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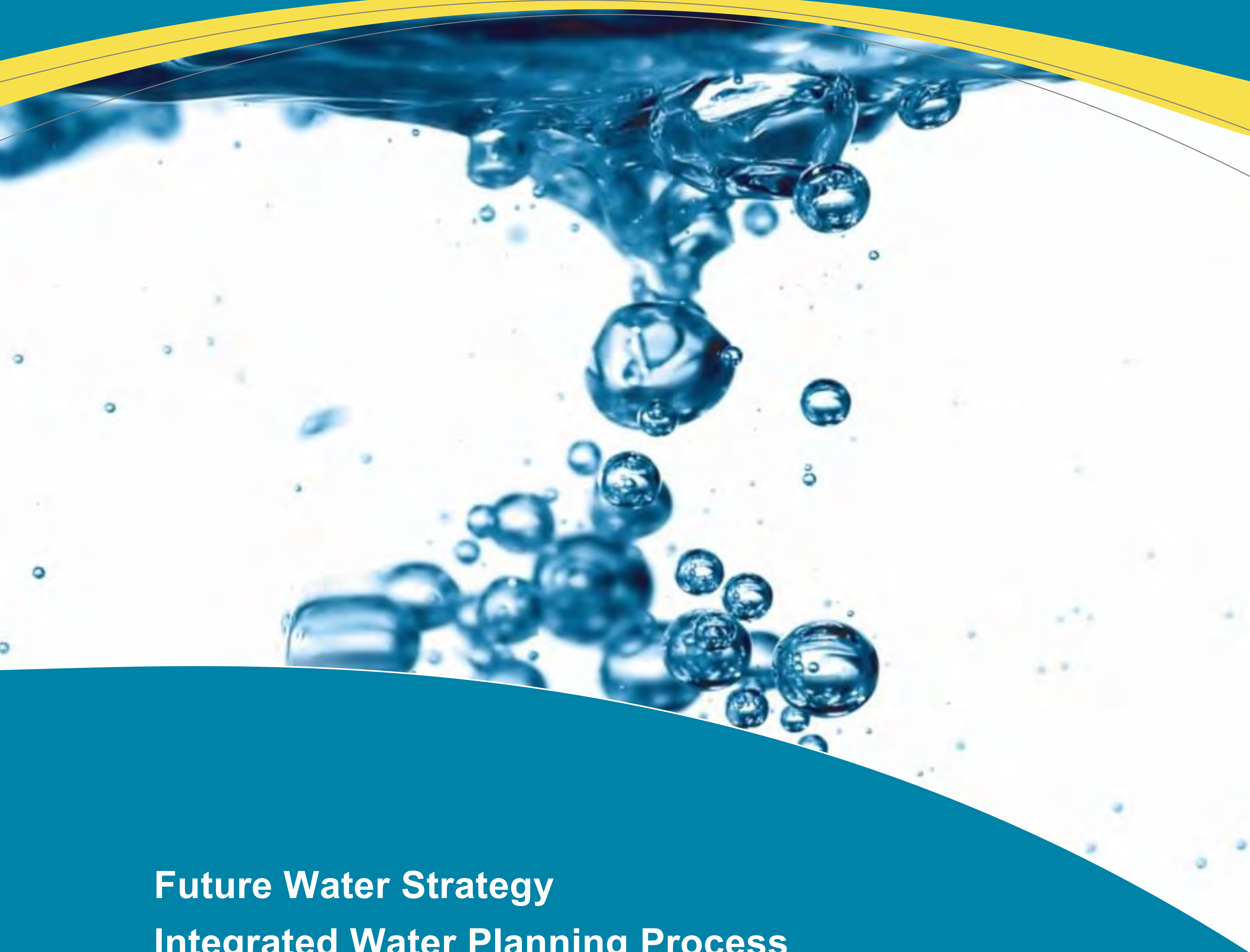

# Future Water Strategy
# Integrated Water Planning Process

Prepared for Rous Water

July 2014

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## Revision Schedule

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# Executive summary

This report captures the background information and the decision making process for the development of the Rous Water Future Water Strategy (FWS) project. The FWS is the preferred approach to enable Rous Water to maintain a secure and sustainable future water supply for current and future water users, until at least 2060.

## Background

Rous Water owns, operates and maintains a range of water supply sources, treatment plants and distribution networks and provides bulk water supplies to Ballina Shire, Byron Shire, Lismore City and Richmond Valley council areas. Rous Water's existing water sources are:

- Rocky Creek Dam.
- Emigrant Creek Dam.
- Wilsons River Source.
- Groundwater bores on Alstonville Plateau.
- Groundwater bores in coastal sands at Woodburn.

These water supplies provide a secure and sustainable water supply for nearly 100,000 people living and working over a 3,000 km$^2$ area that extends from Oceans Shores in the north, as far as Lismore and Coraki in the west and Evans Head in the south.

In 1995, Rous Water adopted the following long-term water supply strategy:

1. Implementation of demand management strategies to promote efficient water use among consumers.
2. Promotion of alternative water supply initiatives, such as dual reticulation of recycled water in new urban developments.
3. Development of the Wilsons River Source, drawing freshwater from the upper limits of the Wilsons River tidal pool, upstream of Lismore.
4. Nomination of the proposed Dunoon Dam, to be developed, if and when required, to maintain water supply security following the implementation of the other options.

Following implementation of the first three options, Rous Water commenced investigations into the proposed Dunoon Dam in 2008. Public consultation undertaken at the time indicated that the community's preference was for Rous Water to consider the future water supply issues more broadly before proceeding with Dunoon Dam. As a result, Rous Water commenced work on the FWS.

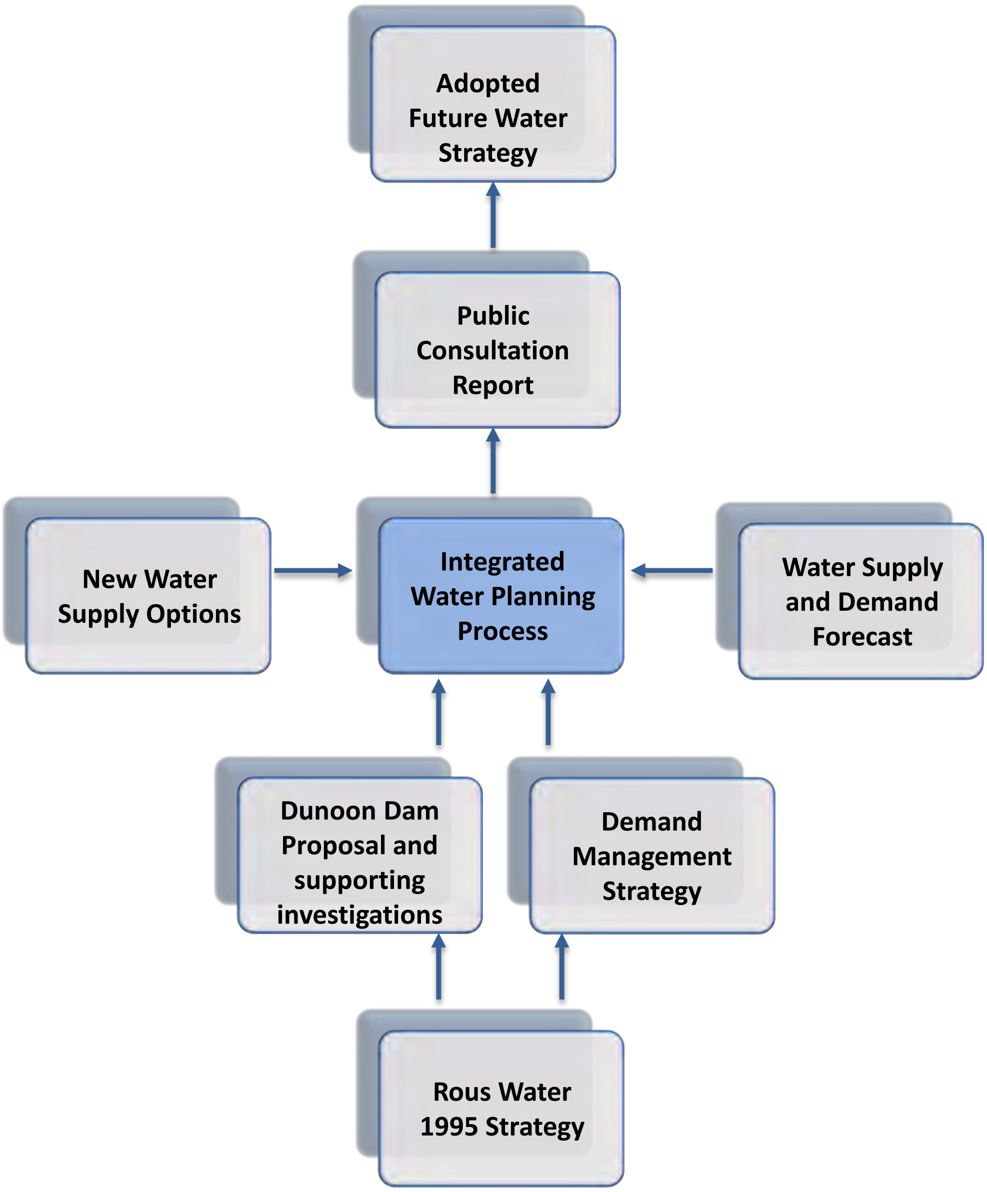
Rous Water commenced work on the FWS in late 2009. Key works undertaken to date include:

- Resolution to build Dunoon Dam if and when required, including supporting investigations to assess viability.
- Formation of Project Reference Group (PRG) comprising community members and stakeholder organisations.
- Identification of potential new water sources options.
- Coarse screen analysis to identify feasible new water source options.
- Long-term water supply security modelling.
- Development of the long-term water demand forecast.
- Development and implementation of on-going Demand Management Strategy.

The FWS brings together information and knowledge from a wide range of sources in an integrated manner to identify a number of preferred options, which together, form the preferred strategy.

The FWS builds on Rous Water's existing long-term water security strategy, adopted by Council in 1995. Development of the FWS has involved reviewing Rous Water's commitment to demand management, as well as the preservation of the Dunoon Dam as a potential future water supply source.

The FWS process and information sources are shown in the chart below. This report documents the Integrated Water Planning (IWP) Process. The IWP Process brings together all of the existing information and incorporates stakeholder input to identify a number of water supply options. The outcomes of this process forms the basis for the FWS which will go through a community consultation process before being finalised in 2014.




## Integrated Water Planning process

The IWP process has been used to define and analyse identified new water source options. This process allowed Rous Water to develop a strategy that best matches demand management opportunities and supply augmentation options to the long term supply and demand forecast.

The integrated planning approach involved:

- Identification of Rous Water's future water management issues over a long term planning horizon.
- Development of strategy assessment triple bottom line objectives and criteria in response to the water management issues.
- Multiple options assessment and scenario development in order to address the water management issues.
- A participatory approach with stakeholder feedback to help Rous Water on the choices faced.

- Recognition of future uncertainties and implementation risks, requiring ongoing monitoring and review.

The intent of the IWP process is to address the future water supply deficit, whilst seeking the best balance in environmental, social and economic objectives identified through this study. The outcomes of this process are used to inform the development of the FWS.

## Water supply challenges

The key water management issues for Rous Water identified include:

1. Future supply-demand deficit in the order of 6,500 ML/a by 2060. The adopted existing supply and demand scenario (which takes into account climate change impacts) suggests that existing supplies will be sufficient to meet the existing demand until 2024.
2. Potential climate change impacts are uncertain, however best available information suggests reduction in supply yield and increased extreme weather events leading to water quality issues and potential infrastructure damage. Secure yield modelling based on climate change predictions shows a 34% decrease in secure yield from 13,800 ML/a currently to 9,100 ML/a in 2060.
3. Lack of regional water supply integration and management with:
    a. Limited source substitution and alternative supplies currently adopted.
    b. Inefficiencies and inconsistencies across jurisdictions.
    c. Potential water quality impacts on water sources.
4. Options to increase supply and reduce demand have potential impacts that need to be understood in decision making. These include:
    a. Increased costs.
    b. Increased energy usage and greenhouse gas emissions.
    c. Increased community dependence for implementation.
    d. Increased water sharing.
    e. Ecological and cultural heritage impacts.
    f. Increased organisational capacity and adaptability.
    g. Long approval and implementation lead-times.
5. Existing water supply assets have limitations associated with ageing and renewal needs as well as capacity (peak demands) limitations.

## Objectives

The water supply challenges identified were used to develop appropriate triple bottom line (TBL) multi-criteria assessment objectives which were used to assess the relative merits of the water supply strategy options. The objectives were developed in collaboration with stakeholders. The objectives are shown below.

| Objective | Criteria |
|---|---|
| Scenario enables adaptive management | Qualitative assessment score |
| Increased system resilience through supply diversity | Qualitative assessment score |
| Effectively utilise demand management | Per capita potable usage |
| Minimise ecological & cultural heritage impacts | Qualitative assessment score |
| Reduce greenhouse gas emissions | Qualitative assessment score |

| Objective | Criteria |
|---|---|
| Scenario is affordable to consumers | Qualitative assessment score |
| Supported by constituent Councils | Qualitative assessment score |
| Maximises community acceptance | Qualitative assessment score |
| Minimise community costs | Community (utility + customer) net present value |

A range of "must do" objectives were defined as a compulsory test for any potential option. These are defined by agreed levels of service or are required as part of option development and legislation, as listed below.

| Compulsory Objective | Criteria |
|---|---|
| Comply with water sharing plans | Water sharing plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. Water sharing plans are being progressively developed for rivers and groundwater systems across New South Wales following the introduction of the *Water Management Act 2000*. |
| Plan for option lead times | Allow sufficient lead time to ensure approvals, design, construction can be completed before augmentation required |
| Protect public health | Meet Australian guidelines for drinking water or recycled water |
| Provide adequate secure yield | Meets secure yield level of service targeted |
| Effectively utlilise existing assets into the future | Must utilise existing assets |

## Regional integration

Regional issues and opportunities were considered through alignment with the Northern Rivers Regional Bulk Water Supply Strategy which is being developed at the same time as the FWS. The Regional Bulk Water Supply Strategy was developed by the Northern Rivers Regional Organisation of Councils (NOROC) to consider a 50 year water supply strategy for the wider region incorporating Tweed Shire to the north and Kyogle Shire to the west of the Rous Water supply area.

The two studies are complementary, with each strategy identifying demand management, water loss management, wastewater re-use, groundwater, surface water and desalination as key opportunities for securing water supplies within the region.

Ongoing collaborative development of both strategies will ensure that future supply augmentation can occur in a considered and appropriate way.

## Water supply options

A long list of potential options to meet the demand/supply deficit was developed and screened during an earlier phase of the FWS undertaken by Rous Water. The resulting short list of water supply options is shown below. The sub-options were developed as part of the IWP process. Only the viable options are presented below.

| Short-listed water supply options | Sub-options |
|---|---|
| A. Demand Management | A1. Existing Demand Management<br>A2. Enhanced Demand Management (including Loss Management) |
| B. Stormwater harvesting for potable | B1. Goonellabah Catchment<br>B2. Alstonville Catchments<br>B3. Cumbalum Ridge Development |
| C. Stormwater harvesting for non-potable | None identified. Consider in demand management programs (BASIX) |
| D. Indirect potable reuse of wastewater | D1. East and South Lismore STP<br>D2. Alstonville STP<br>D3. Alstonville STP plus stormwater harvesting<br>D4. Ballina and Lennox STP |
| E. Non-potable wastewater reuse | No new schemes identified. Considered Ballina Recycled Water Scheme in demand management programs |
| F. Groundwater supply augmentation | F1. Maximise existing sources (Woodburn, Lumley Park)<br>F2. New sources (Coastal Sands)<br>F3. New sources (Fractured basalt) |
| G. Desalination supply augmentation | G1. Tyagarah (marine feed water)<br>G2. South Ballina (marine feed water) |
| H. Proposed Dunoon Dam | H1. Dunoon Dam (50,000 ML)<br>H2. Dunoon Dam (20,000 ML) (added during scenario development) |
| I. Access regulated water associated with Toonumbar Dam | I1. Modified water sharing plan (2020) |
| J. Regional water supply options identified through the NOROC study | J1. Regional desalination |
| K. Application of revised water restrictions | K1. Accept reduced supply security i.e. higher restrictions (5/15/15) |
| L. Raise existing Rocky Creek Dam (resolution of Rous Water Council, February 2013) | L1. Raise Rocky Creek Dam (8 m) |

Each of the water supply options were assessed in terms of cost, supply yield, power consumption and implementation lead time. The development of the sub-options involved reviewing all relevant reports, discussing each of the proposed options with Rous Water staff, including operations (distribution and treatment), technical review and inputs by specialists including process engineer, desalination engineer, as well as experts in environmental approvals and stormwater management. Sub-consultants were engaged to provide advice on groundwater feasibility and to undertake assessment of secure yield. The demand management options were evaluated in detail and are presented as a stand-alone technical document in the study appendices.

The water supply option assessment outcomes were presented to the stakeholders (both PRG and Rous Water Council, although at separate workshops). Participants examined the benefits and constraints associated with each of the options. Participants were also invited to develop a series of potential water supply scenarios by bundling suitable options to meet the supply deficit in 2060. This exercise enabled discussion on the advantages and disadvantages of each option. Stakeholder preferences showed most support for:

1. Enhanced demand management.
2. Groundwater options
3. Wastewater reuse options.
4. Increased restrictions, albeit only at the 5/15/15 level.
5. Dunoon Dam.

There was also clear indication that the following options need not be pursued further:

1. Toonumbar Dam – modified WSP: displaces existing users, with high risks and low yield.
2. Raising Rocky Dam - high capital cost and environmental impact for low future yield.

## Scenario development

Drawing on the options assessment and stakeholder feedback, the project team finalised five scenarios which were accepted by Rous Water for characterisation and assessment. All scenarios meet the '*must do*' objectives. The scenario titles indicate the key theme of each scenario. Suitable contingency supply options, in alignment with the scenario theme, are also identified. Scenario development included an environmental score, greenhouse gas emission estimates, combined yield assessment using the secure yield model, system interconnection and operation considerations. Each of the scenarios was costed in terms of capital and operating costs. The five scenarios are shown in the table below.

| Scenario | Scenario Components (Options) |
|---|---|
| 1.Business as usual | A1. Demand Management, Existing Demand Management<br>H1. The proposed Dunoon Dam, Currently planned Dunoon Dam (50,000 ML) |
| 2. Staged Dunoon Dam | A2. Demand Management, Enhanced Demand Management (including water loss management)<br>H2. The proposed Dunoon Dam, Staged Dunoon Dam (20,000 ML) |
| 3. Extended groundwater | A2. Demand Management, Enhanced Demand Management (including water loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands)<br>F3. Groundwater supply augmentation, New sources (Fractured Basalt)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>*Contingency* - Managed Aquifer Recharge (MAR) through either recycled water or captured stormwater |
| 4. Indirect Potable Reuse | A2. Demand Management, enhanced Demand Management (including water loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>D4. Indirect potable reuse of wastewater, Ballina and Lennox Head STPs<br>D3. Indirect potable reuse of wastewater, Alstonville STP plus stormwater harvesting<br>*Contingency* - D1. Indirect potable reuse of wastewater, South and West Lismore STP |
| 5. Desalination | A2. Demand Management, Enhanced Demand Management (including water |

| Scenario | Scenario Components (Options) |
|---|---|
| | loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>G2. Desalination supply augmentation, South Ballina (marine feed water) |

## Scenario evaluation

The scenarios were compared based on the agreed objectives. As groups, both the PRG and Councillors discussed each scenario and participants scored each scenario against the TBL criteria. Technical guidance was provided at the workshop. PRG participants and Councillors weighted each criteria individually based on their perceived importance. In addition, equal weightings for environmental, social and economic objectives were considered.

The results of the scenario ranking using Councillor group scoring and each of the four weightings are shown below.

| Scenario | Equal across Triple Bottom Line categories | Equal across individual objectives | Councillor nominated weightings | PRG nominated weightings |
|---|---|---|---|---|
| 1. Business as usual | 5 | 5 | 5 | 5 |
| 2. Staged Dunoon Dam | 4 | 4 | 4 | 4 |
| 3. Extended groundwater | 1 | 1 | 1 | 1 |
| 4. Indirect potable reuse | 2 | 2 | 2 | 2 |
| 5. Desalination | 3 | 3 | 3 | 3 |

The scoring and sensitivity exercise showed that:

- Scenario 3, *extended groundwater*, performed the best against the combined project objectives in the multi-criteria analysis. It remained the highest ranking scenario in all sensitivity testing.
- Scenario 4, *indirect potable reuse*, consistently ranked the next highest scenario.

