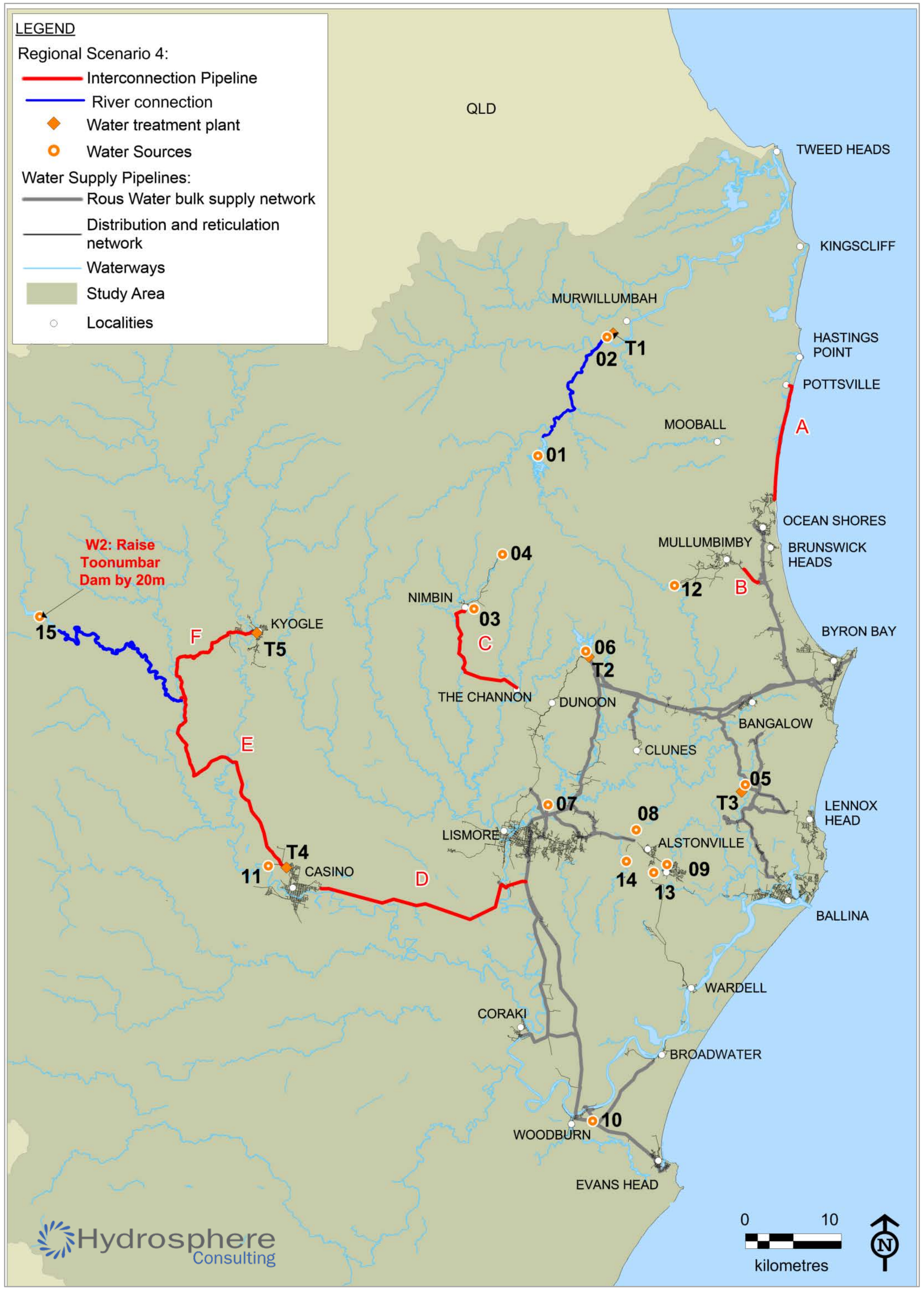
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	125
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure E4: Regional Water Supply Scenario 2 – 85,000 ML Dunoon Dam



SCENARIO 4: TOONUMBAR DAM (RICHMOND RIVER) RAISED BY 20 M

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising of Toonumbar Dam by 20 m (W2, potentially constructed in stages) with the creation and purchase of town water extraction licences and releases from the dam to an extraction point at the confluence of Iron Pot Creek and Richmond River. Raw water from Toonumbar Dam would be transferred to Casino (E) for treatment at the existing Casino WTP (T4) which would be augmented by approximately 12 ML/d and to Kyogle (F) for treatment at the existing Kyogle WTP (T5). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 78,900 existing residential connections (153,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Kyogle in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	4
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	<1
Kyogle	304	<2	441	2
Total Regional Water Supply	*23,044*	*127*	*39,401*	*216*

1. Peak day demand assumes daily average demand and peaking factor of 2.0.

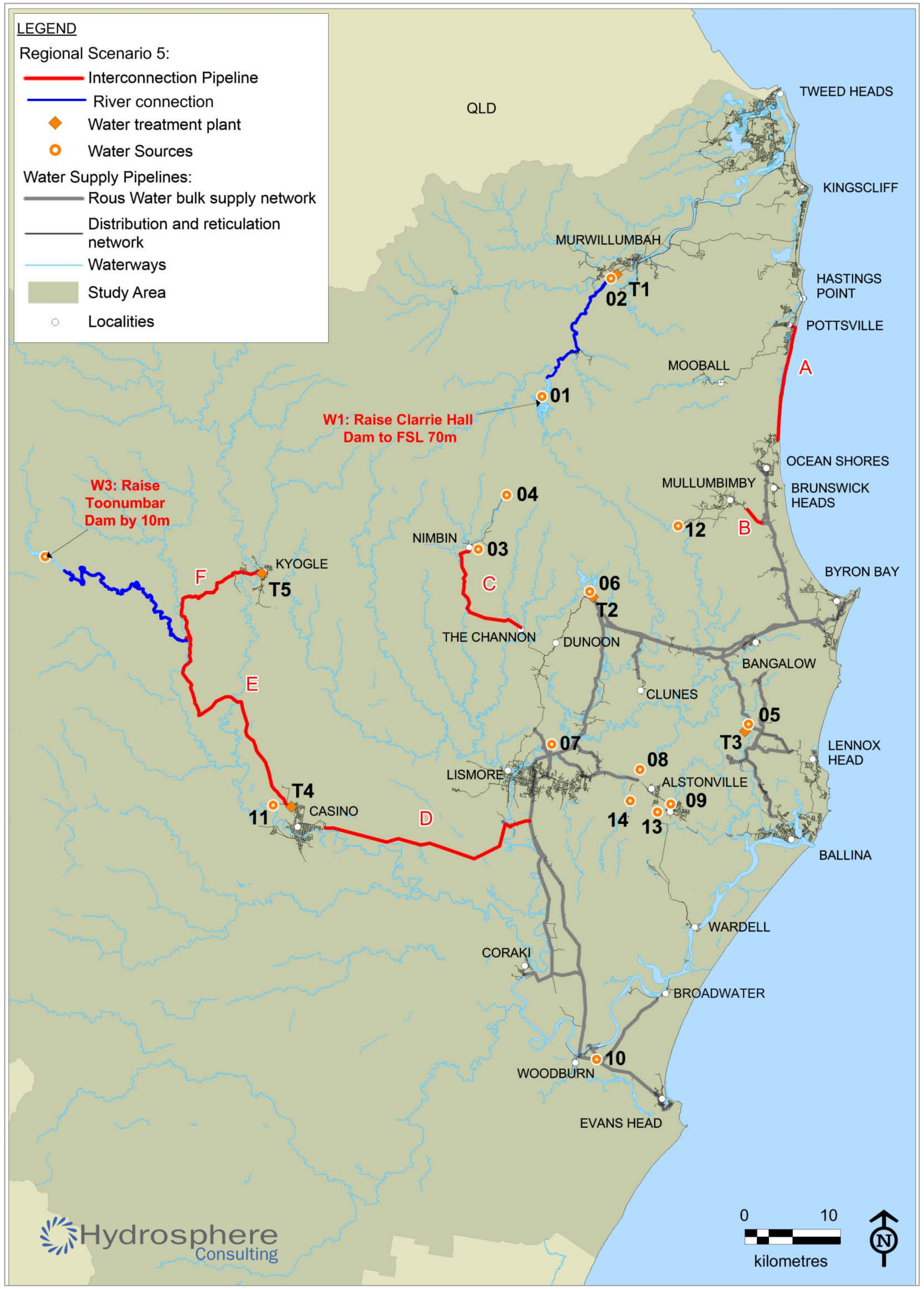
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
15	Kyogle Weir	Richmond River	Kyogle Council	250
16	Kyogle Bores	Richmond River Alluvium		
Total 2060 secure yield of existing sources				*25,950*
Yield Deficit at 2060 (including 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,550*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP (augmented)	Richmond Valley Council	35
T5	Kyogle WTP	Kyogle Council	3.0

Figure E5: Regional Water Supply Scenario 4 – Toonumbar Dam raised by 20m



SCENARIO 5: TOONUMBAR DAM (RICHMOND RIVER) RAISED BY 10 M AND RAISE CLARRIE HALL DAM (TWEED RIVER)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising Clarrie Hall Dam to FSL 70m (W1) and raising of Toonumbar Dam by 10 m (W2) with the creation and purchase of town water extraction licences and releases from Toonumbar dam to an extraction point at the confluence of Iron Pot Creek and Richmond River. Raw water from Toonumbar Dam would be transferred to Casino (E) for treatment at the existing Casino WTP (T4) which would be augmented by approximately 12 ML/d and to Kyogle (F) for treatment at the existing Kyogle WTP (T5). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 78,900 existing residential connections (153,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Kyogle in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	4
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	<1
Kyogle	304	<2	441	2
Total Regional Water Supply	*23,044*	*127*	*39,401*	*216*

1. Peak day demand assumes daily average demand and peaking factor of 2.0.

Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
15	Kyogle Weir	Richmond River	Kyogle Council	250
16	Kyogle Bores	Richmond River Alluvium		
Total 2060 secure yield of existing sources				*25,950*
Yield Deficit at 2060 (including 900 ML/a yield benefit provided by interconnection with Jabour Weir				*12,550*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP (augmented)	Richmond Valley Council	35
T5	Kyogle WTP	Kyogle Council	3.0

Figure E6: Regional Water Supply Scenario 5 – Toonumbar Dam and Raise Clarrie Hall Dam

E5 ASSESSMENT OF REGIONAL SUPPLY SCENARIOS

A range of assessment criteria have been selected to enable comparison of the regional scenarios and identify the most attractive scenario to the region as a whole. The evaluation criteria incorporate the range of benefits of a regional scheme where possible.

Table E2: Regional Scenario Assessment Criteria

Benefits of Regional Approach	Assessment Criteria
Financial – Provide a lower cost drinking water supply to the region over the long term	Ability to stage capital expenditure over time to match demand and reduce initial capital cost
System resilience – Reduce risk of supply shortages	Ability to protect against short-term supply shortages resulting from drought, natural disaster, component failure or contamination
Climate resilience – Reduced vulnerability to the effects of climate change	Ability to address risks of reduction in average yield and increased yield variability due to climate change over the long term
System flexibility – Ability to accommodate a range of supply deficits	Ability to modify source components to adapt to changing demand due to growth and the influence of demand-side initiatives
Potential for scheme expansion – Ability to accommodate additional service areas	Ability to expand the regional network over time to provide benefits to areas that are not regionally networked

The potential for water and cost sharing is a major potential benefit of a regional water supply scheme. The degree of water and cost sharing is determined by the extent of the connected regional network, and the benefits that accrue to the individual water supplies due to those interconnections. All of the short-listed scenarios have significant sharing potential and therefore no significant separation of these scenarios is provided by using cost sharing as an assessment criterion.

Some additional assessment criteria cannot be applied to compare the scenarios at present as detailed design information about the options is not yet available. Additional considerations include:

- Greenhouse gas emissions;
- Ecological and heritage impacts;
- Costs and net present value;
- Affordability;
- Stakeholder support; and
- Community acceptance.

Further development of the schemes will require consideration of the triple bottom line outcomes.

The scenarios have been ranked against the assessment criteria in Table E3.

Table E3: Comparison of Regional Scenarios

Objective	**Financial – Provide a lower cost drinking water supply to the region over the long term**	**System resilience – Reduce risk of supply shortages**	**Climate resilience – Reduced vulnerability to the effects of climate change**	**System flexibility – Ability to accommodate a range of supply deficits**	**Potential for scheme expansion – Ability to accommodate additional service areas**	**Overall Attractiveness**
Assessment Criteria	*Ability to stage capital expenditure over time to match demand and reduce initial capital cost*	*Ability to protect against short-term supply shortages resulting from drought, natural disaster, component failure or contamination*	*Ability to address risks of yield reduction and increased variability in climate due to climate change over the long term*	*Source components can be modified to adapt to changing demand due to growth and the influence of demand-side initiatives*	*Ability to expand the regional network over time to provide benefits to areas that are not regionally networked*	*All*
1 – Coastal desalination	Multiple stages are possible: A desalination facility is easily constructed in stages to meet demand. Significant initial infrastructure cost but highly scalable thereafter.	Excellent. The desalination facility provides a new source that is drought-resistant and independent of existing sources. Supply can be achieved through three major sources and treatment facilities.	Excellent. The desalination facility provides a new source that is fully climate independent.	High. Desalination facilities can be under-utilised or scaled-up as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	High. Meets objectives of study.
Rank	1	1	1	1	3	1
2 – Dunoon Dam (Richmond River, 50,000 ML) and raise Clarrie Hall Dam (Tweed River)	Two or three stages are potentially possible: Significant initial infrastructure cost with either dam constructed first. Supply augmentation stage is achieved through the second dam with potential raising of Dunoon Dam (third stage).	Moderate. The two major dams provide additional surface water redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through two major sources and treatment facilities.	Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply.	Moderate. Source augmentation can only be scaled-up once or potentially twice. Treatment facilities can be under-utilised as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	Moderate. Meets objectives of study but supplies are susceptible to climate-related risks.
Rank	2	4	2	2	3	2

Excellent	High	Moderate	Low-Moderate	Poor

Objective	Financial – Provide a lower cost drinking water supply to the region over the long term	System resilience – Reduce risk of supply shortages	Climate resilience – Reduced vulnerability to the effects of climate change	System flexibility – Ability to accommodate a range of supply deficits	Potential for scheme expansion – Ability to accommodate additional service areas	Overall Attractiveness
3 – Dunoon Dam (Richmond River, 85,000 ML)	One or two stages are potentially possible although feasibility of dam raising is unknown: Significant initial infrastructure cost with dam construction.	Moderate. The two major dams provide additional surface water redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through two major sources and treatment facilities.	Low - Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply.	Low-Moderate. Source augmentation may potentially be scaled up once with dam raising. Treatment facilities can be under-utilised as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	Low – Moderate. Meets objectives of study but supplies are highly susceptible to climate-related risks. Not likely to offer any significant advantages over Scenario 2.
Rank	4	4	2	4	3	5
4 – Use of Toonumbar Dam (with 20 m raising)	One or two stages are potentially possible although feasibility of second raising is unknown: Significant initial infrastructure cost with dam raising, pipe and treatment facilities.	High. The new surface water source provides additional redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through three major sources and treatment facilities.	Low - Moderate. Fully reliant on water surface supplies. It is likely that this more western storage will be more susceptible to climate change impacts but scenario reduces reliance on a single major supply.	Low-Moderate. Source augmentation may potentially be scaled up once with second dam raising. Treatment facilities can be under-utilised as required.	High. Larger regional supply network includes Kyogle LGA.	Low – Moderate. Meets objectives of study but supplies are highly susceptible to climate-related risks.
Rank	4	2	5	4	1	4

Excellent	High	Moderate	Low-Moderate	Poor

Objective	Financial – Provide a lower cost drinking water supply to the region over the long term	System resilience – Reduce risk of supply shortages	Climate resilience – Reduced vulnerability to the effects of climate change	System flexibility – Ability to accommodate a range of supply deficits	Potential for scheme expansion – Ability to accommodate additional service areas	Overall Attractiveness
5 - Toonumbar Dam (with 10m raising) and raise Clarrie Hall Dam	Two or three stages are possible: Significant initial infrastructure cost with either dam raising constructed first. One supply augmentation stage is achieved through second dam raising with potential for second raising of Toonumbar Dam.	High. The new surface water source provides additional redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through three major sources and treatment facilities.	Low-Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply. Toonumbar Dam is more susceptible to climate change risks.	Moderate. Source augmentation may be scaled-up once and potentially twice with a second raising of Toonumbar Dam (to 20m). Treatment facilities can be under-utilised as required.	High. Larger regional supply network includes Kyogle LGA.	Moderate. Meets objectives of study but supplies are susceptible to climate-related risks.
Rank	3	2	4	2	1	2

Excellent	High	Moderate	Low-Moderate	Poor

E6 CONCLUSIONS AND RECOMMENDATIONS

There are significant benefits to be gained from interconnection of the major water supplies in the region in terms of water sharing, cost sharing and improvements in water supply security on a local and regional scale. The major benefits arise with interconnection of the Rous Water bulk supply system with the Tweed (Bray Park) water supply system as these systems both require source augmentation on a large scale and within similar timeframes. Interconnection of the smaller water supply systems of Casino, Mullumbimby, Nimbin and Kyogle would assist with resolution of local water supply security issues but would not significantly influence the viability of the regional scheme. It is recommended that these smaller interconnection options are pursued as part of a larger regional scheme if this is the preferred option to address local water supply security issues.

A regional scheme would require significant investment in a new water supply source or sources within the next 10 years. The most attractive source augmentation option is marine water desalination (Scenario 1) as this is easily scalable to match demand and is independent of climate, thus providing a highly secure water supply. Adding desalination provides climate independence that is currently missing from the region's water supplies. Desalination schemes have been successfully developed elsewhere and improvements in technology are likely to improve the attractiveness in future.

The attractiveness of a desalination solution diminishes if alternative large scale options are implemented by separate LWUs beforehand as the cost-sharing potential of a centralised scheme diminishes markedly once this occurs. Despite the overall attractiveness of desalination, significant uncertainties remain with this option and it is considered appropriate that surface water augmentation options continue to be considered as an alternative regional solution should desalination not be confirmed as a viable strategy. In this case, the most attractive surface water scenarios (Scenarios 2 and 5) involve additional surface water storages in both the Richmond River (Dunoon Dam or Toonumbar Dam) and Tweed River catchments (raising Clarrie Hall Dam). These scenarios are also not restricted by implementation of either component (Tweed or Richmond River storage) in isolation of the regional scheme.

A balance between surface water (through the large volume of existing storage), desalination (providing climate independence and flexibility) as well as groundwater sources (which are a widely distributed, easily accessible resource for small scale localised supply) provides the most robust and logical regional system. Potable demand reduction through demand management, water loss management and source substitution would all contribute to reduced supply deficit and allow the use of existing supplies over a longer timeframe and should be implemented on a local scale but with regional consistency as appropriate. Overall, these do not detract from or enhance the attractiveness of the preferred regional scheme.

Whilst some potential regional schemes have been identified, the merit of each LWU connecting their water supply scheme to a regional scheme must be the subject of an investigation by the respective LWU. As identified above there are a number of major regional schemes and some minor regional schemes that could be of merit.

To progress the development and implementation of the preferred regional water supply strategy (Scenario 1 – Desalination), the following actions are recommended:

- Regional investigations:
    - Investigate feasibility of inter-connection options. The success of a regional surface water scenario is highly dependent on the interconnection and two-way transfer of water between the Tweed/Bray Park water supply system and the Rous Water bulk supply network. Investigations should include pipeline route, transfer system, cost and yield benefit obtained from the interconnection as well as potential administrative and governance arrangements. This study should be conducted in conjunction with the desalination study recommended

below due to the interaction of the two concepts. Similar investigations are required for the interconnection of the region's smaller systems;

  - Desalination study. While the options of small-scale desalination have been investigated on preliminary level, there is a need to develop a concept for the large-scale regional desalination facility including feed water, brine discharge, energy requirements and sources, treatment plant location, staging, transfer systems and cost. This study should be undertaken as a priority and focus on a centrally located large scale plant contributing to both the Tweed and Rous Water systems; and
  - Sufficient investigation of potential surface water storage options (particularly raising Clarrie Hall Dam and raising Toonumbar Dam), including yield and environmental and social impacts, to enable full comparison with the desalination scenario.

- LWU) strategic planning – to assist future planning for water supply in the region, the following should be undertaken:
  - Yield studies. The LWUs should determine the yield of existing water sources and impacts of climate change in accordance with Office of Water guidelines;
  - Monitoring – All LWUs should continue to improve data collection and monitoring of connection growth and demand, with increased regional consistency;
  - Water loss management - All LWUs should continue to improve the understanding of water losses and implement a water loss management program;
  - Demand management - All LWUs should continue to implement programs to reduce per connection demand with regional consistency; and
  - Groundwater investigations – A new Water Sharing Plan is being developed by the Office of Water. Once the regulatory requirements are known, the potential groundwater sources, bore yields, bore locations and water quality should be investigated to enable identification of feasible applications of groundwater supplies. Impacts on groundwater dependent ecosystems will also need to be identified. Whilst groundwater may not be implemented regionally, groundwater may still help to address water supply security issues on a local scale.

CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The Northern Rivers Regional Organisation of Councils (NOROC) aims to increase tangible benefits to member councils through enhanced resource and capacity sharing programs. These programs aim to deliver efficiencies and cost savings for NOROC member councils whilst promoting local government innovation and excellence.

The Northern Rivers Water Group (NRWG) is a collective of water authorities across the Northern Rivers region of New South Wales. The NRWG provides a foundation for development of cooperative partnerships to deliver best practice water supply and sewerage services to the Northern Rivers region of New South Wales and to optimise the sharing of resources in the delivery of services. The NRWG has developed a Memorandum of Understanding (MOU) to provide a foundation for developing a voluntary, cooperative partnership between the member councils to deliver best practice water supply and sewerage services to the Northern Rivers region and to optimise shared resources (staff, equipment, materials, specialist knowledge and capabilities). A targeted objective under this MOU is the development of a long-term (50-year) regional water supply strategy incorporating integrated water cycle management approaches.

In recognition of the benefits of resource sharing, NOROC has resolved to prepare a Bulk Water Supply Strategy for the Northern Rivers region. This regional strategy investigates the potential for integrated regional approaches to improve the security of town water supplies.

The major stages of the strategy development are shown in Figure 1.

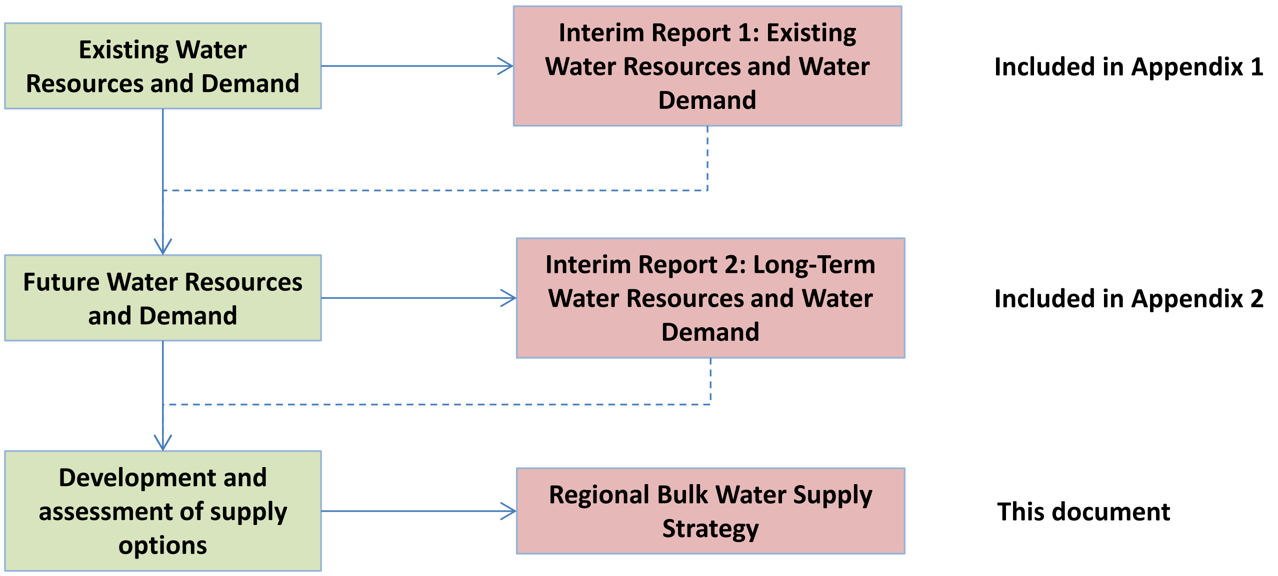


Figure 1: Regional strategy development process

2. STUDY AREA

This Strategy covers the town water supplies in the Local Government Areas (LGAs) of:

- Ballina Shire;
- Byron Shire;
- Kyogle Shire;
- Lismore City;
- Richmond Valley; and
- Tweed Shire.

Figure 2: Northern Rivers Regional Bulk Water Supply Strategy study area

2.1 Water Resources

The topography in the region varies from steeply sloping hills of the Great Diving Range in the west to flat coastal floodplains in the east.

The water resources in the study area can be divided into surface water, groundwater and seawater. The majority of potable town water supply is currently sourced from surface water resources, whilst groundwater is used on a smaller scale to supplement local supplies and provide a back-up source during drought (refer Section 3). Seawater (treated through desalination to produce potable water), whether estuarine or marine, is not currently used as a raw water source in the study area.

2.1.1 Water Sharing Plans

The overarching management of water resources in NSW is governed by Water Sharing Plans. The *Water Management Act, 2000* requires the implementation of the ten-year plans defining water sharing arrangements between the environment and water users. Water Sharing Plans are progressively being developed for rivers and groundwater systems in NSW following the introduction of the Act. The plans set rules for sharing water between the water users and environmental needs of the river or aquifer, and also between the different types of water use such as town water supply, stock watering, rural domestic supply, irrigation and industry.

2.1.2 Surface Water

The major surface water catchments in the NOROC study area are the Tweed River catchment and the Richmond River catchment. The study area also incorporates part of the Clarence River catchment which lies to the west of Kyogle and south of Evans Head.

Surface water catchments and existing water supply sources are illustrated in Figure 3.

Water Sharing Plans which include management of surface water sources in the study area are:

- *Richmond River Area Unregulated, Regulated and Alluvial Water Sources*; and
- *Tweed River Area Unregulated, Regulated and Alluvial Water Sources*.

Existing Surface Water Sources					
Ref	**Water Source**	**Raw Water Resource**	**Ref**	**Water Source**	**Raw Water Resource**
01	Clarrie Hall Dam	Doon Doon Creek	12	Lavertys Gap Weir	Wilsons River
02	Bray Park Weir	Tweed River	15	Kyogle Weir	Richmond River
03	DE Williams Dam	Mulgum Creek	17	Petrochilos Dam	Off stream storage
04	Mulgum Creek Weir	Mulgum Creek	18	Peacock Creek Weir	Peacock Creek
05	Emigrant Creek Dam	Emigrant Creek	20	Tooloom Creek Weir	Tooloom Creek
06	Rocky Creek Dam	Rocky Creek	21	Tyalgum Weir	Oxley River
07	Wilsons River Source	Wilsons River	22	Marom Creek Weir	Marom Creek
11	Jabour Weir Intake	Richmond River			

Figure 3: Surface water catchments and surface water sources currently used to supply potable town water

Tweed River Catchment

The main river system in the Tweed Shire is the Tweed River, with a total catchment area of 1,081 km^2. All tributaries in the catchment drain into the Tweed River and eventually the Pacific Ocean. The Tweed Coast estuaries of Cudgen, Cudgera and Mooball Creeks have discrete catchment areas that drain directly into the Pacific Ocean (refer Figure 3).

Streams in the Tweed catchment are heavily influenced by seasonal climatic variability. Generally high flows occur in all water sources during the periods from January through to July with peak flows typically occurring during January to March.

The major instream water storage structure in the Tweed River catchment is Clarrie Hall Dam, managed by Tweed Shire Council. Releases from the dam flow to Bray Park Weir, upstream of Murwillumbah where water is extracted for town supply. The total annual volume of surface water licensed for extraction under the Water Sharing Plan for the Tweed River Area Unregulated and Alluvial Water Sources is 35,207 ML per year compared to an annual average flow of approximately 365,000 ML for the Tweed River at Bray Park Weir. In addition, there is 780 ML per year of authorised private groundwater extraction from the 'upriver' alluvial aquifers and the 'coastal floodplain' alluvial aquifers within the plan area. These sources have been included in the plan due to the significant degree of connectivity of these aquifers with their parent streams.

Tweed Shire Council holds water access licences (WAL) for Bray Park, Uki and Tyalgum water sources. The share components of Tweed Shire Council LWU access licences authorised to take water from these water sources are 27,567 ML/year in the Mid Tweed River Water Source (Tweed – 27,500 ML/a, Uki – 67 ML/a) and 46 ML/a in the Upper Oxley River Water Source (Tyalgum system). For the Tweed River Catchment extraction management units, the total volume of surface water licensed for extraction is 33,197 ML with about 83% for town water supply.

The Water Sharing Plan specifies operational rules for LWU storages including environmental flow releases from Clarrie Hall Dam and Bray Park weir.

Richmond River Catchment

The Richmond River catchment is bordered by the Nightcap Ranges in the north-east, the Border Ranges in the north and the Richmond Ranges in the west and south-west. The eastern extent of the catchment is dominated by a very large coastal floodplain that extends from Evans Head in the south to Byron Bay in the north. The Evans River catchment is a small coastal catchment that is mostly located within the Broadwater and Bundjalung National Parks.

The Richmond River catchment is made up of three major sub-catchments - the main Richmond River arm, Wilsons River and Bungawalbyn Creek. Sixty per cent of the flow comes from the Wilsons River catchment.

The Richmond River discharges into the Pacific Ocean at Ballina. The average annual discharge from the Richmond River is 1,920,000 ML. This annual discharge fluctuates significantly from as little as 15% to as much as 233% of the annual average discharge. This range illustrates the significant variability in flows between wet and dry years. Variability in stream-flows also occurs between seasons and across the catchment. In the wetter months (summer to early autumn) flow can be six times greater than the dryer months (late winter to spring). Those streams located in the north and north eastern part of the catchment where rainfalls are higher, exhibit markedly higher flows than those in the western and south western part of the catchment which experiences lower rainfall (NSW Department of Commerce, 2005a).

Major in-stream water storage structures in the Richmond River catchment include:

- Toonumbar Dam (11,000 ML) on Iron Pot Creek which is currently used for irrigation purposes;
- Rocky Creek Dam (14,000 ML) which is the major water supply for Rous Water;
- Emigrant Creek Dam which is also managed by Rous Water;
- Kyogle Weir which is Kyogle's main town water supply;

- Jabour Weir at Casino which supplies town water;
- Mulgum Creek Weir which supplies town water to Nimbin;
- Lavertys Gap Weir on the upper Wilsons River which supplies town water to Mullumbimby; and
- Marom Creek Weir which supplies town water to Wardell and surrounding areas.

A 50 km length of river within the Richmond River catchment is regulated through releases from Toonumbar Dam. These releases flow into Iron Pot Creek, which then becomes Eden Creek. The junction of Eden Creek and the Richmond River marks the downstream end of the regulated system.

In addition to the water storages within the catchment, Rous Water also can utilise the Wilsons River Source which pumps fresh water from the upper reaches of the Wilsons River tidal pool to the Nightcap Water Treatment Plant. Although this has a large allocation, this source was established by Rous Water as an emergency supply for its network.

There are approximately 2,345 water licences in the area covered by the *Water Sharing Plan for Richmond River Area Unregulated, Regulated and Alluvial Water Sources*, with a total entitlement of 97,407 ML of 5% of the average annual flow. The majority of these licences are for irrigation, with a significant proportion also used for town water supply.

2.1.3 Groundwater

A number of groundwater sources exist in the study area. The NSW Office of Water (2010a) groups aquifer types into four basic categories:

1. Fractured rock aquifers found in rock formations such as granite or basalt. Groundwater in these rocks occurs mainly within the fractures and joints. The North Coast Fractured Rocks and Alstonville Basalts make up the fractured rock aquifers in the study area;
2. Coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments;
3. Porous rock aquifers found in rock formations such as sandstone or limestone. Groundwater occurs within the pore space in the rock matrix. The Clarence Moreton Basin represents porous rock aquifers in the study area; and
4. Alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

Figure 4: shows the location of groundwater sources in the study area. Further discussion of each of the four main aquifer types is provided in Appendix 3.

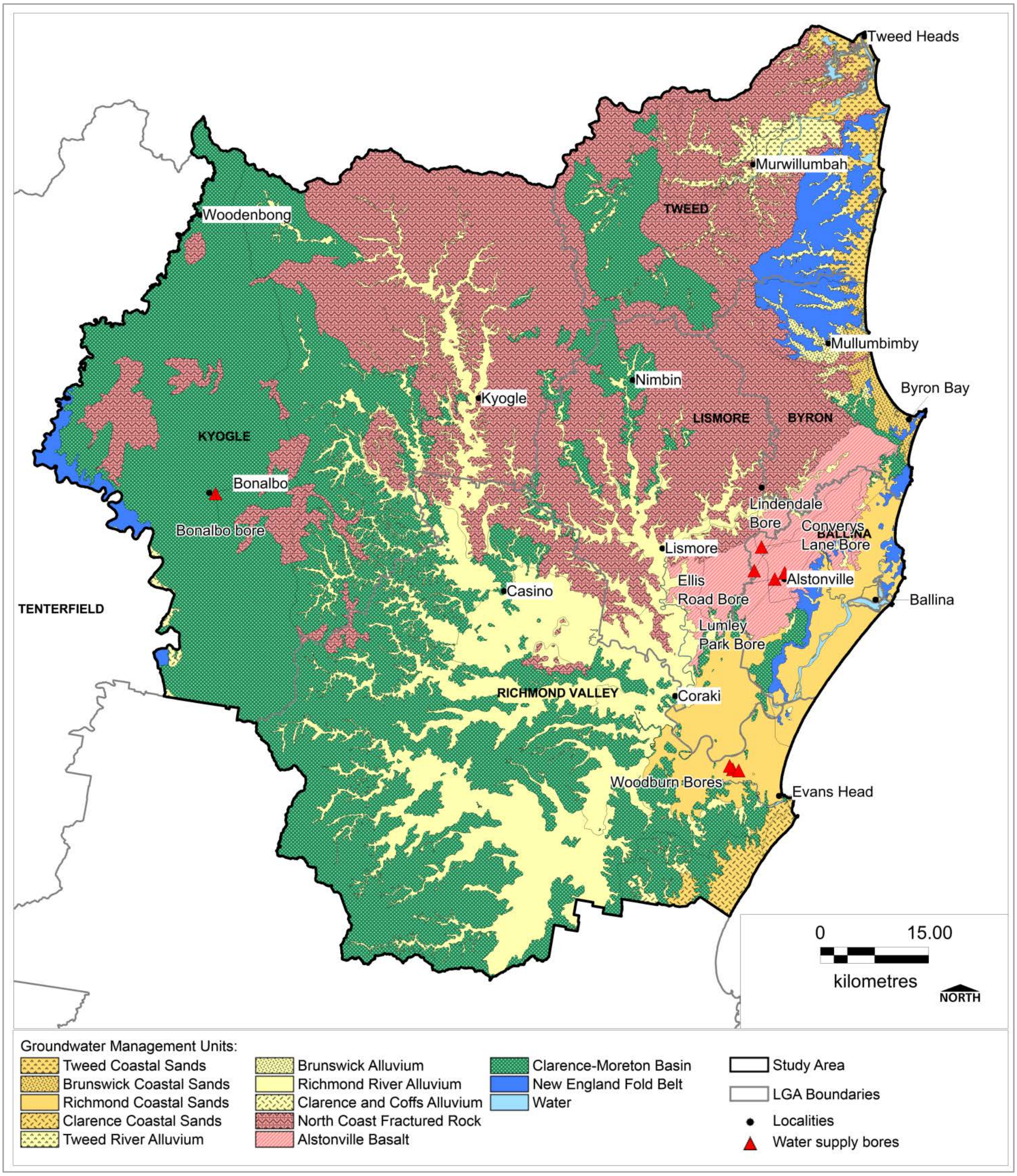


Figure 4: Groundwater sources in the study area

Mapping provided by NSW Office of Water, Jan 2013

Water Sharing Plans manage groundwater sources in the study area for the:

- *Alstonville Groundwater Sources*;
- *Richmond River Area Unregulated, Regulated and Alluvial Water Sources*; and
- *Tweed River Area Unregulated, Regulated and Alluvial Water Sources*.

The NSW Office of Water is currently developing a water sharing plan for the Coastal Sands aquifers on the North Coast which will collate all available information about the water source, and the rules and regulations to govern extraction from this aquifer.

Table 1 collates information on local aquifers from various sources including basic geology, yield and salinity characteristics, connection to surface water, DLWC's aquifer risk assessment rating and whether a Water Sharing Plan exists for the aquifer. In terms of high yields, good water quality, and low level of connection to surface water, the Coastal Sands (outside tidal areas) and North Coast Fractured Rock aquifers stand out as potential future water sources with bore yields up to 40 L/s and 30 L/s respectively.

Table 1: Characteristics of aquifers in the study area

Aquifer	Geology	Level of connection between surface and groundwater	Bore Yields (L/s)	Salinity (mg/L)	DLWC Risk Assess	Water Sharing Plan
North Coast Fractured Rocks/Alstonville Basalt	Fractured Basalt with vesicular zones and interlayered sediments	Low-Moderate	Typical: 1-15 Max: 30	<500	High	Alstonville Basalt only
Coastal Sands – Tweed, Brunswick and Richmond River	Beach and dune sands	Significant (tidal section only)	Typical: 0.5-6 Max: 40	<500	Tweed: Medium, Richmond: High	No – currently being developed
Porous Rocks of Clarence Moreton Basin – Kangaroo Creek Sandstone	Sedimentary rocks- Quartz Sandstone, Conglomerate, Siltstone, Claystone, Coal	Low-Moderate	Typical: 0.3-1.5 Max: 10	<300	Low	No – currently being developed
New England Fold Belt (NEFB)	Fractured and weathered granite	Low-Moderate	Typical: 0.1-0.5 Max: 19	<500	Medium-High	No
Estuarine and Fluvial River Alluvium - Tweed River and Richmond River	Unconsolidated cobbles, gravels, sands, silts, muds and clays	Significant	Typical: 0.5-2.0 Max: 15	200-3,500	High	Yes

Sources: DLWC (1998), DLWC (2001), McKibbin (1995), Sinclair Knight Merz (2006).

2.1.4 Seawater

Saline waters can be sourced from marine or estuarine locations. Desalination of seawater can augment available water resources and can be a virtually unlimited, reliable source of water in coastal regions. Brackish water from estuaries or coastal groundwater can also be used as feed water in desalination processes. Major estuarine water sources on the North Coast include the Evans, Richmond, Brunswick and Tweed River estuaries along with saline/brackish coastal groundwater aquifers.

Currently, there is no utilisation of seawater desalination for water supply within the study area.

2.2 Climate

The Northern Rivers region experiences a subtropical climate, with warm humid summers and mild winters. Within the region, climate varies with distance from the ocean, latitude and elevation. In general, the coastal zone receives higher rainfall and experiences milder temperatures. Table 2 presents average rainfall and maximum temperature data for various locations across the region. Average annual rainfall ranges from a 1,853 mm at Kingscliff in the north east to 1,084 mm at Casino in the central/western area. Average annual maximum temperatures vary from 24.5°C at Ballina on the coast to 25.8°C further inland at Lismore.

Table 2: Rainfall and evaporation data at various locations across the Northern Rivers (2003-2012)

Location	Average Annual Rainfall (mm)	Average Max Temperature (°C)	Latitude (degrees)	Longitude (degrees)	General Location within Region	Elevation (m AHD)
Murwillumbah	1,590	25.7	-28.34	153.38	North	8
Kingscliff	1,853	24.8	-28.26	153.58	North East	5
Ballina	1,828	24.5	-28.84	153.56	South East	1.3
Lismore	1,146	25.8	-28.83	153.26	Central	9
Casino	1,084	25.7	-28.88	153.05	Central-West	21
Kyogle	1,254	N/A	-28.62	153.00	Central-West	80

Source: BOM (2013) Climate Data Online

Seasonal variability in rainfall and evaporation at Ballina is shown in . There is a high degree of season-to-season variation in rainfall demonstrating a clear wet-dry seasonal pattern, which is typical of a subtropical environment. The highest rainfall typically occurs during summer and in early autumn with lowest rainfall occurring in late winter and early spring. During the first half of the year, rainfall typically exceeds evaporation whereas the opposite occurs in the second half. A similar trend is experienced throughout the region.

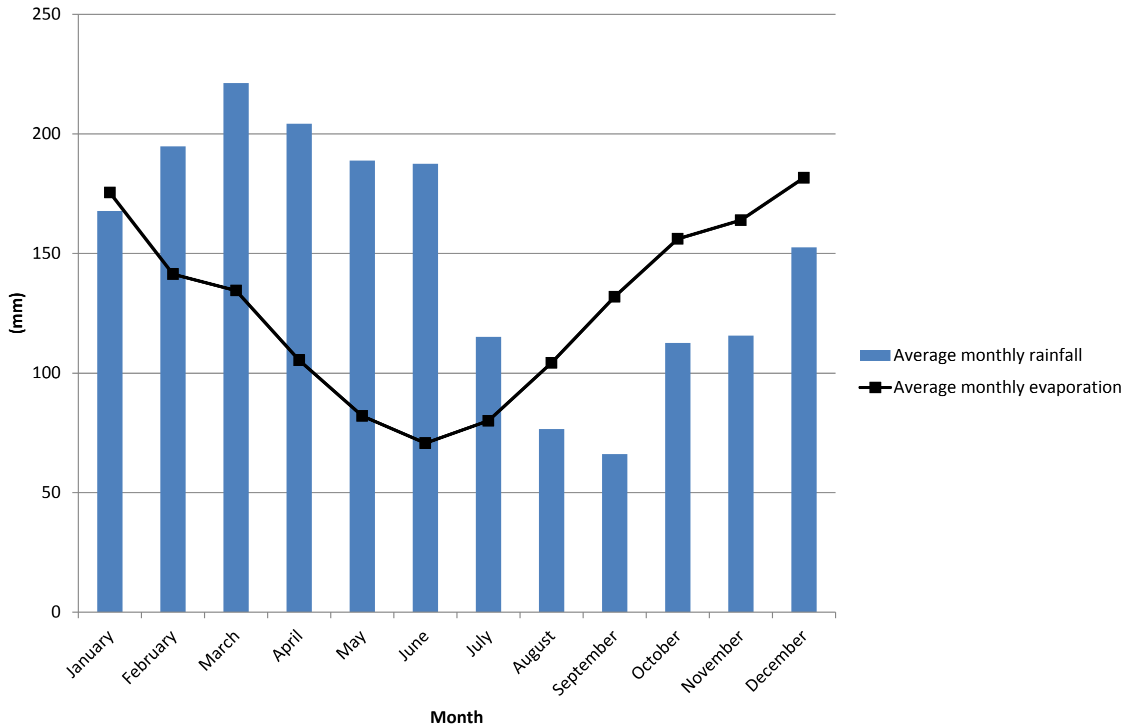


Figure 5: Mean monthly rainfall and evaporation at Ballina (1970-2012)

Source: BOM (2013) Climate Data Online

2.3 Climate Change

In 2007, the Intergovernmental Panel on Climate Change (IPCC) released its fourth assessment report, concluding that:

- Warming of the climate system is unequivocal;

- Humans are very likely to be causing most of the warming that has been experienced since 1950; and
- It is very likely that changes in the global climate system will continue well into the future, and that they will be larger than those seen in the recent past.

These changes have the potential to have a major impact on human and natural systems throughout the world including Australia.

In June 2008, the NSW Department of Water and Environment released a report which provides estimates of future climate and runoff across NSW and ACT. The results provide a prediction of the impacts of future climate on runoff and water availability across the state. Climate change projections for rainfall and runoff in 2030 relative to 1990 from 15 global climate change models are presented in the report.

The NSW Government and the University of NSW have developed climate change forecasts for the NSW State Plan regions (DECCW, 2010).The NSW Climate Impact Profile provides projections of climate change and impacts of these changes on settlements, land and ecosystems of NSW. The profile outlines some of the risks to help decision makers develop their planning and response strategies. The North Coast region profile covers the LGAs of Ballina, Bellingen, Byron, Clarence Valley, Coffs Harbour, Greater Taree, Hastings, Kempsey, Kyogle, Lismore, Nambucca, Richmond Valley and Tweed.

Expected regional climatic changes in the region are (DECCW, 2010);

- Rising temperatures - Average daily maximum temperatures are virtually certain to increase in all seasons. The smallest increases are projected to occur in summer (1.0 - 1.5°C) and the greatest in winter (2.0 - 3.0°C);
- Increasing rainfall in summer and autumn is likely - Summer and autumn rainfalls are expected to increase slightly, while winter rainfall is expected to decrease slightly;
- Increasing evaporation - Evaporation is likely to increase moderately throughout the region during spring, summer and autumn. A slight to moderate increase in evaporation is likely in winter; and
- Impact of the El Nino-Southern Oscillation (ENSO) is likely to become more extreme - ENSO years will continue to be drier than average but also become hotter, leading to more extreme impacts. La Niña years are likely to continue to be wetter than average but will also become warmer. In El Niño events, water stress is likely to be more intense because of higher temperatures.

In terms of water supply availability, the expected physical responses to these changes are:

- Increased evaporation - Despite projected increases in rainfall in summer and autumn, soil conditions are likely to be drier for most of the year, particularly in spring and winter, as a result of increased temperatures and evaporation;
- Changes in run-off - Substantial increases in run-off depths and the magnitude of high flows are very likely in summer. A moderate decrease in run-off depths is likely in spring; and
- Short term hydrological droughts are likely to become more severe - Short-duration droughts are likely to become more severe and medium and long-term droughts are expected to remain similar to current conditions.

Changes in rainfall and higher evaporation rates are likely to lead to less water for streams and rivers in the Northern Rivers Catchment, which will have downstream consequences for storages and place strains on the catchment’s water resources (CSIRO, 2007).

3. EXISTING POTABLE WATER SUPPLIES

3.1 Town Water Supply

The existing town water supplies in the study area are discussed in detail in Interim Report 1 (Appendix 1). The major sources of water are Rocky Creek Dam in the Richmond River catchment and Clarrie Hall Dam in the Tweed River catchment providing 48% and 38% of the region's water supply respectively. These larger centralised water sources also serve the majority (90%) of the study area population over the longest distribution systems. There are also many smaller water sources serving the towns and villages within the study area. The existing potable water supply systems are shown on Figure 6 and summarised in Table 3.

Table 3: Urban Water Supplies in the Region

Local Water Utility	Service Areas	Water Sources
Rous Water bulk water supply	• Ballina Shire Council, excluding Wardell; • Byron Shire Council, excluding Mullumbimby; • Lismore City Council, excluding Nimbin; and • Richmond Valley Council, excluding Casino and all land west of Coraki.	• Surface water – Rocky Creek Dam, Emigrant Creek Dam, Wilsons River Source • Groundwater – Woodburn bores, Alstonville Plateau bores
Rous Water retail supply	Rural and urban connections within the Constituent Council areas served directly from the bulk supply system	
Ballina Shire Council	Wardell, Meerschaum Vale, Cabbage Tree Island and some rural customers	• Surface water - Marom Creek Weir • Groundwater – Alstonville Plateau bores
	Ballina Heights, North Ballina, West Ballina, Ballina Island, East Ballina, Lennox Head, Wollongbar, Russellton and Alstonville and some rural customers	Rous Water bulk supply
Byron Shire Council	Mullumbimby	• Surface water - Laverty's Gap Weir • Rous Water bulk supply (emergency supply)
	Bangalow, Brunswick Heads, Byron Bay, Suffolk Park, Ocean Shores	Rous Water bulk supply
Kyogle Council	Kyogle	• Surface water - Kyogle Weir • Groundwater – Kyogle bores
	Bonalbo	• Surface water – Peacock Creek Weir and Petrochilos Dam • Groundwater – Bonalbo bores
	Woodenbong and Muli Muli	Bulk water supplied by Tenterfield Shire Council
Lismore City Council	Nimbin	• Surface water - Mulgum Creek Weir and DE Williams dam
	Lismore City, Dunoon, Modanville, The Channon, Dunoon Road, Clunes, North Woodburn	Rous Water bulk supply
Richmond Valley Council	Casino	• Surface water - Jabour Weir
	Evans Head, Woodburn, Broadwater and Rileys Hill and Coraki	Rous Water bulk supply

Local Water Utility	Service Areas	Water Sources
Tweed Shire Council	Murwillumbah, Tweed Heads, the coastal strip from Kingscliff to Pottsville and the villages of Mooball and Burringbar	• Surface water – Clarrie Hall Dam and Bray Park Weir • SEQ Water Grid (minor emergency supply)
	Uki	• Surface water – Clarrie Hall Dam
	Tyalgum	• Surface water – Tyalgum Weir Pool

Existing Water Sources							
Ref	**Water Source**	**Raw Water Resource**	**Local Water Utility**	**Ref**	**Water Source**	**Raw Water Resource**	**Local Water Utility**
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	12	Lavertys Gap Weir	Wilsons River	Byron Shire Council
02	Bray Park Weir	Tweed River		13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council
03	DE Williams Dam	Mulgum Creek	Lismore City Council	14	Lindendale Bore	Alstonville Basalt Aquifer	
04	Mulgum Creek Weir	Mulgum Creek		15	Kyogle Weir	Richmond River	Kyogle Shire Council
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	16	Kyogle Bores	Richmond River Alluvium	
06	Rocky Creek Dam	Rocky Creek		17	Petrochilos Dam	Off stream storage	
07	Wilsons River Source	Wilsons River		18	Peacock Creek Weir	Peacock Creek	
08	Converys Lane Bore	Alstonville Basalt Aquifer		19	Bonalbo bore	unknown	
09	Lumley Park Bore	Alstonville Basalt Aquifer		20	Tooloom Creek Weir	Tooloom Creek	
10	Woodburn Bores	Coastal Sands Aquifer		21	Tyalgum Weir	Oxley River	Tweed Shire Council
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	22	Marom Creek Weir	Marom Creek	Ballina Shire Council

Figure 6: Northern Rivers water sources and existing potable town water supply systems

3.2 Current Water Demand

Table 4 lists the regional water sources and their respective contribution to the region's water supply and Table 5 presents the current number of connections, per connection demand, unmetered water and total demand for each water supply system. Further detail is provided in Appendix 1.

Table 4: Regional Water Sources

Water Supply System	Water Source	Water Sourced in 2011/12 (ML/a)	% of total study area
Rous Water			
Rous Water bulk supply	Rocky Creek Dam	11,121	48.2 %
	Emigrant Creek Dam	6	0.03 %
	Wilsons River Source	-	-
	Converys Lane bore	-	-
	Lumley Park bore	-	-
	Woodburn bores	-	-
Total Rous Water Sources		*11,127*	*48.3%*
Kyogle Council			
Kyogle	Kyogle weir	290	1.26%
Bonalbo	Peacock Creek weir	28	0.12%
	Bonalbo bores	6	0.02%
Woodenbong/Muli Muli	Tooloom Creek weir (bulk supply from Tenterfield Shire Council)	52	0.22%
Total Kyogle Council sources		*374*	*1.62%*
Nimbin	Mulgum Creek weir	63	0.77%
Casino	Jabour weir	2,180	9.46%
Wardell	Marom Creek Weir	119	0.52%
Mullumbimby	Lavertys Gap Weir	358	1.55%
Tweed Shire Council			
Tweed District/Uki	Clarrie Hall Dam/Bray Park weir	8,808	38.2%
Tyalgum	Tyalgum weir	22	0.10%
Total Tweed Shire Council sources		8,830	*38.3%*
Total Study Area		23,052	100%

Table 5: Current (average) demand in each system

Water Supply	Residential connections (2012)		Non-residential connections (2012)		Unmetered Water (% of total demand)	Total Current Demand (ML/a)
	Total Number	Average per connection demand (kL/a)	Total Number	Average per connection demand (kL/a)		
Ballina bulk supply	12,967	174	1,489	330	26%	3,325
Byron bulk supply	8,853	177	1,134	664	8%	2,429
Lismore bulk supply	13,000	178	1,268	674	13%	3,543
RVC bulk supply (MLRR)	2,323	161	274	651	17%	657
Rous Water retail	2,229	335	-	-	-	756
Rous Water bulk unmetered water	-	-	-	-	2%	193
Total Rous Water Bulk Supply Area	*39,372*	-	*4,165*	-	*16%*	*10,903*
Kyogle	1,182	162	203	450	7%	304
Bonalbo [1]	148	116	44	197	N/A	34
Woodenbong and Muli Muli	189	160	47	275	16%	52
Total Kyogle Shire	*1,519*	-	*294*	-	*10%*	*391*
Tweed District	32,471	165	1,701	1,245	19%	9,062
Uki	173		7			52
Tyalgum	99		15			31
Total Tweed Shire	*32,743*	-	*1,723*	-	*19%*	*9,145*
Mullumbimby	1,482	164	197	385	10%	378
Wardell [2]	284	N/A	28	N/A	10%	123
Nimbin [2]	247	153	68	314	10%	60
Casino [3]	4,070	190	453	2,871	10%	2,338
Total Region	*79,717*	-	*6,928*	-	*17%*	*23,344*

1. As raw water is pumped into an off-stream storage, total unmetered water is not available. Total demand is reported as the total raw water extraction from the river.

2. In the absence of data, unmetered water has been estimated as 10% of raw water extraction.

3. The average per connection demand includes Food Producers. Non-residential demand excluding Food Producers is 666 kL/a.