Each scenario has merit for consideration. All scenarios are developed to meet the *must-do objectives*. The best balance of triple bottom outcomes as defined by the multi-criteria assessment objectives favours Scenario 3 (Extended groundwater). Scenario 3 provides the following advantages:

1. The ability to adapt requirements to future changes as the FWS proceeds. The number and location of borefields can be modified over the planning horizon to suit changing needs such as supply deficit. Groundwater is also likely to fit into any future regional approaches which may occur.
2. System resilience is increased through overall supply system diversity. The borefields can be located near to the major development areas and isolated supply zones. It is also likely to be more resilient than surface water to climate change impacts.
3. Power usage and greenhouse gas emissions are anticipated to be relatively low compared to the other supply options, through low material needs and the ability to locate borefields near development areas.
4. Groundwater is the most widely used drinking water source in the world. It is likely to receive broad community and LWU support once the approach to ensure water quality and environmental concerns is understood.
5. Groundwater is expected to be relatively cost effective.
6. The ability to reduce environmental impacts and costs through well investigated borefield site selection.

The key concerns related to Scenario 3 include:

1. The quantity, quality and reliability of each borefield requires proving. Groundwater quality problems (predominately aesthetics related) have occurred at sites within the region. The problems can vary with changing aquifer levels and with increased extraction. Sustainable yields can vary, as well as treatment requirements.
2. Recognition of existing users and environmental dependencies. Modification of aquifer levels with groundwater extraction can impede existing uses. In addition groundwater resources support ecological communities (GDEs). Sustainable yield assessment will require in-field assessment of environmental constraints and consideration in dry and wet years.
3. A high level of investment has been made to support Dunoon Dam. There is also high current community expectation for the dam.

## Recommended strategy

The FWS identifies the following new water sources for further investigations. The strategy aims to establish the project viability between 2014 and 2018, and to allow staged implementation, as required, to maintain water security. The strategy will include the following:

1. Enhanced demand management is proposed to maximise existing water uses, promote greater water efficiency while minimising costs and off-set the need for new water sources. Major programs include greater community engagement, open space water efficiency, business water reduction focussing on major users, residential rebate programs and water loss management.
2. Existing groundwater sources at Woodburn and on the Alstonville Plateau will be assessed and reviewed to maximise their reliability and contribution to water supply security. Investigations will determine whether these existing sources should be maintained, upgraded or abandoned in favour of more prospective sites.
3. New groundwater sources will be considered, commencing with desktop investigations, and progressed through field based exploratory drilling and testing. New sources investigation would seek to find new sites within both the coastal sand aquifers and fractured basalt. Likely yields are to be assessed as soon as possible to ascertain the likely volume, quality and reliability of the groundwater sources. This will assist in determining whether additional measures such as MAR, IPR or desalination are required.

Contingencies will need to be employed if groundwater proves unsuitable. Contingencies include:

1. IPR is proposed as a complementary solution that could be used in conjunction with groundwater augmentation if groundwater is not able to provide the required volume of water. It is unlikely that IPR would be required before the mid to late 2030s based on current projections and taking into account a conservative groundwater allowance. Community acceptance would be critical to the viability of this options and early engagement with community and stakeholder groups is proposed to test support for this option,
2. Technical investigations into Dunoon Dam show that it is viable despite some specific ecological and cultural heritage concerns. A staged approach to the construction of the dam may be viable, enabling a progressive approach and off-setting upfront capital costs. Compared with both groundwater and IPR the viability of the Dunoon Dam proposal is well understood. Rous Water will retain the option of the Dunoon Dam should the other sources prove unviable or insufficient.
3. Desalination is a potential new water source, however should only be considered as a safeguard should other sources prove unviable or insufficient.
4. Increased water restrictions could be implemented to further reduce capital expenditure and delay the need for new water supply options, however, this would need to be fully tested against the communities willingness to accept a lower level of service (compared to the remainder of NSW).

## Implementation plan

The recommended FWS provides the framework for sustainable management of Rous Water water supply into the future. The implementation plan described outlines the key FWS activities and their timing. The plan allows for exploratory groundwater investigations to confirm suitable resources, with a parallel communications program and supporting studies for IPR and Dunoon Dam, should either of these contingency approaches be required. Initial critical decision dates for the contingency approaches are suggested based on potential lead times.

The table below summarises the key implementation steps with currently estimated timing.

| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| 1 | FWS community consultation | Community engagement | Public display and invitation for feedback from draft FWS | 2013 - 2014 |
| 2 | NOROC Regional Bulk Water Supply Strategy | | Review report and consider key recommendations. Align documents where feasible. | 2013-2014 |
| 3 | Engage in Coastal Sands Water Sharing Plan process | | Engage with NOW in the development process | 2013-2014 |
| 4 | Council acceptance of FWS | | Council adoption of FWS following community consultation | Early to mid-2014 |
| 5 | Revise Water Supply Agreement | | Update and implement the water supply agreement with constituent councils to reflect the FWS and enhanced demand management plan | 2014 |
| 6 | Supply system review | | Detailed supply system review – confirmed design criteria and optimised operational management in line with proposed supply sources | 2014 |
| 7 | Implement enhanced demand management and monitoring | Improved information for ongoing FWS evaluation | Rous Water and LWU implementation of demand management programs and FWS monitoring (refer to Appendix B for specifics) | 2014 onwards |
| 8 | FWS Communications Program | Community capacity building | Ongoing community education and survey including groundwater, IPR, increased restrictions messages | 2014 - 2018 |
| 9 | Groundwater exploratory program | Improved understanding of groundwater resources | 1. Undertake detailed desk studies to locate most prospective and convenient bore locations.<br>2. Identify several exploratory sites (additional to anticipated needs).<br>3. Investigate relationship of each well-field with GDEs and other environmental aspects e.g. saline waters and acid-sulfate soils.<br>4. Pump testing to confirm sustainable yield and water quality. Likely to require multi-day testing programmes at each | 2014-2018 |

| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| | | | location.<br>5. Apply for licence for each source, based on interpretation of pump testing results. Interpretation will need to include numerical modelling to determine interactions with GDEs, coastal salinity and acid-sulphate soil deposits. | |
| 10 | Dunoon Dam supporting investigations | Ability to timely proceed, if required | Much of the base investigation work has been completed. However refinements to the concept maybe required with further community input and any changes to policies. | 2014-2018 |
| 11 | IPR supporting investigations | Ability to timely proceed, if required | Ongoing studies and discussions with LWUs to confirm requirements for IPR approaches. Refinements maybe required with further community input and any changes to policies.<br>Consider MAR opportunities | 2014-2018 |
| 12 | Groundwater Stage 1 | New water source – Woodburn | 1. Budgeting, funding allocation, subsidy and any applicable grant approvals.<br>2. Land acquisition and environmental approvals.<br>3. Design and documentation.<br>4. Development of procurement and operational arrangements.<br>5. Construction and commissioning.<br>6. System management, operation and monitoring. | 2022-2026 |
| 13 | Groundwater Stage 2 (coastal sands) | New water sources | As above | 2025-2029 |
| 14 | Groundwater Stage 3 (fractured basalt) | New water sources | As above | 2040-2045 |
| 15 | Review of demand management program every 2 years | Enhanced demand managemen t program | Review and update. LWUs to develop and regularly update their own plans also. | Every 2 years (next due 2014) |
| 16 | Review of FWS every six years | Allows for FWS to be | Review of FWS | Every 6 years (in |

| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| | | adapted | | line with IWCM best practice) |
| 17 | Review of Strategic Business Plan (SBP) | | Review and update including financial modelling with revenue considerations. | Every 3 years |

## Monitoring and evaluation

The FWS should be reviewed every six years to incorporate improved information and confirm strategy actions.

## Recommendations

It is recommended that Rous Water adopts the strategy outlined in this report and use it as the basis of the FWS for the next steps:

1. Documenting the FWS for public exhibition and comment.
2. Finalising the FWS for Rous Water Council adoption.
3. Continuing to engage in FWS Implementation Plan initiatives timed for current activity.

# Rous Water

## Future Water Strategy

## Integrated Water Planning Process

## CONTENTS

Executive summary .......... i
Glossary of terms .......... 5
1 Introduction .......... 7
1.1 Aims .......... 7
1.2 Background .......... 7
1.3 Future Water Strategy development .......... 8
1.4 Integrated water planning process .......... 8
1.5 Regional integration .......... 9
1.6 Report outline .......... 9
2 The study approach .......... 11
2.1 Study area .......... 11
2.2 Study process .......... 12
2.3 Data sources .......... 13
3 The need for water security improvement .......... 15
3.1 Rous Water best practice targets .......... 15
3.2 Demand forecast .......... 16
3.3 Water availability .......... 17
3.4 Water supply and demand balance .......... 20
4 FWS objectives .......... 22
4.1 Water supply challenges .......... 22
4.2 Objectives and criteria .......... 22
5 Options to improve water security .......... 24
5.1 Option development .......... 24
5.2 Coarse screening of options .......... 24
5.3 Demand management .......... 27
5.4 Stormwater harvesting .......... 29
5.5 Recycled water .......... 34
5.6 Groundwater .......... 42
5.7 Desalination .......... 47
5.8 Proposed Dunoon Dam .......... 52
5.9 Regional interconnections – Toonumbar Dam .......... 54
5.10 Regional water supply options .......... 55
5.11 Revised water restrictions .......... 57

5.12 Raising Rocky Creek Dam .......... 58
5.13 Summary of options .......... 59
5.14 Option assessment .......... 61
6 Scenario development .......... 62
6.1 Process .......... 62
6.2 Scenario estimates .......... 63
6.3 Scenario 1: Business as usual (BAU) .......... 64
6.4 Scenario 2: Staged Dunoon Dam .......... 67
6.5 Scenario 3: Extended Groundwater .......... 70
6.6 Scenario 4: Indirect potable reuse .......... 73
6.7 Scenario 5: Deferred desalination .......... 75
6.8 Increased restrictions .......... 78
7 Scenario comparison .......... 79
7.1 Multi-criteria assessment framework .......... 79
7.2 Scenario scoring and ranking .......... 83
7.3 Sensitivity of community NPV .......... 83
7.4 Scenario selection .......... 84
8 Recommended strategy .......... 85
8.1 Strategy overview .......... 85
8.2 Implementation plan .......... 87
9 Conclusions and recommendations .......... 95
10 Bibliography .......... 97

## LIST OF TABLES

Table 1-1: Report outline .......... 9
Table 2-1: Descrption and purpose of stakeholder engagement workshops .......... 13
Table 2-2: Key data sources used in the IWP process .......... 13
Table 3-1: Rous Water best practice targets .......... 15
Table 3-2: Current Rous Water water supply sources .......... 18
Table 3-3: Impact of climate change on average annual climate conditions in 2030 for the Rous Water system 20
Table 3-4: 5/10/10 secure yield with climate change .......... 20
Table 4-1: Compulsory objectives .......... 23
Table 4-2: Objectives and criteria .......... 23
Table 5-1: Demand management annualised costs and water savings .......... 28
Table 5-2: Stormwater options description .......... 30
Table 5-3: Stormwater options available supply estimates .......... 33
Table 5-4: Stormwater harvesting options benefits and constraints .......... 34
Table 5-5: IPR options description .......... 36
Table 5-6: IPR options benefits and constraints .......... 41

Table 5-7: Groundwater options description ....... 44
Table 5-8: Groundwater options - additional yield estimates ....... 46
Table 5-9: Groundwater options constraints and benefits....... 46
Table 5-10: Desalination options description ....... 48
Table 5-11: Desalination options constraints and benefits....... 51
Table 5-12: Dunoon Dam additional yield ....... 53
Table 5-13: Dunoon Dam constraints and benefits ....... 53
Table 5-14: Secure yield estimate Toonumbar Dam – modify WSP ....... 54
Table 5-15: Benefits and constraints ....... 54
Table 5-16: Regional desalination benefits and constraints....... 57
Table 5-17: Revised water restrictions....... 57
Table 5-18: Benefits and constraints associated with revised restrictions ....... 58
Table 5-19: Statistics for existing and raised Rocky Creek Dam ....... 58
Table 5-20: Additional yield including climate change impacts ....... 59
Table 5-21: Evaluation summary for each water supply option ....... 59
Table 6-1: Assessed FWS scenarios ....... 62
Table 6-2: Characteristics of 50,000 ML storage ....... 65
Table 6-3: Scenario 1 - capital, operating and energy consumption ....... 67
Table 6-4: Characteristics of 20,000 ML storage ....... 69
Table 6-5: Scenario 2 capital, operating costs and energy consumption ....... 70
Table 6-6: Assumed timing and contribution from each new source ....... 71
Table 6-7: Scenario 3- capital, operating and energy consumption ....... 72
Table 6-8: Scenario 4 – sizing and staging ....... 74
Table 6-9: Scenario 4 – capital, operating and energy consumption ....... 75
Table 6-10: Scenario 5 – staging and sizing ....... 77
Table 6-11: Scenario 5 – capital and operating costs and energy consumption ....... 78
Table 7-1: MCA criteria and preliminary weightings....... 79
Table 7-2: Technical information for assessing scenarios ....... 81
Table 7-3: Sensitivity testing of scenarios....... 83
Table 7-4: Community NPV by scenario ....... 83
Table 8-1: Implementation risks and mitigation ....... 86
Table 8-2: Implementation initiative description ....... 88
Table 8-3: Implementation plan ....... 91
Table 8-4: Rous Water FWS investment plan (2013 dollars '000) ....... 93
Table 8-5: Monitoring and evaluation plan ....... 94

# LIST OF FIGURES

Figure 1-1: FWS development process....... 8
Figure 2-1: Rous Water water supply system ....... 11

Figure 2-2: Integrated water planning process ..... 12
Figure 3-1: Number of connections forecast (Hydrosphere Consulting, 2012) ..... 17
Figure 3-2: Water demand forecast (Hydrosphere Consulting, 2012) ..... 17
Figure 3-3: Existing Rous Water secure yield and demand forecast (with and without climate change) . 21
Figure 5-1: Forecast water demand with enhanced demand management (ML/a) ..... 28
Figure 5-2: Enhanced demand management supply/demand impact ..... 29
Figure 5-3: Option B1 indicative collection area and transfer ..... 31
Figure 5-4: Option B2 indicative collection area and transfer ..... 32
Figure 5-5: Option B3 indicative collection area and transfer ..... 33
Figure 5-6: Option D1 STP locations and transfer ..... 38
Figure 5-7: Option D2 and D3 STP location and transfer ..... 39
Figure 5-8: Option D4 STP locations and transfer ..... 40
Figure 5-9: Existing bores and potential groundwater option locations ..... 45
Figure 5-10: Indicative location and layout for desalination Option G1 ..... 50
Figure 5-11: Indicative location and layout for desalination option G2 ..... 51
Figure 5-12: Dunoon Dam location ..... 53
Figure 5-13: Regional desalination option ..... 56
Figure 6-1: Scenario 1 - location of proposed Dunoon Dam ..... 65
Figure 6-2: Scenario 1 supply/demand graph ..... 66
Figure 6-3: Scenario 2 – location of the proposed Dunoon Dam (20,000 ML) ..... 68
Figure 6-4: Scenario 2 supply/demand ..... 69
Figure 6-5: Scenario 3 – prospective location of groundwater sources ..... 71
Figure 6-6: Scenario 3 supply/demand graph ..... 72
Figure 6-7: Scenario 4 – location of water sources and main transfers ..... 74
Figure 6-8: Scenario 4 supply/demand graph ..... 75
Figure 6-9: Scenario 5 – indicative location of water sources ..... 76
Figure 6-10: Scenario 5 supply/demand graph ..... 77
Figure 8-1: Capital investment plan for FWS implementation ..... 8-92

# Appendices

A Stakeholder engagement plan and outcomes

B Evaluation of demand management measures

C Yield modelling

D Coarse screening of options

E Environmental constraints

F Groundwater options assessment

G Financial modelling (FINMOD)

H GHG assessment

I Risk assessment

J Options and scenario details

# Glossary of terms

| Word | Definition |
|---|---|
| ADD | Average day demand (water supply) |
| ADWF | Average dry weather flow (sewage) |
| ADWG | Australian Drinking Water Guidelines |
| AGWR | Australian Guidelines for Water Recycling |
| Annualised cost | The present value of the cost of an program converted to an annual cost divided by the average annual reduction in demand resulting from that program |
| BASIX | Building and Sustainability Index |
| BOM | Bureau of Meteorology |
| CMA | Catchment management authority |
| Community objectives | What the community considers important and the urban water service or the utility can assist or influence. These are used to consider the benefits an urban water service provides to a community in addition to meeting the utility's targets |
| Constituent Council | Councils provided with bulk water from Rous Water: Ballina Shire, Byron Shire, Lismore and Richmond Valley. |
| DECCW | NSW Department of Environment, Climate Change and Water (formerly DECC and EPA) |
| DSM DSS | Demand Side Management Decision Support System - a spreadsheet based *end use model* which allows development of water and sewage forecasts and benefit cost analysis of demand management measures (through least cost planning) |
| DOH | NSW Department of Health |
| DOP | NSW Department of Planning |
| End Use Model | A model that looks to take account of the impact of different water conservation and source substitution programs on the volume of water used in different end uses and then aggregates these savings into an estimate of the total potential water to be saved |
| Environmental flows | River flows, or characteristics of the river flow pattern that are either protected or created for an environmental purpose, usually the protection of habitat or an ecological process |
| FWS | Future Water Strategy |
| GDE | Groundwater Dependent Ecosystem |
| IWCM | Integrated Water Cycle Management – The principal planning tool by which urban water uses are considered within a catchment and policy framework, seeking to deliver sustainable environmental, economic and social outcomes |
| LGA | Local government area |
| LoS | Levels of service |
| LWU | Local water utility |
| MCA | Multi-criteria assessment |

| Word | Definition |
|---|---|
| MFR | Multi-family residential |
| NOW | NSW Office of Water (formerly DWE and DEUS) |
| NPV | Net present value |
| NRW | Non-revenue water (water supply) |
| Options | Actions which can assist solve water supply issues. Options are combined to form scenarios to solve all issues. |
| PDD | Peak day demand (water supply) |
| PRG | Project reference group |
| PWWF | Peak wet weather flow (sewage) |
| Recycled water | Water generated from sewage, grey water or stormwater systems and treated to a standard that is appropriate for its intended use |
| Secure yield | An estimate of the annual demand which can be supplied by a water source and its associated storage, based on an assessment of historical drought flows and acceptable restriction guidelines |
| Scenario | A scenario is a mix of options that together address the urban water service issues. Scenarios form different ways to provide the desired urban water service |
| Sewage | Wastewater from homes, offices, shops, factories and other premises discharged to the sewer. About 99 percent of sewage is water |
| SFR | Single family residential |
| SMI | Soil moisture index |
| SPS | Sewage pumping station |
| Stormwater | Rainfall that flows over hard surfaces in urban areas and is collected in drainage systems for disposal |
| STP | Sewage treatment plant (or wastewater treatment plant) |
| Targets | The legislation, licence conditions, contracts and levels of service requirements that the utility or service must comply with or has agreed to achieve |
| TBL analysis | Triple bottom line analysis. Consideration of the economic, social and environmental outcomes in decision-making |
| TN | Total nitrogen |
| TP | Total phosphorous |
| TSS | Total suspended solids |
| WSP | Water Sharing Plan |

# 1 Introduction

Rous Water is the regional water supply authority providing bulk potable water to the local government areas (LGAs) of Lismore, Ballina, Byron and Richmond Valley. A population of nearly 100,000 is currently serviced by this water supply system.

Rous Water's sources have a current secure yield of approximately 13,800 ML/year and a current demand of approximately 11,600 ML/year. Forecast population growth is anticipated to increase water demands beyond available supply, with peak day capacities being approached in parts of the system.

In 2009, Rous Water resolved to develop a Future Water Strategy (FWS) to guide long-term water supply security. This report captures the background information and the decision making process in the development of the Rous Water FWS project. The FWS documents the preferred approach to enable Rous Water to maintain a secure and sustainable future water supply for current and future water users, until at least 2060.