The NSW Office of Water produces the annual NSW Water Supply and Sewerage Performance Monitoring Report. The report presents the key performance indicators for all NSW urban water utilities which enables each utility to monitor and improve its performance through benchmarking against similar utilities. Figure 7 shows an analysis of annual residential demand data compared to LWUs of a similar size in NSW. Demand fluctuates from year to year, however the general trend since 2004 is that residential water demand in the region is decreasing. Demand has dropped on average by 20% across the region since 2004 with the highest reduction (41%) within Richmond Valley area. The historical average residential demand for the region is 184 kL/connected property/year compared to the state-wide historical average of 182 kL/connected property/year.

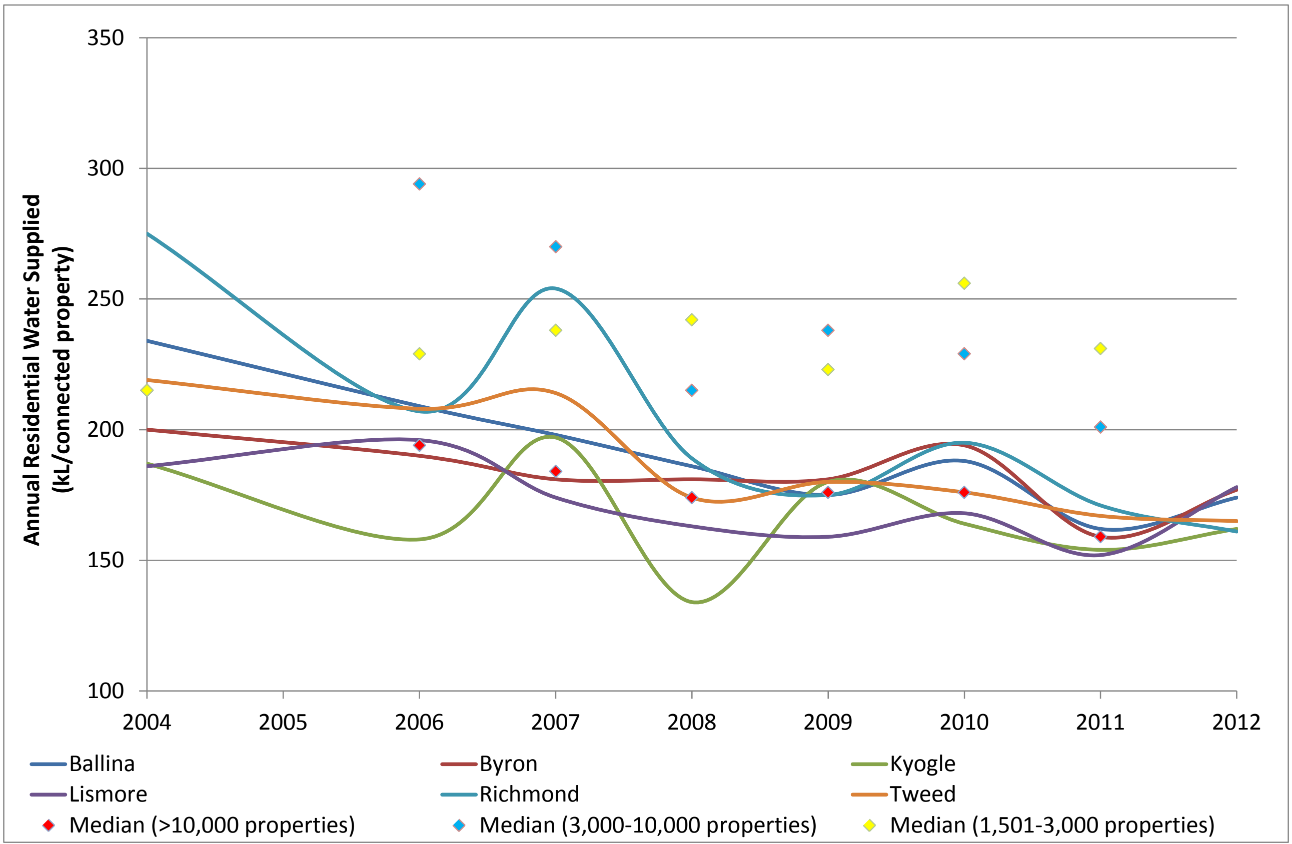


Figure 7: Residential water demand

Note: Median values are based on LWU sizes. Ballina, Byron, Lismore and Tweed are in the >10,000 category, Richmond Valley is in the 3,000-10,000 category and Kyogle in the 1,501-3,000 category. The 2004 median value is a state-wide value and no value is available for 2005.

Rous Water's demand management plan (Rous Water, 2012) also reports a declining trend in water consumption per connection despite a population increase over the same period and suggests that the trend is attributable to two key factors:

- The reduction in per dwelling occupancy over time; and
- Ongoing demand management initiatives which include increased community awareness about using water.

Tweed Shire Council's Demand Management Strategy in 2009 also reported that demand in the Tweed supply area had dropped from approximately 490 L/person/day in 1992 to approximately 290 L/person/day in 2010.

Climate is often perceived to be a key driver of water demand however previous work for Rous Water by AWT (reported in Hydrosphere Consulting, 2012b) found significant error in the attempted correlation between climate variables and demand. It was found that higher temperature may be a key driver of higher demands but the corresponding decrease for abnormally cool conditions was not apparent. Any relationship between climatic factors and demand variability is blurred by many other factors such as tourism, consumption behaviour, land development or water losses.

Notwithstanding a potential link to short-term climate variations, there has been a significant decrease in residential demand per connection over time. This trend is likely to continue with ongoing demand management initiatives as well as state government initiatives such as BASIX (as more connections in future will be BASIX compliant). Demand hardening is discussed in Section 3.4.

While the current level of demand is not considered to be a problem and ongoing actions will continue to reduce the demand, the LWU demand management programs (refer Section 8.6.1) should be evaluated to determine if further reduction is feasible.

3.3 Private Water Supplies

Within the study area, properties not connected to town water supplies rely on household rainwater tanks, bore water or direct river extraction. In times of prolonged drought, rainwater tanks may be depleted or groundwater/surface water extraction may be restricted and these private water supplies may purchase potable water from town water supplies via water carters.

Of the total potable water demand in the region, the average external bulk sales in the study area is estimated to be less than 100 ML/a. The maximum demand (experienced in 2009/10) is expected to be less than 150 ML/a (refer Interim Report 1 in Appendix 1).

The potential for increased demand from private water supplies during prolonged droughts is not known. However, an increase in demand may result from external sales of potable town water to fill private rainwater tanks during a drought. When drought restrictions are in force, it is expected that town water demand would be reduced below the forecast average demand and water carting would be restricted. Therefore, any short-term increased demand resulting from external sales is not expected to be significant when compared to the annual average regional demand. However, as the demand approaches the secure yield of the water supply systems, the risk of increased demand during hot, dry weather must be considered when planning for water supply augmentation.

3.4 Secure Yield

3.4.1 Existing Secure Yield

Given that climate and rainfall are highly variable from year to year, it is necessary to establish the amount of water that can be reliably obtained from the water sources during any year, regardless of climatic conditions. Secure yield is calculated using historic climate and stream flow data and a set of rules that describe water demand and the long-term effect of water restrictions. Secure yield was historically determined using the NSW Security of Supply Methodology (the highest annual water demand that can be supplied from a water supply headworks system whilst meeting the 5/10/20 rule - restrictions no more than 5% of the time with a frequency of no more than 1 in 10 years and on average a 20% reduction in consumption). The secure yield estimates for the region’s water sources using the 5/10/20 rule are provided in Table 6.

Table 6: Comparison of current demand and supply yield

Water Supply	Total Current Demand (ML/a)	Current Secure Yield (ML/a) [1]	Current Supply Surplus (ML/a)	Current Supply Surplus (%)
Ballina bulk supply	3,325	14,600	3,697	25%
Byron bulk supply	2,429			
Lismore bulk supply	3,543			

Water Supply	Total Current Demand (ML/a)	Current Secure Yield (ML/a) [1]	Current Supply Surplus (ML/a)	Current Supply Surplus (%)
RVC bulk supply (MLRR)	657			
Rous Water retail	756			
Rous Water unmetered water	193			
Kyogle	304	320	16	5%
Bonalbo	34	52	18	35%
Woodenbong and Muli Muli	52	83	31	37%
Tweed District	9,062	13,750	4,636	34%
Uki	52			
Tyalgum	31	120	89	74%
Mullumbimby	378	435	57	13%
Wardell	123	N/A	N/A	N/A
Nimbin	60	101	35	35%
Casino	2,338	2,525	187	7%
Total Region	*23,344*	*Approx. 32,000*	*Approx. 8,800*	*27%*

1. Secure yield determined using the 5/10/20 rule.

Over the last 20 years there has been a significant reduction in average water use per connection due to increased water awareness within the community and increased use of water efficient fixtures and appliances, as promoted through demand management programs and the BASIX efficient building requirements (refer Section 4.1). Increased water efficiency and demand management strategies have reduced or eliminated many of the non-essential uses of water from everyday life, meaning that it is now harder for water restrictions to achieve sustainable long-term reductions in demand (demand hardening). Future water supply planning in NSW is now based on achieving a 10% reduction in consumption i.e. a “5/10/10 rule”, which supersedes the previous “5/20/10 rule”. This dictates that a water supply should be designed to be able to supply a minimum of 90% (instead of 80%) of normal water demand during the worst drought.

Apart from Rous Water, the local water utilities have not yet assessed the impact of demand hardening on their water supplies. The impact of demand hardening is predicted to result in a reduction in the secure yield of Rous Water supplies of 800 ML/a (or 5.8%) to 13,800 ML/a.

3.4.2 Future Secure Yield

In recent years secure yield estimates have been reassessed to estimate the future impacts of climate change on the availability of water. The potential effects of climate change including alterations to local temperature, rainfall, evaporation, runoff and stream-flows were discussed in Section 2.2. The secure yield of a water supply system is expected to be impacted by the effects of climate change which are considered likely to reduce water supply availability.

Rous Water has been investigating the impacts of climate change on the secure yield of its water resources as part of a NSW Office of Water pilot study in 2010 and more recently through analysis of its system headworks model. The pilot study is based on the IPCC Emission Scenarios A1B which describes a future world of very rapid economic growth, global population that peaks in the mid-21st century and declines thereafter, and the rapid introduction of new and more efficient technologies with a balance across all energy sources (IPCC, 2007). The A1B scenario is considered to represent the ongoing global response to increasing awareness of climate change. The A1B scenario indicates the most likely climate change impacts will be an increase in average global maximum daily temperatures of 0.9°C over 1990 conditions by 2030 and an increase of 2°C by 2060. The Office of Water pilot study predicted a reduction in Rous Water's secure yield for the 0.9°C warming scenario of 9%.

Subsequent to the NSW Office of Water pilot study in 2010, Rous Water has undertaken further analysis of its system headworks model to determine secure yield currently and allowing for future climate change. The new modelling indicates that the reduction in secure yield between 0 and 1.0°C warming is 17.5% and between 0 and 2.0°C is 33.7%. The higher reduction in secure yield is apparently due to the decreased rainfall and runoff assumptions utilised in the yield model but no further details are available.

There are no data available on the impact of climate change on the secure yield of the other regional water sources. In the absence of local data for the other water supply systems in the Northern Rivers region, it is considered appropriate that water supply planning considers the impact of a 10% reduction in secure yield of surface water sources due to climate change by 2030 as this is consistent with the Office of Water pilot study and other work undertaken by Seqwater (south-east Queensland) which is subject to similar climatic conditions to the study area. Beyond 2030, it is considered that the loss in secure yield will be at least 20%, however, the recent work by Rous Water suggests this may be as high as 33.7%. Given the preliminary nature of this long-term forecasting, combined with the limited assessment of current secure yield for the other water supply systems, it may be premature to apply these higher reductions to the remainder of the region and therefore an interim forecast of 20% reduction by 2060 has been assumed for all other water supplies (refer Appendix 2). Despite this, this study will consider the risk of future increased reductions in secure yield and the ability of any adopted options to be able to cater for greater climate change impacts should they occur.

NSW Guidelines on assessing the impact of climate change on secure yield are being developed as part of the NSW requirements under the Best-Practice Management program. For LWUs with a storage dam or shallow bores, analysis similar to that carried out in the pilot study is generally recommended.

4. WATER SUPPLY SECURITY ISSUES

4.1 Supply Deficit

The current secure yield of the region's water resources (approximately 32,000 ML/a) is expected to decrease with the impacts of future climate change by approximately 6,000 ML/a or 26% by 2060 (refer Appendix 2). This represents a 33% reduction in Rous Water's supplies (based on recent studies) and 20% reduction in the other supplies in the region (refer Section 3.4.2). These predictions are inexact as there is significant uncertainty with the current secure yield and the impacts of demand hardening, environmental flow requirements and climate change into the future. Despite this, there is little doubt that augmentation of the majority of the water supplies in the region will be required due to population growth and the reduction in available water resources.

The expected demand, secure yield and supply deficit at 2060 is summarised in Table 7. The total regional supply deficit by 2060 is expected to be in the order of 14,000 ML/a, approximately 43% additional to the existing supplies. Major augmentations will be required to meet the growth in demand within the Rous Water bulk supply area and the Tweed Shire Council Bray Park system. Mullumbimby and Kyogle will also require significant additional supply compared to current sources. Smaller increases (compared to current supply) are also required in Casino, Bonalbo and Nimbin.

Table 7: Future demand, secure yield and supply deficit (ML/a)

Supply Area	2060 Forecast Demand	2060 Predicted Secure Yield [1]	Year that augmentation may be required	2060 Predicted Supply Deficit	2060 Supply Deficit (% of current supply)
Rous Water bulk supply	15,790	10,695 – 9,160	2022	5,100 – 6,600	37% - 48%
Wardell	201	unknown	unknown	unknown	unknown
Mullumbimby	691	380	2025	310	71%
Kyogle	441	250	2015	190	59%
Bonalbo	47	52	2048	5	10%
Woodenbong and Muli Muli	59	66	Not required within next 50 years		
Nimbin	88	unknown	unknown	unknown	unknown
Casino	2,410	2,020	2025	390	15%
Bray Park (Tweed District and Uki)	19,983	13,750	2030	6,230	45%
Tyalgum	61	96	Not required within next 50 years		
Region	*40,000*	*26,000*		*14,000*	*43%*

1. Secure yield of Rous Water supplies has been determined using the 5/10/10 rule. Secure yield of all other supplies has been determined using the 5/10/20 rule.

4.2 Drought Management and Emergency Response

The status of the region's drought management planning and response is given in Table 8. Further details of emergency supply options are provided in Interim Report 1 (Appendix 1). In some cases, drought planning needs to be reviewed or emergency supplies are not considered adequate to provide an appropriate response to drought or emergencies.

Table 8: Status of drought and emergency management planning

Supply Area	Drought Management Strategy/Restrictions Policy	Emergency Supply (contingency measure for highest level of restrictions)	Overall Status
Rous Water bulk supply area	Regional Water Management Strategy, 2009	Temporary suspension of licensing rules to allow additional pumping from the Wilson's River, supplemented by up to 3ML/d from Ballina Shire's Marom Creek Weir if required.	The drought management strategy should be updated with new information on current and future demand, demand hardening and secure yield.
Wardell	Rous Water Regional Water Management Strategy applies to Wardell residents.	Lindendale and Ellis Road bores.	The groundwater bores are rarely used and Council should confirm the operational viability and yield of the bores.
Mullumbimby	Water Restriction Regime Mullumbimby Water Supply, 2003	Emergency supply pipeline to Rous Water bulk supply at St Helena (0.5 ML/d). The emergency pipeline cannot supply water to high level areas. If the Laverty's Gap water source is exhausted, it would be necessary to truck water into these areas.	The drought management strategy should be updated with new information on current and future demand, demand hardening and secure yield.
Kyogle	Drought Management Plan, 2005	Groundwater supply from Kyogle bores (1.5 L/s), cartage from Casino water supply (treated) and dead storage in Toonumbar Dam.	The drought management plan should be updated with new information on current and future demand at each restriction level, demand hardening and secure yield.
Bonalbo		Groundwater supply from Bonalbo bores (4 L/s) used when low flow in Peacock Creek or poor surface water quality, cartage from Casino water supply (treated).	
Woodenbong and Muli Muli	Tenterfield Shire Drought Management Plan, 2010	Cartage from Lismore water supply (0.35 ML/d)	Kyogle Council should participate in any review of the Tenterfield Drought Management Plan.

Supply Area	Drought Management Strategy/Restrictions Policy	Emergency Supply (contingency measure for highest level of restrictions)	Overall Status
Nimbin	None	None	A drought management strategy should be prepared based on the Rous Water regional strategy. Planning for emergency response should be undertaken as part of the Nimbin water quality improvement project.
Casino	Drought Management Plan, 2006 (not yet implemented), Guidelines for Imposing of Water Restrictions (Council Policy, no date)	An operational emergency supply strategy has not yet been developed. Council is currently considering the feasibility of groundwater sources as an emergency supply.	Due to inconsistencies between the number of stages in the Drought Management Plan and Council's existing restriction policy, the Drought Management Plan has not yet been adopted by Council. An emergency/back-up source is required.
Bray Park (Tweed District and Uki)	Drought Management Strategy, 2009, Drought Water Restrictions Policy, 2012	Minor emergency supply connection (3 ML/d) to south-east Queensland water supply at Tweed Heads.	The Tweed IWCM Review Background Paper (Hydrosphere Consulting, 2012a) recommended a review of water supply contingency measures including normal, restricted and emergency demand requirements, the impacts of water sharing plan rules and potential fish passage requirements. Feasible contingency measures to cater for emergency scenarios (such as prolonged drought, infrastructure failure and raw water contamination) also need to be developed.
Tyalgum		Water cartage from Bray Park system	The drought management strategy should be updated with new information on current and future demand, demand hardening and secure yield.

5. OTHER MANAGEMENT ISSUES

5.1 Data Adequacy

The development of a long-term water supply management strategy relies on adequate data to predict current and future demand and water supply availability.

Key data requirements are:

- Existing number of water supply connections;
- Existing potable water supply demand;
- Future (long-term) number of water supply connections;
- Future (long-term) potable water supply demand;
- Existing secure yield of water sources; and
- Future (long-term) secure yield of water sources.

For most water utilities in the region, technical assessment has been undertaken but further assessment is required to provide enough certainty about its accuracy for detailed project development such as selection or design of a preferred source augmentation option. However the information available is adequate to support long-term planning. Where no data are available or an estimate is available but there is too much uncertainty about its accuracy for decision making, future data collection is required.

In particular:

- This study (refer Appendix 1 and 2) has documented the available data as well as many assumptions regarding connection growth and demand for each water supply area. It is important that the appropriateness of these assumptions are monitored and reviewed regularly so that the demand profile can be updated;
- Increased confidence is required in the current secure yield of the water supplies. Water supply planning in NSW is now to be based on achieving 10% reduction in consumption i.e. a "5/10/10 rule", which supersedes the previous "5/10/20 rule" as discussed in Section 3.4.1. In addition, the current secure yield needs to consider environmental flow requirements, future demand predictions (normal and restricted demand) and the relevant drought restrictions policy;
- Apart from Rous Water's supplies, there are no data available on the impact of climate change on the secure yield of the region's water sources. The NSW Office of Water has suggested the methodology and results of the pilot study (refer Section 3.4.2) should be applied to other NSW LWUs; and
- For all data it is considered that ongoing review and update will be required.

5.2 Water Losses

The average level of unmetered water in the region is 17% (Table 9) which represents a significant proportion of the current water demand. The level of unmetered water is higher than the regional average in Ballina bulk supply area and Tweed Shire. Water losses in Lismore, Richmond Valley bulk supply and Woodenbong and Muli Muli are also considered to be high. For Wardell and Nimbin, the level of unmetered water is unknown but has been assumed to be 10% of raw water extraction for the purposes of this study.

The National Performance Reporting Framework classifies water losses in the distribution system as either apparent losses (unauthorised consumption, retail metering errors) or real losses (leakage and overflows from mains, service reservoirs and service connections prior to customer meters). Non-revenue water (NRW) includes the water lost through unknown leakage, meter inaccuracies, theft, water provided for fire-fighting, known and unavoidable leakage, use of unmetered standpipes plus water lost during emergency and planned maintenance of water mains. This is equivalent to the total sourced potable water less the water sold to customers. The "real losses" represent a wasted resource, reduce the effective capacity of a water supply system and may result in unnecessary operating costs.

For this study, the level of unmetered water has been reported as the difference between raw water extraction (or bulk supply) and consumption which also includes bulk supply and treatment losses. Table 9 provides the available data on bulk supply and distribution system losses (NRW).

Table 9: Components of water losses

Component of Water Balance	Rous Water bulk supply area	Kyogle	Tweed	Mullumbimby	Casino
Bulk supply and treatment losses (as % of raw water extraction/bulk supply)	1.8%	N/A	6.3%	N/A	N/A
NRW (as % of treated water)	15%	N/A	14%	N/A	N/A
Total losses as % of raw water extraction	17%	10%	19%	10%	10%

The Infrastructure Leakage Index (ILI) has been proposed as an indicator which measures how effectively real losses are being managed at current operating pressure while accounting for other influential factors such as length of mains, number of service connections and customer meter location. The ILI is calculated from the ratio of the Current Annual Real Losses (CARL) to the Un-Avoidable Real Losses (UARL). The National Performance Framework has adopted the ILI as a measure of leakage and the NSW Office of Water has reported the ILI for each LWU since 2005/06. The NSW Office of Water will also continue to report leakage as L/d per connection and kL/km of water main/d as these are considered to be better measures for tracking an LWU's leakage performance over time. These indicators are also preferred in the National Performance Framework. The available data for 2008/09 – 2010/11 are given in Table 10.

Table 10: Data on historical real losses (leakage)

LWU	L/d/connection (2008/09)	L/d/connection (2009/10)	L/d/connection (2010/11)	kL/km/day (2010/11)	ILI (2010/11)
Ballina	120	200	190	6.7	3.3
Byron	50	100	100	4.3	2.7
Lismore	110	130	40	1.6	1.0
Kyogle	40	40	30	1.1	1.0
Richmond Valley	110	N/R	70	2.7	N/R
Tweed	60	90	60	2.0	1.0
State-wide median	-	-	70	1.7	1.1

Source: NSW Office of Water (2012b)

N/R – Not reported

Rous Water recently engaged Water Loss and Pressure Management Pty Ltd (WLPM) to undertake a water loss analysis for the Rous Water supply area. WLPM completed a desktop analysis using customised professional software from the Water Service Association of Australia, based on the data and information provided by the different Councils. A summary of the water losses determined by this study is given in Table 11.

Table 11: Rous Water supply area water losses derived from WLPM study

LWU	Ballina	Byron	Lismore	Richmond Valley [1]
Current Annual Real Losses (CARL)	763	564	221	19
Unbilled Consumption	19	15	16	0
Apparent losses	62	51	122	6
Total non-revenue water	844	630	359	25
NRW (as % of water input into system)	23%	21%	11%	8.5%
Unavoidable Annual Real Losses (UARL)	241	132	304	14
Infrastructure Leakage Index (ILI)	3.17	4.27	0.73 [2]	1.38

1. Values are for Evans Head only.

2. An ILI of <1.0 suggests inaccuracy in data.

Other Councils report unbilled consumption, apparent losses and real losses as part of the annual performance reporting. In most cases, industry standard values are adopted in the absence of measured data (e.g. meter inaccuracies are estimated as 2% of residential consumption and unbilled consumption is estimated as 0.5% of treated water production).

Tweed Shire Council has adopted a non-revenue water target of 10% of water produced by 2013. Other water utilities have not adopted targets for water loss reduction.

Best-practice associated with water loss and mains pressure management involves the effective use of water supplies. In particular, reduced water losses help to ensure that existing water supplies can best meet future demand for water, potentially deferring the need to construct new water sources. In addition, efficient water distribution will increase the value derived from additional water source augmentation.

The key issues relating to water losses are:

- Data adequacy issues as discussed in Section 5. Investment in a water loss management program requires confidence in the flow and consumption data;
- High reported losses are reported for Ballina, Lismore and Richmond Valley bulk supply areas, Tweed Shire and Woodenbong and Muli Muli water supply system (compared to regional and state-wide averages);
- Due to the characteristics of the water supply sources as well as operational regimes, the water losses in Nimbin and Bonalbo cannot be quantified;
- Due to the lack of data on customer consumption, the level of water losses in Wardell cannot be quantified; and
- Consistent water loss indicators need to be applied so that regional targets can be developed and management programs can be tailored to the individual water utility issues.

6. REGIONAL SUPPLY OPTIONS

Each LWU has previously identified future water source options that could potentially meet future shortfalls in supply although none of the LWUs have progressed those potential supply options to a point where the future supply can be considered secure. The options considered by the individual LWUs are discussed in the following sections.

In investigating future supply options, the LWUs have investigated options involving water sharing with neighbouring utilities, although water supply options on a regional scale have not yet been considered.

6.1 Potential Benefits of Regional Supply Options

While local supply options can be implemented separately by each LWU to ensure water supply security, a regional approach can provide improved financial outcomes through economies of scale as well as access to a wider range of options to improve efficiency, system resilience and operational flexibility. By looking at a regional approach with the best solutions drawn from across the region, rather than restricted to supply solutions within the LWU boundaries, optimised supply schemes can be developed. The potential benefits of interconnecting the region's water schemes are discussed below.

6.1.1 Financial

There is potential to provide a lower cost drinking water supply to the region over the long-term when compared to stand-alone schemes. This can be achieved through:

- Opportunities for staging of water source development – Major capital expenditure can be delayed through staged implementation of sources servicing the region rather than development of multiple local sources in the short-term;
- Increased flexibility in scheme development – Access to a wider range of water sources provides opportunities to implement lower cost solutions;
- Reduced duplication of infrastructure – Sharing of major headworks infrastructure such as water sources and treatment facilities is cost-effective; and
- Sharing of costs over a larger customer base – Regional interconnection provides the opportunity to access a larger customer base and hence reduce customer costs.

6.1.2 System Resilience and Flexibility

There is potential to reduce the risk of supply shortage in the region through:

- Supply diversity - A regional scheme with multiple water sources has the potential to be more resilient to drought;
- Supply redundancy - The impacts of emergency situations (such as the loss of a supply through natural disaster or contamination event or the loss of major infrastructure through fire) can be minimised with the availability of alternative headworks infrastructure;
- Secure yield - The combined operation of the LWUs existing sources may result in an increase in secure yield from those sources when incorporated in a regional scheme;
- Climate resilience - The existing water supply schemes feature surface water sources which are vulnerable to future climate change. A regional scheme can cost-effectively incorporate a range of climate resilient supply sources to address risks of reduction in average yield and increased yield variability due to climate change over the long term; and

- System Flexibility - By virtue of its size and diversity, a regional scheme offers increased flexibility and scalability. It is possible to incorporate future sources in a regional scheme that can be constructed in stages allowing adaption to changing demand growth patterns and the influence of demand side initiatives.

6.1.3 Environmental and Social Outcomes

The development of significant infrastructure raises extensive planning and approval challenges. The potential considerations for various supply options are discussed in later sections. A regional approach allows access to a wider range of options to improve environmental and social outcomes.

6.1.4 Management and Administration

While this study is focussed on regional infrastructure approaches, a regional scheme would also provide opportunities for improved management and administration through:

- Improved skills - A larger workforce can bring together the current skill groups of the individual LWUs allowing both the sharing of those skills across the region as well as the enhancement of skills that a larger work group can afford through specialisation;
- Improved resilience to an ageing workforce – A future shortfall in skills in the water industry is predicted due to the ageing workforce and the more volatile nature of the workforce (Armstrong, I and Gellatly, C, 2009). A regional approach would provide a larger skills base to cover the skills required as well as provide a training area for replacing those skills; and
- Increased efficiency - A regional approach can provide greater efficiency through less duplication of infrastructure and administrative processes.

6.2 Regional Interconnection Options

Existing supply interconnection is discussed in Section 3. Potential new regional interconnections are discussed below.

6.2.1 Potential New Regional Interconnections

Physical interconnection of the region's water supplies may provide additional opportunities for sharing of water resources and infrastructure costs, increased utilisation of existing headworks infrastructure as well as additional benefits relating to increased operational flexibility and water supply security. Potential regional interconnection options have previously been considered by the LWUs and other government bodies as discussed in Section 3.1 and illustrated schematically in Figure 8.

Previous studies have not identified any options for interconnection of the smaller water supply systems of Tyalgum and Bonalbo. This study has not identified any drivers (e.g. supply deficit, drought management, cost-sharing) that would warrant interconnection with the other supplies in the region.

Table 12: Potential regional water supply interconnections

Interconnection	Key Purpose	Comments
SEQ Water - Bray Park (Tweed District)	Drought supply for Tweed District	The Tweed District Water Supply Augmentation Study considered a pipeline link between the SEQ Water Grid and the Tweed system for drought supply. A minor supply pipeline already exists.
Rous Water - Bray Park (Tweed District)	Drought supply for Tweed District	The Tweed District Water Supply Augmentation Study considered a pipeline link between Rous Water at Ocean Shores and the Tweed system at Pottsville with a capacity of 5 ML/day.
Rous Water - Bray Park (Tweed District)	Supply augmentation Tweed District/ Rous Water	A similar pipeline may be considered as a permanent connection between Rous Water and Tweed District to augment supplies and enable water sharing.
Rous Water – Mullumbimby	Supply augmentation for Mullumbimby	Byron Shire Council has also investigated the option of using the Rous Water bulk supply to supplement demands that cannot be supplied by Laverty's Gap weir (assumed to be 3% of normal demand).
Rous Water – Casino	Drought supply for Casino	Connection to the Rous Water bulk supply network was considered as an option to provide an emergency source for Casino as part of the Casino Water Supply Augmentation Scoping Study (2008).
Rous Water – Casino	Supply augmentation for Casino	Rous Water and RVC have recently investigated the interconnection of the Rous Water and Casino water supply systems to increase security for both supplies. Preliminary modelling undertaken as part of this study found that the secure yield of the combined Casino-Rous Water supply is in the vicinity of 18,000 ML/a, an increase of approximately 900 ML/a (including allowance for environmental flows from Jabour Weir) when compared to the current secure yields of approximately 2,500 ML/a for Casino and 14,600 ML/a for Rous Water. Based on the operating rules applied, this suggests that combining the system provides a secure yield benefit of 740 ML/a for the Casino water supply and 160 ML/a for Rous Water. If environmental flows were not required, the increase in combined secure yield would increase by a further 900ML/a.
Casino - Rous Water	Supply augmentation for Rous Water	
Casino – Kyogle	Supply augmentation for Kyogle	The 2006 Kyogle IWCM Strategy considered purchase of water from RVC (Casino supply) and transfer to Kyogle.
Rous Water – Nimbin	Supply augmentation for Nimbin	Lismore City Council is currently implementing modifications to the Nimbin water supply to improve water quality and has also commenced preliminary investigations for a permanent connection to the Rous Water bulk supply.

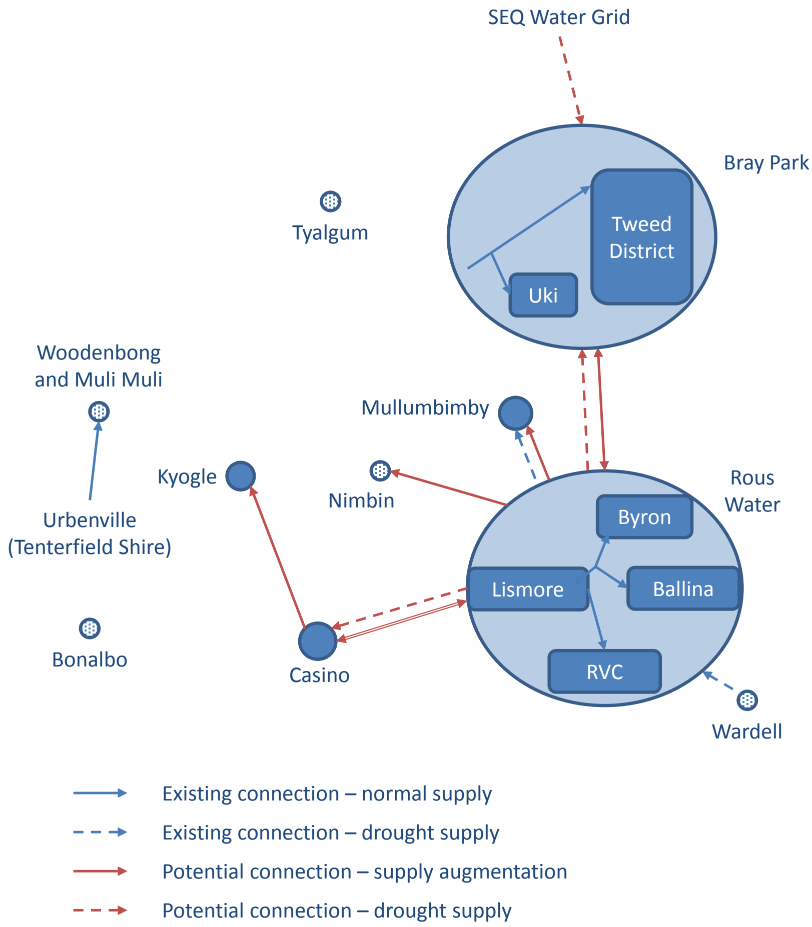


Figure 8: Existing and potential interconnection options

6.2.2 Key Considerations for the Regional Water Supply

Yield

While physical interconnections may provide increased operational flexibility and opportunities for cost-sharing, there is unlikely to be any significant increase in secure yield directly resulting from the sharing of water resources within the same river system due to the similar climate and flow patterns experienced. Interconnection between different river basins may provide a larger benefit although hydrological modelling is required to confirm this.

The benefits to smaller systems from connection to a larger system are likely to be more significant with the ability to access the increased and more flexible resource. This is illustrated with the modelling of the Casino and Rous Water supplies suggesting that combining the system provides a secure yield benefit of 740 ML/a for the Casino water supply and 160 ML/a for Rous Water (refer Table 12).

Transfer System

Key technical considerations for design of the transfer systems would include:

- Connection point and existing network capacity;
- Pipeline route;
- Storage, pumping systems, power supplies and pipeline design;
- Network length and disinfection requirements; and
- Operational protocols (flow direction, scheduling, demand, staging).

6.3 Surface Water Sources

Existing water sources utilised by the region are discussed in Section 3.

6.3.1 Potential Additional Surface Water Source Options

Investigations of surface water supplies have included augmentation of existing sources (i.e. raising dams or weirs to increase yields) and creation of new water supply storages in the region. Investigations have been undertaken by local water authorities and on a broader scale (incorporating the Clarence River catchment) by the National Water Commission (NWC) who also looked at interconnection options for south-east Queensland.

A summary of the potential options investigated in the NOROC region is provided in Table 13 (augmenting existing storages) and

Table 14 (creating new water storages) and Figure 9 shows the approximate locations of the potential storages.

Table 13: Potential options to augment existing surface water storages

Option	Location/Details	Study	Predicted Secure Yield Increase (ML/a)
Tweed River Catchment			
Raise Clarrie Hall Dam	Doon Doon Creek approx. 20kms southwest of Murwillumbah, Tweed Shire. Maximum raising is 8.5m to FSL 70m.	MWH (2009b) – Tweed District Water Supply Augmentation and SMEC (2007) Water supply options for SE Queensland	8,250
Richmond River Catchment			
Raise Rocky Creek Dam	Rocky Creek approx. 25kms north of Lismore, Lismore Shire. Maximum raising is 8m.	DPWS (1995) – Rous Water supply augmentation option	1,200
Raise Jabour Weir	Richmond River at Casino, Richmond Valley Shire. Raising up to 3m is potentially feasible.	Hydrosphere Consulting (2010) – Casino water supply augmentation option	Not significant due to environmental flow requirements
Raise Laverty's Gap Weir	Wilsons River at Mullumbimby, Byron Shire. Raising the weir by 3.84m was considered to provide the necessary increase in storage.	JWP (2005) – Mullumbimby long-term water supply	Not significant due to environmental flow requirements
Toonumbar Dam	Richmond River approx. 30kms west of Kyogle, Kyogle Shire. Raising by 10m and 20m considered to be potentially feasible.	Kyogle IWCM (2006) and DPWS (1995) – Rous Water supply augmentation option.	10,000 – 20,000 with dam raising

Table 14: Potential options for creating new surface water supply storages

Option	Location/Details	Study	Predicted Secure Yield Increase (ML/a)
Tweed River Catchment			
Byrrill Creek Dam	Byrrill Creek approx. 30kms southwest of Murwillumbah, Tweed Shire. Storage up to 36,000 ML considered.	MWH (2009b) – Tweed District Water Supply Augmentation and SMEC (2007) Water supply options for SE Queensland	9,000 ML/a from 16,300 ML storage, unknown yield from larger storage

Option	Location/Details	Study	Predicted Secure Yield Increase (ML/a)
Oxley River Dam	Oxley River approx. 20kms west of Murwillumbah, Tweed Shire.	MWH (2009b) – Tweed District Water Supply Augmentation and SMEC (2007) Water supply options for SE Queensland	20,000 ML/a from 35,000 ML storage
Rous River	Rous River, upstream of Chillingham, Tweed Shire	SMEC (2007) Water supply options for SE Queensland	Not available
Roland Creek	Near Uki, Tweed Shire	SMEC (2007) Water supply options for SE Queensland	Not available
Richmond River Catchment			
Dunoon Dam	Rocky Creek downstream of Rocky Creek Dam, approx. 20kms north of Lismore, Lismore Shire. Storages of 17,000 to 85,000 ML considered	DPWS (1995) and more recently as part of the Future Water Strategy – Rous Water supply augmentation option	6,100 ML/a from 50,000 ML storage, potentially additional 6,000 ML/a with larger storage
Wilsons River Weir	Near Binna Burra, Lismore Shire	SMEC (2007) Water supply options for SE Queensland	Not available
Richmond River	Upstream of Kyogle, Kyogle Shire	SMEC (2007) Water supply options for SE Queensland and MWH (2006) as part of Kyogle IWCM	Not available
Richmond River	Upstream of Grevillia, Kyogle Shire	SMEC (2007)	Not available
Richmond River off-stream storage	Upstream of Kyogle, Kyogle Shire. A 200 ML off-stream storage facility was considered the best option to be implemented to secure long-term water supply for Kyogle.	MWH (2006) as part of Kyogle IWCM	Unknown
Casino off-stream storage	Casino, Richmond Valley Shire.	JWP (2008) RVC IWCM Strategy Plan	Not available
Mullumbimby off-stream storage	Wilsons River, near Binna Burra, Lismore Shire. Storage of 430ML was considered to provide the necessary increase in yield.	SMEC (2007)	Not available
Clarence River Catchment			
Tooloom Creek Dam	Downstream Urbenville	SMEC (2007)	20,000 ML/a
Clarence River Dam	Upstream Tabulam	SMEC (2007)	100,000 ML/a
Mann River Weir	Near Jackadgery. Pumping pool within river.	SMEC (2007)	50,000 ML/a
Mann River Dam	Upstream Jackadgery	SMEC (2007)	100,000 ML/a

Existing Water Sources						**Previously investigated surface water sources**	
Ref	**Water Source**	**Raw Water Resource**	**Ref**	**Water Source**	**Raw Water Resource**	**Ref**	**Water Source**
01	Clarrie Hall Dam	Doon Doon Creek	12	Lavertys Gap Weir	Wilsons River	W1	Raise Clarrie Hall Dam
02	Bray Park Weir	Tweed River	13	Ellis Road Bore	Alstonville Basalt Aquifer	W2	Dunoon Dam
03	DE Williams Dam	Mulgum Creek	14	Lindendale Bore	Alstonville Basalt Aquifer	W3	Toonumbar Dam
04	Mulgum Creek Weir	Mulgum Creek	15	Kyogle Weir	Richmond River	W4	Rous River Dam
05	Emigrant Creek Dam	Emigrant Creek	16	Kyogle Bores	Richmond River Alluvium	W5	Oxley River Dam
06	Rocky Creek Dam	Rocky Creek	17	Petrochilos Dam	Off stream storage	W6	Roland Creek Dam
07	Wilsons River Source	Wilsons River	18	Peacock Creek Weir	Peacock Creek	W7	Byrill Creek Dam
08	Converys Lane Bore	Alstonville Basalt Aquifer	19	Bonalbo bore	unknown	W8	Mullumbimby off-stream storage
09	Lumley Park Bore	Alstonville Basalt Aquifer	20	Tooloom Creek Weir	Tooloom Creek	W9	Wilsons River Weir
10	Woodburn Bores	Coastal Sands Aquifer	21	Tyalgum Weir	Oxley River	W10	Richmond River Dam (upstream Kyogle)
11	Jabour Weir Intake	Richmond River	22	Marom Creek Weir	Marom Creek	W11	Richmond River Dam (Grevillia)
						W12	Tooloom Creek Dam
						W13	Kyogle off-stream storage
						W14	Clarence River Dam
						W15	Clarence Weir

Figure 9: Surface water supply options previously investigated in the study area

The purchase of water from Toonumbar Dam has previously been considered by Rous Water and Kyogle Council. There are existing irrigation allocations that are not being accessed that could potentially be utilised for town water supply. However, as general security allocations, the entitlement may be reduced in times of drought. Conversion of these licences to higher security town water supply licences may be possible but would be of significantly less volume (potentially nil) and is not currently permitted within the Water Sharing Plan. The viability of the Toonumbar Dam option is significantly increased with raising of the dam and creation of additional town water licences.

The potential options listed in Table 13 and

Table 14 cover a wide range of potential storage locations which have previously been identified as the preferred choices for local supply augmentation. These represent storages both within and outside the region's river catchments. While additional locations and variations on the above options may be possible, it is considered that the feasibility of other options would reduce due to increased distances from population areas and increased environmental and social impacts.

The current status of planning for the local and regional water supply authorities with regard to surface water storages is as follows:

- Rous Water has previously resolved to build Dunoon Dam if and when required to secure its water supply. In order to assess the suitability of the Dunoon Dam proposal, Rous Water is preparing the Future Water Strategy which considers a range of alternative water supply options;
- Tweed Shire Council is currently preparing a review of its IWCM Strategy which will consider the potential options and timing requirements for augmentation of the Tweed District water supply;
- Richmond Valley Council has determined that raising Jabour Weir will not significantly increase the secure supply due to environmental flow requirements and is progressing investigations for an emergency water supply source; and
- Kyogle Council has prepared a concept design for the Kyogle off-stream storage with the aim of constructing the storage when required to meet demand.

6.3.2 Key Considerations for the Regional Water Supply

Climate susceptibility

All surface water options are dependent on rainfall to maintain supply and are therefore susceptible to drought and climate change impacts.

Storage Size and Yield

As discussed in Section 5, there is significant uncertainty regarding estimates of yield both currently and in future when considering the risk of climate change. However, it is unlikely that the smaller surface water options alone would meet the supply deficit over the long-term. Larger storages or combinations of smaller storages would be required if a regional scheme was to continue the current reliance on surface water sources.

Environmental Impacts

Surface water storages such as dams and weirs have attributes that must be appropriately managed to avoid unacceptable environmental impact. The general types of impacts include:

- Changes to flows to downstream environments which can alter the natural wetting and drying pattern of aquatic areas by:
    - o reducing the amount and altering the timing of flood flows;

  - reducing the frequency of small rises in the river, called "freshes";
  - prolonging low flows, thus preventing drying out of riverine habitats; and
  - reversing the seasonal pattern of flow, with higher flows than natural in late summer (when water is being released for downstream users) and lower flooding in late winter and spring (when water is being trapped in the dam for later release);

- Flows are a critical cue for spawning, recruitment and migration/dispersal for many fish species. Changes in flow volumes, velocities and timing of flows therefore have the potential to result in major changes to fish communities;
- Interruption of fish passage caused by in-stream structures such as weirs and dams. As many Australian fish species migrate as part of their life cycle, barriers to fish passage can lead to disruptions in breeding cycles, changes to local populations and potential local extinction of some species;
- Inundation of terrestrial vegetation and /or habitat to form the water storage can result in the loss of significant environmental values; and
- Poor aquatic habitat value within storages due to bathymetric and water quality influences. Water storages are inherently different to flowing river systems and typically do not provide the variety and quality of habitats found in unmodified systems.

Environmental impacts of water storages and any barriers to flow must be considered as part of the planning stages. Dam design and operation, such as allowance for environmental flows, can mitigate many of the adverse environmental impacts. Compensatory measures (such as riparian restoration) are generally adopted with the aim of offsetting any residual impacts.

Social Impacts

Large surface water storages inundate significant tracts of land, often resulting in displacement of landholders, changes in land use and impacts on cultural heritage and environmental values. Dams also may affect water availability for downstream use, alter aesthetic qualities of key vantage points or alter recreational opportunities for waterway users. For these reasons, there is often a high degree of community opposition to proposals for creation of new water storages.

Costs

Construction and operational costs of the various surface water storages have been estimated as part of preliminary investigations by the local water utilities. The cost estimates are not directly comparable as costs are highly dependent on site specific factors including location, size, requirements for land acquisition and access, infrastructure requirements etc. As a result of these variables, costs can vary significantly from one proposal to another.

Shannon Creek Dam, located south of Grafton in the Coffs Harbour City Shire was completed in 2008 for a cost of approximately $114 million (in current dollars including construction of the 30,000ML off-stream water storage facility, road upgrades, a new bridge, and a new 4.6km access road, Coffs Harbour City Council, 2013).

Costs for construction of Dunoon Dam (50,000 ML storage and associated infrastructure) were estimated by Rous Water in 2009 to be $156 million (current dollars), based on the costs of Shannon Creek Dam, and adapted for the proposed size and characteristics of the Dunoon proposal. The raising of Clarrie Hall Dam was estimated to be $33.5 million (current dollars, MWH, 2009b).

6.4 Groundwater Sources

The regional groundwater resource is described in Section 2.1.3.

6.4.1 Potential Options

The current level of groundwater use for urban water supply in the study area is low with groundwater used infrequently to augment water supply during drought periods. Investigations undertaken by the LWUs indicate that there are opportunities for greater utilisation of groundwater for town water supply in the region. Groundwater has the potential to be used in continuous supplementary supply, or for use as a drought or back up emergency source.

Based on the available information, the Coastal Sands and Fractured Rock aquifers are the most promising target aquifers based on their reliable yields, generally good water quality and proximity to existing urban centres and water supply infrastructure. The key constraint to assessing the feasibility of groundwater to augment town water supply is that the Water Sharing Plans for a number of sources have not yet been finalised and so the total volume of water available for town water supply (extraction limits) and extraction rules and regulations involved in extraction are not currently known. Preliminary assessments undertaken by the NSW Office of Water indicate that each of the various aquifers in northern NSW can sustain some differing increase in extraction for town water supply purposes subject to further detailed investigation.

Based on the available information the following potential bore production volumes are estimated for the aquifers in the study area. It is important to note that depending on local conditions, yield may vary significantly between locations within the same aquifer and pumping tests would be required in order to confirm actual yield. Restrictions imposed by a Water Sharing Plan or water extraction licence may also affect the total amount of water that can be extracted.

Table 15: Estimated potential bore production

Aquifer	Estimated likely bore production	Estimated maximum bore potential production (per bore)	Estimated maximum production from borefield containing 20 bores
Coastal Sands	10 – 95 ML	535 ML/a	10,700 ML/a
Fractured Basalt (including Alstonville Basalt, North Coast Fractured Rock aquifers)	15 – 235 ML	600 ML/a	12,000 ML/a

Source: Adapted from Parsons Brinckerhoff, 2011

Potential locations for groundwater bores or bore fields based on the conclusions of previous studies are shown in Figure 10. The key sites are recommended based on location of suitable aquifers, their proximity to existing water supply infrastructure (particularly WTPs) and distance from rivers and groundwater dependent ecosystems (GDEs). These sites are:

- Tweed Coastal Sands at Chinderah/Cudgen (EHA, 2008);
- Brunswick Coastal Sands at Byron Bay (Parsons Brinckerhoff, 2011);
- Richmond River Coastal Sands at Ballina (Parsons Brinckerhoff, 2011);
- Richmond River Coastal Sands – augmentation of existing Woodburn bores (Parsons Brinckerhoff, 2011);
- Fractured Basalt at Casino (Hydrosphere Consulting, 2012);
- Fractured Basalt at Rocky Creek Dam (Parsons Brinckerhoff, 2011); and
- Fractured Basalt at Emigrant Creek Dam (Parsons Brinckerhoff, 2011).

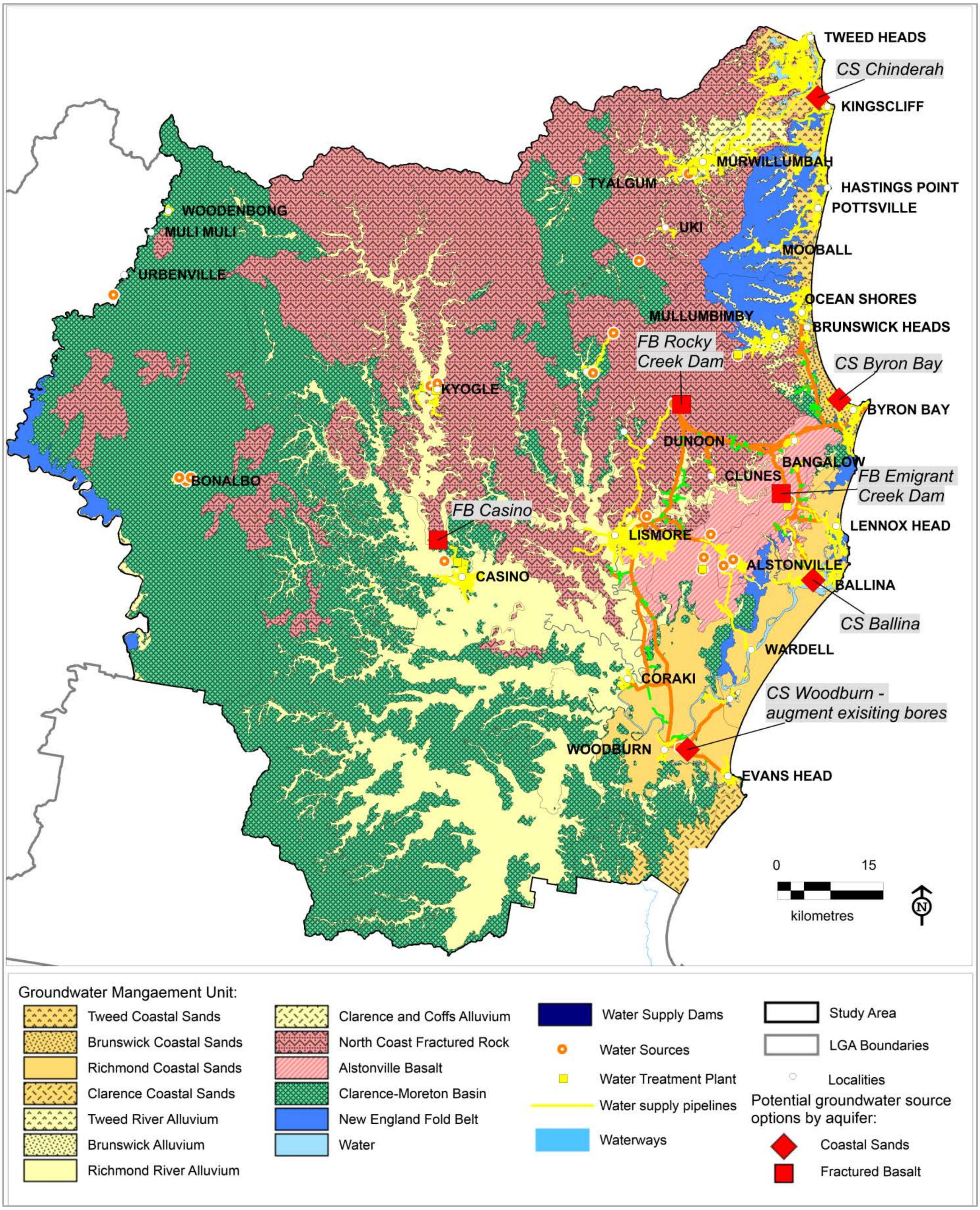


Figure 10: Potential locations of groundwater source options

Groundwater aquifer mapping provided by NSW Office of Water, Jan 2013

6.4.2 Key Considerations for the Regional Water Supply

Information gaps

There is a high degree of variability in the quality and quantity of groundwater supplies at any given location. Existing information on the typical quality and yield of groundwater bores from different aquifers can be gained from background information and existing bores. However, to confirm the assumptions regarding the viability of groundwater supplies to meet quality and quantity requirements, test bores would be required at specific locations. NSW Office of Water requires pumping tests to determine yields and potential drawdown impacts prior to granting bore extraction licences.

Yield

Although the potential water availability from the region’s aquifers is high, this resource is widely distributed and not concentrated at any one location to allow efficient exploitation to achieve the yield required as part of a regional scheme.

Given the distributed nature of the resource and higher degree of independence from short-term climate impacts than surface waters, this source option is better suited to providing localised supplies for areas not served by the regional network or providing emergency supply for the smaller water supplies in the region (e.g. Casino). Groundwater supplies may potentially offset the size and timing of any expenditure for major source options for these supplies, however they are not considered to be a regional supply option due to the local application.

Environmental Impacts

The impact of groundwater extraction on downstream environments and GDEs are not yet known. GDEs are communities of plants, animals and other organisms that depend on groundwater for survival. Examples include groundwater-fed wetlands such as seepages and springs, riparian and aquatic ecosystems within or adjacent to streams fed by groundwater baseflow, terrestrial vegetation communities that have seasonal groundwater dependency, such as rainforest remnants that access the shallow groundwater and sand beds along the coast supporting coastal wetlands, lakes and lagoons. The potential impacts on groundwater dependent ecosystems need to be considered with respect to each proposed town water supply bore. This will be assessed for each aquifer in the development of Water Sharing Plans to determine the environmental water requirements and therefore total extraction limits.