## 1.1 Aims

The aim of the FWS is to:

1. Maintain a secure and sustainable future water supply until at least 2060.
2. Deliver an acceptable balance of water supply and demand options to meet forecast requirements to 2060.
3. Provide an implementation plan for the strategy.

## 1.2 Background

In 1995, Rous Water adopted the following long-term water supply strategy:

1. Implementation of demand management strategies to promote efficient water use among consumers.
2. Promotion of alternative water supply initiatives, such as dual reticulation of recycled water in new urban developments.
3. Development of the Wilsons River Source, drawing freshwater from the upper limits of the Wilsons River tidal pool, upstream of Lismore.
4. Nomination of the proposed Dunoon Dam, to be developed, if and when required, to maintain water supply security following the implementation of the other options.

Following implementation of the first three options, Rous Water commenced investigations into the proposed Dunoon Dam in 2008. Public consultation undertaken at the time indicated the community's preference that Rous Water consider the future water supply issues more broadly before proceeding with Dunoon Dam. As a result, Rous Water commenced work on the FWS.

Rous Water commenced work on the FWS in late 2009. Key works undertaken to date include:

- Resolution to build Dunoon Dam if and when required, including supporting investigations to support viability.
- Formation of a Project Reference Group (PRG) comprising community and stakeholder organisations.
- Identification of potential new water source options.
- Coarse screen analysis to identify feasible new water source options.
- Long-term supply security modelling.
- Development of the long-term water demand forecast.
- Development and implementation of on-going Demand Management Strategy.

## 1.3 Future Water Strategy development

The FWS brings together information and knowledge from a wide range of sources for consideration in an integrated manner to identify a number of preferred options, which together, form the preferred strategy.

The FWS builds on Rous Water's existing long-term water security strategy, adopted by Council in 1995. Development of the FWS has involved reviewing Rous Water's commitment to demand management, as well as the preservation of the Dunoon Dam as a future water supply source.

The FWS development process relies on other related studies as shown in Figure 1-1. This report documents the Integrated Water Planning (IWP) process (as highlighted in Figure 1-1). The IWP Process brings together all of the existing information and incorporates stakeholder input to identify a number of water supply options. The outcomes of this process are used as the basis of the FWS which will go through a community consultation process before finalisation in 2014.

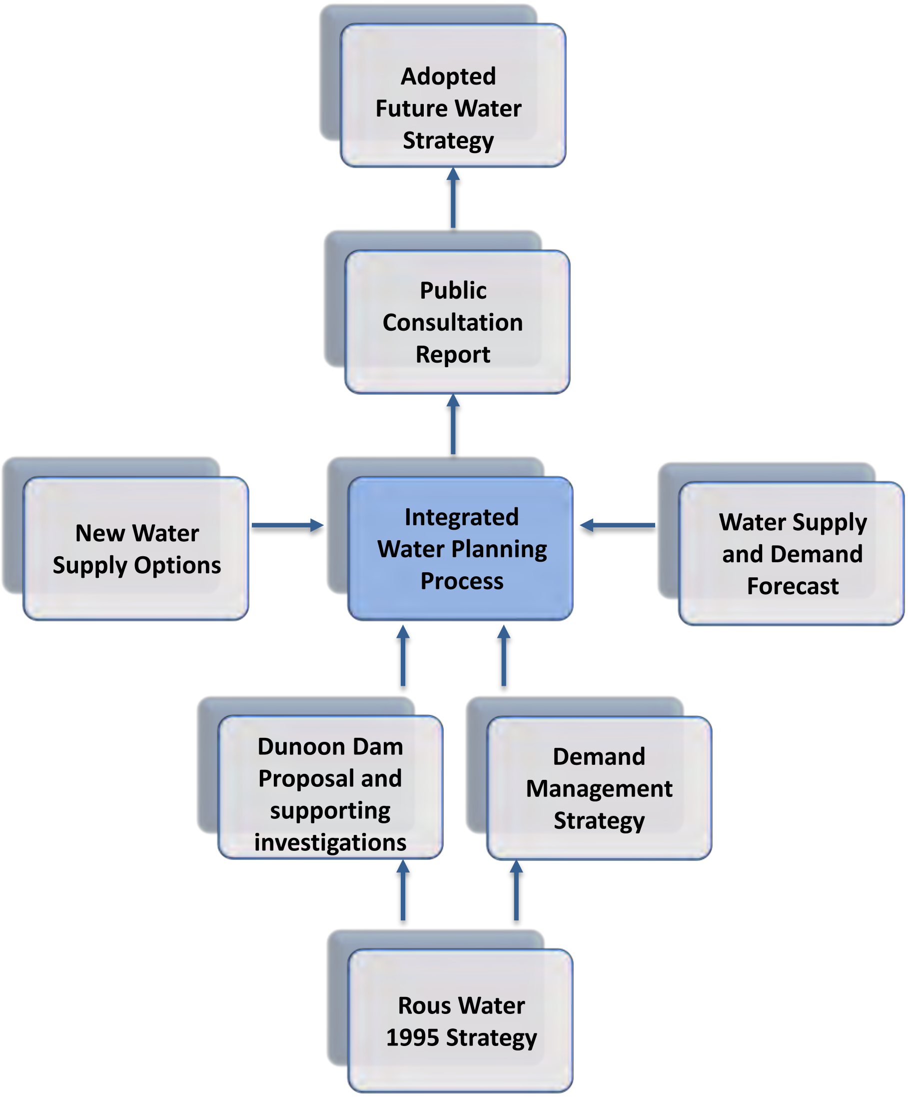



**Figure 1-1: FWS development process**

## 1.4 Integrated water planning process

The IWP process was used to define and analyse identified new water source options. This process allows Rous Water to develop a strategy that best matches demand management opportunities and supply augmentation options to the long term demand forecast.

The integrated planning approach involves:

- Identification of Rous Water's future water management issues over a long term planning horizon.
- Development of strategy assessment triple bottom line objectives and criteria in response to the water management issues.
- Multiple options assessment and scenario development in order to address the water management issues.
- A participatory approach with stakeholder feedback to help Rous Water with the assessment of options.
- Recognition of future uncertainties and implementation risks, requiring on-going monitoring and review.

The intent of the IWP process is to address the future water supply deficit needs, whilst seeking the best balance in environmental, social and economic objectives identified through this study. The outcomes of this process are used to inform the development of the FWS. The next phase of work will document the FWS building upon the outcomes of this report and incorporating community feedback.

## 1.5 Regional integration

Rous Water will also consider a regional view of the water supply issues and options, through the Northern Rivers Regional Organisation of Councils (NOROC) group, of which Rous Water is a member, together with Lismore City, Ballina Shire, Byron Shire, Richmond Valley Shire, Tweed Shire, Kyogle Shire and Clarence Valley councils. NOROC is concurrently undertaking an independent study examining bulk water supply options for the region. A draft report has been released which is referred to in the report (Hydrosphere, 2013).

The FWS and NOROC studies are complementary and ongoing collaborative development of both strategies will ensure that future supply augmentation can occur in a considered and appropriate manner.

## 1.6 Report outline

The report outline is shown in Table 1-1.

**Table 1-1: Report outline**

| No. | Section | Description |
|---|---|---|
| 1 | Introduction | • Objectives<br>• Background |
| 2 | The study approach | • The study area<br>• The study approach<br>• Community engagement process<br>• Review of previous studies |
| 3 | The need for water security improvements | • Rous Water mandatory requirements and best practice targets<br>• Demand forecasts and secure yield |
| 4 | FWS objectives | • Water supply issues<br>• Assessment objectives and criteria |
| 5 | Opportunities to improve water security | • Confirm water supply options<br>• Option development including: |

| No. | Section | Description |
|---|---|---|
| | | ○ Conceptual layout, including sizing and staging<br>○ Costing and energy requirements<br>○ Constraints and benefits |
| 6 | Scenario development | • Scenario development including:<br>○ Staging, sizing and costs<br>○ Operational requirements<br>○ Demand/supply balance schedules |
| 7 | Scenario comparison | • Scenario assessment using multi-criteria analysis<br>• Sensitivity testing of scenarios<br>• Identification of preferred scenario/s |
| 8 | Recommended strategy | • Strategy outline<br>• Implementation plan<br>• Monitoring and evaluation |
| 9 | Conclusions and recommendations | |
| 10 | Bibliography | |

# 2 The study approach

This section describes the study area and planning process adopted in the study. Available information sources and summary of previous studies are also provided.

## 2.1 Study area

Rous Water provides bulk water to the four local water utilities (LWUs) on the far north coast of New South Wales, servicing the urban areas of the following Local Government Areas (LGA):

1. Ballina Shire Council, excluding Wardell.
2. Byron Shire Council, excluding Mullumbimby.
3. Lismore City Council, excluding Nimbin.
4. Richmond Valley Council, excluding Casino and all land west of Coraki.

These LGAs are referred to as ‘the constituent Councils’ and are responsible for the distribution and reticulation services from the bulk water meters to customers within their own LGAs.

In addition to the 30,000 connections serviced by the constituent Councils from the bulk supply, Rous Water provides water to approximately 2,000 predominantly rural connections directly from the trunk mains.

Rous Water’s water supply network extends from Ocean Shores in the north and Byron Bay in the east, west to Lismore and south across the Richmond River near Woodburn to Evans Head as illustrated in Figure 2-1.


**Figure 2-1: Rous Water water supply system**

## 2.2 Study process

The NSW Office of Water (NOW) promotes best practice management of urban water and sewerage for LWUs through a set of guidelines (DWE, 2007). Integrated Water Cycle Management (IWCM) and Demand Management Planning are key planning tools within the guidelines. The approach adopted in this study incorporates an IWP process which is consistent with NSW best practice processes.

The integrated water planning process adopted for this study is outlined in Figure 2-2. It builds on stakeholder engagement and studies undertaken since 2009.

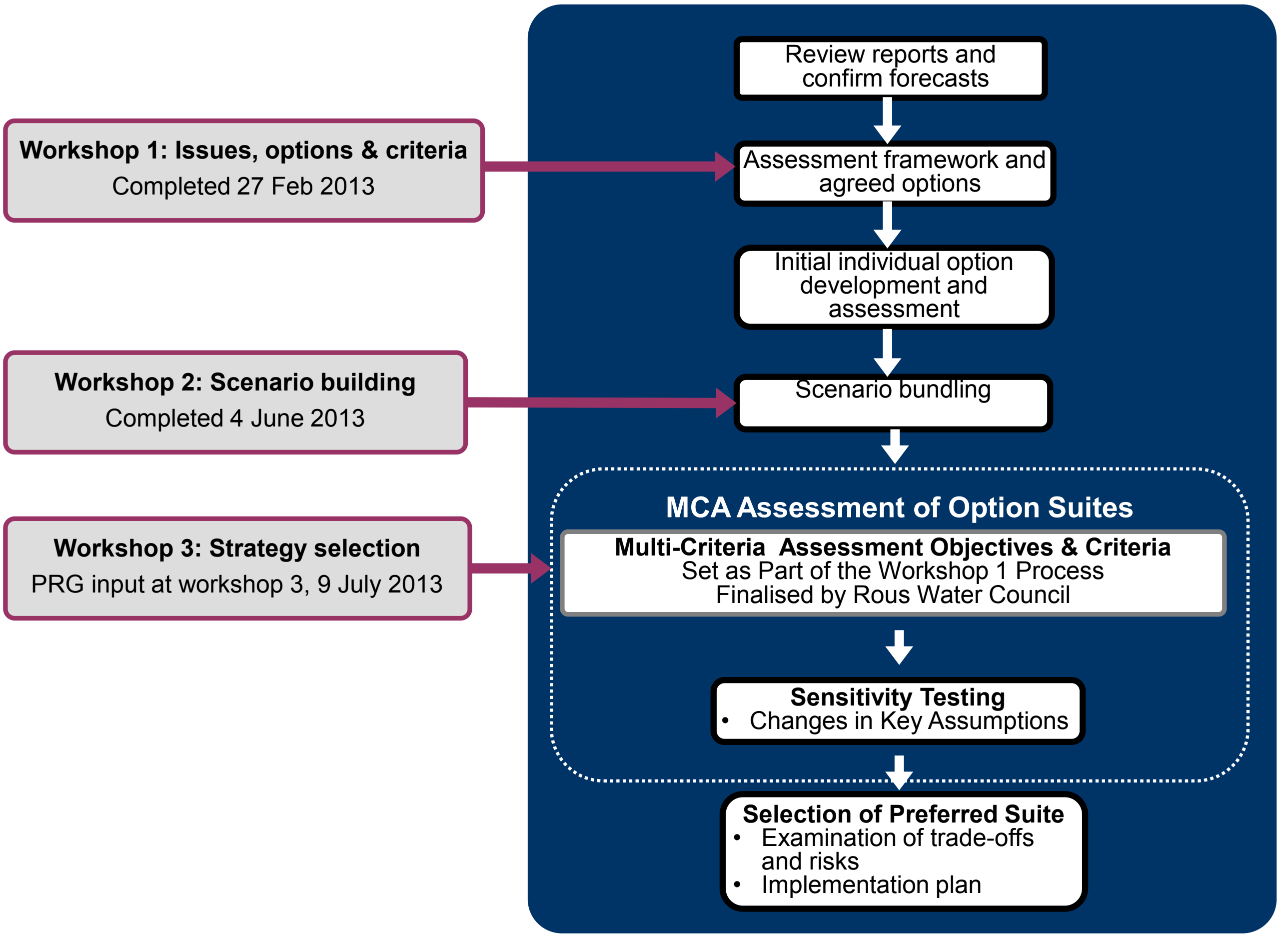



**Figure 2-2: Integrated water planning process**

The process is consistent with best practice principles and includes stakeholder engagement at critical points in the process. It identifies water utility issues to confirm project goals and assist develop assessment criteria. NOW guidance on the selection of option assessment criteria has been considered.

The process considers a wide range of potential options to address to identified water supply issues. Each supply option is described in terms of quantity (capacity to meet peak demands), quality (fit for purpose uses) and reliability (yield).

The highest ranked options are grouped into scenarios for triple bottom line assessment and comparison. The process for grouping of options includes consideration of compatibility and future resilience to changes (flexibility, multiple sources and adaptability). Development of the implementation plan includes assessment of risks and on-going monitoring and evaluation.

The decision making process is supported with a simple spreadsheet-based multi-criteria analysis (MCA) of scenarios for clear display and comparison. The approach allows scoring of scenarios against the agreed assessment criteria in the environmental, social and economic fields. Individual criteria or groups of criteria are weighted to test the sensitivity of results. The MCA is not the final decision step in the analysis, but rather as a tool that assists the trade-offs between competing outcomes to be identified.

Stakeholders, through a community Project Reference Group (PRG) and the Rous Water Council (with invited technical directors) were invited to input to the MCA scores, test sensitivity and provide feedback on the choices Rous Water is facing. Separate stakeholder workshops were held for both the PRG and Rous Water Council groups. The purpose of each workshop is outlined in Table 2-1.

**Table 2-1: Descrption and purpose of stakeholder engagement workshops**

| Workshop | Purpose |
|---|---|
| 1 Issues and options | Develop an understanding of the planning process.<br>Feedback on the triple bottom line assessment framework.<br>Foster a shared understanding of issues and Rous Water's situation.<br>Gain a sense of the types of management options available. |
| 2 Scenario building | Review of the assessment of individual options.<br>Feedback on the bundling of options into scenarios. |
| 3 Strategy selection | Provide feedback through a transparent and objective decision making process.<br>Assessment of strategic options and identification of preferred approach. |

Details of the stakeholder engagement approach and outcomes from each workshop are provided in Appendix A.

## 2.3 Data sources

This study makes use of a number of data sources provided by Rous Water and other organisations. The data sources are summarised in Table 2-2. Key document references are provided in the bibliography (section 10). A detailed document register of all data sources used in this project was compiled and provided separately for Rous Water's reference.

**Table 2-2: Key data sources used in the IWP process**

| Organisation | Data sources |
|---|---|
| Rous Water | Previous studies (summarised in section below)<br>Capital and operational works budget (2010-2013)<br>Marginal cost analysis<br>GIS showing key water supply and treatment infrastructure, major pipelines, reservoirs<br>Aerial photography<br>Daily historical bulk water production (total, by WTP and by Retailer)<br>Diameter and length of pipelines<br>Water treatment plant capacities and treatment trains.<br>Water supply operational protocols |
| Constituent Councils | Relevant studies<br>Historical Sewage Treatment Plant (STP) inflows and water quality<br>GIS showing key water supply and treatment infrastructure, stormwater catchment, STP locations<br>Topographic, contour cadastral, roads and catchment/stream data<br>Land use layers (current and future development) |

| Organisation | Data sources |
|---|---|
| NSW Public Works Department | Dunoon Dam quantity and cost estimates for 50,000 ML and 20,000 ML capacity dams |
| NSW Urban Water Services Consultants | Secure yield modelling results |
| Hydrosphere Consultants | Financial Modelling (FINMOD) analysis of scenarios<br>Number of connections by customer sector for each LGA<br>Quarterly consumption by customer sector for each LGA<br>Forecast number of connections by LGA |
| Australian Bureau of Statistics | Census data |
| Department of Planning | Population growth projections by LGA |
| NSW Office of Water | Water sharing plans<br>NSW Reference Rates Manual<br>Best practice guidelines for water supply and sewerage |
| SILO | Interpolated historical climate data for each LGA (1970-2013) |
| NOROC | Northern Rivers Bulk Water Supply Strategy - draft |

# 3 The need for water security improvement

Rous Water's service obligations set the context for FWS development and are summarised in this section. Demand forecasts are prepared and combined with current and future secure yield estimates provide an outlook for water security improvement needs.

## 3.1 Rous Water best practice targets

The concept of targets is taken from NOW's IWCM best practice process. Targets may be standards, legislation, legal contracts, accepted best practice business planning or agreed levels of service.

The Water Supply Agreement (Rous Water et al, 2008) documents the responsibilities and roles of Rous Water and the LWUs and is a key source for Rous Water's best practice targets. It includes:

- Protocols for communication, information collection, complaints, information sharing, education, and operations.
- Levels of service requirements.
- Accountability requirements including primary obligations, testing and metering.

Table 3-1 lists identified Rous Water best practice targets.

**Table 3-1: Rous Water best practice targets**

| Element | Obligation | Target | Reference |
|---|---|---|---|
| Water quality | Under then Public Health Act 2010 and the Public Health Regulation 2012 from September 2014 suppliers of drinking water will be required to establish and adhere to a quality assurance program | Quality assurance program must address the elements of the Framework for the Management of Drinking Water Quality, set out in the Australian Drinking Water Guidelines. | (NHMRC, 2011) |
| Potable water quality sampling | Legislative requirement | Compliance with NSW Health sampling requirements | |
| Water extraction licences | Legislative requirement | Compliance with licence conditions | |
| Best Practice Management of Water Supply Services | Best practice | Compliance with NSW guidelines | (Hydrosphere, 2009) (NSW Department of Commerce, 2009) (Rous Water, 2012) |
| Service interruptions | Agreed level of service | Planned (retail supply): 48 hours<br>Planned (bulk supply): 7 days<br>Max duration: 24 hours (planned); 8 hours (unplanned) | (Rous Water et al, 2008) |
| Main breaks | Agreed level of service | 1 break/20km main/year | (Rous Water et al, 2008) |
| Supplied water quantity/quality target | Agreed level of service | Planned: 7 days<br>Unplanned: 1 hour from | (Rous Water et al, 2008) |

| Element | Obligation | Target | Reference |
|---|---|---|---|
| departure notification times | | Rous observation. | |
| Water quality complaints | Agreed level of service | Dirty water: <30 per year<br>Taste and odour: <30 per year | (Rous Water et al, 2008) |
| Security of water supply (restrictions) | Agreed level of service | The 5/10/20 rule. NOW recommends 5/10/10 with climate change consideration for future water security[1]. . | (Rous Water et al, 2008) |
| Supply quantity (maximum volume) | Agreed level of service | Average annual demand: 200 kL/property<br>Peak day demand: 2.5 kL/property | (Rous Water et al, 2008) |
| Water losses | Agreed level of service | Target not yet defined | (Rous Water et al, 2008) |
| Environmental protection | Legislative requirement | Compliance with licence conditions | |
| Dam safety | Legislative requirement | Comply with dam safety requirements | |
| Occupational Health & Safety | Legislative requirement | Compliance with statutory requirements | |
| Demand management | Best practice | Demand management plan to be prepared by each party in accordance with state government best practice management guidelines. | Local plans have not been prepared. |

## 3.2 Demand forecast

### 3.2.1 Baseline forecast

Rous Water has developed a water demand forecast for the period between 2010 and 2060 based on proposed development plans from each of the constituent Councils (Hydrosphere Consulting, 2012).