It is also noted that Permian Coal Measures that are explored for coal seam gas potential are present in the study area and these developments need to be considered when planning the development of any borefield.

Regulation

Water Sharing Plans are being developed for a number of potential groundwater sources. The limitations imposed by the plans are therefore not yet known. NSW Office of Water has reported that preliminary assessments associated with groundwater aquifers in Northern NSW indicate there may be potential for increase in extraction for town water supply purposes subject to further detailed investigation. Preliminary indications from the NSW Office of Water are that up to 10,000 ML/a may be allocated to town water supply in the Coastal Sands Water Sharing Plan, however location specific constraints such as impacts on GDEs or saline intrusion may reduce the feasibility of borefield extraction in some areas. It is anticipated that the draft Water Sharing Plan will be released by the end of 2013.

Climate Susceptibility

The dependence on rainfall and susceptibility to climate change would depend on the groundwater source being considered. Groundwater is recharged by rainfall, leakage from creeks, lakes, dams and by water from other aquifers (either infiltration from above or rising from deeper aquifers). It has been shown that rainfall is the most important climate parameter influencing recharge, followed by rainfall intensity and temperature (McCallum *et al.* 2010).

The physical attributes of a particular aquifer system including soil properties, geology, topography and level of river-aquifer connectivity will determine the potential sensitivity to climate change. Typically, unconfined groundwater aquifers close to the ground surface or those associated with rivers (e.g. alluvial aquifers) are highly susceptible to changes in rainfall and streamflow, while deeper aquifers, confined below layers of rock are less susceptible to changes in rainfall in the short term. The quality of coastal groundwater aquifers may also be adversely affected by rising sea levels and salt-water infiltration (CSIRO, 2007). Additionally, climate change may also lead to greater groundwater extraction rates. Aquifers with a high proportion of groundwater usage and those which coincide with highly developed surface water resources (such that there is little additional capacity) are likely to be most sensitive.

The National Water Commission (Barron *et al*., 2011) characterised the sensitivity of Australian aquifers to possible changes in climate. Aquifer types and their general sensitivity to changes in climate are summarised in Table 16. Both coastal sands and coastal alluvium were identified as a high priority aquifers based on importance as a groundwater resource and their sensitivity to climate change. Basalts and fractured rock aquifers had variable sensitivity to climate change and sedimentary basins such as the porous rocks of Clarence Moreton Basin had low sensitivity.

Table 16: Aquifer types and their general sensitivity to climate change

Aquifer type	Definition	Likely sensitivities to climate change
Coastal Sands	Shallow coastal sedimentary aquifers with ocean discharge	• High sensitivity due to: o Direct recharge by rainfall; o Shallow depth to water table; o Limited storage; and o Potential for salt water intrusion with sea level rise.
Coastal Alluvium	Alluvial aquifers with connection to coast and/or estuaries.	• High sensitivity due to: o Surface water–groundwater connectivity sensitive to climate changes; o Shallow depth to water table; and o Potential for salt water intrusion.
Fractured Rock and Basalts	Aquifers hosted in fractures and fissures in geology or porous zones in basalt.	• Variable sensitivity depending on the depth and whether it is confined or unconfined. • Generally have limited storage relative to recharge and short flow paths from recharge to discharge zones.
Porous Rock/ Sedimentary Basins	Aquifers hosted in thick, sedimentary sequences that are often confined.	• Not particularly sensitive given high level of groundwater storage relative to recharge.

Source: adapted from Barron *et al*., (2011)

Costs

Cost estimates and capital and operating costs of functioning groundwater supply systems are provided in Table 17. Costs of groundwater collection and treatment systems will vary greatly depending on supply yield and quality. Access to high quality groundwater (less treatment required) would result in lower capital costs. If significant treatment of the raw groundwater is required to address parameters such as iron, manganese or colour, then the costs of the options increase.

Table 17: Approximate costs of groundwater supply options for existing supplies and potential future supply

Location	Description	Cost (indexed to 2013$)	Source
Casino (Richmond Valley Shire)	Range of estimates for transfer system from groundwater to WTP at Casino @ 1.2ML/d	$2.1 - $6.1milllion (upper figure equates to approx. $5 million per ML/d)	Hydropshere Consulting (2012)
Bribie Island (SE QLD)	Cost of recently completed project for 4.32 ML/d borefield in coastal sand system with moderate water quality	$45 million (capital cost including 20 bores, monitoring, pumps, reticulation, full treatment plant) (equates to approx. $10 million per ML/d) $229 per ML/a (equivalent operating unit cost)	EHA (2008)
Tweed Shire	Estimate for borefield at Bray Park	$7-10 million per ML/d (capital cost including full treatment) $6 million per ML/d if high quality groundwater can be accessed	EHA (2008)

6.5 Seawater Desalination

6.5.1 Potential Options

There are currently no desalination plants in the NOROC study area. Seawater desalination presents an attractive option for future water supply due to its potential to supply a virtually unlimited amount of water that is independent from climate impacts such as drought. Investigations undertaken in recent years have concluded that desalination is approaching a level of technological maturity where it can underpin future urban water needs at a reasonable cost if water efficiency, water recycling, return flow and river source options are fully utilised (Department of Commerce, 2005). There are many issues to consider when considering desalination as a water supply option including the source of water (either seawater, estuarine or brackish groundwater), brine disposal, energy consumption and costs.

6.5.2 Key Considerations for the Regional Water Supply

Source Water

Often referred to as “feedwater”, the source of water for desalination can include seawater, brackish estuarine water, groundwater and sewage effluent. Feed water quality parameters that impact on desalination process selection and design include salinity levels, the concentration of scale forming salts and non-ionic species, turbidity and organic content, pH and temperature. The selection of source water is an important determinant in the overall costs and feasibility of desalination. Treatment to improve water quality of feedwater will increase the costs of desalination.

Site Location

Key site considerations include distance to feedwater location, land requirements and availability, connection to potable water distribution system and proximity to energy supplies. Potential locations have been considered in Appendix 4. A site south of Pottsville in the Tweed Shire is considered to be a potentially feasible location as it is central to the major water demand centres and sufficient land is likely to be available with appropriate distances from sensitive land uses and environmental protection areas. This area is also located near the potential interconnection between the Tweed and Rous Water supply areas. A comprehensive site selection process would need to be completed as part of further investigation if the desalination option is to be progressed.

Brine Disposal

High salinity brine is produced through the desalination process. The quantity and quality of the brine will depend on the feed water quality, the technology adapted and the product recovery rate (NSW Department of Commerce, 2005). There are a range of brine disposal methods available which have particular advantages and disadvantages that need to be assessed as part of site specific investigations. Options include direct ocean discharge, discharge with treated effluent (to allow for dilution), groundwater injection, evaporation ponds and salt production.

Energy Consumption

Desalination has a high energy demand. Hoang *et al.*, (2009) report that the average energy consumption is 3.0-3.7 kWh/kL for seawater and 0.7-1.0 kWh for brackish water. In comparison, the Wilsons River water source uses 1.23 kWh/kL, Rocky Creek Dam 0.30 kWh/kL and Emigrant Creek Dam 0.65 kWh/kL (GeoLINK, 2011). The most commonly used energy source is mains energy supply. Four out of five operating desalination plants studied in NSW Department of Commerce (2005) utilise mains electricity with the remaining one operating on electricity from a natural gas power plant.

Alternative desalination energy sources include solar energy, wind power, wave power, ocean currents, gas, geothermal heat and biomass (e.g. sugar cane co-generation) sources. A 20ML/d solar-powered desalination plant driven by a 275 dish solar array was evaluated in 1999 as a supply option for the Clarence Valley and Coffs Harbour regional water supply. The estimated cost was approximately $2.20/kL (current dollars), more costly than the off-river storage scheme. However, given the advances in solar power technology in the years since, it is reasonable to assume that the viability of a solar powered desalination plant will have also improved. A completely solar powered desalination plant has recently been approved in South Australia, which will produce 5.5 GL/a of potable water, integrated with commercial salt production at an estimated cost of $370 million. Such opportunities are highly dependent on local climate, and no assessment of solar power opportunities for desalination has been undertaken within the study area.

Costs

Table 18 presents a range of cost estimates for different desalination proposals in the local area. The cost of desalination is dependent on a number of factors including the size and location of the plant, treatment and brine disposal requirements and energy costs. GeoLINK (2011) presents possible capital costs between $47-95 million for a 14ML/d plant on the North Coast. These calculations were made on the basis that a typical cost for a desalination plant is $2-3 million per ML/d of plant capacity and that the plant constitutes 30-40% of the overall desalination scheme (as per advice from the National Centre of Excellence in Desalination). The GeoLINK (2011) estimate represents the most recent local estimate taking into account current innovations in technology and corresponding cost factors.

Table 18: Approximate costs of seawater desalination estimated for local areas (indexed to 2013$)

Location	Description	Capital Cost ($M)	Source
Rous Water supply area	14 ML/day, seawater fed	~47 - 95	GeoLINK (2011)
NSW north and mid-north coast	20 ML/d seawater fed plant, solar powered plant	~178	NSW Department of Commerce (2005)
Tweed Shire	20 ML/d seawater fed plant	~217	MWH (2009b)
Ballina Shire	20 ML/d seawater fed, solar powered plant	~242	DPWS (2002)

6.6 Supply from Neighbouring Water Utilities

The study area is bounded by Tenterfield Shire Council to the west, Clarence Valley Council to the south and south-east Queensland to the north.

The villages of Woodenbong and Muli Muli in Kyogle Council area are located on the border of Kyogle and Tenterfield Shires and are supplied by Tenterfield Shire Council's Urbenville water supply system. Tenterfield Shire and the western part of Kyogle Council area are located in the upper Clarence catchment. Inter-catchment transfers across the Richmond range were considered in the SMEC (2007) study which concluded that of the three river systems, the Clarence River basin offers the best potential for abstraction of large quantities of water due to the large river flows. However, the distance to the larger demand centres of Ballina, Lismore and Tweed would create significant costs in addition to the topographic issues to be addressed by any transfer system. Inter-catchment transfers are also likely to require a large storage within the study area.

The Shannon Creek Dam, near Grafton in northern NSW, is a key component of the Clarence Valley and Coffs Harbour Regional Water Supply Strategy. The dam is part of a regionally interconnected water supply system providing a high level of drought security and improved protection of the rivers from which the water is extracted. There are 90 km of underground pipelines linking the Nymboida River with the new Shannon Creek Dam, the existing Rushforth Road reservoir at South Grafton and Karangi Dam near Coffs Harbour.

Shannon Creek Dam will help secure water supply to an estimated 220,000 people in the Clarence and Coffs Harbour Region over the next 50 years. The dam comprises a 47 metre high embankment with a crest length of 400 metres and a capacity of 30,000 ML. The design of the dam enables future raising of the dam by 9.6 metres to increase the capacity to 70,000 ML. Shannon Creek Dam has been designed as part of the overall regional water supply strategy to cater for the predicted population growth in the Clarence and Coffs Harbour Region to 2046. It is not known if further dam raising (beyond 9.6 m) is possible at the Shannon Creek Dam site. Depending on actual population growth over the next few decades and ongoing water demand, it is possible that the current regional supply system may produce surplus water, particularly in the short-term. If water sharing arrangements between the NOROC study area and the Coffs/Clarence system were feasible, connection would involve an extensive pipeline over 130 km long. In addition to the significant cost of transfer between the two systems, it is likely that an additional source would be required to meet the additional demand of the NOROC region.

Tweed Shire Council has previously investigated a connection to the south-east Queensland water grid to provide an emergency supply. A pipeline to the SEQ Water Grid was found to have high risks associated with cross-border issues, the high bulk purchase price of water and the lack of assurance as to whether supply from the SEQ Water Grid would be maintained (MWH, 2009b). While these issues may be resolved for an emergency supply situation, it is considered that a more permanent supply solution for the region could not be guaranteed given the climate similarities and population growth experienced in south-east Queensland.

6.7 Localised sources and offsets

There is a range of integrated water cycle management options that maybe be implemented on a local scale that should be considered as part of any water supply scheme. These are discussed in Section 8 and include potable substitution, demand management and water loss management initiatives to reduce reliance on the potable water supply. These options are likely to be implemented on a local scale and would assist with partially meeting the future supply deficit or potentially delaying the need for a major source augmentation. As such they are not considered to be primary regional supply options.

7. POTENTIAL REGIONAL SUPPLY SCENARIOS

The key water supply security issues for the region discussed in the previous sections are:

- Current sources are heavily dominated by surface water storages;
- There is increasing uncertainty into the future with climate change, but the consensus is that the yield of surface water storages will decrease;
- Population will continue to grow, particularly within Tweed Shire and Ballina;
- Despite historical reduction in water use per connection, there will be a regional deficit in the order of 14,000 ML/a by 2060, which is a significant volume representing 43% of the current supply; and
- Although demand management and source substitution are likely to result in some benefits into the future, there is no doubt that major augmentation of potable water supplies is required throughout the region in the coming decades.

In light of this, and considering the significant potential benefits of adopting a regional approach in addressing this future supply deficit, a range of potential interconnection/supply scenarios were evaluated to assist in strategy development and determination of the most appropriate next steps.

7.1 Development of Scenarios

The scenarios are focussed on strategies to resolve the predicted 2060 water supply deficit for the region as a whole and are influenced by two key attributes:

1. Physical interconnections: The degree to which the water supply system is connected within the region; and
2. Water supply augmentation: The potential new or augmented sources that can be utilised to provide the required secure yield.

A four stage process was adopted to enable development of potential regional scenarios and identification of preferred scenarios:

1. Identification of interconnection options;
2. Preliminary assessment of primary sources (scenario components);
3. Identification of potential regional scenarios including interconnection options and most attractive primary sources; and
4. Comparison of regional scenarios against project objectives;

7.2 Interconnections Options

The degree of water supply inter-connection within the study area will determine what ultimately is considered to be part of the regional scheme and consequently the population that is to be served by the scheme and the likely future water demand to be met by the scheme.

The viability of the interconnection options will depend on:

- The supply augmentation options included in the regional scheme – for example inclusion of Kyogle water supply would be more attractive if augmentation options in the western parts of the region (e.g. Toonumbar Dam) were included;

- The need for augmentation of local supplies (i.e. due to future yield deficit or emergency source requirements) and the benefits that would be derived locally from being connected to the regional network; and
- The opportunities for sharing the costs of major infrastructure and whether the additional costs of connecting an area to the regional network are justifiable from an absolute cost as well as an overall cost sharing perspective.

The potential interconnection options were discussed in Section 6.2. The mutual benefit to both the region and the individual areas being connected needs to be apparent. The large 2060 yield deficit likely to be experienced by Rous Water (5,850 ML/a) and Tweed Shire Council (6,230 ML/a) and the predicted timing of required augmentation (2022 and 2030 respectively) suggest that a substantial benefit may be achieved from interconnection of these supplies through water sharing and cost sharing opportunities. The interconnection of these two systems is considered critical in achieving a true regional approach for the NOROC study area. The outer limits of these two systems are in close proximity to each other, potentially minimising costs associated with the connection pipeline. While this option has not been investigated in any detail, there are no known technical barriers.

In addition to this major connection to the Tweed system, Rous Water's current bulk supply network could also be extended to include Casino, Mullumbimby and Nimbin or Kyogle. The interconnection of these smaller water supply systems does not significantly alter the predicted yield deficit of a scenario involving connection of the Bray Park system and the Rous Water system (<5% increase). These options could be implemented either as part of the overall regional scheme or could be implemented purely to resolve local supply issues at these centres and are not considered essential components of a regionalised scheme.

Not all of the individual LWU water supplies would be connected to a regional scheme. While opportunities to connect will depend on the future needs and proximity of infrastructure, the current information suggests that:

- Water supplies are adequate to serve future demand in Tyalgum, Woodenbong and Muli Muli for the next 50 years;
- Water supplies are adequate to serve future demand in Bonalbo for the next 35 years; and
- While data on secure yield are currently not available, a future supply deficit has not been identified for Wardell. Future connection to the regional scheme is considered to be relatively simple due to its proximity to the Rous Water distribution network.

7.3 Potential New Primary Sources

There are a wide range of primary source options and it is necessary to consider their viability as part of a regional supply approach. Section 6 presented the range of source augmentation options. The scale of the long-term yield deficit necessitates a primary source option that can address a significant component of the yield deficit either alone or in combination with other options. The timing of the need for augmentation also suggests that a major source would need to be implemented within ten years.

The regional schemes would be developed incorporating the most attractive individual supply options. Surface water, groundwater and desalination options are considered to be potential components of the regional supply scenarios as:

- Supply from neighbouring utilities does not offer any significant benefits over the local options;
- Given the potential risks of potable reuse options (refer Section 8), these schemes are not likely to be acceptable within the required timeframe; and

- Potable substitution options cannot be considered a primary source option as they are likely to be only implemented on a local scale where the opportunity exists to resolve multiple wastewater and water supply issues. This is discussed further in Section 8).

Based on the discussion in Section 6, the main primary sources could be:

- Seawater desalination (marine or estuarine waters);
- Raising Clarrie Hall Dam;
- Raising Toonumbar Dam and creating town water licences;
- A new dam at Dunoon;
- A new dam on Byrrill Creek;
- Raising Rocky Creek Dam; and
- Groundwater (decentralised local supplies).

7.4 Preliminary Assessment of Source Options

A preliminary evaluation of the individual water source options was undertaken to document the attractiveness and issues related to primary sources in the region. The preliminary assessment criteria are given in the following table and the assessment is included in Appendix 5.

Table 19: Preliminary assessment criteria – source options

Preliminary Options Assessment Criteria	Measure
Yield or Capacity	Ability of the option to supply bulk water and make a significant contribution to water supply deficit in the region
Availability/Reliability	Ability of the option to supply water when most needed (i.e. drought)
Scalability	Ability to expand the option sequentially over time to match demand and to reduce initial capital cost
Compatibility	Compatibility of the option with existing infrastructure or operations – considers additional infrastructure required to enable combination with existing systems.
Acceptability	Social (prevailing community opinion), political, cultural heritage (known issues) and legal (current regulatory environment)
Timeliness	Potential to be implemented efficiently in the timeframe required (lead time including studies required, approval requirements, and construction timeframe). Although all options will require significant lead time, it is important to identify those they may take too long.
Technical Feasibility	Proven and reliable technology that can be applied with certainty
Environmental Sustainability	Ecological impact and resource use – known issues and potential footprint
Potential Attractiveness	How certain are we that this could be part of the regional solution given our current knowledge?

All source augmentation options are considered to require significant upfront investment in planning, approvals and construction as well as significant annual expenditure. Cost has not been considered in the preliminary assessment as there is little information available on the costs of the specific options and cost is not considered to be a primary decision-making factor. However, an indication of the relative cost of each option is included in the preliminary assessment.

The key outcomes of the preliminary assessment of the potential primary sources are:

- Large-scale centralised desalination is an attractive option in terms of yield, climate independence and scalability. Potential risks factors are energy requirements and brine disposal although acceptable solutions have been developed elsewhere and there is no reason why the same level of acceptability will not apply locally. The greatest unknown with desalination is cost;
- The surface water options could be either single large storages meeting the full deficit or a combination of storages to achieve the same outcome. The options involving new surface water storages do not provide climate independence but storages on the coast are likely to be more resilient to climate change. There are significant risks with approval of surface water options related to legislative acceptability, environmental and cultural heritage impacts. Whilst there is significant community opposition to the construction of new dams, raising of existing dams is likely to be less controversial. The cost of these options is likely to be influenced by the measures required to reduce these risks and impacts;
- The most attractive Tweed River surface water option is the raising of Clarrie Hall Dam. The potential yield realised from raising the FSL to 70m (maximum size) is 8,250 ML/a (MWH, 2009b);
- The most attractive option for a new storage on the Richmond River is Dunoon Dam. Preliminary analysis undertaken for Rous Water suggests a 50,000ML storage is predicted to yield 6,100 ML/a with an additional 6,000 ML/a potentially available from a 85,000 ML storage; and
- Raising Toonumbar Dam and creating town water supply licences could yield 10,000 ML/a with a 10m raising. A 20m raising is also potentially feasible but the additional yield is unknown (CMPS&F, 1995).

7.5 Potential Regional Scenarios

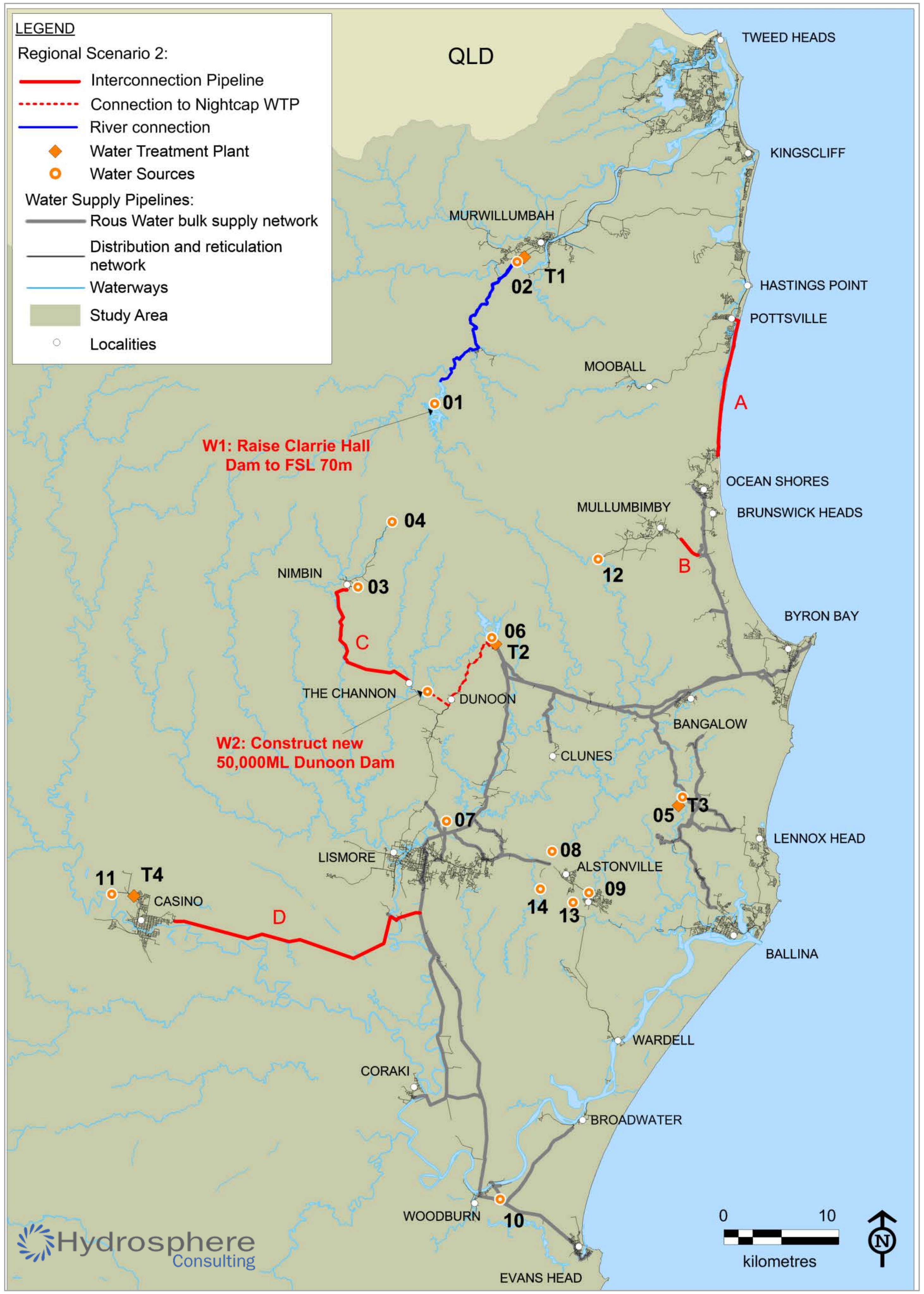
A regional water supply strategy should maximise the benefits of interconnection and optimise the utilisation of water resources in the region. It is mandatory that any potential scheme is able to provide secure yield to satisfy the future (2060) demand within the connected network. Any scenarios that do not meet this pre-requisite have not been considered further. It is acknowledged that there are significant uncertainties regarding the yield of potential surface water options and therefore it is not appropriate to limit the scenarios to particular local solutions.

The schemes must also be able to supply water meeting the Australian Drinking Water Guidelines or the Recycled Water Guidelines as applicable. Public health considerations would be addressed in future design stages of the scheme. While multiple variations on interconnection and supply options could be considered to satisfy the supply deficit and these each have intrinsic positive and negative aspects, a range of regional scenarios has been considered to meet the objectives of the study:

- Scenario 1 - Desalination;
- Scenario 2 - Dunoon Dam (Richmond River, 50,000 ML) and raise Clarrie Hall Dam (Tweed River);
- Scenario 3 - Dunoon Dam (Richmond River, 85,000 ML);
- Scenario 4 - Use of Toonumbar Dam (with 20 m raising); and
- Scenario 5 – Use of Toonumbar Dam (with 10m raising) and raise Clarrie Hall Dam.

All scenarios require interconnection of the Rous Water and Bray Park systems. Casino, Mullumbimby and Nimbin may also be connected to the regional scheme although this does not significantly alter the demand or yield of the scheme. Connection of these smaller supplies would address local supply issues but would introduce additional costs as well as cost-sharing opportunities.

The scenarios are described in the following figures.