The forecast is based on the expected number of new connections in the Rous water supply area allowing for expected regional growth and improvements in water efficiency. Figure 3-1 presents the predicted breakdown of connection types for each 5 year period between 2010 and 2060. By 2060, Rous Water is predicted to serve approximately 63,700 residential properties (including 3,200 properties in the retail supply area) and 8,600 non-residential connections.

The predicted future demand per connection has been estimated for each connection type in each supply area. Figure 3-2 shows the predicted future demand, not including any allowances for climate variation or additional demand management initiatives. The baseline allows for BASIX plus the increase in dual reticulated connections to urban release areas in Lennox Head and Ballina (Ballina Shire). The demand for water at 2060 is predicted to be approximately 15,800 ML/a, an increase of approximately 4,900 ML/a over current demand.

[1] NOW guidelines are in draft form and have not been formally released.

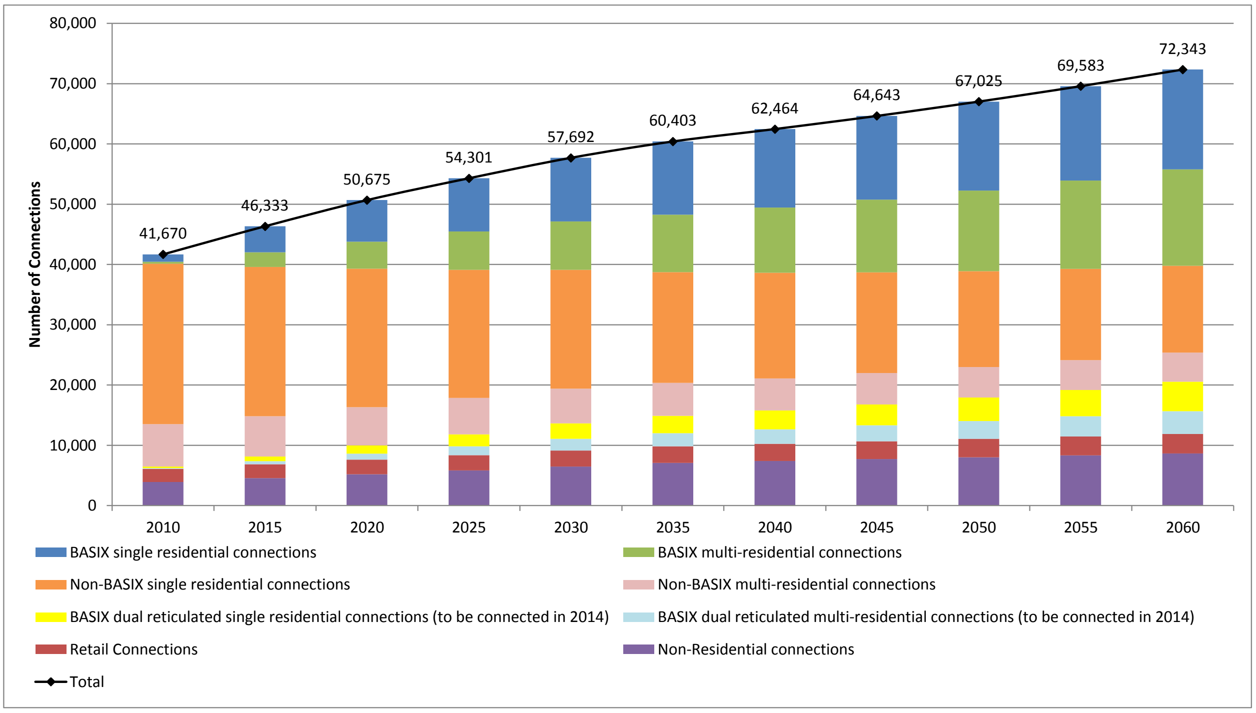



**Figure 3-1: Number of connections forecast (Hydrosphere Consulting, 2012)**

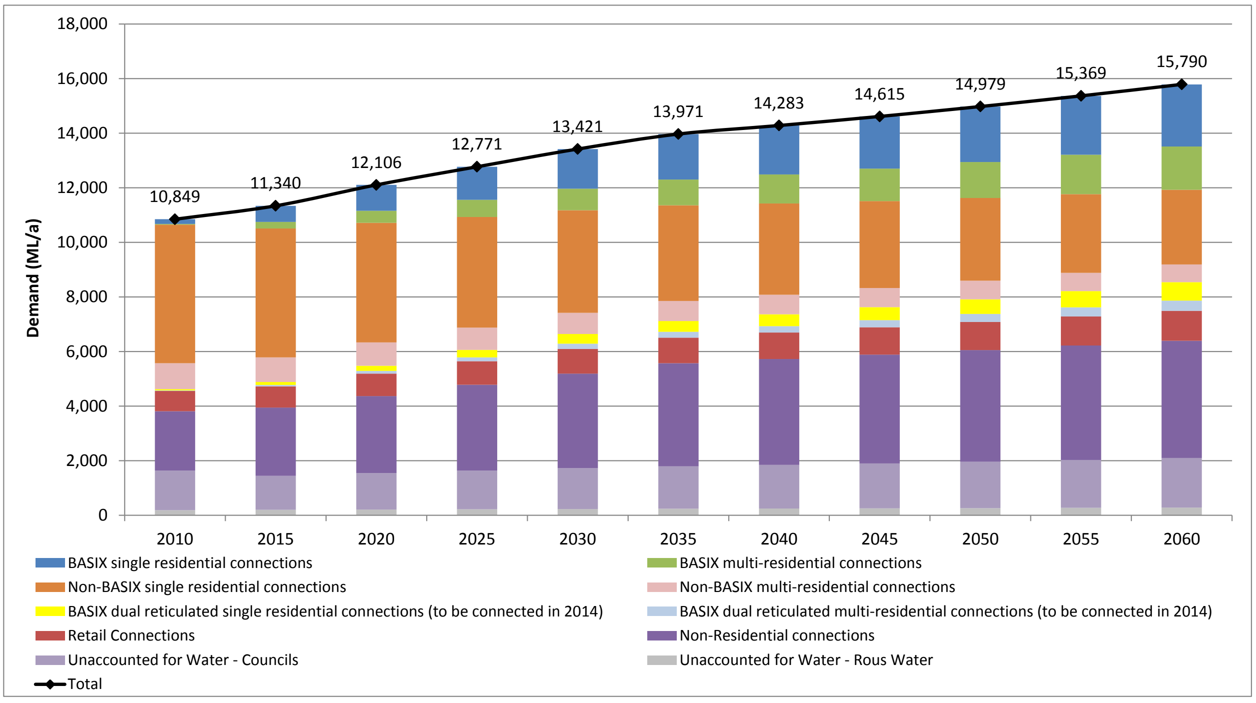



**Figure 3-2: Water demand forecast (Hydrosphere Consulting, 2012)**

## 3.3 Water availability

### 3.3.1 Current sources

The principal source of the Rous Water supply network is Rocky Creek Dam. Other water sources utilised by Rous Water include Wilsons River Source, Emigrant Creek Dam, untreated bore water at Convery's Lane and Lumley Park in the Ballina area, as well as bores near Woodburn.

The water from these sources is distributed, mostly by gravity to Rous Water's four LWUs using its distribution network and bulk reservoirs. The four LWUs are:

- Byron Shire Council.
- Ballina Shire Council.
- Lismore City Council.
- Richmond Valley Shire Council.

#### 3.3.1.1 Rocky Creek Dam

Rous Water currently draws about 10,000 ML/a of raw water from the Rocky Creek Dam and treats it at the 70 ML/d capacity Nightcap Water Treatment Plant (WTP). Historically, this represents about 95% of the water supplied by Rous Water. Rocky Creek Dam is located in the Nightcap Range approximately 27 km north of Lismore. Rocky Creek Dam has a maximum effective storage capacity of 14,000 ML.

#### 3.3.1.2 Wilsons River Source

The Lismore Source system consists of two pump stations (“low lift” and “high lift”) and a 20 km long steel rising main to pump water from the Wilsons River tidal pool, directly to the Nightcap WTP. This system is capable of supplying between 5 to 30 ML/d of water to the Rous Water system via the Nightcap WTP. It is limited by licenced pumping allocations which reflect the flow in the Wilsons River.

#### 3.3.1.3 Emigrant Creek Dam

Rous Water currently draws about 500 ML/a of raw water from the Emigrant Creek Dam and with treatment at the 7.5 ML/d capacity Emigrant Creek WTP. The dam is located approximately 15 km north west of Ballina. The dam has a maximum effective storage capacity of 750 ML.

#### 3.3.1.4 Plateau bores

Rous Water owns two licensed bores on the Alstonville Plateau which are only operated in response to drought conditions. These bores are located at Lumley Park, Alstonville and Converys Lane at Wollongbar. The combined production of these bores is approximately 1 ML/day.

#### 3.3.1.5 Woodburn borefield

Rous Water owns three licensed bores at Woodburn. Planned highway works necessitates the relocation of the bores. Based on the production tests it is estimated that up to about 2 ML/d of water can be extracted from these bores (NSW Department of Commerce, 2009) but the combined license permits abstraction of no more than 242 ML/a.

#### 3.3.1.6 Summary of current water supply sources

Table 3-2 summarises the current water supply sources, the storage capacity of each (where applicable) and the licence entitlement for each.

**Table 3-2: Current Rous Water water supply sources**

| Water Source | Storage capacity | Licence entitlement |
|---|---|---|
| Rocky Creek Dam | 14,000 ML | 12,358 ML/a |
| Emigrant Creek Dam | 820 ML | 2,620 ML/a |
| Wilsons River Source | - | 5,400 ML/a |
| Alstonville plateau bores | - | 680 ML/a |
| Woodburn bores | - | 242 ML/a |
| **TOTAL** | **14,820 ML** | **21,300 ML/a** |

### 3.3.2 Current secure yield

A water balance model was used to estimate Rous Water’s secure yield incorporating streamflow records from 1892. A description of the model and the secure yield analysis undertaken as part of the FWS is provided in Appendix C.

Secure yield is an estimate of the annual demand which can be sustainably supplied by a water source, based on an assessment of historical inflows and acceptable restriction guidelines. Previously, *5/10/20* restriction rules were applied representing:

1. Restriction duration - enforced no more than 5% of the time
2. Restriction frequency - no more than once in 10 years on average
3. Restriction intensity - representing a 20% reduction in consumption.

Over the last 20 years there has been a significant reduction in average water use per connection throughout NSW, generally attributed to increased water awareness within the community and increased demand management program efforts. Recognising the potential for 'demand hardening', NOW secure yield guidelines propose a *5/10/10* rule which requires future water security planning on the basis of a long term average demand reduction of 10% during restrictions rather than the former 20% (NSW Office of Water, 2012). The revisited guideline is constantly being updated and has not been formally released, however, it was agreed with NOW to use the new guidelines requirements at the commencement of the project.

The adoption of the new guidelines results in a reduction in the secure yield of Rous Water supplies from 14,600 ML/a to 13,800 ML/a.

### 3.3.3 Climate change impacts

Significant uncertainty exists in the potential climate change impacts on secure yield.

In response to the potential effect of climate change on water supply security the NOW formed a Climate Change Steering Group and undertook a pilot study to assess the effect of climate change on the secure yield of 11 NSW urban water supplies (NSW Public Works, 2010). Rous Water was one of the water supplies included in the pilot study. The findings of this investigation have been used to determine likely climate change scenarios at 2030 and 2060.

The pilot study was based on the International Panel on Climate Change's (IPCC) Special Report on Emission Scenarios, A1B global warming scenario. The A1B scenario describes a future with 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 (Intergovernmental Panel on Climate Change (IPCC), 2007). There are a number of scenarios available however the A1B scenario is represented to be a fairly moderate scenario in terms of the ongoing global response to increasing awareness of climate change. It estimates an increase in average global maximum daily temperatures of 0.9 degrees Celsius over 1990 conditions by 2030, and an increase of 2.0 degrees Celsius by 2060.

The methodology used for the pilot study considered likely climate change impacts on secure yield at 2030 and involved the following steps (NSW Public Works, 2010):

1. Inputting estimated daily historical rainfalls and evapotranspiration for 106 years into a daily rainfall-runoff model to provide corresponding estimates of historical daily stream flows.
2. Inputting the above historical stream flows (as well as rainfalls and estimated evaporation) into the Rous Water system behaviour model to determine historical estimates of secure yield.
3. Inputting daily estimates of rainfall and evapotranspiration for the same historical period as above (1) adjusted for global warming effects using 15 separate Global Climate Models (GCMs) into the daily rainfall-runoff model to provide corresponding estimates of global warming changed daily stream flows.
4. Inputting each of the 15 above (3) daily global warming changed stream flows (and rainfalls and estimated evaporation) into the Rous Water system behaviour model to determine revised estimates of secure yield under global warming scenario A1B.
5. The results for the median change in secure yield (of the 15 GCM's analysed) were then selected as the most probable effect of climate change.

The results for the median GCM indicate that under the A1B climate change scenario median rainfall for the Rous Water supply decreases, while there is an increase in evaporation and evapotranspiration (see Table 3-3). This is reflected in decreased modelled stream flows.

**Table 3-3: Impact of climate change on average annual climate conditions in 2030 for the Rous Water system**

| Other measures | Historic conditions | Median of 15 GCM's at 2030 | 2030 % change against historic conditions |
|---|---|---|---|
| Average Annual Rainfall (mm) | 1,666 | 1,622 | -2.64 |
| Average Annual Evaporation (mm) | 1,512 | 1,535 | 1.52 |
| Average Annual Evapotranspiration (mm) | 1,435 | 1,457 | 1.53 |
| Average Annual Stream flow (ML) | 813,056 | 773,553 | -4.86 |

Rous Water commissioned further modelling to explore the effects of 1.0 and 2.0 degree mean global warming scenarios. Under these scenarios the water balance model predicts a 17.5% reduction in Rous Water's secure yield at 1.0 degrees and 33.6% reduction in secure yield at 2.0 degrees, relative to current levels. The current system secure yield with climate change impacts is shown in Table 3-4. These yields has been adopted by Rous Water as the FWS planning scenario.

**Table 3-4: 5/10/10 secure yield with climate change**

| Current climate (based on historical) (ML/a) | 2030 (ML/a) | 2060 (ML/a) |
|---|---|---|
| 13,800 | 11,500 | 9,100 |

## 3.4 Water supply and demand balance

The interaction of future water demand projections and supply assumptions provides an estimate of both the capacity of the existing water supply to continue to meet future demand as well as the magnitude of any surplus/deficit of supply versus demand at key points in time. The interaction of secure yield and water demand is shown in Figure 3-3.

Under the adopted climate change scenario, existing water supplies are considered sufficient to meet annual demand until 2024 and, should the forecast trends continue, by 2060 there would be a likely secure yield shortfall of approximately 6,500 ML/a.

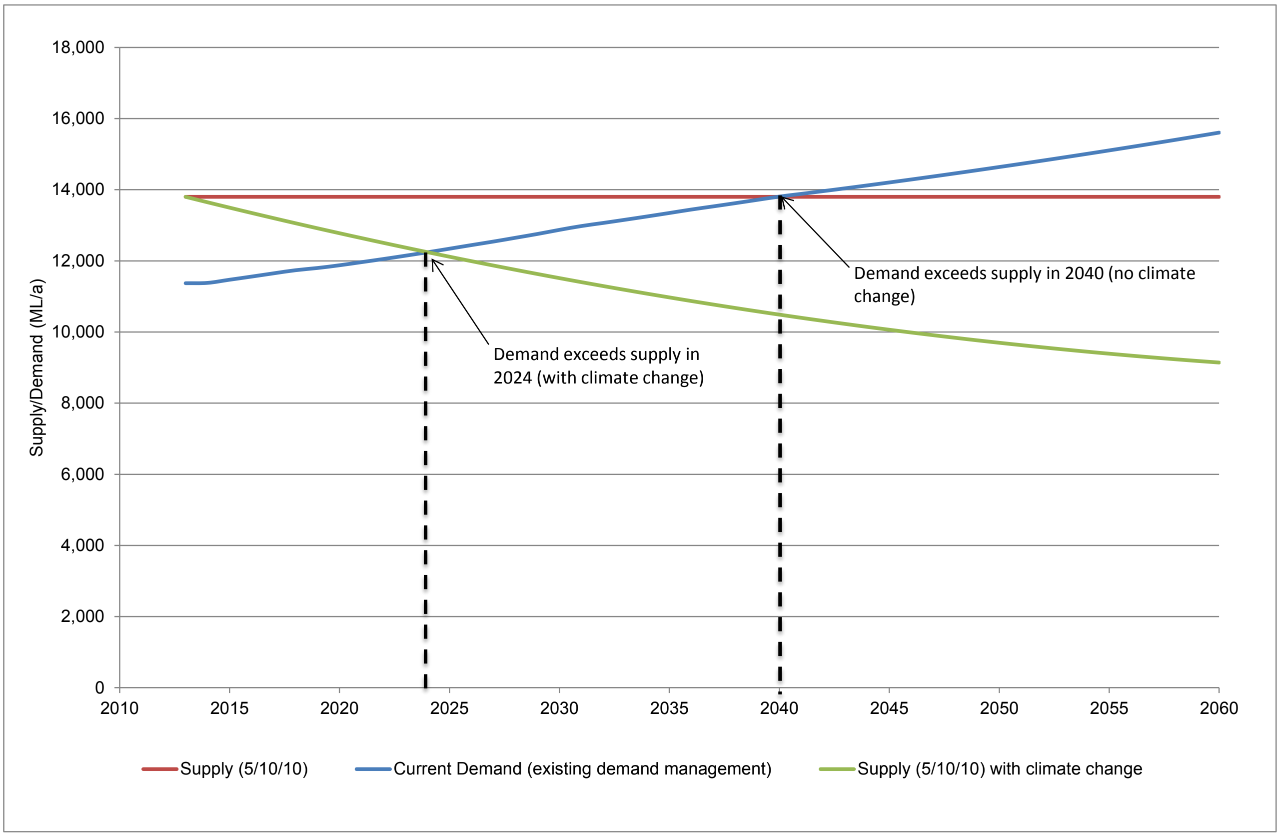



**Figure 3-3: Existing Rous Water secure yield and demand forecast (with and without climate change)**

There is significant uncertainty associated with both the demand and supply forecasts. The demand forecast is strongly driven by serviced area growth rates and customer water usage behaviour. The supply forecast is highly influenced by future climate conditions. The supply-demand balance adopted in this study provides a starting point for strategic assessment, using available information and practices. It also recognises that the forecasts are uncertain and include the need for ongoing monitoring and regular review of foundation assumptions, as well as the promotion of adaptive management.

# 4 FWS objectives

Section 3 sets the context for Rous Water's service obligations and water security issues. This section outlines water supply challenges expected to be faced by Rous Water over the planning horizon. The identified challenges were used to formulate objectives and criteria for assessment of potential solutions. The issues and objectives are developed in consultation with stakeholders.

## 4.1 Water supply challenges

Potential water supply issues expected to be faced by Rous Water over the planning horizon are compiled from a number of sources:

1. Preliminary FWS studies.
2. The IWCM Strategy (Hydrosphere Consulting, 2009).
3. PRG input since 2009.
4. Best practice targets (Table 3-1).

The key identified challenges include:

1. Future supply-demand deficit in the order of 6,500 ML/a by 2060.
2. Potential climate change impacts are uncertain, however best available information suggests reduction in supply yield and increased extreme events such as flooding and violent storms potentially leading to water quality issues and infrastructure damage.
3. Lack of regional water supply integration and management with:
    a. Limited source substitution and alternative supplies currently adopted.
    b. Inefficiencies and inconsistencies across jurisdictions.
    c. Potential water quality impacts on water sources.
4. The options to increase supply and reduce demands include potential impacts such as:
    a. Increased costs.
    b. Increased energy usage and greenhouse gas emissions.
    c. Community dependence.
    d. Increased water sharing.
    e. Ecological and cultural heritage impacts.
    f. Require increased organisational capacity and adaptability.
    g. Long approval and implementation lead-times.
5. Existing water supply assets have limitations associated with ageing and renewal needs as well as capacity (peak demands) limitations.