SCENARIO 1: DESALINATION

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below) and will be supplemented by treated water from a new 70 ML/day marine desalination facility (P1), potentially located between Ocean Shores and Pottsville. The desalination facility will include a marine feedwater pipeline, a major energy source, brine disposal pipeline and transfer to the regional supply network. Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

2. Peak day demand assumes daily average demand and peaking factor of 2.0.

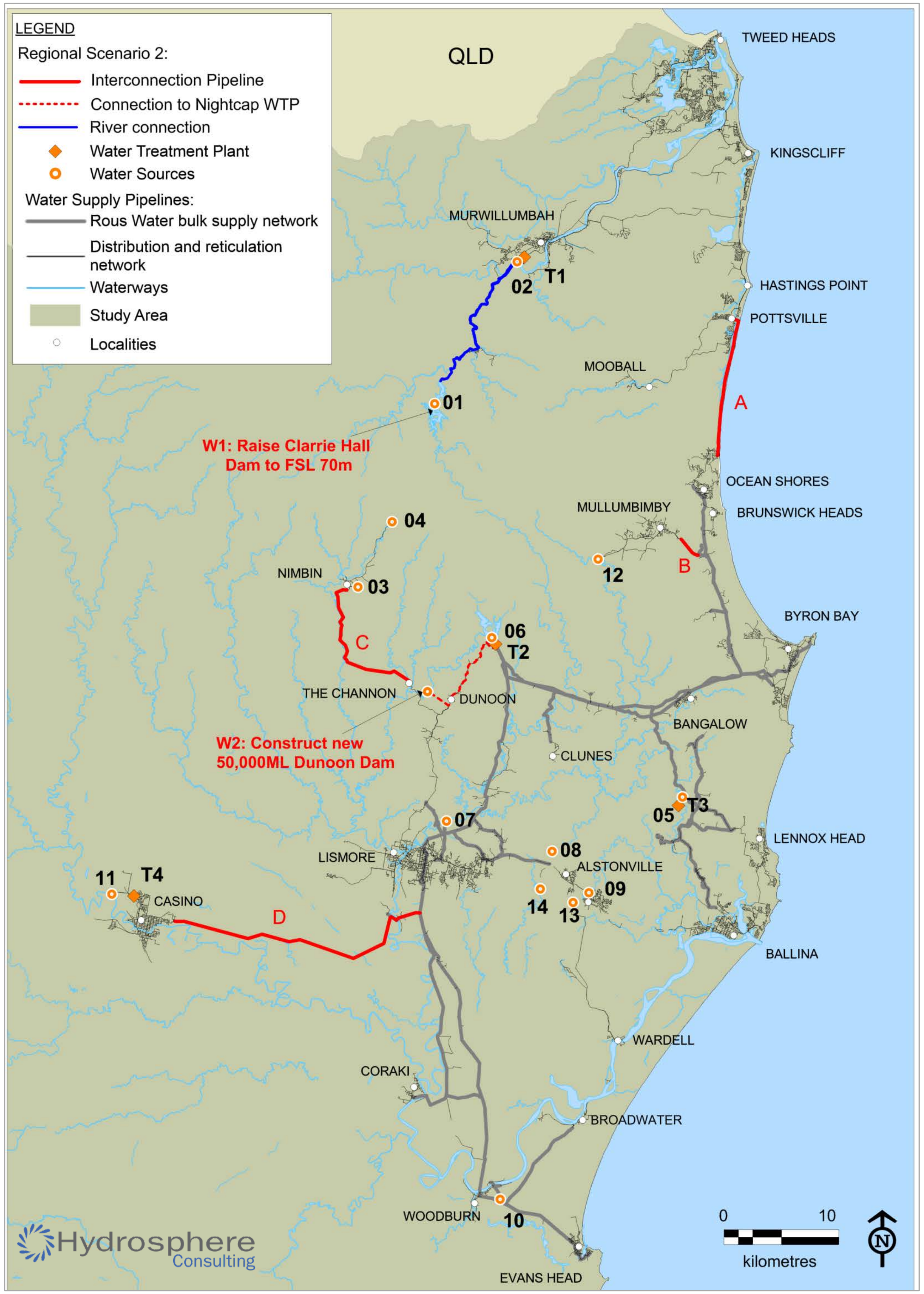
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure 11: Regional Water Supply Scenario 1 – Desalination



SCENARIO 2: DUNOON DAM (RICHMOND RIVER, 50,000 ML) AND RAISE CLARRIE HALL DAM (TWEED RIVER)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising Clarrie Hall Dam to FSL 70m (W1) and construction of a new 50,000 ML dam on the Richmond River at Dunoon (W2). Raw water from Dunoon Dam would be treated at the existing Nightcap WTP (T2) which would be augmented by approximately 15 ML/d. Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

3. Peak day demand assumes daily average demand and peaking factor of 2.0.

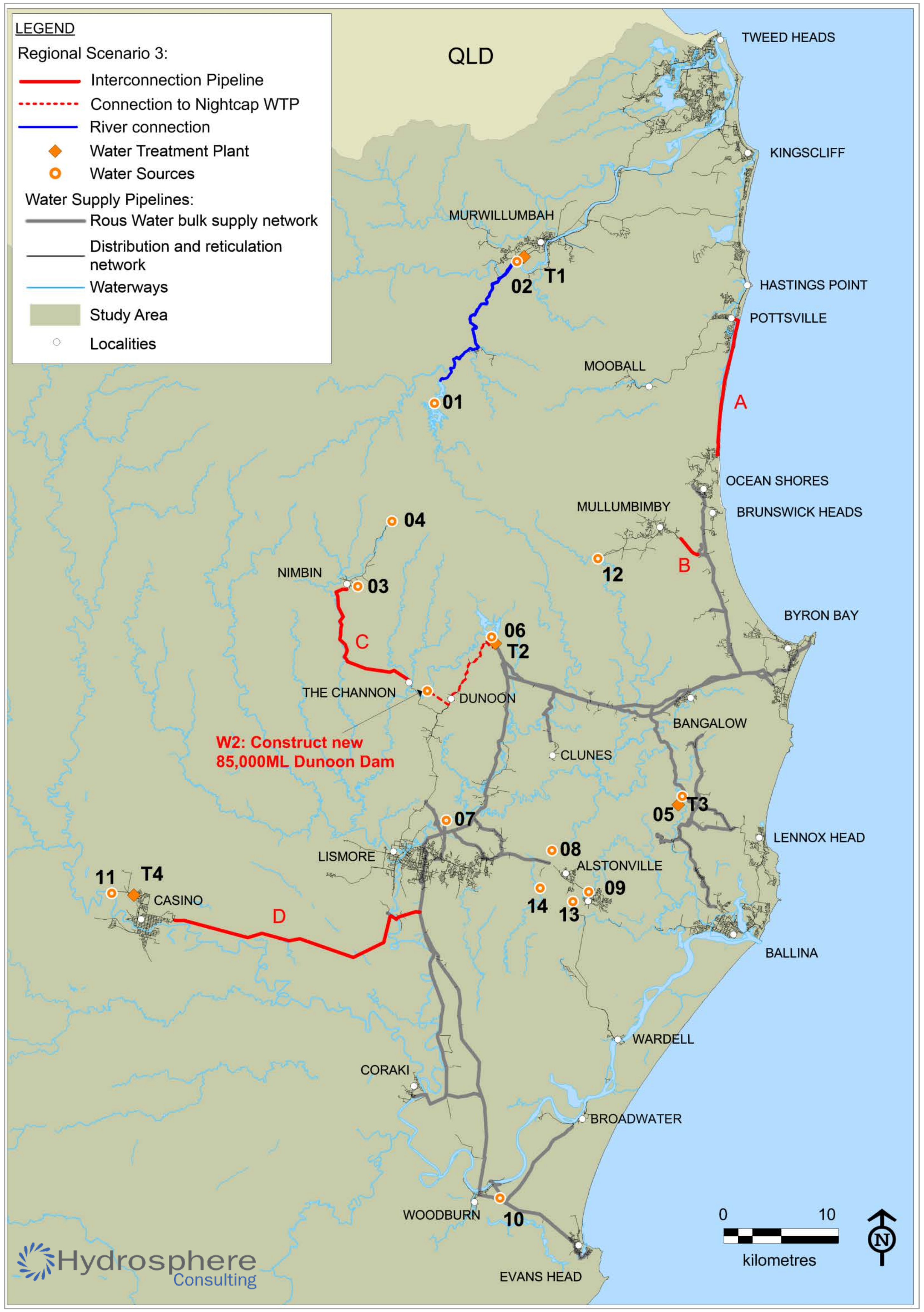
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure 12: Regional Water Supply Scenario 2 – 50,000 ML Dunoon Dam and Raise Clarrie Hall Dam



SCENARIO 3: DUNOON DAM (RICHMOND RIVER, 85,000 ML)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by construction of a new 85,000 ML dam on the Richmond River at Dunoon (W2, potentially constructed in stages). Raw water from Dunoon Dam would be treated at the existing Nightcap WTP (T2) which would be augmented by approximately 55 ML/d (potentially in stages). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 77,800 existing residential connections (151,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Casino in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	3.8
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	0.5
Total Regional Water Supply	*22,740*	*125*	*38,960*	*213*

2. Peak day demand assumes daily average demand and peaking factor of 2.0.

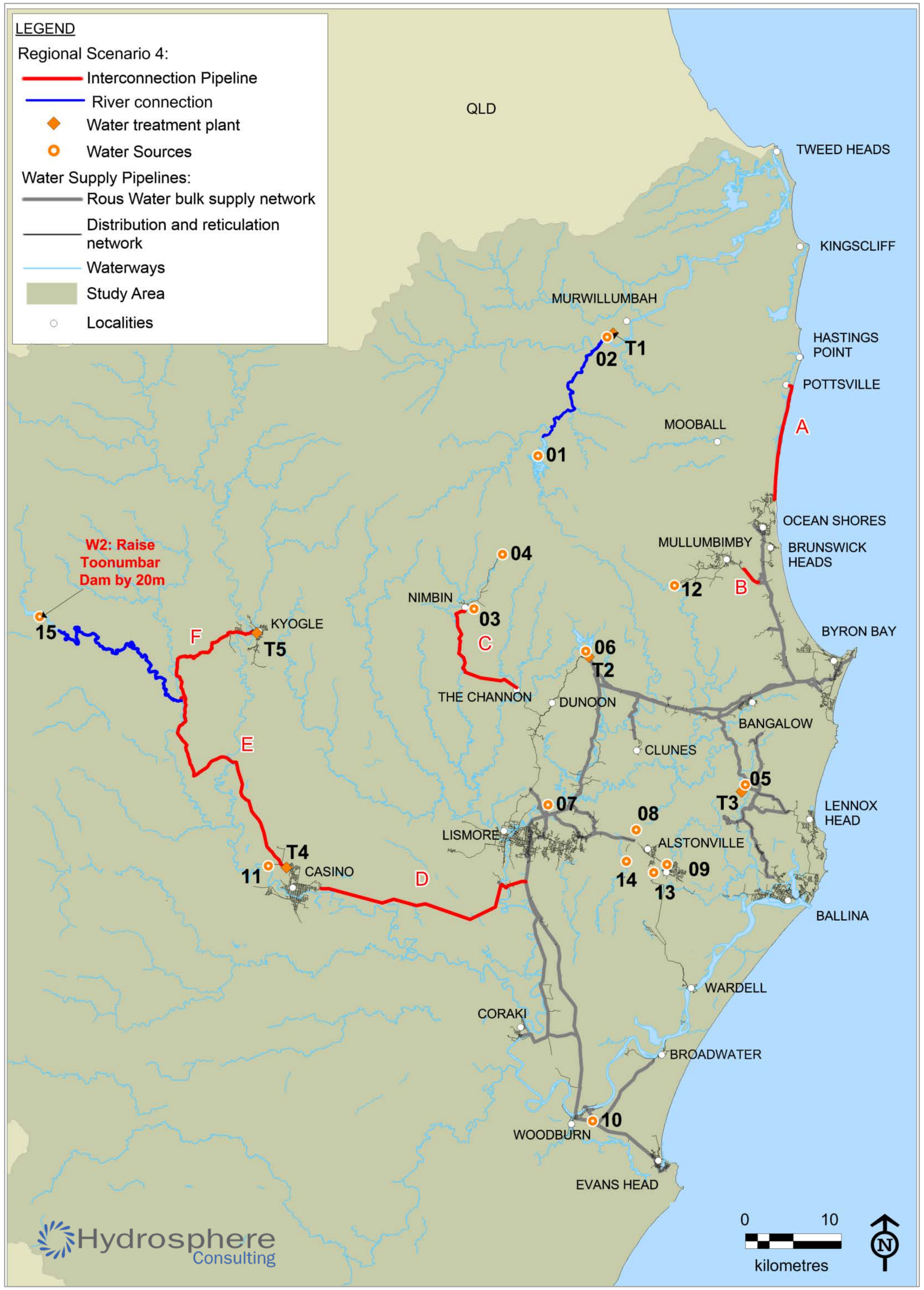
Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
Total 2060 secure yield of existing sources				*25,700*
Yield Deficit at 2060 (incl. 900 ML/a yield benefit provided by interconnection with Jabour Wei)r				*12,360*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	125
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP	Richmond Valley Council	23

Figure 13: Regional Water Supply Scenario 3 – 85,000 ML Dunoon Dam



SCENARIO 4: TOONUMBAR DAM (RICHMOND RIVER) RAISED BY 20 M

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising of Toonumbar Dam by 20 m (W2, potentially constructed in stages) with the creation and purchase of town water extraction licences and releases from the dam to an extraction point at the confluence of Iron Pot Creek and Richmond River. Raw water from Toonumbar Dam would be transferred to Casino (E) for treatment at the existing Casino WTP (T4) which would be augmented by approximately 12 ML/d and to Kyogle (F) for treatment at the existing Kyogle WTP (T5). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 78,900 existing residential connections (153,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Kyogle in the west.

Current and Future Service Area Demand

Service Area	**Current Demand**		**2060 Demand**	
	Annual Average (ML/a)	**Peak Day (ML/d)** [1]	**Annual Average (ML/a)**	**Peak Day (ML/d)** [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	4
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	<1
Kyogle	304	<2	441	2
Total Regional Water Supply	*23,044*	*127*	*39,401*	*216*

2. Peak day demand assumes daily average demand and peaking factor of 2.0.

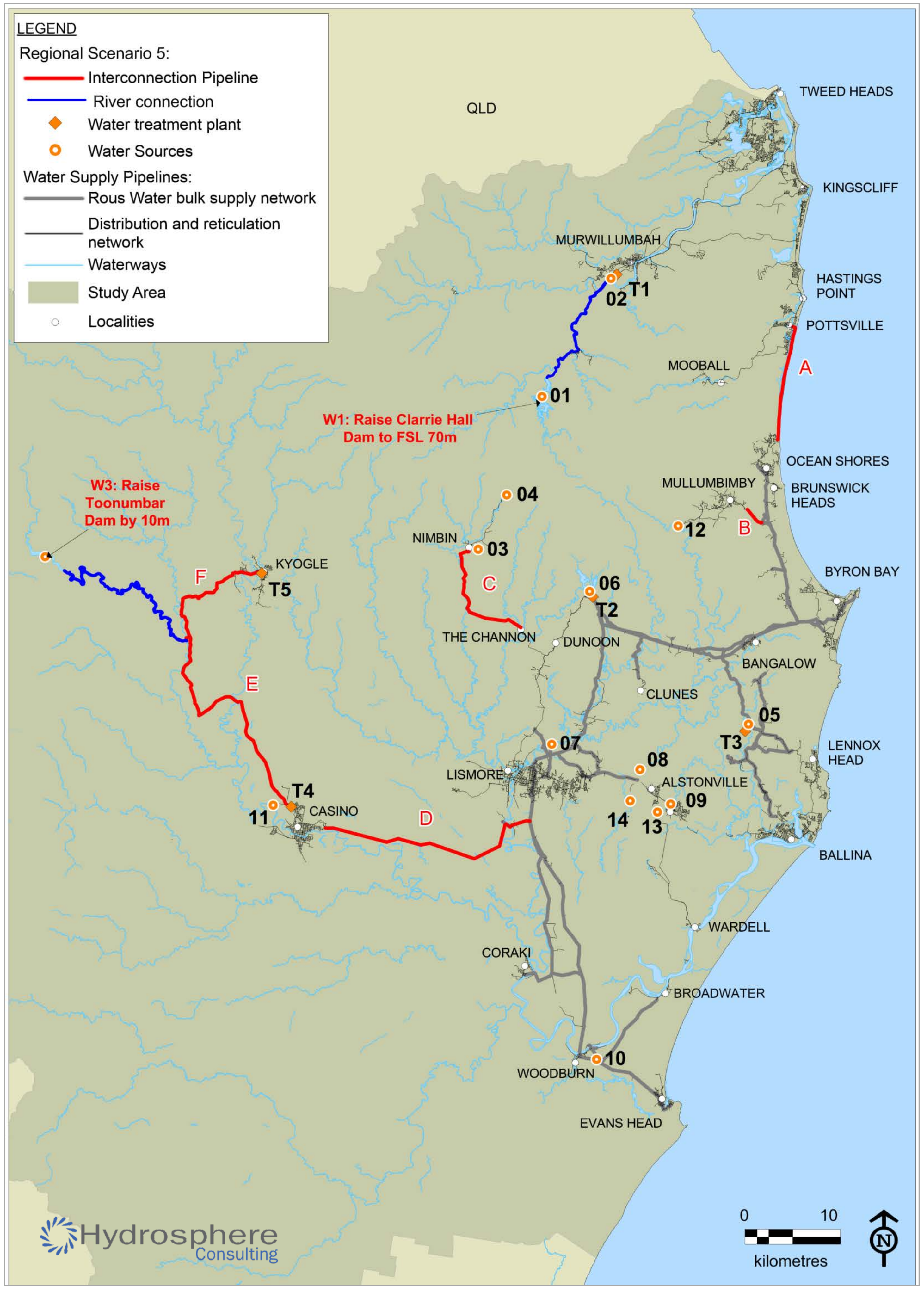
Existing Water Sources

Ref	**Water Source**	**Raw Water Resource**	**Local Water Utility**	**Predicted 2060 Secure Yield (ML/a)**
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
15	Kyogle Weir	Richmond River	Kyogle Council	250
16	Kyogle Bores	Richmond River Alluvium		
Total 2060 secure yield of existing sources				*25,950*
Yield Deficit at 2060 (including 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,550*

Existing Treatment Facilities

Ref	**Treatment Facility**	**Local Water Utility**	**Capacity (ML/d)**
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP (augmented)	Richmond Valley Council	35
T5	Kyogle WTP	Kyogle Council	3.0

Figure 14: Regional Water Supply Scenario 4 – Toonumbar Dam raised by 20m



SCENARIO 5: TOONUMBAR DAM (RICHMOND RIVER) RAISED BY 10 M AND RAISE CLARRIE HALL DAM (TWEED RIVER)

The regional water supply scheme requires a new treated water pipeline (A) between Ocean Shores and Pottsville, augmentation of the existing treated water pipeline (B) between Mullumbimby and Brunswick Heads, a new treated water pipeline (C) between Nimbin and The Channon and a new treated water pipeline (D) between Casino and South Lismore.

The scheme relies on existing surface water storages and minor groundwater supplies (refer below). Additional surface water would be provided by raising Clarrie Hall Dam to FSL 70m (W1) and raising of Toonumbar Dam by 10 m (W2) with the creation and purchase of town water extraction licences and releases from Toonumbar dam to an extraction point at the confluence of Iron Pot Creek and Richmond River. Raw water from Toonumbar Dam would be transferred to Casino (E) for treatment at the existing Casino WTP (T4) which would be augmented by approximately 12 ML/d and to Kyogle (F) for treatment at the existing Kyogle WTP (T5). Potential modifications to the existing system may be required to cater for the increased demand.

The regional scheme would serve approximately 78,900 existing residential connections (153,000 connections by 2060). The service area extends from Tweed Heads in the north to Evans Head in the south and Kyogle in the west.

Current and Future Service Area Demand

Service Area	Current Demand		2060 Demand	
	Annual Average (ML/a)	Peak Day (ML/d) [1]	Annual Average (ML/a)	Peak Day (ML/d) [1]
Bray Park (Tweed District)	9,062	50	19,980	109
Rous Water (bulk supply area)	10,903	60	15,790	87
Mullumbimby	378	2	690	4
Casino	2,338	13	2,410	13
Nimbin	60	<1	90	<1
Kyogle	304	<2	441	2
Total Regional Water Supply	*23,044*	*127*	*39,401*	*216*

2. Peak day demand assumes daily average demand and peaking factor of 2.0.

Existing Water Sources

Ref	Water Source	Raw Water Resource	Local Water Utility	Predicted 2060 Secure Yield (ML/a)
01	Clarrie Hall Dam	Doon Doon Creek	Tweed Shire Council	13,750
02	Bray Park Weir	Tweed River		
03	DE Williams Dam	Mulgum Creek	Lismore City Council	Not used
04	Mulgum Creek Weir			
05	Emigrant Creek Dam	Emigrant Creek	Rous Water	9,930
06	Rocky Creek Dam	Rocky Creek		
07	Wilsons River Source	Wilsons River		
08	Converys Lane Bore	Alstonville Basalt Aquifer		
09	Lumley Park Bore	Alstonville Basalt Aquifer		
10	Woodburn Bores	Coastal Sands Aquifer		
11	Jabour Weir Intake	Richmond River	Richmond Valley Council	2,020
12	Lavertys Gap Weir	Wilsons River	Byron Shire Council	Not used
13	Ellis Road Bore	Alstonville Basalt Aquifer	Ballina Shire Council	Rous Water emergency supply
14	Lindendale Bore	Alstonville Basalt Aquifer		
15	Kyogle Weir	Richmond River	Kyogle Council	250
16	Kyogle Bores	Richmond River Alluvium		
Total 2060 secure yield of existing sources				*25,950*
Yield Deficit at 2060 (including 900 ML/a yield benefit provided by interconnection with Jabour Weir)				*12,550*

Existing Treatment Facilities

Ref	Treatment Facility	Local Water Utility	Capacity (ML/d)
T1	Bray Park WTP	Tweed Shire Council	100
T2	Nightcap WTP (augmented)	Rous Water	85
T3	Emigrant Creek WTP	Rous Water	7.5
T4	Casino WTP (augmented)	Richmond Valley Council	35
T5	Kyogle WTP	Kyogle Council	3.0

Figure 15: Regional Water Supply Scenario 5 – Toonumbar Dam and Raise Clarrie Hall Dam

7.6 Assessment of Regional Supply Scenarios

A range of assessment criteria have been selected to enable comparison of the regional scenarios and identify the most attractive scenario to the region as a whole. The evaluation criteria incorporate the range of benefits of a regional scheme discussed in Section 6.1 where possible.

Table 20: Regional scenario assessment criteria

Benefits of Regional Approach	Assessment Criteria
Financial – Provide a lower cost drinking water supply to the region over the long term	Ability to stage capital expenditure over time to match demand and reduce initial capital cost
System resilience – Reduce risk of supply shortages	Ability to protect against short-term supply shortages resulting from drought, natural disaster, component failure or contamination
Climate resilience – Reduced vulnerability to the effects of climate change	Ability to address risks of reduction in average yield and increased yield variability due to climate change over the long term
System flexibility – Ability to accommodate a range of supply deficits	Source components can be modified to adapt to changing demand due to growth and the influence of demand-side initiatives
Potential for scheme expansion – Ability to accommodate additional service areas	Ability to expand the regional network over time to provide benefits to areas that are not regionally networked

The potential for water and cost sharing is a major potential benefit of a regional water supply scheme. The degree of water and cost sharing is determined by the extent of the connected regional network, and the benefits that accrue to the individual water supplies due to those interconnections. All of the short-listed scenarios have significant sharing potential and therefore no significant separation of these scenarios is provided by using cost sharing as an assessment criterion.

Some additional assessment criteria cannot be applied to compare the scenarios at present as detailed design information about the options is not yet available. These additional considerations include:

- Greenhouse gas emissions;
- Ecological and heritage impacts;
- Costs and net present value;
- Affordability;
- Stakeholder support; and
- Community acceptance.

Further development of the schemes will require consideration of the triple bottom line outcomes.

The scenarios have been ranked against the assessment criteria to identify the most attractive scenarios for the region (refer Table 21). The desalination scenario ranks the highest against each of the criteria. Scenarios 2 and 5, including additional surface water storage on the Richmond River and Tweed River, ranks second against each of the criteria.

Table 21: Comparison of regional scenarios

Objective	Financial – Provide a lower cost drinking water supply to the region over the long term	System resilience – Reduce risk of supply shortages	Climate resilience – Reduced vulnerability to the effects of climate change	System flexibility – Ability to accommodate a range of supply deficits	Potential for scheme expansion – Ability to accommodate additional service areas	Overall Attractiveness
Assessment Criteria	*Ability to stage capital expenditure over time to match demand and reduce initial capital cost*	*Ability to protect against short-term supply shortages resulting from drought, natural disaster, component failure or contamination*	*Ability to address risks of yield reduction and increased variability in climate due to climate change over the long term*	*Source components can be modified to adapt to changing demand due to growth and the influence of demand-side initiatives*	*Ability to expand the regional network over time to provide benefits to areas that are not regionally networked*	*All*
1 – Coastal desalination	Multiple stages are possible: A desalination facility is easily constructed in stages to meet demand. Significant initial infrastructure cost but highly scalable thereafter.	Excellent. The desalination facility provides a new source that is drought-resistant and independent of existing sources. Supply can be achieved through three major sources and treatment facilities.	Excellent. The desalination facility provides a new source that is fully climate independent.	High. Desalination facilities can be under-utilised or scaled-up as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	High. Meets objectives of study.
Rank	1	1	1	1	3	1
2 – Dunoon Dam (Richmond River, 50,000 ML) and raise Clarrie Hall Dam (Tweed River)	Two or three stages are potentially possible: Significant initial infrastructure cost with either dam constructed first. Supply augmentation stage is achieved through the second dam with potential raising of Dunoon Dam (third stage).	Moderate. The two major dams provide additional surface water redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through two major sources and treatment facilities.	Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply.	Moderate. Source augmentation can only be scaled-up once or potentially twice. Treatment facilities can be under-utilised as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	Moderate. Meets objectives of study but supplies are susceptible to climate-related risks.
Rank	2	4	2	2	3	2

Excellent	High	Moderate	Low-Moderate	Poor

Objective	Financial – Provide a lower cost drinking water supply to the region over the long term	System resilience – Reduce risk of supply shortages	Climate resilience – Reduced vulnerability to the effects of climate change	System flexibility – Ability to accommodate a range of supply deficits	Potential for scheme expansion – Ability to accommodate additional service areas	Overall Attractiveness
3 – Dunoon Dam (Richmond River, 85,000 ML)	One or two stages are potentially possible although feasibility of dam raising is unknown: Significant initial infrastructure cost with dam construction.	Moderate. The two major dams provide additional surface water redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through two major sources and treatment facilities.	Low - Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply.	Low-Moderate. Source augmentation may potentially be scaled up once with dam raising. Treatment facilities can be under-utilised as required.	Moderate. Regional supply is limited to Tweed, Byron, Ballina, Lismore and RVC LGAs.	Low – Moderate. Meets objectives of study but supplies are highly susceptible to climate-related risks. Not likely to offer any significant advantages over Scenario 2.
Rank	4	4	2	4	3	5
4 – Use of Toonumbar Dam (with 20 m raising)	One or two stages are potentially possible although feasibility of second raising is unknown: Significant initial infrastructure cost with dam raising, pipe and treatment facilities.	High. The new surface water source provides additional redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through three major sources and treatment facilities.	Low - Moderate. Fully reliant on water surface supplies. It is likely that this more western storage will be more susceptible to climate change impacts but scenario reduces reliance on a single major supply.	Low-Moderate. Source augmentation may potentially be scaled up once with second dam raising. Treatment facilities can be under-utilised as required.	High. Larger regional supply network includes Kyogle LGA.	Low – Moderate. Meets objectives of study but supplies are highly susceptible to climate-related risks.
Rank	4	2	5	4	1	4

Excellent	High	Moderate	Low-Moderate	Poor

Objective	Financial – Provide a lower cost drinking water supply to the region over the long term	System resilience – Reduce risk of supply shortages	Climate resilience – Reduced vulnerability to the effects of climate change	System flexibility – Ability to accommodate a range of supply deficits	Potential for scheme expansion – Ability to accommodate additional service areas	Overall Attractiveness
5 - Toonumbar Dam (with 10m raising) and raise Clarrie Hall Dam	Two or three stages are possible: Significant initial infrastructure cost with either dam raising constructed first. One supply augmentation stage is achieved through second dam raising with potential for second raising of Toonumbar Dam.	High. The new surface water source provides additional redundancy between catchments and some resilience is provided by minor sources. Supply can be achieved through three major sources and treatment facilities.	Low-Moderate. This scenario is fully reliant on surface water supplies which are likely to be increasingly climate affected, but this scenario reduces reliance on a single major supply. Toonumbar Dam is more susceptible to climate change risks.	Moderate. Source augmentation may be scaled-up once and potentially twice with a second raising of Toonumbar Dam (to 20m). Treatment facilities can be under-utilised as required.	High. Larger regional supply network includes Kyogle LGA.	Moderate. Meets objectives of study but supplies are susceptible to climate-related risks.
Rank	3	2	4	2	1	2

Excellent	High	Moderate	Low-Moderate	Poor

Excellent	High	Moderate	Low-Moderate	Poor

8. INTEGRATED WATER CYCLE MANAGEMENT APPROACHES

8.1 Potable Reuse of Treated Wastewater

8.1.1 Indirect Potable Reuse

Indirect potable reuse involves delivery of highly treated reclaimed water directly into an existing major storage dam or possibly a groundwater source, for subsequent extraction, treatment and transfer using existing distribution infrastructure. Through the use of reclaimed water from an urban wastewater treatment plant, this option can provide a new water source that is always available even in drought conditions. The yield of the supply is only limited by the effluent flows and the capacity of the reclaimed water treatment facilities. The process already occurs unintentionally in a number of locations within Australia. Within the study area, the Wilson River Source intake is downstream of Bangalow's Wastewater Treatment Plant.