## 4.2 Objectives and criteria

The identified water management challenges and preliminary objectives were presented to stakeholders prior to the first workshop (refer to Appendix A). As part of the first stakeholder workshop, stakeholders were invited to:

- Reflect on preliminary water management issues and objectives.
- Consider potential criteria which could be used to assess each water supply option.
- Identify and rank their highest priority objectives.

The principles of setting objectives that the workshop participants were asked to consider were:

- Environmental, social and economic option assessment criteria.
- Assigning of weightings and normalised scores to each criteria.

- Comparison of options using aggregated index/s for ranking.
- Sensitivity testing of weightings.
- Selection of criteria which value the project goals and objectives, and which minimise double-counting.
- A participatory approach – stakeholder input and transparency of assumptions, trade-offs and decisions.

This information was then used by the project team and staff from Rous Water to refine and reconsider the preliminary water management objectives and to recommend appropriate criteria by which each objective could be measured.

As an outcome of this process, the following objectives and criteria were recommended, and agreed to, with Rous Water for use in the multi-criteria assessment of short listed water supply options.

Table 4-1 lists the 'must do' objectives to be met by all scenarios developed in the FWS. Table 4-2 lists the objectives for comparison of the potential solutions.

**Table 4-1: Compulsory objectives**

| Compulsory Objective | Criteria |
|---|---|
| Comply with water sharing plans | Water sharing plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. Water sharing plans are being progressively developed for rivers and groundwater systems across New South Wales following the introduction of the *Water Management Act 2000*. |
| Plan for option lead times | Allow sufficient lead time to ensure approvals, design, construction can be completed before augmentation required |
| Protect public health | Meet Australian guidelines for drinking water or recycled water |
| Provide adequate secure yield | Meets secure yield level of service targeted |
| Effectively utilise existing assets into the future | Must use existing assets |

**Table 4-2: Objectives and criteria**

| Objective | Criteria |
|---|---|
| Enable adaptive management | Qualitative assessment score |
| Increased system resilience through supply diversity | Qualitative assessment score |
| Effectively utilise demand management | Per capita potable usage |
| Minimise ecological and cultural heritage impacts | Qualitative assessment score |
| Reduce greenhouse gas emissions | Qualitative assessment score |
| Affordable to consumers | Qualitative assessment score |
| Supported by constituent Councils | Qualitative assessment score |
| Maximise community acceptance | Qualitative assessment score |
| Minimise community costs | Community (utility + customer) net present value |

# 5 Options to improve water security

## 5.1 Option development

The primary focus of the IWP process is to further define and analyse the new water supply options. Option development includes preparation of layout, sizing, operation (process) and interconnection arrangements. Each of the options have been considered in terms of overall yield, capital cost, operating cost, energy consumption, land requirements and assessed against known environmental constraints. This section presents the high level detail of each of the options appropriate for strategy level. Further detailed information regarding each option is presented in Appendix J.

Generally, option development considers:

1. Any previous investigations.
2. Maximising supply yield for the type of supply option.
3. Proximity to and use of existing water supply infrastructure.
4. Land zoning and ability to run pipelines along road corridors.
5. Preliminary treatment needs.
6. Preliminary check of environmental constraints.
7. Preliminary costing.

The options development involved extensive consultation with Rous Water staff including operations (treatment and distribution) and relevant specialist input with regards to treatment processes, desalination, stormwater management, environmental issues and heritage. Groundwater experts were engaged to assess the viability of regional groundwater options (see Appendix F) and water security modelling was undertaken to assess the additional yield from each option (see Appendix C). LWUs were also consulted with regards to option viability.

The supply options are viewed as stand-alone approaches. Preliminary infrastructure sizing and costing is provided for major infrastructure only. All identified water infrastructure remains subject to confirmation through design and approval processes. Combined options (scenarios) to address system wide needs are developed in Section 6.

## 5.2 Coarse screening of options

A long list of water supply options to meet FWS objectives was identified using a 2-stage approach:

1. Broad-based option identification and scoping.
2. Coarse screening to test feasibility of options and remove non-feasible options.

Coarse screening was completed between 2010 and 2012 by GeoLink in conjunction with the PRG. The coarse screening criteria are based on Rous Water's vision statement and include:

1. Healthy - safe / fit for purpose.
2. Reliable - availability, measureable benefit.
3. Sustainable - meet principles of Ecologically Sustainable Design.
4. Acceptable - community.
5. Integration - resource management, infrastructure.
6. Achievable - legal, practical, timeliness.

Cost was not considered as a criterion. A pass or fail was agreed for each option. The complete long list of options including the assessment is shown in Appendix D.

From this process a number of potential water supply options for further consideration in this study have been identified. This list below includes additional options including 'Demand Management', 'Regional Water Supply Options' and 'Revised water supply restrictions' which were not considered in the coarse screening exercise. 'Raising Rocky Creek dam' initially received a 'Fail' rating however has been included for assessment as part of this study based on the resolution of Rous Water Council. The adopted list of potential options is:

A. Demand Management
B. Potable use of stormwater
C. Urban stormwater for non-potable urban use and urban irrigation
D. Indirect potable reuse
E. Recycling of reclaimed water for non-potable urban use
F. Groundwater
G. Desalination
H. Dunoon Dam
I. Regional connections –Establish new Town Water Supply licence for Toonumbar Dam
J. Regional water supply options identified through NOROC study
K. Revised water supply restrictions
L. Raising Rocky Creek Dam

### 5.2.1 Secure yield modelling

For the past 25 years most urban water supply headworks in country NSW have been sized on a robust 'security of supply' basis. This security of supply basis was developed to cost-effectively provide sufficient dam storage capacity to allow the water utility to effectively manage its water supply in future droughts of greater severity than experienced over the past 100 or more years. 'Secure yield' is the water demand that can be expected to be supplied with only moderate restrictions during a significantly more severe drought than had been experienced since about 1895 (from when generally reliable rainfall records are available).

Modelling of the behaviour of the water supply headworks system is required to determine the secure yield. The aim of the modelling is to determine the maximum annual demand that satisfies the '5/10/10' rules. This is done using a storage and system behaviour model using an iterative process to satisfy all the requirements implied by the rules and available water from the various sources.

Rous Waters' previous system behaviour model developed and used and tested over many years was updated for this study to incorporate the various proposed water supply options to be examined. The model is essentially driven by operating conditions such as the need to meet a specified demand whilst satisfying constraints such as available water from streamflows and meeting environmental flow objectives. In addition to the hydrometeorological data that has to be input into the computer simulation model, other data has to be incorporated into the model.

The secure yield estimates determined from the behaviour modelling for the water suppy options are described in this section. The cases modelled were a reflection of the development and refinement of proposed water supply options as the FWS progressed towards preferred options which in turn were informed by the secure yield estimates of the modelled options.

The results presented in this section are based on historical climate. Adjustments to these results can be made to allow for projected climate change scenarios using defined methodology and these results.

The expected level of security arises from the 5/10/10 rules which provides for 10% restrictions occurring in 10% of the years for 5% of the time. For some cases the expected levels of security were varied to examine their sensitivity.

It is important to note that the secure yield of combined options when bundled into scenarios is not necessarily the same as the sum of each individual supply option. Secure yield modelling is repeated to refine the sizing of supply sources in each scenario (Section 6). Details of the secure yield modelling and assumptions are provided in Appendix C. Note also, that not all options and scenarios which were modelled are included in the final list of options and scenarios.

### 5.2.2 Infrastructure sizing

Generally sizing of water supply infrastructure is based on:

- WTPs and reservoirs (network) – peak day demand (PDD)
- Trunk mains and water pumping stations – PDD over 22 hours (i.e. 24/22*PDD). Velocity check <2.0 m/s. Friction loss as 3 m/1000 m. 80% overall pump efficiency
- Treatment requirements assessed at a high level based on requirements of Australian Drinking Water Guidelines (NHMRC, 2011) and Australian Guidelines for Water Recycling (Environment Protection and Heritage Council, 2006).
- Desalination sized to meet average day demand (ADD).
- Recycled water treatment facilities sized based on average dry weather flow (ADWF).

### 5.2.3 Cost estimates

High level cost estimates are provided to allow strategic comparison of the options. The cost estimates are not suitable for budgeting purposes. It is assumed that design, approvals and detailed costing for budgeting would occur in subsequent implementation stages of the FWS. Where possible, costs are sourced from Rous Water's capital expenditure budgets. In cases where the sizing of the infrastructure is altered to meet the changed demands, costs are modified on a pro-rata basis or sourced from the *NSW Reference Rates Manual*, (NSW Ministry of Energy and Utilities, 2003). Otherwise generally, the manual's reference rates have been adopted which includes allowances for survey, investigation and design costs of approximately 32%.

Other general costing and sizing assumptions include:

- Year 2013 costs. Cost escalation based on historic construction cost indexes.
- Pipe material selection: DICL pressure mains.
- NSW Reference Rate Manual construction factors were applied to all of the reticulation, rising and trunk main costs. These included:
    - Rock excavation allowance factor: assuming 10% rock and pipelines laid at a minimum depth.
    - Moderate construction difficulty factor: assuming alignments are through suburban sites with roads.
    - No additional allowance has been made for firefighting requirements in the sizing of the potable and recycled systems.
    - A contingency of 30% has been applied to all options.

Concept level capital costs for Dunoon Dam and associated infrastructure have been developed (NSW Public Works, 2013).

Ongoing costs take into account energy use (see below), treatment costs and maintenance and depreciation costs.

### 5.2.4 Energy use

Annual operational energy requirements are estimated. Energy use is associated with extraction (bore pumps), transfer (pumps, hydro-schemes) and treatment (process units and pumps). Customer (household) energy is primarily associated with hot water systems and rainwater pumps/controls.

### 5.2.5 Environmental constraints

A desktop review of environmental constraints has been undertaken for each of the developed options (Appendix E). Data base searches that were undertaken included:

- EPBC Protected Matters Search Tool.
- NSW Natural Resource Atlas.
- NSW Atlas of Aboriginal Places.
- Aboriginal Heritage Information Management System (AHIMS).
- Australian Heritage Database.

- Australian Heritage Places Inventory.
- Atlas of NSW Wildlife.
- NSW Vegetation Information System.
- DECC Contaminated Land Report.
- Local Government maps/LEPs.

Separate detailed environmental investigations have been undertaken for the proposed Dunoon Dam (Eco Logical Australia, 2012), (SMEC, 2011).

## 5.3 Demand management

Demand management is an integral part of Rous Water's approach to planning and management of regional water assets. Since 1995 Rous Water has implemented an ongoing and evolving program of demand management. The *Rous Water Demand Management Plan 2012-2016* (Rous Water, 2012) outlines the implementation plan for the current suite of programs.

As part of the development of the FWS, a strategic level cost-benefit assessment for the existing and additional demand management measures was undertaken (refer to Appendix B for the complete assessment). Two cases were considered:

1. Existing demand management - mandatory measures plus the current suite of Rous Water demand management initiatives.
2. Enhanced demand management - mandatory measures and all identified measures which are considered cost-effective.

Enhanced demand management includes:

- **Greater community engagement** – retaining effective elements of Rous Water's existing education and engagement programs, while incorporating more direct engagement with target audiences and more tailored information to consumers based on their personal circumstances.
- **Open space water efficiency** – implementing water savings through more efficient irrigation controls in public open spaces, such as parks and sporting grounds.
- **Business water reduction program** – continuing the existing program, but with renewed focus on non-residential water users with high water use, including the introduction of smart metering.
- **Residential rebate programs** – continuing and expanding residential rebate programs (for example showerheads, tanks and dual flush toilets) where they represent value for money.
- **Water loss management** – there is significant opportunity to reduce operational water losses associated with the distribution of potable water through the Rous Water region. While some level of loss from a large water distribution network is unavoidable, Rous Water will work in partnership with LWUs to implement improved leak detection, maintenance and pressure management strategies.

A full explanation of both demand management cases including the measures included in each case can be found in Appendix B. The final measures to be included are to be finalised through inclusion of environmental and social considerations in the next review of the Demand Management Plan (due 2014).

The demand forecasts for each of the cases are shown in Figure 5-1.

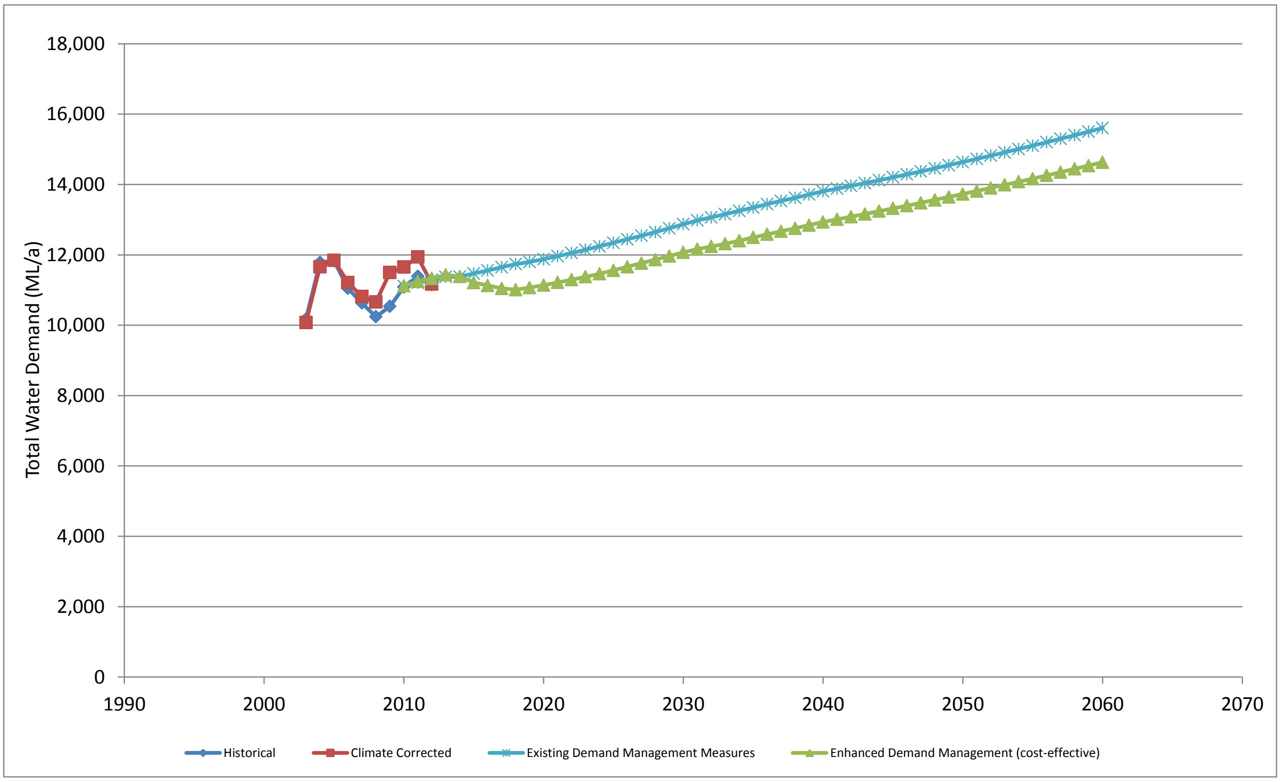



**Figure 5-1: Forecast water demand with enhanced demand management (ML/a)**

The existing demand management case includes BASIX and recycled water connections in Lennox Heads and Ballina plus a suite of current measures including residential rebates, the Blue and Green Business Program, school and community education initiatives and voluntary permanent water saving measures. It produces a slightly reduced baseline demand forecast than what was presented in Section 3.2.

The enhanced demand management case reduces overall demand hence delaying the need for new water supply sources by approximately 5 years and reduces the supply deficit in 2060 by approximately 1,000 ML/a. The annualised costs and average annual water savings for each case are shown in Table 5-1.

**Table 5-1: Demand management annualised costs and water savings**

| Case | Total Community Annualised Costs ($/kL)[2] | Average Water Savings (ML/a)[3] |
|---|---|---|
| A1. Existing demand management measures | $3.90 | 1,200 |
| A2. Enhanced demand management | $2.30 | 1,950 |

The impact of implementing enhanced demand management on delaying and downsizing future water supply needs is shown in Figure 5-2. By adopting the enhanced demand management case the need for additional water sources is delayed by approximately 4 years.

[2] $Annualised\ Cost = \frac{\sum C_t/(1+r)^t \times r/(1-(1+r)^t)}{\sum W_t/t}$
Where C is the cost (capital and operating) at time t, Wt is the water demand conserved or supplied or in year t and r is the discount rate.
[3] Annual average potable water savings, over the full planning horizon.

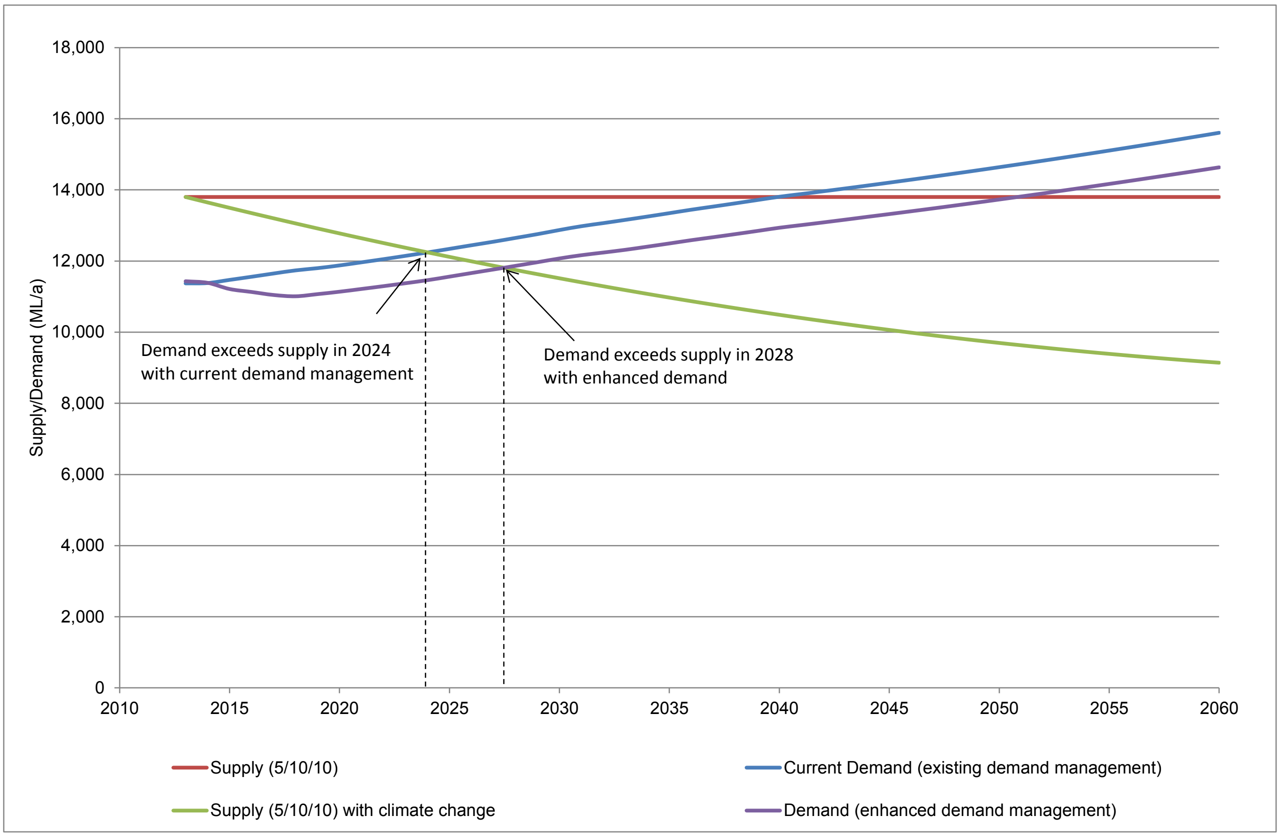



**Figure 5-2: Enhanced demand management supply/demand impact**

## 5.4 Stormwater harvesting

### 5.4.1 Potable use of stormwater

Stormwater harvesting for potable use involves collection of stormwater runoff downstream of an urban development area with storage and preliminary treatment. The collected water would then be pumped via a new dedicated pipeline to an existing water treatment plant (e.g. Nightcap WTP or Emigrant Creek WTP) for subsequent supply to consumers. In this way the stormwater would be used to supplement Rous Water's existing raw water sources (e.g. Rocky Creek Dam, Emigrant Creek Dam and the Wilson River Source). Ongoing engagement with Constituent Councils is required for on-going management of stormwater harvesting options.

Allowances for reasonable water quality management, treatment and catchment management have been included in costing of options.

The following issues were considered when identifying potential stormwater catchment locations:

- Adequate sized catchments and runoff.
- High urban content – harvestable yields.
- Available areas for seasonal storage.
- Roof water opportunity in new developments with recycled water dual reticulation.

All potential urban catchments in the Rous Water area of supply were considered for potential stormwater harvesting. Local climate characteristics, catchment area and catchment runoff characteristics have been taken into account when determining available yield. Viability of the catchments for stormwater capture was also discussed with Rous Water staff before short listing the options.

Based on these criteria, three potential stormwater harvesting options for potable use were identified as described in Table 5-2.

**Table 5-2: Stormwater options description**

| Option | Description | Location | Use |
|---|---|---|---|
| B1. Goonellabah Catchment | Stormwater runoff collected from catchments (1,900 ha) in the Goonellabah area for indirect potable reuse. Treated stormwater would be transferred to the Wilsons River transfer main to supplement transfers to Nightcap WTP when required.<br>Infrastructure required includes transfer mains, pump stations, water treatment and storage tanks. | Harvesting of existing urban stormwater catchments in Goonellabah. | Supplement potable supply via transfer to Wilson's River source and Nightcap WTP |
| B2. Alstonville catchment A, B &C (Ballina) | Stormwater runoff collected from catchments (980 ha) in Alstonville area for indirect potable reuse. Treated stormwater would be transferred to the Emigrant Creek Dam when system storage below 95%. Can be staged. Opportunity to combine with wastewater reuse.<br>Infrastructure required includes transfer mains, storage pond and water treatment plant. | Harvesting of existing urban stormwater catchment areas in Alstonville | Supplement potable supply via transfer to Emigrant Creek Dam |
| B3. Ballina Cumbalum Ridge Developments A, B & C | Roofwater collected from 3,900 new houses for indirect potable reuse. Roofwater would be transferred from communal tanks to the Emigrant Creek Dam when system storage below 95%. Dependent on house construction rates. System management arrangements to be determined.<br>Infrastructure required includes a dedicated roof water collection system, balancing (communal) tanks for each development area, transfer mains and pump stations and water treatment plant. | Harvesting of roof areas from new developments | Supplement potable supply via transfer to Emigrant Creek Dam |

### 5.4.2 Locations and interconnections

The approximate locations assumed for each option are shown below in Figure 5-3, Figure 5-4 and Figure 5-5. Indicative pipeline routes and interconnections were determined as part of the option development and used for option costing and assessment of environmental constraints.

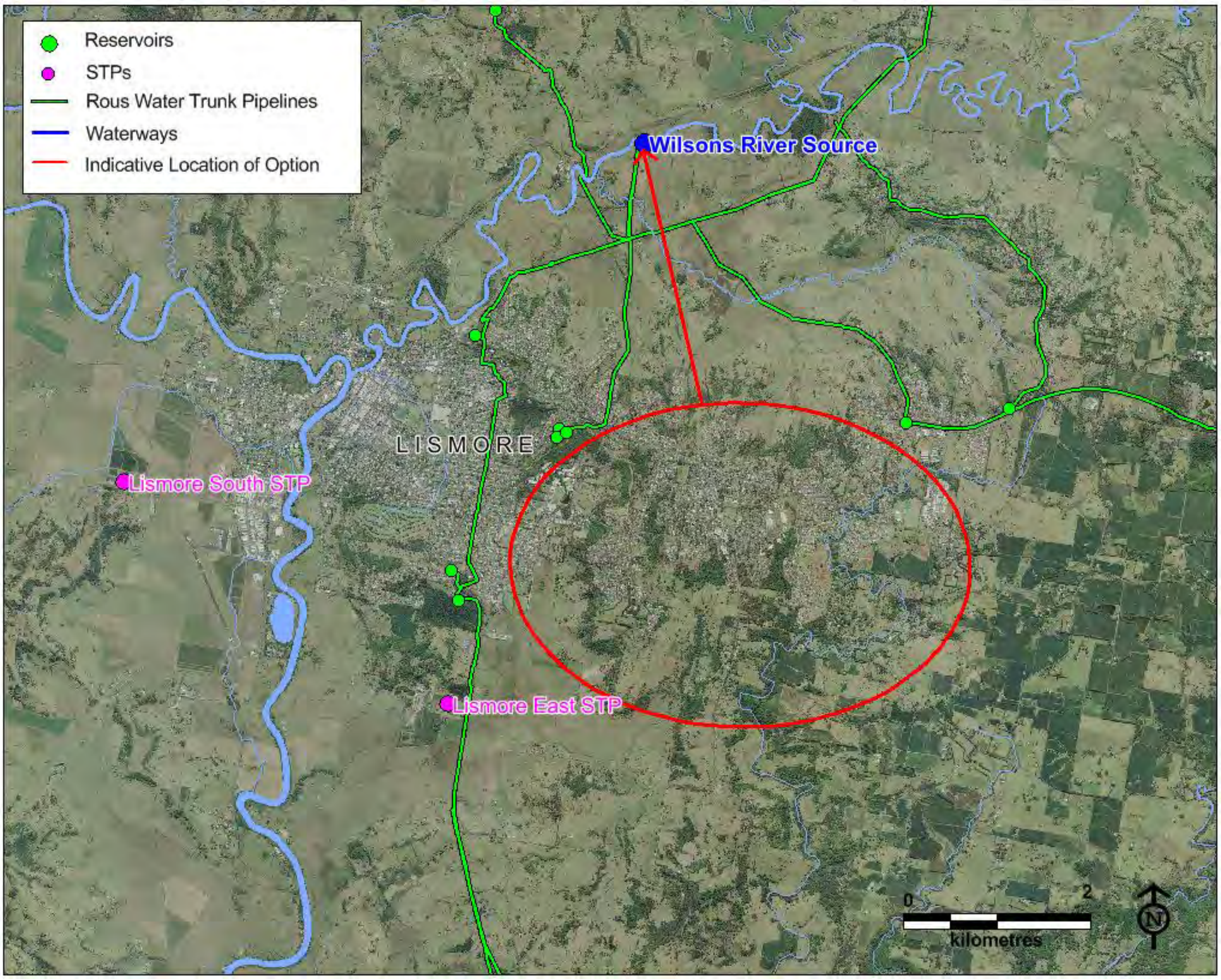



**Figure 5-3: Option B1 indicative collection area and transfer**

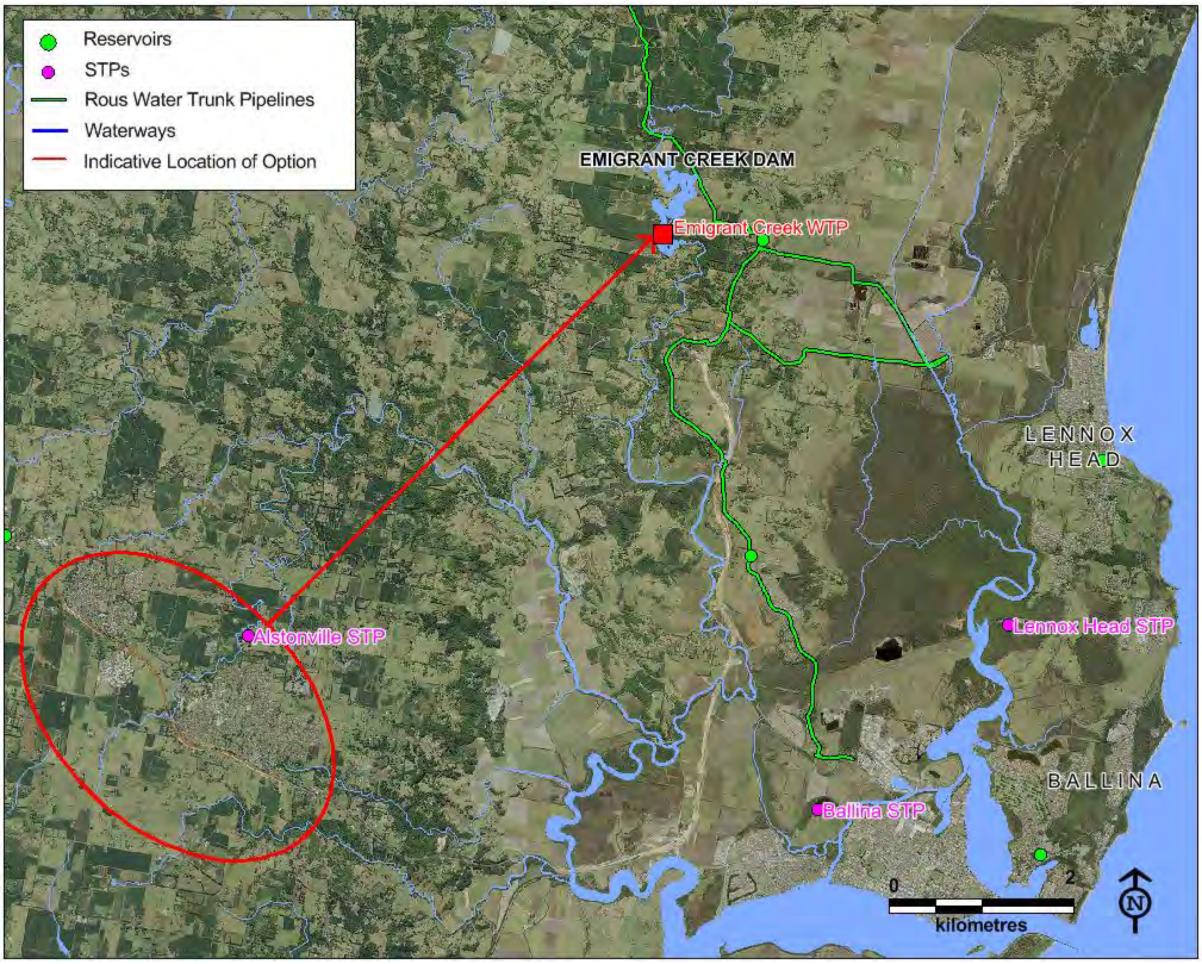



**Figure 5-4: Option B2 indicative collection area and transfer**

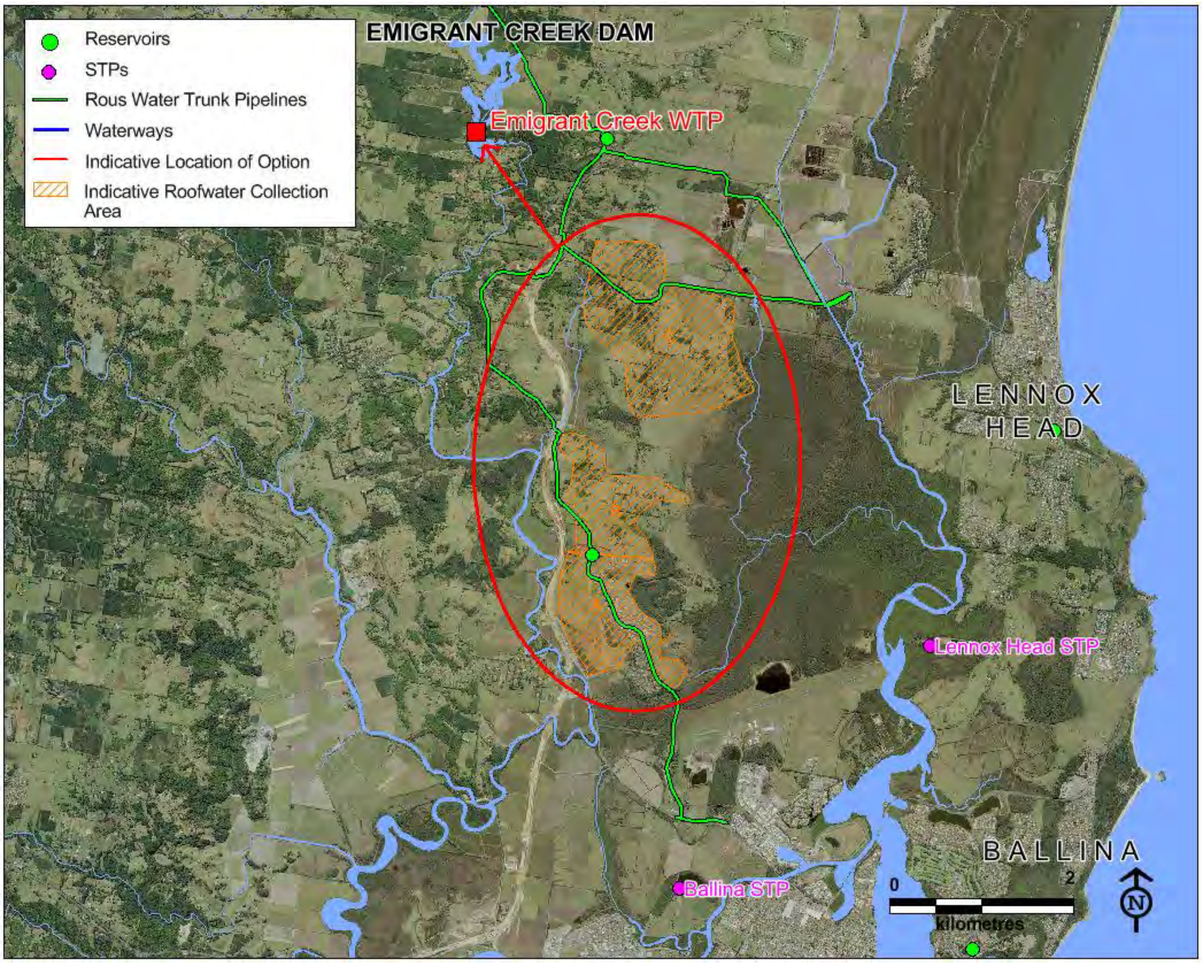



**Figure 5-5: Option B3 indicative collection area and transfer**

### 5.4.3 Additional yield

The additional (i.e. over and above the existing) secure yield from each stormwater harvesting option allowing for climate change impacts is shown in Table 5-3. The available yield from each catchment was determined using a daily water balance model which considered local climate conditions, runoff characteristics based on land use, catchment area and assumed storage volume. The additional yield was then estimated using the secure yield model (refer to Appendix C). The additional yield estimates take into account the impact of anticipated climate change on secure yield.

**Table 5-3: Stormwater options available supply estimates**

| Option | Additional yield (ML/a) | | |
|---|---|---|---|
| | Current | 2030 | 2060 |
| B1. Goonellabah Catchment | 600 | 500 | 400 |
| B2. Alstonville catchment A, B &C (Ballina) | 600 | 500 | 400 |
| B3. Ballina Cumbalum Ridge Developments A, B & C | 400 | 300 | 300 |

### 5.4.4 Benefits and constraints

The constraints and benefits associated with each option are provided in Table 5-4.

**Table 5-4: Stormwater harvesting options benefits and constraints**

| Option | Benefits | Constraints |
|---|---|---|
| B1. Goonellabah Catchment | Opportunity to use existing storage pond at Lismore University | Wilsons River Source is energy intensive.<br>Low yield compared to overall target (6% of required yield in 2060) |
| B2. Alstonville catchment A, B &C (Ballina) | Potential for aquifer recharge, potential opportunity to supplement recycle water reuse from Alstonville sewage treatment plant for new development.<br>Some environmental benefits from diverting runoff away from waterways | Low yield compared to overall target (6% of required yield in 2060)<br>Agricultural activities in catchment could increase the level of treatment required. |
| B3. Ballina Cumbalum Ridge Developments A, B & C | Cleaner source of stormwater, requiring less treatment compared to options B1 and B2 | Low yield compared to overall target (5% of required yield in 2060)<br>Roofwater harvesting collection network costs are high.<br>Ownership of roofwater- residents may want to use rainwater for their own purposes. |

### 5.4.5 Urban stormwater for 'non-potable' urban use and irrigation

Centralised stormwater harvesting for non-potable use involves a significant storage dam downstream of a new urban development area, with a dedicated treatment plant and a dedicated reticulation system to supply treated water for outside use and toilet flushing within the new urban development area. No specific non-potable stormwater harvesting options have been considered as part of the FWS as they are unlikely to generate sufficient volumes to contribute to Rous Water water supply deficit due to limited local demands for non-potable water supply.

Stormwater harvesting for non-potable use could still be developed at a localised level to off-set potable water demands e.g. rainwater tanks or local system.

To meet BASIX requirements it has been estimated that over 20,000 new dwellings will install rainwater tanks over the planning horizon (refer to Appendix B for more details on rainwater tank uptake). Rainwater is commonly used for toilet flushing, washing machines and irrigation. It is estimated that use of rainwater tanks for new development will reduce demand by an average of 400 ML/a over the planning horizon. Rous Water also has a rainwater tank rebate program for non-BASIX households which targets 100 installations a year resulting in a saving of approximately 70 ML/a on average over the planning horizon.

## 5.5 Recycled water

### 5.5.1 Indirect potable reuse

Indirect potable reuse (IPR) involves provision of a sophisticated treatment process, pumping station and transfer pipeline to deliver highly treated reclaimed water directly into an existing major storage dam or river (e.g. Rocky Creek Dam or Emigrant Creek Dam) or possibly a groundwater source through managed aquifer recharge (MAR), for subsequent extraction, treatment and transfer using existing infrastructure.

The development of recycled water options considers the following:

- Assessed current and future dry weather flows to STPs.
- Any planned recycled water allocations.

- Proximity to and use of existing STPs and existing water supply infrastructure, as well as demand centres.

All STPs operated by LWUs in the Rous Water water supply area were initially considered for IPR. Each of the STPs were screened for applicability based on the above criteria. Four IPR options were deemed to be suitable for further consideration and discussed with Rous Water staff. Option D3 combines wastewater from Alstonville STP with stormwater harvesting (option B3).

**Table 5-5: IPR options description**

| Option | Description | Location | Use |
|---|---|---|---|
| D1. East and South Lismore STP wastewater for indirect potable reuse- Staged | STP effluent would be treated to a high level before being transferred to the Wilsons River Source to supplement river flows when required. Additional treatment would occur at Nightcap WTP before being used for indirect potable reuse. This option can be staged. Potential for future yield increase. Public health and environmental risk management procedures are required, involving community consultation.<br>Infrastructure required includes advanced treatment (membrane filtration) followed by UV and disinfection, clear water tanks, upgraded power and other ancillaries, pumps and delivery mains. | East and South Lismore STP wastewater- currently discharged to Monaltrie Creek and Hollingsworth Creek | Supplement potable supply via transfer to Wilson's River Source |
| D2. Alstonville STP wastewater for indirect potable reuse | STP effluent would be treated to a high level before being transferred to Emigrant Creek Dam. Further treatment would occur at Emigrant Creek WTP before being used for indirect potable reuse. Potential for future yield increase. Opportunity for combining with stormwater harvesting (refer to Option D3). Public health and environmental risk management procedures required, involving community consultation.<br>Infrastructure required includes advanced treatment (membrane filtration) followed by UV and disinfection, clear water tanks, upgraded power and other ancillaries, pumps and delivery mains. | Alstonville STP wastewater- currently discharged to Maguire’s Creek | Supplement potable supply via transfer to Emigrant Creek Dam |
| D3. Alstonville STP wastewater for indirect potable reuse and stormwater harvesting | Treated STP effluent and stormwater collected from the Alstonville area would be transferred to Emigrant Creek Dam. The recycled water would then receive further treatment at Emigrant Creek WTP for indirect potable reuse. Provides for shared infrastructure and staging. Public health and environmental risk management procedures required, involving community consultation.<br>Infrastructure required includes advanced treatment (membrane filtration) followed by UV and disinfection, raw water pumps to collect stormwater from creeks, clear water tank, storage dam for stormwater, upgraded power and other ancillaries, pumping station and delivery mains. | Alstonville STP wastewater- currently discharged to Maguire’s Creek | Supplement potable supply via transfer to Emigrant Creek Dam |
| D4. Ballina and Lennox STP wastewater indirect potable reuse | Treated STP effluent would be transferred to Emigrant Creek Dam. The recycled water would then receive further treatment at Emigrant Creek WTP for indirect potable reuse. This option can be staged. Potential for future yield increase. Public health and environmental risk management procedures required, involving community consultation.<br>Ballina and Lennox STPs have recently been upgraded and will soon provide high | Ballina and Lennox STP. STP wastewater- currently discharged to North Canal Creek | Supplement potable supply via transfer to Emigrant Creek Dam |

| Option | Description | Location | Use |
|---|---|---|---|
| | quality recycled water for urban non-potable uses (through dual reticulation) and open space irrigation. This option relies on using treated wastewater not allocated in these schemes. This has been calculated based on anticipated available recycle water volumes.<br><br>Infrastructure required includes advanced treatment (membrane filtration) followed by UV and disinfection, clear water tanks, upgrades power and other ancillaries, pumps and delivery mains. | and Ocean at Skennars Head, respectively | |

### 5.5.2 Locations and interconnections

The location of the IPR options is shown in Figure 5-6, Figure 5-7 and Figure 5-8. Indicative pipeline routes and interconnections were identified and used to cost the options and for assessment of environmental constraints.