Previous investigations by the local water utilities have considered the option of indirect potable reuse:

- Rous Water will continue to consider the option as part of its Future Water Strategy in recognition of the trend of increasing community understanding of water treatment technology and water cycle management principles, despite conflicting advice from the Ministry of Health as to whether that authority would approve this type of scheme (GeoLINK, 2011b);
- Richmond Valley Council's IWCM Strategy considered the option of indirect potable reuse (IPR) of effluent from Casino STP to the river 2 km upstream of Jabour weir; and
- Tweed Shire Council's water supply augmentation options assessment for the Tweed District considered advanced treatment 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 but concluded that the option is expensive and not socially acceptable (MWH, 2009b).

Key Considerations for the Regional Water Supply

A multi-barrier approach to public health risk management consisting of a complex treatment process would be necessary to gain regulatory approval for an indirect potable reuse scheme. The wastewater system would also need to be well managed, with a very high level of monitoring and extended detention within the storage dam (GeoLINK, 2011b). There are significant distances between the existing storage dams in the region and the existing wastewater treatment plants, so this option would involve considerable pumping and pipeline infrastructure.

There are some existing indirect potable and non-potable reuse schemes in Australia and overseas which provide a precedent for this type of scheme. Nevertheless, community and regulator acceptance is considered to be a significant risk, particularly in the short-term until water becomes more highly valued and reuse schemes become more acceptable. Based on recent history at Toowoomba and the western corridor in south-east Queensland, the deliberate implementation of this option would struggle to gain community support in the near future.

8.1.2 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) involves treating wastewater to a high standard and injecting it into groundwater for subsequent extraction and reuse. Reuse options include irrigation extraction by other water users or aquifer recharge. The option is similar to indirect potable reuse discussed above except that storage is provided by underground aquifers.

Key Considerations for the Regional Water Supply

Regulation of the water table in the aquifer is a key concern for ASR in terms of environmental impacts. The key issue is dryland salinity which is caused when the water table rises to the ground's surface bringing dissolved salts from the soil profile to the surface. This can cause severe soil degradation and vegetation death leading to erosion, as well as downstream impacts due to salts in the soil being runoff to rivers and creeks. Acid sulphate soil (ASS) is another issue to be considered as changes to the water table can mean that soils become exposed to oxygen and begin to oxidise producing toxic concentrations of aluminium and iron and high acidity. ASS has been reported widely in the North Coast region on the lower flood plain areas.

Contamination of water through direct and indirect means such as contamination from bores or infiltration of contaminants from the ground's surface is also a key concern for ASR feasibility. A shallow water table and unconfined condition are primary risk factors in susceptibility to aquifer contamination.

The feasibility of ASR could be determined in parallel with any consideration of groundwater sources in relation to the above risks.

8.1.3 Direct Potable Reuse

Direct potable reuse involves transfer of highly treated effluent from the wastewater treatment plants to the existing water supply distribution network and direct to customers. In contrast to indirect potable reuse, there is no intermediate return of the treated water before subsequent abstraction and reuse.

Key Considerations for the Regional Water Supply

Implementation of direct potable reuse presents substantial technical and management challenges. The need for reliability of processes, vigilance of monitoring and highly skilled operators is magnified for direct augmentation of water supplies with treated effluent. Significant time, skilled resources and expenditure are required to develop appropriate risk management procedures and undergo the required consultative process. As with indirect potable reuse, there is likely to be significant community opposition to this option within the foreseeable future.

8.2 Recycled Water for Non-Residential Uses

Recycled water (both treated effluent and recycled stormwater) is used for a range of non-residential uses throughout the Northern Rivers. Table 22 provides a summary of the non-residential uses and amount of recycled water used in each supply area.

Table 22: Non-residential non-potable recycled water uses in the Northern Rivers

LWU	Uses	Volume of Effluent Recycled in 2010/11 (% of total effluent)
Ballina	Irrigation of public spaces and a turf farm.	123 ML (2%)
Byron	Agriculture, playing fields and bowling club.	489 ML (15%)
Kyogle	Pasture and crops Woodenbong and Bonalbo school agricultural plots and golf courses	19 ML (3%)
Lismore	Tea tree and other agricultural uses	1%
Richmond Valley	Golf courses and agriculture	136 ML (6%)
Tweed	Agriculture, sugar mill cooling water and irrigation of playing fields and golf courses	436 ML (5%)

Source: NSW Office of Water (2012)

The irrigation users would be unlikely to irrigate with potable water during normal climate periods where rainfall would be sufficient. Therefore, apart from the Sugar Mill, these effluent reuse opportunities do not contribute to significant potable water demand reduction apart from periods of dry weather. In prolonged dry weather, it is likely that restrictions would prohibit the use of town water for irrigation.

For the use of recycled water for non-residential uses to be effective at reducing potable water demand, potable substitution opportunities need to be identified.

8.3 Residential (Urban) Reuse

Recycling or reclaiming water for reuse in specified residential end uses is generally accepted as an effective and sustainable measure of potable substitution. Dual reticulation is a system of supplying treated wastewater to households in addition to the potable supply. Recycled water in dual reticulated regions is generally supplied for toilet flushing, clothes washing and outdoor uses with the exception of filling pools and spas.

Dual reticulation schemes remove or reduce the constraint of other water saving methods such as water restrictions which allows householders to maintain water use even in dry times. Dual reticulation schemes have a range of environmental advantages including reducing the quantum of effluent disposal, improving the receiving water quality through reducing the pollutants discharged into downstream water systems as well as reduced extraction from water sources. On the downside, these schemes can be energy intensive due to the energy required for the recycled water treatment processes, as well as the additional pump energy required to distribute two separate water supply sources to the household. Dual reticulation schemes are generally high cost with extra pipes and installation, internal fittings and plumbing and retrofitting a system to an existing house.

In Australia, residential developments adopting dual reticulation have been implemented. Table 23 provides a summary of dual reticulation schemes in Australia. It is noted that the actual extent of reclaimed water use achieved is dependent on the realisation of anticipated growth rates. It may also be affected by future changes in water use patterns due, for example, to changes in the permitted uses of recycled water or due to climate variation.

Table 23: Operating dual reticulation schemes in Australia

Scheme	General Climate	Description	Recycled water end uses	Predicted/actual potable water savings
Rouse Hill, Sydney	Warm (28°C) wet (290 mm) summers with cool (19°C) moist (193 mm) winters.	Online 2001 Will serve up to 36,000 homes Centralised supply system	Toilet and outdoor uses	Predicted = 40% Actual = 35-40% reduction on total demand
Mawson Lakes, Adelaide	Warm (28°C) dry (61mm) summers with cool (16°C) rainy (223 mm) winters.	Online 2005 Will serve up to 3500 homes	Toilet and outdoor uses	Prediction = 50% of householder's water demand (265 kL/year)
New Haven Village, Adelaide	Warm (28°C) dry (61mm) summers with cool (16°C) rainy (223 mm) winters.	65 homes	Toilet and outdoor uses	Prediction = 30-40% Actual = 50%
Aurora (VicUrban), Melbourne	Mild (26°C, 154 mm) summers with cold (14°C, 147 mm) winters	8,500 lots Development onsite collection & reuse	Toilet and outdoor uses	Prediction = Up to 45% (recycled water & conservation)

Scheme	General Climate	Description	Recycled water end uses	Predicted/actual potable water savings
Pimpama Coomera, SEQ	Hot (29°C) wet summers 446mm summer with mild (21°C) moist (223mm) winter	Online end 2009 Will serve up to 45,000 homes Centralised supply system	Toilet and outdoor uses	Prediction = 35-45% Actual= 32.2%
Marriott Waters, Melbourne	Mild (26°C, 154 mm) summers with cold (14°C, 147 mm) winters	Online February 2009 Currently 100 homes On completion 1000 homes Dual reticulated development supply	Toilet and outdoor uses	Prediction= up to 40%

Source: Willis, *et al.*, (2009), Willis *et al.*, (2011)

The Ballina Shire Council dual reticulation scheme will commence in 2013/14 and will include supply of high quality treated effluent for:

- Urban dual reticulation (residential and commercial) - toilet flushing, clothes washing, car washing and garden usage;
- Urban open space irrigation; and
- Vegetation restoration.

The scheme is predicted to supply 383 L/dwelling/day (140 kL/dwelling/year) of recycled water to approximately 8,000 homes over the next 50 years.

8.3.1 Key Considerations for the Regional Water Supply

Yield

Ballina Shire Council's dual reticulation scheme will result in reduction in potable water demand for the Rous Water bulk supply area. The predicted reduction in per connection demand has been considered in the calculation of the future potable demand for the bulk supply area (refer Appendix 2). At its peak supply (2060), the scheme will provide approximately 19% of Ballina's bulk water demand and 3% of the region's total water demand. While recycled water schemes will provide benefits from local potable water reduction and environmental benefits due to reduced effluent discharges, there is unlikely to be any significant contribution to meeting the regional yield deficit.

Cost

The cost of the greenfield development scenarios increases significantly with the inclusion of recycled water components. Despite the costs, the benefits of recycled water schemes can be attractive. Ballina Shire Council recognised that wastewater discharges were negatively impacting environmental values for the Richmond River, and there was a strong community desire to improve the health of the river. This desired environmental outcome became a primary driver for the decision to upgrade their wastewater treatment facilities to improve the quality of wastewater discharges and reduce the total discharge of wastewater to the environment through increased recycling initiatives (e.g. open space and agricultural irrigation, dual reticulation for new developments etc.). Other councils in the region (Tweed) have also received community support for the use of alternative water sources such as treated wastewater (Hydrosphere Consulting, 2012a).

Taylor *et al.* (2012) analysed the costs and uptake of the Pimpama Coomera scheme. Taking into account infrastructure costs (excluding wastewater treatment) and annual operating costs the scheme was predicted to cost $8.90 per kL based on the 2050 scheme size.

8.4 Household Rainwater Tanks

Regulatory Requirements

BASIX, the NSW Building Sustainability Index, was introduced by NSW government for most new residential dwellings in 2005. It has now been extended to all residential developments valued in excess of $50,000. BASIX sets energy and water reduction targets for new homes and apartments. Rainwater tanks are now required for all new developments in NSW including new developments for swimming pools or spas that require a BASIX certificate. Water targets range from 40% to 0% across NSW (40% in the Northern Rivers), taking into account the significant variances in climate. NSW Department of Planning is currently proposing to increase the BASIX water reduction target for some areas, including the Northern Rivers to 50%. This would, in addition to a rainwater tank, require an internal connection from the tank to both toilets and washing machines.

In addition to the BASIX requirements, some councils in the region have developed rainwater tank policies. Tweed Shire Council recommends a tank of at least 5,000 L and a minimum roof catchment of 160 m^2. Byron Shire Council provides guidance for tank selection by roof catchment and usage.

Rebates

Rebates encourage residential water consumers, particularly those in pre-BASIX non-efficient houses, to become water efficient houses. While BASIX mandates the inclusion of rainwater tanks in new developments, additional incentives are required for existing customers to install a rainwater tank or for new developments to install a larger tank.

Rous Water offers three levels of rebate, based in the first instance on the tank volume ($100 for 2,000 – 4,499 L, $400 for 4,500 – 8,999 L and $500 for 9,000 L or more). Additional rebates are available if rainwater from the tank is supplied for flushing toilets ($500) and/or to the washing machine ($500).

Rous Water estimates that the installation of tanks has reduced average household water use by 50 kL/connection per year (Rous Water Demand Management Program 2012-2016). The cost to Rous Water is estimated at $9.41/kL saved per year. Similar water savings are predicted using the DWE Rainwater Tank Model (for Ballina and Murwillumbah) for a 5,000L tank used for external use only with 100 kL/connection per year savings with external use and connection to toilets and washing machine (10,000 L tank).

Key Issues and Constraints for the Regional Water Supply

Yield

Rainwater tanks provide opportunities for reduction in demand during normal climatic conditions (i.e. when tanks are refilled by rain). During droughts, the effectiveness of rainwater tanks diminishes with larger tanks able to store more water for dry periods. The BASIX requirements will address any demand reduction opportunities from rainwater tanks in new developments and rebates can assist with encouraging water efficiency in pre-BASIX houses. However, rainwater tanks in existing water supply areas are likely to fail in severe drought and customers will rely on town water supplies.

8.5 Large-Scale Urban Stormwater Reuse

Urban areas generate large amounts of stormwater due to vast areas of impervious surfaces such as roads, pavements, car parks and buildings. Stormwater can be an alternative to mains water supply use, particularly for non-potable uses. However, there are health and environmental risks associated with the use of stormwater due to its associated pollutants. Unlike recycled water, stormwater supplies are very sporadic, especially in a sub-tropical climate of high rainfall during summer and low rainfall during winter such as the Northern Rivers. As a result, stormwater is very climate dependent with supply in dry times being unreliable. Any stormwater storage in the region would need to be large enough to capture large rainfall events during the wet season and supply it throughout the low rainfall times of the dry season.

Urban stormwater is not reused in Ballina Shire, Lismore and Richmond Valley Councils, except for household rainwater tanks. In Kyogle Shire, urban stormwater is used to irrigate parts of the Bonalbo golf course and adjoining sports field and there are a significant number of household rainwater tanks, particularly in the villages of Bonalbo and Woodenbong. In the Tweed Shire, Banora Point Golf Course is irrigated by a local stormwater storage system.

As with the use of recycled water for non-residential uses, the large scale reuse of stormwater often contributes very little to the reduction in potable water demand.

8.6 Potable Demand Management

8.6.1 Current Demand Management Programs

Rous Water and the Constituent Councils

In 2012, Rous Water adopted the Rous Water Demand Management Plan 2012-2016. The purpose of the plan is to provide a strategic, prioritised set of actions designed to achieve a range of demand management objectives. The key actions from the plan are:

- Develop greater understanding of the water demand profile;
- Implement programs to achieve sustained water savings by residential customers;
- Implement programs to achieve sustained water savings by non-residential customers;
- Undertake education and awareness programs to embed a water conservation culture in the Rous community;
- Implement programs to reduce and monitor water losses;
- Investigate opportunities for sustainable alternative water supplies;
- Develop improved monitoring, evaluation and reporting mechanisms; and
- Invest in effective governance partnerships.

Rous Water has developed a residential rainwater tank, dual flush toilet, water efficient showerhead and water efficiency products rebate program as part of the Demand Management Program. The rebates also apply to the other water supply systems in the constituent council areas (Casino, Wardell and Mullumbimby).

Rous Water and the constituent councils have also introduced voluntary permanent water saving measures.

Additional local initiatives have also been developed for Mullumbimby to complement the Rous Water program. Residents of Lismore are encouraged to follow the odds 'n' evens watering regime in addition to the permanent water saving measures. This regime is being promoted as an added water saving initiative by Lismore City Council.

Tweed Shire Council

The adopted demand management strategy currently focuses on the following demand management programs:

- Ongoing communication and education;

- Residential consumption targets – currently 180 L/p/d;
- Assistance to top non-residential water users to reduce consumption;
- Reduction in water losses;
- Effluent reuse schemes (and recycled water target of 15%);
- Residential retrofits and rebates; and
- Rainwater tank policy.

Kyogle Council

Kyogle Council has implemented a rainwater tank and dual flush toilet rebate scheme since 2006. Permanent water conservation measures adopted by Tenterfield Shire Council also apply to residents of Woodenbong and Muli Muli.

Other Rebate Programs

In 2007 the NSW government introduced the NSW Home Saver Rebates Scheme. The aim of the scheme was to make NSW households more water and energy efficient. The scheme delivered over 330,000 rebates throughout NSW, saving an estimated 4.8 billion litres of water, before the scheme ended in June 2011. There are currently no State or Federal government rebates applicable to the region.

WELS program

Introduced nationwide in 2005, the WELS program is Australia's water efficiency labelling scheme. The scheme requires certain to be registered and labelled with their water efficiency in accordance with the standard set under the national *Water Efficiency Labelling and Standards Act 2005*. The program was introduced so consumers could make informed decisions and choose water efficient products to help save water.

8.6.2 Water Loss Management

All LWUs in the region have undertaken some level of planning and implementation of water loss programs including identification and implementation of pressure management zones, leakage reduction programs, regular ongoing maintenance and leak repair and identification of unmetered water consumption. Most participated in the Water Loss Management Program for Regional NSW Water Utilities between 2006 and 2011.

A more recent water loss program undertaken for Rous Water and the Constituent Councils found that there are potential water savings in Ballina and Byron Councils through leak detection, repair and pressure management. The study also found that a pressure management program would be beneficial for Richmond Valley Council (RVC) lower river area (WLPM, 2012).

8.6.3 Future Demand Management

As discussed in Section 3.2, the existing demand management programs have been successful in reducing per connection demand. Any regional supply scenario should include demand management and water loss management programs to continue to avoid water wastage. A regional approach would also include resource sharing opportunities and the development of consistent approaches to demand reduction.

9. CONCLUSIONS AND RECOMMENDATIONS

There are significant benefits to be gained from interconnection of the major water supplies in the region in terms of water sharing, cost sharing and improvements in water supply security on a local and regional scale. The major benefits arise with interconnection of the Rous Water bulk supply system with the Tweed (Bray Park) water supply system as these systems both require source augmentation on a large scale and within similar timeframes. Interconnection of the smaller water supply systems of Casino, Mullumbimby, Nimbin and Kyogle would assist with resolution of local water supply security issues but would not significantly influence the viability of the regional scheme. It is recommended that these smaller interconnection options are pursued as part of a larger regional scheme only if this is the preferred option to address local water supply security issues.

The region requires significant investment in a new water supply source or sources within the next 10 years to maintain secure supply. The most attractive source augmentation option for a regional scheme is the incorporation of marine water desalination (Scenario 1) as this is easily scalable to match demand and is independent of climate, thus providing a highly secure water supply. Adding desalination provides climate independence that is currently missing from the region's water supplies. Desalination schemes have been successfully developed elsewhere and improvements in technology are likely to improve the attractiveness in future.

The attractiveness of a desalination solution diminishes if alternative large scale options are implemented by separate LWUs beforehand as the cost-sharing potential of a centralised scheme diminishes markedly once this occurs. Despite the overall attractiveness of desalination, significant uncertainties remain with this option and it is considered appropriate that surface water augmentation options continue to be considered as an alternative regional solution should desalination not be confirmed as a viable strategy. In this case, the most attractive surface water scenarios (Scenarios 2 and 5) involve additional surface water storages in both the Richmond River (Dunoon Dam or Toonumbar Dam) and Tweed River catchments (raising Clarrie Hall Dam). These scenarios are also not restricted by implementation of either component (Tweed or Richmond River storage) in isolation of the regional scheme.

A balance between surface water (through the large volume of existing storage), desalination (providing climate independence and flexibility) as well as groundwater sources (which are a widely distributed, easily accessible resource for small scale localised supply) provides the most robust and logical regional system. Potable demand reduction through demand management, water loss management and source substitution would all contribute to reduced supply deficit and allow the use of existing supplies over a longer timeframe and should be implemented on a local scale but with regional consistency as appropriate. Overall, these do not detract from or enhance the attractiveness of the preferred regional scheme.

Whilst some potential regional schemes have been identified, the merit of each LWU connecting their water supply scheme to a regional scheme must be the subject of an investigation by the respective LWU. As identified above there are a number of major regional schemes and some minor regional schemes that could be of merit.

To progress the development and implementation of the preferred regional water supply strategy (Scenario 1 – Desalination), the following actions are recommended:

- Regional investigations:
    - Investigate feasibility of inter-connection options. The success of a regional surface water scenario is highly dependent on the interconnection and two-way transfer of water between the Tweed/Bray Park water supply system and the Rous Water bulk supply network. Investigations should include pipeline route, transfer system, cost and yield benefit obtained from the interconnection as well as potential administrative and governance arrangements. This study should be conducted in conjunction with the desalination study recommended

below due to the interaction of the two concepts. Similar investigations are required for the interconnection of the region's smaller systems;

- Desalination study. While the options of small-scale desalination have been investigated on preliminary level, there is a need to develop a concept for the large-scale regional desalination facility including feed water, brine discharge, energy requirements and sources, treatment plant location, staging, transfer systems and cost. This study should be undertaken as a priority and focus on a centrally located large scale plant contributing to both the Tweed and Rous Water systems; and
- Sufficient investigation of potential surface water storage options (particularly raising Clarrie Hall Dam and raising Toonumbar Dam), including yield and environmental and social impacts, to enable full comparison with the desalination scenario.

- LWU) strategic planning – to assist future planning for water supply in the region, the following should be undertaken:
    - Yield studies. The LWUs should determine the yield of existing water sources and impacts of climate change in accordance with Office of Water guidelines;
    - Monitoring – All LWUs should continue to improve data collection and monitoring of connection growth and demand, with increased regional consistency;
    - Water loss management - All LWUs should continue to improve the understanding of water losses and implement a water loss management program;
    - Demand management - All LWUs should continue to implement programs to reduce per connection demand with regional consistency; and
    - Groundwater investigations – A new Water Sharing Plan is being developed by the Office of Water. Once the regulatory requirements are known, the potential groundwater sources, bore yields, bore locations and water quality should be investigated to enable identification of feasible applications of groundwater supplies. Impacts on groundwater dependent ecosystems will also need to be identified. Whilst groundwater may not be implemented regionally, groundwater may still help to address water supply security issues on a local scale.

10. ABBREVIATIONS

ADWG	Australian Drinking Water Guidelines
ASS	Acid Sulfate Soil
BASIX	Building Sustainability Index
FSL	Full supply level
IWCM	Integrated Water Cycle Management
kL	Kilolitre
L	Litre
L/person/d	Litres per person per day
LWU	Local water utility
ML	Megalitre
NOROC	Northern Regional Organisation of Councils
NRW	Non-Revenue Water
WSP	Water Sharing Plan
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

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APPENDIX 1: INTERIM REPORT 1 – EXISTING TOWN WATER RESOURCES AND DEMAND

APPENDIX 2: INTERIM REPORT 2 – LONG-TERM WATER RESOURCES AND DEMAND

APPENDIX 3: ADDITIONAL INFORMATION ON GROUNDWATER RESOURCES IN THE STUDY AREA

GROUNDWATER RESOURCES

A number of groundwater sources exist in the study area. The NSW Office of Water (2010a) groups aquifer types into four basic categories:

1. Fractured rock aquifers found in rock formations such as granite or basalt. Groundwater in these rocks occurs mainly within the fractures and joints. The North Coast Fractured Rocks and Alstonville Basalts make up the fractured rock aquifers in the study area (shown in pink in Figure A3.1);
2. Coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments;
3. Porous rock aquifers found in rock formations such as sandstone or limestone. Groundwater occurs within the pore space in the rock matrix. The Clarence Moreton Basin (shown in green) in Figure 4: represents porous rock aquifers in the study area; and
4. Alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

Figure A3.1 shows the location of groundwater sources in the study area. Further discussion of each of the four main aquifer types is provided below.

A1.1 Fractured Rock aquifers

The fractured basalt aquifers are an important resource of fresh groundwater and the majority of groundwater use in the study area is from these aquifers. Permeability is due to jointing and vesicular zones within the basalt and perennial springs from the basalt maintain a large number of creeks (Drury, 1982). Bore yields are variable, ranging from less than 0.5 L/s to greater than 30 L/s. High yields are dependent on intersecting one or more of the water bearing fracture zones.

The basalt groundwater system can be divided into two main components:

- A shallow, unconfined groundwater flow system in the weathered and shallow highly fractured basalt. This system tends to be localised with groundwater flow direction following topography; and
- A deep, semi-confined to confined groundwater flow system in fractured horizons within the basaltic sequence. Groundwater flow is controlled by geology with flow direction following the dip of the geological sequence.

The main basalt aquifers in the study area are:

- The Alstonville Basalt aquifer managed under the *Alstonville Groundwater Sources Water Sharing Plan*, which commenced on 1 July 2004; and
- The North Coast Fractured Rock Basalt aquifer which includes all basalt aquifers outside the boundary of the Alstonville Basalt Water Sharing Plan area and is not managed by a Water Sharing Plan.

Basalt aquifers of the plateau generally contain low salinity groundwater and have low nitrate concentrations. The pH values range from 4.6 to 9.8, and generally increase (becoming more alkaline) with depth. Shallow groundwater is slightly acidic, possibly due to the acidic krasnozem soils, and this causes a natural increase in dissolved metal concentrations, particularly aluminium, zinc, manganese, copper, iron and lead (Parsons Brinckerhoff, 2011). Bore yields range between 7 and 16 L/s for the bores installed in the Alstonville Basalt aquifer.

Rous Water currently operates two bores on the Alstonville Plateau and is licensed to extract 150 ML/a from Convery's Lane bore and 530 ML/a from Lumley Park bore. Ballina Shire Council also hold groundwater licences for extraction of a combined total of 550 ML/a at Ellis Road and Lindendale Road bores near Alstonville. An assessment by Parsons Brinckerhoff (2011) concluded that none of the Rous Water bores are used to either their licensed volume or their maximum pumping capacity.