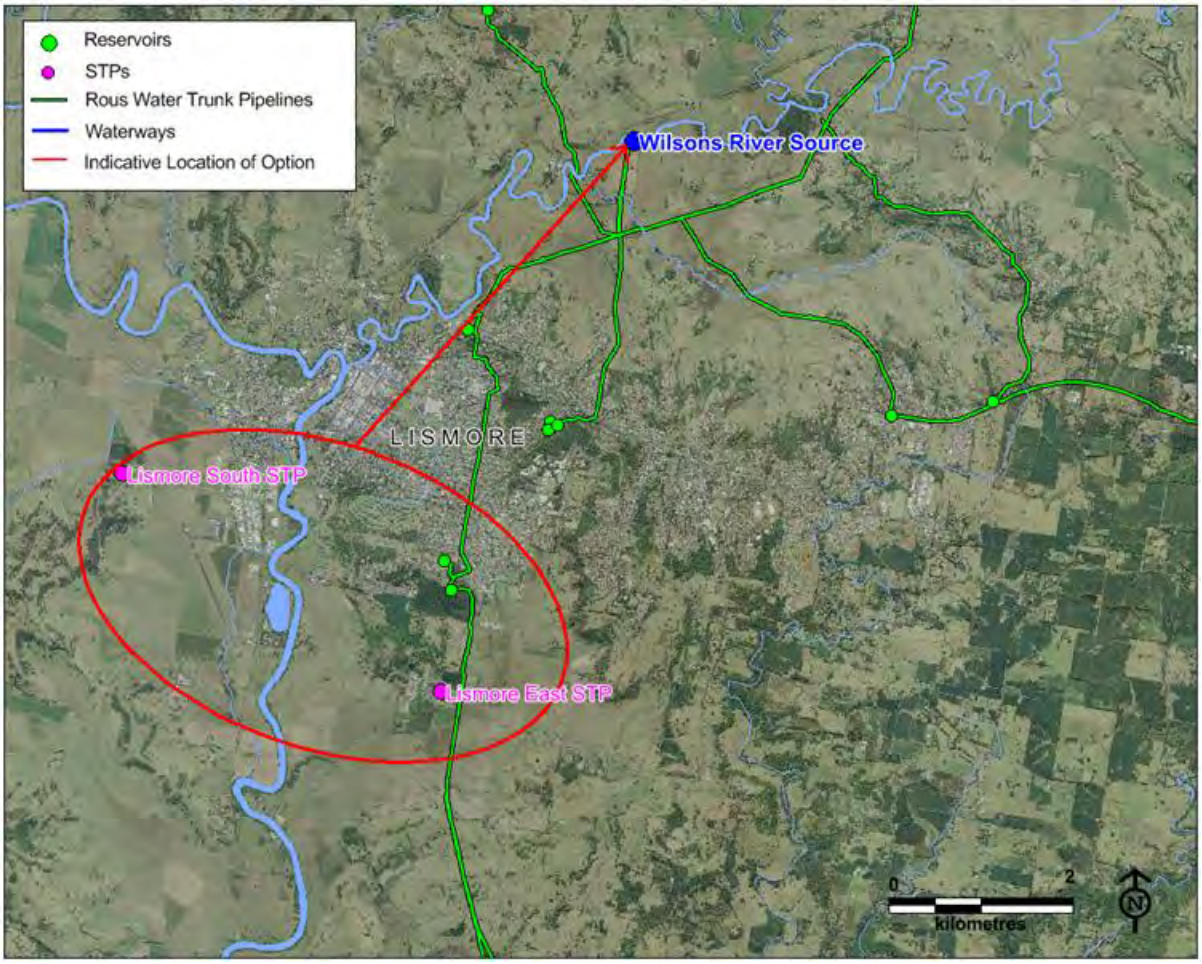



**Figure 5-6: Option D1 STP locations and transfer**

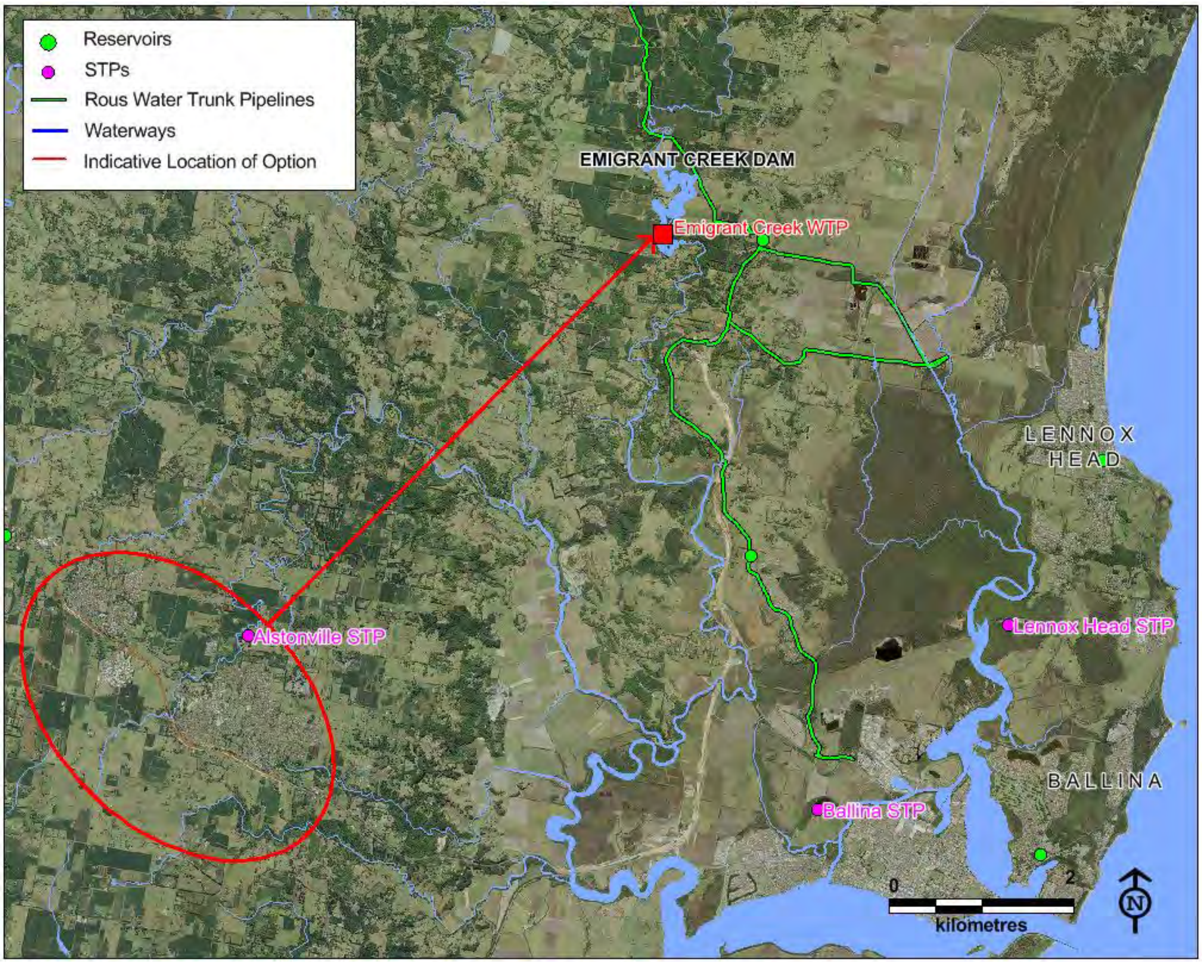



**Figure 5-7: Option D2 and D3 STP location and transfer**

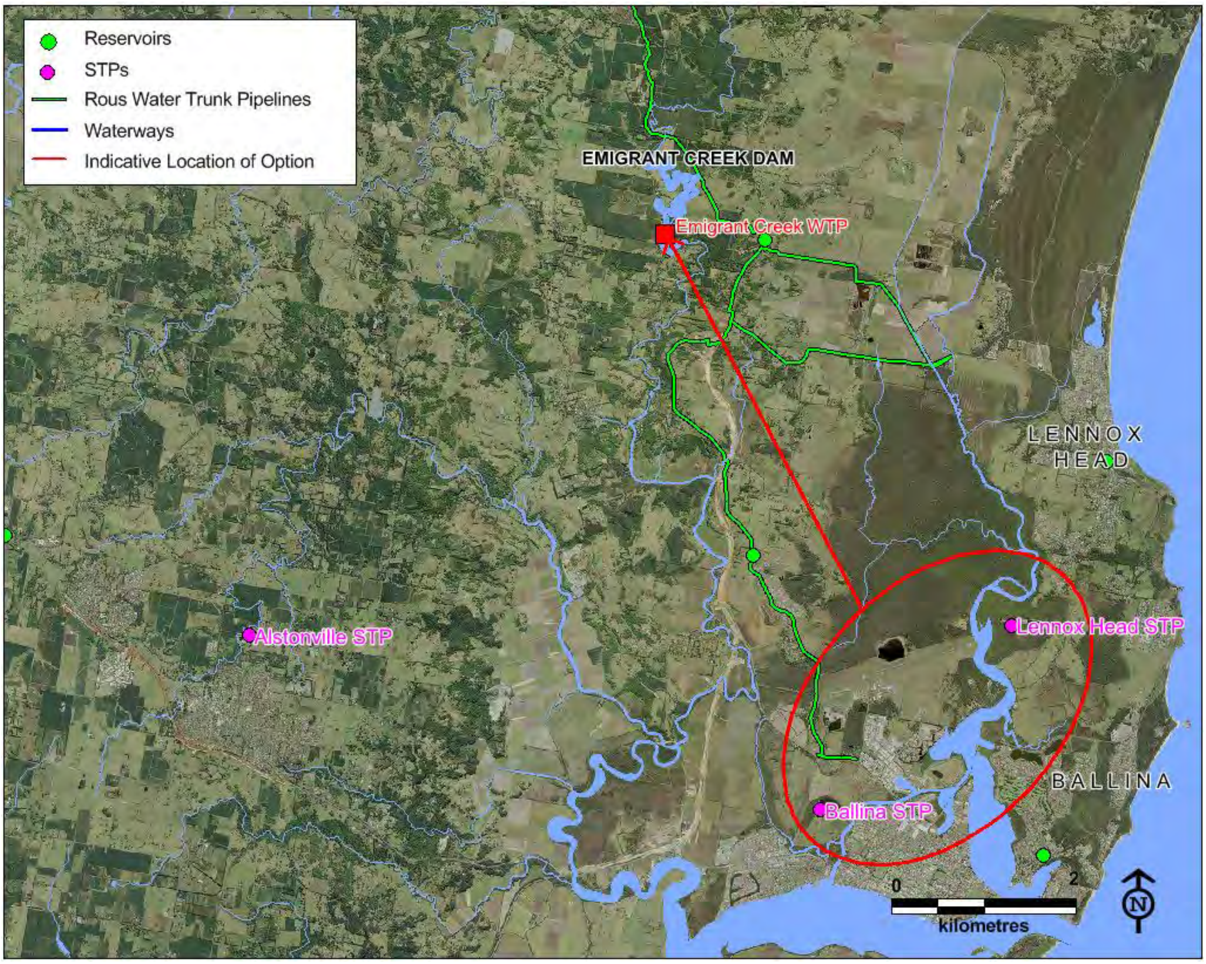



**Figure 5-8: Option D4 STP locations and transfer**

### 5.5.3 Additional yield

Additional supply estimates have been determined based on the average dry weather flow from each of the targeted STPs. The secure yield model was used to estimate the additional supply from each source taking into account climate change impacts (see Table 5-6). The additional yield increases in available treated effluent volume due to population increases however this is off-set by climate change which ultimately reduces the available yield.

**Table 5-6: IPR options additional yield estimates**

| Option | Additional yield (ML/a) | | |
|---|---|---|---|
| | Current | 2030 | 2060 |
| D1. East and South Lismore STP wastewater for indirect potable reuse- Staged | 2,700 | 2,900 | 1,900 |
| D2. Alstonville STP wastewater for indirect potable reuse | 700 | 1,200 | 600 |
| D3. Alstonville STP wastewater for indirect potable reuse and Stormwater harvesting | 1,300 | 1,700 | 1,000 |
| D4. Ballina and Lennox STP wastewater indirect potable reuse | 1,300 | 1,700 | 1,000 |

### 5.5.4 Benefits and constraints

The benefits and constraints associated with each of the IPR options are discussed in Table 5-6.

**Table 5-6: IPR options benefits and constraints**

| Option | Benefits | Constraints |
|---|---|---|
| East and South Lismore STP wastewater for indirect potable reuse- Staged | High yield<br>Can be staged<br>Beneficial reuse of treated wastewater | Wilsons River Source is energy intensive<br>Community acceptance use of recycled water in water supply<br>High ongoing costs |
| Alstonville STP wastewater for indirect potable reuse | Medium yield<br>Beneficial reuse of treated wastewater | EC WTP would need to be upgraded to cater for additional inflow<br>Community acceptance use of recycled water in water supply<br>High ongoing costs |
| Alstonville STP wastewater for indirect potable reuse and Stormwater harvesting | Low annualised cost<br>Shared infrastructure<br>Beneficial reuse of treated wastewater | Low yield compared to overall target<br>EC WTP would need to be upgraded to cater for additional inflow<br>Community acceptance use of recycled water in water supply<br>High ongoing costs |
| Ballina and Lennox STP wastewater indirect potable reuse | Medium yield<br>Close to major demand centres<br>Beneficial reuse of treated wastewater | EC WTP would need to be upgraded to cater for additional inflow<br>Recycled water from these STPs is already allocated for dual reticulation and open space irrigation.<br>Community acceptance use of recycled water in water supply<br>High ongoing costs |

### 5.5.5 Recycling of reclaimed water for non-potable urban use

Recycled water for non-potable use involves provision of further treatment of reclaimed water produced by a sewage treatment plant, and provision of a pumping station, transfer pipeline and dedicated reticulation system to deliver treated reclaimed water for outside use and toilet flushing within new urban development areas. As with non-potable use of stormwater, non-potable recycled water schemes are unlikely to significantly contribute to the Rous Water water supply because of limited localised demand for non-potable water due to low external use and thus have not been considered in the FWS.

All new residential development in the Lennox and Cumbalum development areas of Ballina Shire will be serviced with recycled water for irrigation, toilet flushing and washing machines (cold tap). This has been factored into the baseline water demand forecast. Other localised schemes could also be implemented by developers/LWUs to further off-set potable water demands and form part of individual LWU demand management plans.

## 5.6 Groundwater

Background information on the hydrology, geology, hydrogeology and groundwater dependence of ecosystems within the Rous Water catchments is summarised in a document entitled 'The Future Water Strategy; Groundwater Options Position Paper' (Parsons Brinkerhoff, 2011).

An investigation has been undertaken as part of this study which provides a more detailed assessment of the potential groundwater sources that are most likely to significantly augment Rous Water's future water supplies (see Appendix F).

The potential groundwater sources may be grouped into three broad subdivisions; enhancement and maximisation of existing groundwater sources, identification and exploitation of new groundwater supplies from suitable aquifers, and the potential use of managed aquifer recharge (MAR), for example irrigation or injection of suitably treated water or effluent, for storage and later abstraction.

### 5.6.1 Existing bores

Rous Water currently operate five groundwater bores, two bores on the Alstonville Plateau at Lumley Park and Convery's Lane and three bores in the coastal sand aquifer at Woodburn. These bores are generally only operated during droughts and have a combined licensed volume of approximately 922 ML per year. Ballina bores are also used during drought. As discussed in Appendix F, Convery's Lane should not be relied on except for low volumes during drought periods, and it may be preferable to decommission the well and trade the licence for a new, better performing well in a more robust aquifer where permitted by the Water Sharing Plan (WSP). Lumley Park has the potential to provide a reasonable yield and should be tested to ascertain sustainable supply limits. Woodburn Bores will need to be relocated to cater for the Pacific Highway upgrade.

### 5.6.2 New water sources

Three potential sources for new groundwater sources were identified taking into consideration the likely yield of bores, licensing requirements and the groundwater quality of the various aquifers in the study area. The options for increasing groundwater supply are

- Coastal Sands,
- Fractured Basalt, and
- Kangaroo Creek Sandstone.

Kangaroo Creek Sandstone is not recommended for further consideration. Proven yields and water quality are generally only moderate however and there is little evidence that this or other local aquifers could sustain the volumes that would contribute significantly to Rous Water's Future Water targets (see Appendix F for further justification).

### 5.6.3 Managed aquifer recharge

MAR is the intentional recharge of an aquifer under controlled conditions, either by injection or infiltration, in order to store a water source for later abstraction and use (indirect reuse), or for environmental benefits. In coastal sand aquifers, MAR schemes generally involve injection or irrigation of surplus water into them and then re-abstraction of the water when it is required. In hard-rock aquifers, MAR schemes generally use direct injection of waters (e.g. summer excess from local surface waters or treated stormwater or effluent) via boreholes screened in confined aquifers with sufficiently high permeability.

While no specific MAR opportunities have been identified for inclusion in the FWS, the potential exists for stormwater harvesting and/or effluent reuse MAR applications.

### 5.6.4 Criteria

Groundwater is typically accessed by discrete abstraction points, either bores or springs. Key criteria used to determine suitable locations for new bores in groundwater options include:

- New bores must be sited a minimum distance of 500 m from existing licensed irrigation bores and 400 m from an existing NOW monitoring bores. These distance constraints are in accordance with current NSW licensing requirements for this study area.

- Distance from rivers and identified groundwater dependent ecosystems. A minimum distance of 40 m from the nearest stream or recognised Groundwater Dependent Ecosystems (GDE) is assumed and this correlates to the recommendations from NOW (Parsons Brinkerhoff, 2011).
- General and high level consideration of the known areas of demand and infrastructure constraints.
- Embargoed areas (Zones 1 & 2 of the Alstonville WSP) and unsuitable aquifers were excluded.

These criteria were applied and four potential groundwater sources have been identified (two in the coastal sands and two in fractured basalt). Table 5-7 considers these new sources in addition to the use of existing groundwater sources.