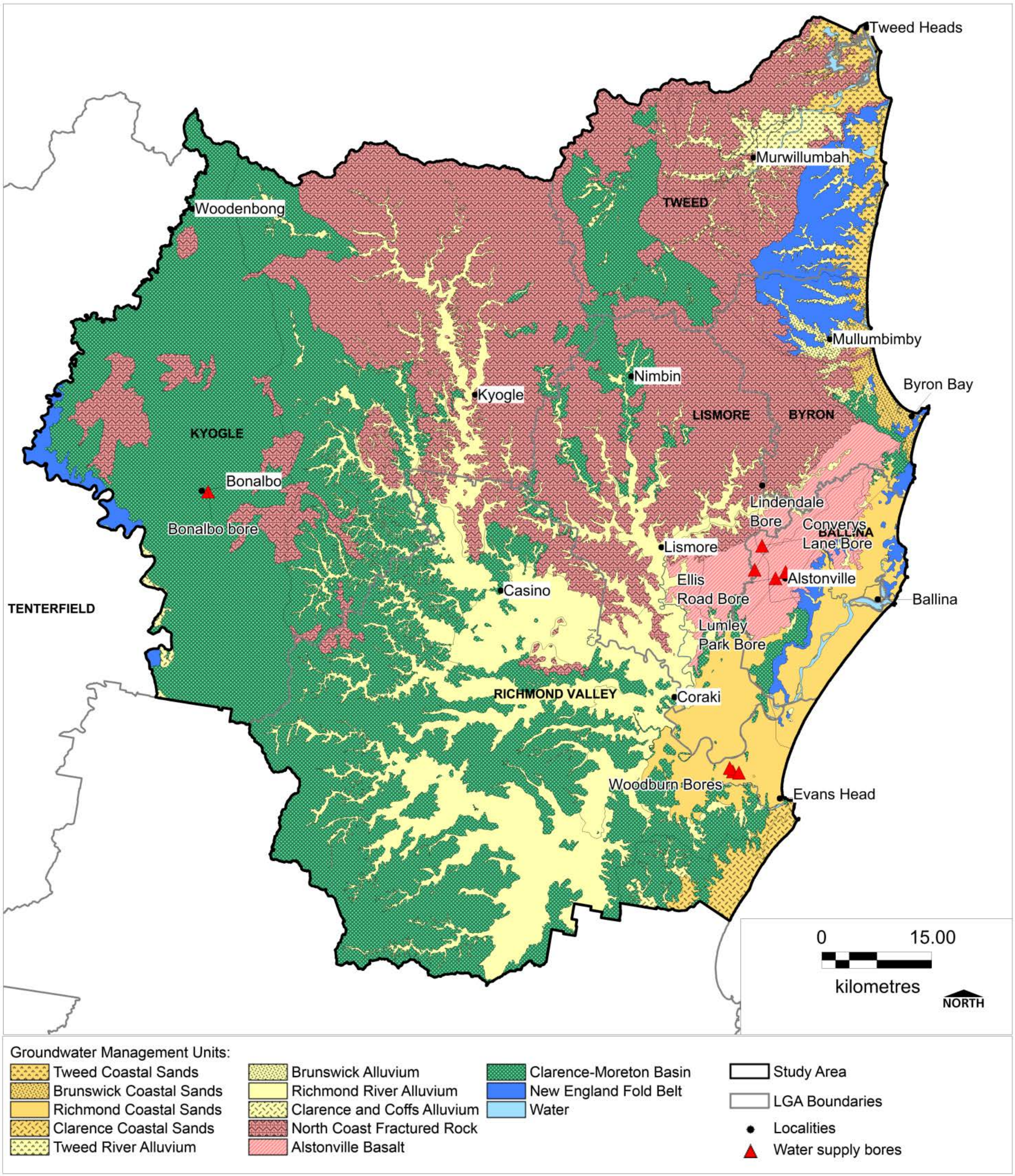

Figure A3.1: Groundwater sources in the study area

Mapping provided by NSW Office of Water, Jan 2013

The New England Fold Belt metasediments are categorised by NSW Office of Water into the Fractured Rocks category. The geology differs from the fractured basalts and consists of ancient rocks that have been deformed over hundreds of millions of years and mainly consist of slates, greywacke and granites. The New England Fold Belt generally lies beneath the fractured basalt layers, except for notable outcrops in the

Tweed region and small outcrops along the coast near Byron Bay, Alstonville and Ballina. This aquifer generally has much lower yields than the fractured basalt (typical yields of 0.1-0.5 L/s), although occasional supplies up to 5 L/s have been recorded around Murwillumbah (McKibbin, 1995). Consistently high yielding bores from the New England Fold Belt metasediments have not been established in NSW (EHA, 2008).

A1.2 Coastal Sand Aquifers

McKibbin (1995) reported that interspersed between rocky headlands, coastal sand masses extend almost the entire seaboard length of the upper north coast of NSW. McKibbin (1995) 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. A key advantage of coastal sands aquifers is their proximity to existing urban centres and water supply infrastructure in coastal areas. McKibbin (1995) 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, care is necessary to avoid saline intrusion. Depending on the location of the aquifer, discharge from coastal sands may feed local rivers, waterways or coastal swamps. Freshwater lagoons, lakes and freshwater habitat within the sand beds are common and represent windows in the water table.

McKibbin (1995) also noted that whilst groundwater salinity within these sediments is generally low (<500 mg/L TDS), water quality issues exist in some areas associated with the presence of hydrogen sulphide, iron, low pH or excessive colour. DLWC (1998) rated the vast majority of coastal sand units to be of “High” aquifer vulnerability due to their shallow, unconfined and highly permeable characteristics. The water tables were typically less than 5 metres deep, combined with shallow soil depth, low slope and high to very high permeability, which placed them in the high risk category for contamination and variation in yield.

The Coastal Sands groundwater sources which have been previously delineated in the study area are:

- Tweed Coastal Sands – from the Tweed River to Mooball Creek;
- Brunswick Coastal Sands - from Mooball Creek to Tallow Creek; and
- Richmond River Coastal Sands – from Tallow Creek to the Evans River.

The Woodburn Sand aquifer is located within the Richmond River Coastal Sands and is an example of one of the main coastal sand aquifers currently used for water supply in the study area. The estimated potential yield from the Woodburn Sand ranges from 4.5 to 6 L/s. Rous Water currently extracts periodically from this source to augment town water supplies during drought conditions. The water needs to be treated to correct low pH, high iron and dissolved carbon dioxide levels. The aquifer is very transmissive, but has a lower potential yield due to limited available drawdown. Drury (1982) suggests that large groundwater supplies (>25 L/s) could potentially be obtained from the Woodburn Sands using a number of bores.

The NSW Office of Water is currently developing a water sharing plan for the Coastal Sands aquifers on the North Coast which will collate all available information about the water source, and the rules and regulations to govern extraction from this aquifer.

A1.3 Porous Rocks of Clarence Moreton Basin- Kangaroo Creek Sandstone aquifer

The Clarence Moreton Basin covers a vast area from 50km south of Grafton through to Queensland and is made up of a number of sedimentary formations at various depths. The porous sedimentary rock aquifers of the Clarence Moreton Basin have variable groundwater potential with bore yields previously described as generally low with variable salinity (McKibbin, 1995). DLWC (2001) reported average yields of approximately 0.4 L/s with potential for yields up to 1.5 L/s. Sustainable yields have not been estimated for this aquifer to date but DLWC (2001) has classified this source as low risk of over extraction.

A1.4 Alluvial aquifers

Alluvial aquifers consist of unconsolidated sediments which were deposited in relatively recent times by fluvial processes (flowing water) over the hard rock geology of the sedimentary Clarence Moreton Basin and volcanic deposits of Tertiary Basalt. The aquifers are associated with major river systems and can stretch from upper catchment locations far inland to the coast. Alluvial aquifers can have a significant connection to their parent streams, depending on the type of alluvial material. For example, where alluvial aquifers are found in upriver situations and are made from coarse material such as sands and gravels, groundwater and surface waters interact significantly. However, in the lower catchment areas closer to the coast, where alluvial materials tend to be finer, there is generally only moderate connection between groundwater and the river (NSW Office of Water, 2010b).

Major alluvial aquifers in the study area are:

- Richmond River Alluvium managed under the *Water Sharing Plan for the Richmond River Area Unregulated, Regulated and Alluvial Water Sources*; and
- Tweed River Alluvium managed under the *Water Sharing Plan for the Tweed River Area Unregulated, Regulated and Alluvial Water Sources*.

Alluvial aquifers commonly exists at 0-30 m below the ground surface (Drury, 1982). The water tables are generally shallow, often only a few metres from the natural surface level (DLWC, 2001). Because alluvial aquifers are unconfined and the water table is located close to the ground surface (<5 m depth), there is potential for contamination of groundwater supplies. DLWC (1998) assigned a ‘high’ risk rating to this aquifer for this reason.

APPENDIX 4: PRELIMINARY ASSESSMENT OF POTENTIAL DESALINATION FACILITY SITES

ASSESSMENT OF POTENTIAL LOCATIONS FOR DESALINATION FACILITIES

Consideration of potential locations for a desalination plant within the NOROC study area has been undertaken to provide context for this option. Broad assessment criteria were developed to identify potentially suitable locations for further investigation. For the purposes of this report, general localities have been identified, not specific parcels of land. Note this assessment does not constitute an exhaustive assessment of all potential locations for a desalination plant, and while the outcomes are the preferred locations based on the currently available information, they should not be interpreted as the only possible sites. A comprehensive site selection process would need to be completed as part of further investigation if the desalination option is to be progressed.

The key considerations for potential desalination plant locations are as follows:

1. Less than 2 km from the ocean to minimise the cost of pumping, energy and transport;
2. Land parcel >24 ha in area to cater for approximate footprint of the desalination plant. This has been based on the Tugun desalination plant and allowing for a 100 m buffer;
3. The site must be located on suitable land with adequate buffer distances from:
    - Urban areas;
    - Tourism areas;
    - Protected agricultural areas, such as state significant farmland;
    - National Parks and Nature Reserves;
    - Other protected areas including SEPP14 (Coastal Wetlands), SEPP26 (Littoral Rainforest) areas, SEPP44 (Koala habitat), Marine Parks, other key habitats, wildlife corridors and areas protected by relevant LEPs.
4. Central to the main water users in the study area and areas for increased future demand (i.e. between Tweed and Ballina population centres);
5. Close to existing water supply infrastructure;
6. Proximity to existing electricity supply;
7. Major primary works requirements such as new river crossings, etc.;
8. Topography (to minimise the cost of pumping and energy, etc.).

Based on the above considerations, potential locations have been shortlisted for consideration. Table A4.1 presents a description of how well each shortlisted location meets the listed criteria. Figure A4.1 shows the spatial assessment undertaken to shortlist sites within 2 km of the coastline.

Wooyung, located south of Pottsville in the Tweed Shire is considered to be the preferred location based on its position central to the major water demand centres, suitable land with appropriate distances from sensitive land uses and environmental protection areas, and proximity to planned regional interconnection pipeline (A).

Table A4.1: Assessment of potential desalination plant locations

Location	Location relevant to major demand	Connection to Water Supply Network	Connection to Electricity Supply	Other advantages/ disadvantages	Conclusion
Wooyung, Tweed Shire	Central to major water demand centres	New connection pipeline would be required. The planned interconnection pipeline between Tweed Shire and Rous Water (Regional Scenarios) would provide connection at this location.	Hastings Point zone substation is approximately 12 km away. The capacity would need to be increased to cater for desalination demands.	• Relatively flat topography • Low lying areas are flood prone • Low visibility (away from urban centres and major highways, etc.)	The preferred location based on assessment criteria
Tyagarah, Byron Shire	Central to major water demand centres	Close to existing Rous Water bulk supply pipelines.	Ewingsdale zone substation is approximately 3-4 km away. The substation has current capacity issues, but is scheduled for upgrade in 2012/13 to overcome these issues. The capacity would need to be increased to cater for desalination demands.	• Relatively flat topography • Low lying areas are flood prone • Pipeline to coast would have to go through Tyagarah Nature Reserve • Byron Bay Marine Park is located offshore and the marine feedwater intake and brine disposal is likely to be contrary to the objects of the Marine Park. • Potential conflict with tourism industry of Byron Bay (temporary offshore rig may decrease amenity of Byron/ Belongil Beach)	Not considered viable due to environmental constraints associated with the Byron Bay Marine Park.
Seven Mile Beach Lennox Head Ballina Shire	Central to major water demand centres	Existing bulk supply pipelines lies approx. 5 km from nearest northerly point of this location and would require crossing the Richmond River	The nearest zone substation is in Ballina approx. 5 km from nearest northerly point of this location and would require crossing the Richmond River	• Relatively flat topography • Low lying areas are flood prone • Byron Bay Marine Park is located offshore and the marine feedwater intake and brine disposal is likely to be contrary to the objects of the marine park.	Not considered viable due to environmental constraints associated with the Byron Bay Marine Park
South Ballina, Ballina Shire	Some distance south of the major demand centres	Existing bulk supply pipelines lies approx. 7 km from this location.	The nearest zone substation is in Lennox Head approx. 3 km from nearest southerly point of this location.	• Relatively flat topography • Low lying areas are flood prone • Need for major river crossing of the Richmond River	Not considered viable due to distance from the main urban centres, and the requirement for a major river crossing of the Richmond River.

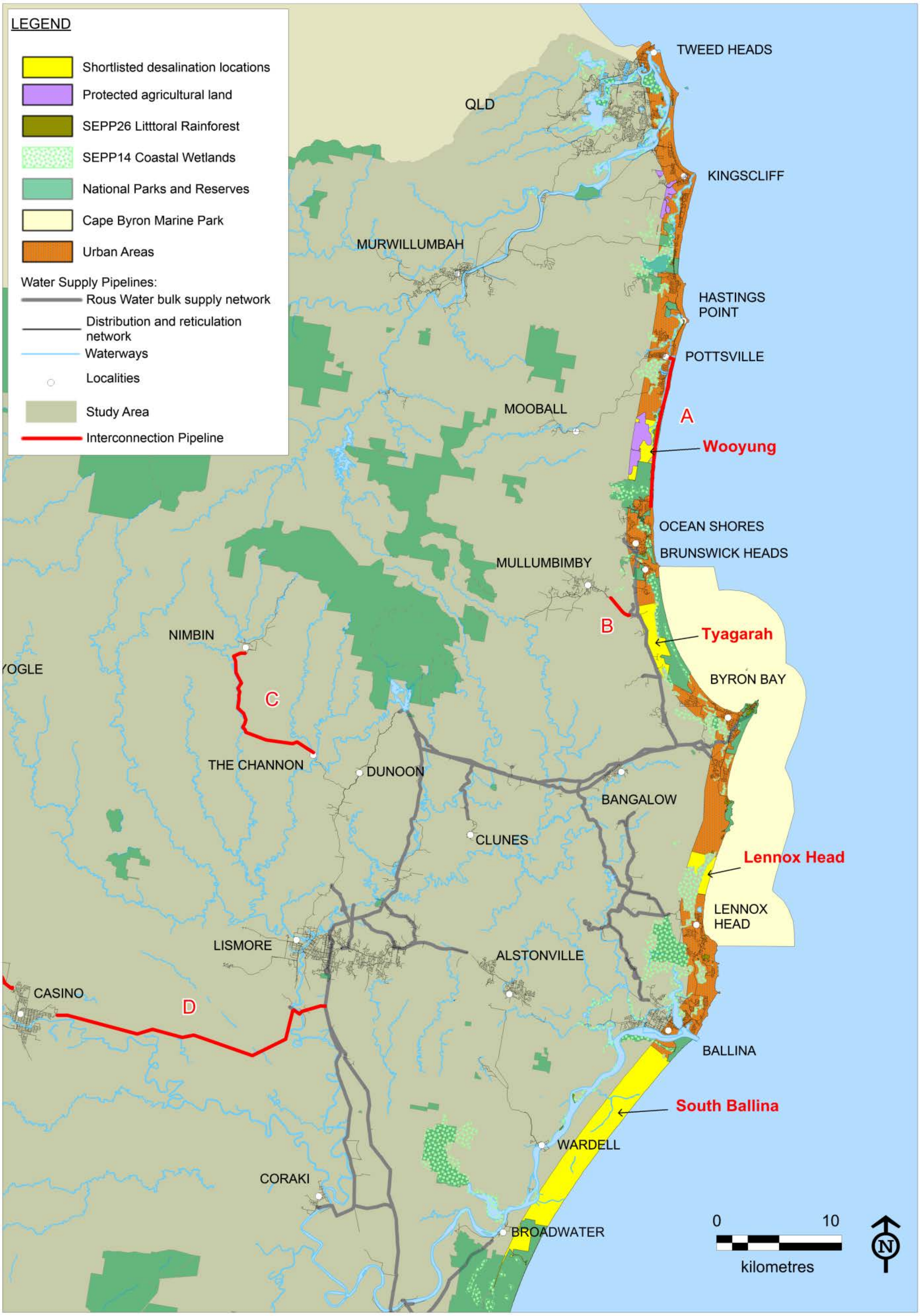

Figure A4.1: Spatial assessment of potential desalination plant locations

APPENDIX 5: PRELIMINARY ASSESSMENT OF PRIMARY SOURCES

Option	**Yield or Capacity** (Ability to supply bulk water and make a significant contribution to water supply deficit in the region)	**Availability/ Reliability** (will the option be able to supply water when most needed (i.e. drought)	**Scalability** (can the option be expanded sequentially to reduce initial capital)	**Compatibility** (is the option compatible with existing infrastructure or operations, and the surrounding built environment)	**Acceptability** (Social/ Political/ Cultural Heritage/ Legal)	**Timeliness** (can the option be implemented efficiently in the timeframe required)	**Technical Feasibility** (is the technology proven and reliable, can it be applied with certainty)	**Environmental Sustainability** (ecological impact, resource use, etc.)	**Potential Attractiveness** (how certain are we that this could be part of the regional solution given our current knowledge)	**Key approval issues and potential solutions**		**Indicative Cost**	
										Issue	**Solutions**	**Capital**	**Operating (per ML)**
Large scale, centralised desalination	Excellent. Virtually unlimited – full 14,000 ML/a 2060 deficit could be accommodated.	Excellent. This option is not climate dependant	Excellent. Easily scalable	Good. There are no fundamental hurdles to incorporating this solution. Interconnection of the high growth areas between the Tweed and Rous Water systems, with the desalination plant located centrally would provide the greatest regional benefit. New electricity supply infra-structure would be required.	Good. There are several contemporary examples of new plants being approved, but is generally regarded as being an expensive option with high energy needs.	Low- Moderate – Although significant study, site selection, land acquisition, etc. is required, there is no reason to doubt that this option could not be implemented by the required time	Good. There are many case studies from which to draw on and the key uncertainties are environmental, not technical in nature. The technology is considered to be maturing and further advances in technology are likely which may be able to be retrofitted in the future.	Moderate. Although desalination of seawater is energy intensive, these impacts can be offset. Other potential issues include potential effects on coastal visual amenity from plant and power infrastructure, effects of the brine discharge on receiving waters (relatively minor)	Good. This has been an accepted solution in several other locations within Australia and overseas. There is no fundamental reason why the same level of acceptability will not apply locally.	Source water availability	Seawater supply line needs to extend a significant distance offshore to avoid coastal processes.	High	High
										Brine discharge	Brine discharge to ocean is the best option and would necessitate offshore pipeline		
										Energy usage and power supply availability	Desalination plants can be either co-located with energy sources (e.g. on site solar) or utilise grid power where offsets are available through the purchase of green power.		
										Infrastructure effects on coastal processes, visual amenity	Under-boring of pipelines, low-impact site and power line route selection.		
Raise Clarrie Hall Dam	Good. The estimated yield of the dam (raised by 8.5m to FSL 70m) would be increased by 8,250 ML/a and further benefits may arise due to interconnection	Moderate but does not provide any additional independence from existing surface water sources	Low. FSL 70m is maximum optimum size	Excellent. There are no fundamental hurdles to incorporating this solution with the existing system	Moderate. Raising of CHD was ranked highly in Tweed's studies but there is significant opposition from parts of the community. Heritage studies have not been undertaken.	Low-Moderate. Approvals, land acquisition, design and construction is likely to be protracted.	High. Foundation conditions and potential materials areas are well understood. Some revision of concepts required following spillway upgrade.	Moderate. Additional inundation of land and properties and Aboriginal site. Threatened species and potential referral under EPBC Act.	Moderate. There are no known issues with raising the dam. Interconnection transfer rates and feasibility is not known at this time.	Inundation of land	No direct mitigation, only offsets available (e.g. veg regeneration elsewhere)	High	Low

Option	**Yield or Capacity** (Ability to supply bulk water and make a significant contribution to water supply deficit in the region)	**Availability/ Reliability** (will the option be able to supply water when most needed (i.e. drought)	**Scalability** (can the option be expanded sequentially to reduce initial capital)	**Compatibility** (is the option compatible with existing infrastructure or operations, and the surrounding built environment)	**Acceptability** (Social/ Political/ Cultural Heritage/ Legal)	**Timeliness** (can the option be implemented efficiently in the timeframe required)	**Technical Feasibility** (is the technology proven and reliable, can it be applied with certainty)	**Environmental Sustainability** (ecological impact, resource use, etc.)	**Potential Attractiveness** (how certain are we that this could be part of the regional solution given our current knowledge)	**Key approval issues and potential solutions**		**Indicative Cost**	
										Issue	**Solutions**	**Capital**	**Operating (per ML)**
Raise Toonumbar Dam and create town water supply licences with pipeline to South Lismore	Good. 10,000 ML/a could be available with 10m raising. Raising up to 20m is technically feasible. Unknown additional yield from larger storage.	Moderate. Raising of the dam provides additional security, however this location has higher risk of climate change reductions in yield than more coastal storages	Moderate. Raising to 20m may be feasible following 10 m raising.	Moderate. This option would also require new pipeline and WTP to connect to existing system	High. Inundation of pasture and regrowth only.	Low - Moderate – although significant study required there is no reason to doubt that this option could not be implemented by the required time.	Good. Unknown with respect to pipeline however there are no obvious technical show stoppers.	Good. Nothing significant identified to date.	Moderate - Details of dam raising, pipeline route or WTP have not yet been investigated.	Ability to procure and convert licences to town water	May require a market study or licence holder survey	High	Medium
										Pipeline route issues	Constraints mapping and preliminary EA in the to identify issues		
Dunoon Dam	Good. Storages of 17,000 to 85,000 ML considered. 6,100ML/a yield from 50,000 ML storage. Potentially additional 6,000 ML/a with larger storage and further benefits may arise with inter-connection	Moderate. Dunoon Dam will be similarly affected as Rocky Creek Dam and does not provide full hydrological independence	Moderate. Dam design may incorporate options to raise the dam.	Excellent. There are no fundamental hurdles to incorporating this solution with the existing system	Poor. There is significant opposition to the building of new dams and presence of Aboriginal burial sites, however this option may be approved if other viable alternatives are not identified	Moderate. Land acquisition, preliminary design and investigations are well progressed	Good. No major technical obstacles have been identified	Low-Moderate. Some high value terrestrial habitat lost, significant resources involved in new dam construction.	Moderate. No insurmountable issues have been identified with the dam. Interconnection transfer rates and feasibility is not known at this time. Yield of larger storage unknown. Heritage issues will need to be resolved to improve the viability of this option.	Landholder displacement and potential compulsory acquisition	Increased compensation	High	Low
										Aboriginal burial sites	To be negotiated with the Aboriginal community		

Option	**Yield or Capacity** (Ability to supply bulk water and make a significant contribution to water supply deficit in the region)	**Availability/ Reliability** (will the option be able to supply water when most needed (i.e. drought)	**Scalability** (can the option be expanded sequentially to reduce initial capital)	**Compatibility** (is the option compatible with existing infrastructure or operations, and the surrounding built environment)	**Acceptability** (Social/ Political/ Cultural Heritage/ Legal)	**Timeliness** (can the option be implemented efficiently in the timeframe required)	**Technical Feasibility** (is the technology proven and reliable, can it be applied with certainty)	**Environmental Sustainability** (ecological impact, resource use, etc.)	**Potential Attractiveness** (how certain are we that this could be part of the regional solution given our current knowledge)	**Key approval issues and potential solutions**		**Indicative Cost**	
										Issue	**Solutions**	**Capital**	**Operating (per ML)**
Large-scale groundwater (decentralised implementation)	Potentially high with up to 10,000 ML/a allocated to town water in the draft Water Sharing Plan	Good – the resource is less climate dependent than surface water sources, however availability may be constrained by environmental requirements and saline intrusion	Excellent. This option can be highly modular and can be deployed in numerous locations	Excellent. Only minor additional treatment is likely to be required.	Excellent. Groundwater is a generally well accepted solution.	Moderate. Technical investigations and trials required.	Moderate. Although the technology is well established, yield, recharge rates, potential for saline intrusion and linkage to GDE's for specific areas are unknown.	Unknown impacts on Groundwater Dependent Ecosystems such as coastal lakes	High. This option is likely to be particularly attractive for emergency supply and source augmentation on a local scale, but not likely to be suitable to develop as a single centralised solution.	Effects on GDEs	Extraction limits	Low	Low
										Saline intrusion	Extraction limits		
										Potential effects of groundwater contamination on supply	Appropriate selection of source aquifer depth, etc.		
										Terrestrial habitat inundation and effects on threatened species	Provision of compensatory habitat.		
										Reduced capacity for future primary production due to conversion of licences	Unknown		
Byrrill Creek Dam	Good. Storage up to 36,000 ML considered (9,000 ML/a yield from 16,300 ML storage). Unknown additional yield from larger storage. Further benefits may arise with interconnection	Good. Large storage, moderately close to the coast will be less climate change affected than more western storages.	Moderate. Dam design may (?) incorporate options to raise the dam	Highly compatible as Bray Park weir and WTP used.	Poor. There is significant opposition to the building of this dam. Not permitted in current Water Sharing Plan.	Low-Moderate. Approvals, land acquisition, design and construction is likely to be protracted.	No major technical obstacles have been identified	Poor. Large inundation area and effects on threatened species. Large carbon footprint in construction.	Low-Moderate. The dam is highly controversial. Interconnection transfer rates and feasibility is not known at this time.	Landholder displacement and potential compulsory acquisition.	Increased compensation	High	Low

Option	**Yield or Capacity** (Ability to supply bulk water and make a significant contribution to water supply deficit in the region)	**Availability/ Reliability** (will the option be able to supply water when most needed (i.e. drought)	**Scalability** (can the option be expanded sequentially to reduce initial capital)	**Compatibility** (is the option compatible with existing infrastructure or operations, and the surrounding built environment)	**Acceptability** (Social/ Political/ Cultural Heritage/ Legal)	**Timeliness** (can the option be implemented efficiently in the timeframe required)	**Technical Feasibility** (is the technology proven and reliable, can it be applied with certainty)	**Environmental Sustainability** (ecological impact, resource use, etc.)	**Potential Attractiveness** (how certain are we that this could be part of the regional solution given our current knowledge)	**Key approval issues and potential solutions**		**Indicative Cost**	
										Issue	**Solutions**	**Capital**	**Operating (per ML)**
Raise Rocky Creek Dam (by 8m)	Poor. Secure yield increase is estimated at 1,200 ML/a.	Moderate but does not provide any additional independence from existing surface water sources	Low. Raising of dam >8m not likely to be achievable/ justifiable	Poor. Dam raising would inundate existing treatment infrastructure	Poor. This option inundates WHA listed forest	Low-Moderate. The approvals process is likely to be protracted.	Unknown	Poor. There is significant inundation of WHA, however the actual ecological impacts are unknown. Large carbon footprint in construction Small yield gain for degree of impact.	Low. This option provides minimal yield increase and is unlikely to gain stakeholder acceptance or approval.	Inundation of WHA land	Potential offsets (problematic due to WHA status)	High	Low

Green	Excellent
Blue	Good
Brown	Moderate
Orange	Low-Moderate
Red	Poor