**Table 5-7: Groundwater options description**

| Option | Description | Location | Use |
|---|---|---|---|
| F1. Maximise Existing Sources | Lumley Park and Convery's Lane bore are excluded from further analysis as advised by Rous Water. They have unreliable yield and require additional treatment to address water quality issues. Consider transferring licence for Convery's Lane bore to new area where permitted by WSP.<br>Relocate Woodburn bores and treatment facilities to allow for highway upgrade.<br>Infrastructure required includes new borefields (pump and well), treatment facilities (conventional water treatment), headwork infrastructure, storage reservoir, transfer pumping station and transfer mains. | Fractured basalt<br>Coastal sands (existing licence) | Transfer treated water to nearby reservoirs |
| F2. Coastal Sands | New shallow bore fields would be developed in the Coastal Sands aquifer. Water treatment facilities and transfer system to nearby reservoirs to be provided. Requires exploratory drilling and testing (current quality and quantity) and modelling assessment of the sustainability of quality and quantity, and impacts on receptors, e.g. groundwater dependent ecosystems (GDEs). Opportunity for staging and increased yields. New extraction licences required. A request has been made by Rous Water to allocate 5,000 ML/a for town supply as part of the new coastal sands water sharing plan[4].<br>Infrastructure required includes new borefield (pumps and wells), treatment facilities (conventional water treatment), monitoring wells, headwork infrastructure, storage reservoir, transfer pumping station and transfer mains. | Groundwater (coastal sands) - close to Ballina | Nominated connection point: Pine Av Reservoir (5km max) |
| | | Groundwater (coastal sands) - close to Byron | Nominated connection point: St Helena Reservoir (7km max). |
| F3. Fractured Basalt | New deep bore fields would be developed in the Fractured Basalt aquifers. Water treatment facilities and transfer system to nearby reservoirs to be provided. Requires exploratory drilling and testing (quality and quantity), hydrogeological assessment of sustainability and consideration of groundwater dependent ecosystems. Opportunity for staging and increased yields. Extraction licences required.<br>Infrastructure required includes new borefields (pump and well), treatment facilities (conventional water treatment), headwork infrastructure, storage reservoir, transfer pumping station and transfer mains. | Groundwater (fractured basalt) - north of Emigrant Creek Dam | Connection to adjacent pipeline. |
| | | Groundwater (fractured basalt) - South of Rocky Creek Dam | Connection to adjacent pipeline. |

[4] Licence allocation and available yield can be different

### 5.6.5 Locations and interconnections

The location of each of the groundwater options is shown in Figure 5-9. The locations are indicative only. Further exploration and assessment is required before the locations can be defined. Indicative pipeline routes and interconnection points have been determined for costing purposes and for assessment of environmental constraints.

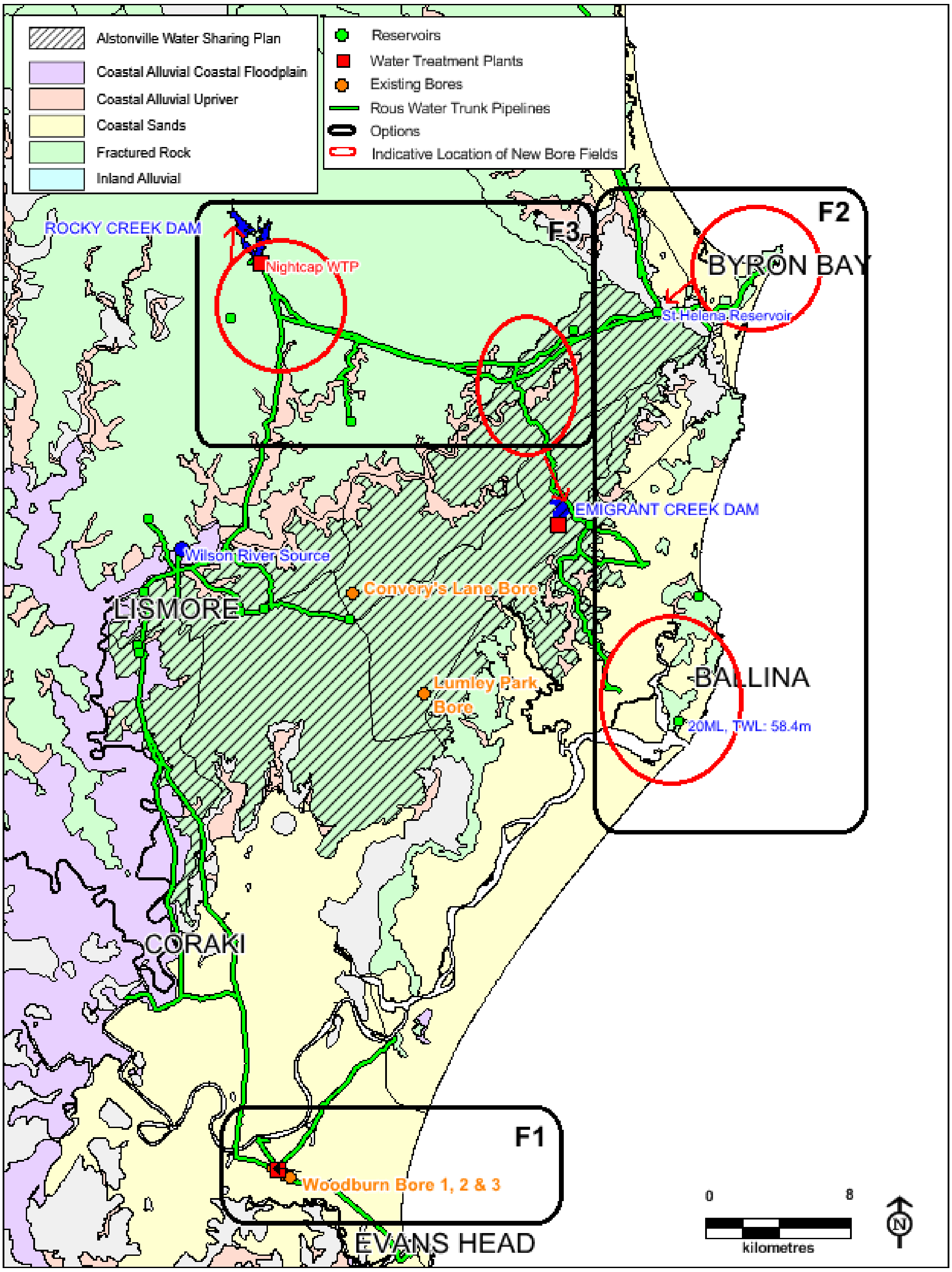



**Figure 5-9: Existing bores and potential groundwater option locations**

### 5.6.6 Additional yield

Preliminary yields are based on interpretation of available data (Appendix F and (Parsons Brinkerhoff, 2011)). Proving of sources is required and may result in significantly different yields being obtained due to aquifer characteristics and/or abstraction impacts on receptors, e.g. other groundwater users and environmental flows.

The likely impact of potential climate change on groundwater sources is not well researched. Latest research suggests deep aquifers may be less impacted than shallow aquifers. Changes to aquifer recharge rates are likely to be important and require site by site assessment. As a starting point for this study, it is assumed that secure yield climate change reductions for groundwater sources are the same as those for surface sources.

**Table 5-8: Groundwater options - additional yield estimates**

| Option | Additional yield (ML/a) | | |
|---|---|---|---|
| | Current | 2030 | 2060 |
| F1. Maximise Existing Sources | 640 | 500 | 400 |
| F2. Coastal Sands | 2,000 | 1,700 | 1,300 |
| F3. Fractured Basalt | 1,200 | 1,000 | 800 |

### 5.6.7 Benefits and constraints

The benefits and constraints associated with each of the groundwater options are described in Table 5-9.

**Table 5-9: Groundwater options constraints and benefits**

| Option | Benefits | Constraints |
|---|---|---|
| F1. Maximise Existing Sources | Existing licence<br>Approvals and licensing process is well-defined<br>Low power consumption<br>Low annualised cost | Uncertain water quality and supply yield<br>Remote from main demand centres<br>Needs to be moved as part of Pacific Highway upgrade - however this has been budgeted for<br>Low yield (6% of additional yield required) |
| F2. Coastal Sands | Close to growth centres and existing supply network<br>Excellent water quality sources exist, however, investigation and consideration of ASS is required<br>Flexibility in staging to match variations in demands<br>Easily integrated into existing water supply infrastructure<br>Low power consumption<br>Low annualised cost<br>Medium yield (20% of additional yield required) | Uncertain water quality and supply yield<br>Land is more intensively used in these areas, making sustainable abstraction more difficult<br>The sustainability of a coastal aquifer bore field on the north coast will be constrained by the ways that it is connected to GDEs, by the risks of oxidising potential acid sulphate soils and of inducing increased saline intrusion into the aquifer.<br>The water sharing plan is currently being developed. |
| F3. Fractured Basalt | Close to growth centres or existing supply system<br>Approvals and licensing process is well-defined. | Uncertain water quality and supply yield<br>Generally deeper aquifers and higher drilling costs compared to coastal sands |

| Option | Benefits | Constraints |
|---|---|---|
| | Excellent water quality sources exist.<br>Low power consumption<br>Low annualised cost<br>Opportunity to consider use of existing treatment facilities<br>Medium yield (12% of additional yield required) | The water sharing plan is currently being developed. |

## 5.7 Desalination

Desalination is the process whereby salt and other minerals are removed from water. Desalination enables ocean water or brackish (i.e. moderately salty) groundwater or river water to be converted to fresh water that is suitable for potable use. Various processes can be used in desalination plants however in recent years reverse osmosis (RO) has become the dominant process in Australia. This is mainly due to lower energy consumption compared to other processes (Geolink, 2011).

Desalination of marine water, estuarine water or saline groundwater can provide significant quantity of water to the region's major urban areas. Desalination plants can be staged in modules with capacities of say 5 ML/day and augmented as required. It is also a relatively climate change resilient water source. It does however have significant power requirements and brine management constraints, and associated environmental and social considerations.

Key considerations in developing desalination options include:

- Conclusions from previous studies including 'Preliminary Feasibility Assessment of Desalination as a Water Supply Option' (Geolink, 2011).
- Land zoning.
- Proximity to power sources and system capacities.
- Proximity to trunk mains and water transfer infrastructure.
- Source water quality.
- Brine discharge point use of existing outfall or STP discharge if available.

The 'Preliminary Feasibility Assessment of Desalination as a Water Supply Option' report identified three potential desalination scenarios for the Rous Water supply area. With regards to potential locations only general localities were identified. Specific parcels of land were not identified or assessed for the location of the desalination plant or associated infrastructure. The following localities and sources of feed water were selected:

- Scenario 1- Tyagarah (marine feed water).
- Scenario 2 - Lennox Head (groundwater feed water).
- Scenario 3 – South Ballina (estuarine feed water).

Treatment of saline groundwater is an unlikely option in lieu of the potential non-saline groundwater options available. Estuarine sources in the Richmond River have been assessed. No significant advantages over ocean water sources were identified when considering suitable locations, distance to demand centres and treatment needs. Estuarine water also has additional treatment requirements due to high turbidity.

Two marine desalination options are tabled (Table 5-10). The South Ballina sub-option could draw on estuarine water if it proved advantageous.

**Table 5-10: Desalination options description**

| Option | Description | Location | Connection |
|---|---|---|---|
| G1. Tyagarah | Desalination of ocean water extracted via a sub-surface beach well system at Tyagarah Beach to augment water supply. The plant would be staged with brine discharge via a new ocean outfall. The plant would best operate continuously. Opportunity to size to meet full supply deficit range. Renewable power is to be sourced.<br>The key infrastructure associated with this scenario includes:<br>• Beach well intake system, consisting of a horizontal collector well system beneath Tyagarah Beach<br>• Pumping station and pipeline to transfer the feed water from the intake system to the desalination plant<br>• Desalination plant to remove salt and other minerals from the water and produce fresh, desalinated water<br>• Pumping system and pipeline to transfer the desalinated water from the plant to the connection point into the existing water reticulation network.<br>• Discharge pipeline extending from the desalination plant to Tyagarah Beach and out into the ocean to the discharge location. | Marine water extraction at Tyagarah Beach. | Approximately 2 km to existing Rous Water bulk supply pipelines (300 mm) or Brunswick Head reservoirs |
| G2. South Ballina | Desalination of ocean water extracted via a sub-surface beach well system at South Ballina to augment water supply. The plant would be staged. Brine discharge via new ocean outfall or river. The plant would best operate with limited excess capacity on a semi-continuous basis. Opportunity to stage sizing to meet full supply deficit range and draw on estuarine water. Renewable power source is to be sourced. Potential to trigger Commonwealth EIS requirements (EPBC) and complicated approvals.<br>The key infrastructure associated with this scenario includes:<br>• Beach well intake system, consisting of a horizontal collector well system beneath South Ballina.<br>• Pumping station and pipeline to transfer the feed water from the intake system to the desalination plant.<br>• Desalination plant to remove salt and other minerals from the water and produce fresh, desalinated water.<br>• Pumping system and pipeline to transfer the desalinated water from the plant to the | Marine water extraction to the south of Ballina | Approx. 5km away from Pine Av Reservoir and would require crossing of the Richmond River |

| Option | Description | Location | Connection |
|---|---|---|---|
| | connection point into the existing water reticulation network. Crossing of Richmond River required.<br><br>Discharge pipeline extending from the desalination plant to South Ballina and out into the ocean to the discharge location.(potential to discharge into Richmond River). | | |

### 5.7.1 Locations and interconnections

Indicative locations and interconnections for the desalination options are shown in Figure 5-10.

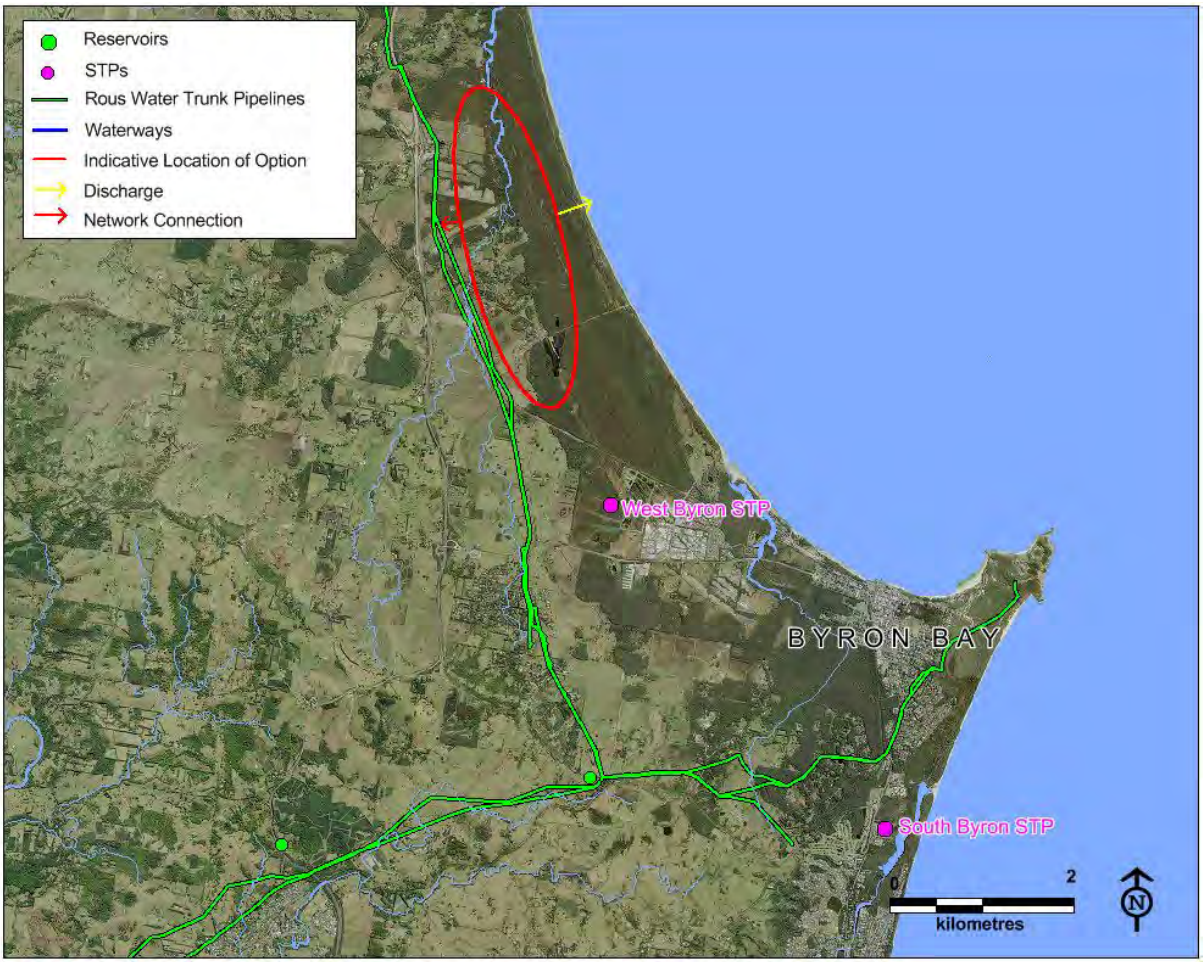



**Figure 5-10: Indicative location and layout for desalination Option G1**

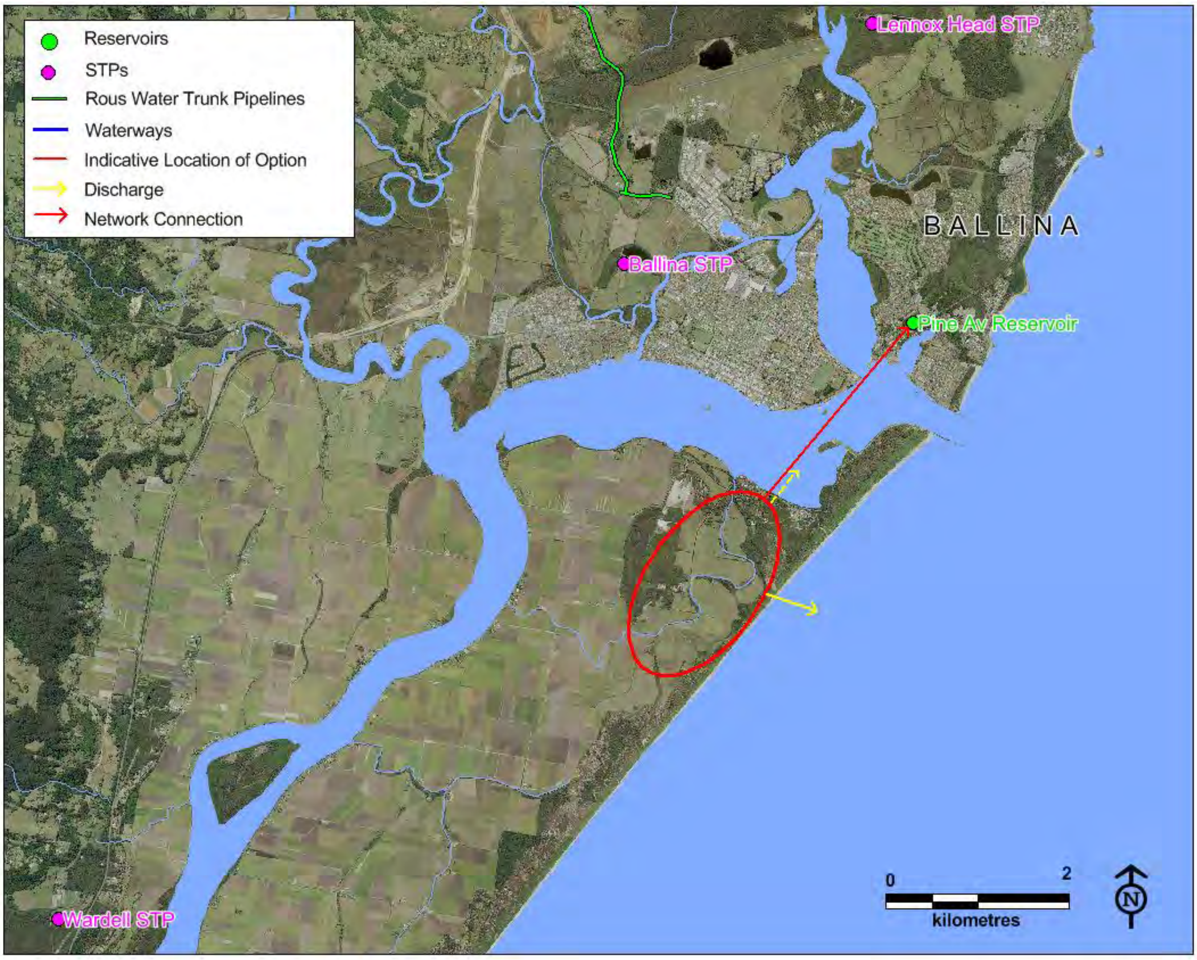



**Figure 5-11: Indicative location and layout for desalination option G2**

### 5.7.2 Additional yield

The desalination plants have been sized to meet the full supply/demand deficit in 2060. The plants will be staged in modules of 5 ML/day. This is a practical size which allows for modular expansion. The plants are assumed to run continuously and contribute to base load demand. The plants have been sized to account for the proportion of inflow which is rejected as brine.

### 5.7.3 Benefits and constraints

The benefits and constraints associated with each of the desalination options are described in Table 5-11.

**Table 5-11: Desalination options constraints and benefits**

| Option | Benefits | Constraints |
|---|---|---|
| G1. Tyagarah | Flexibility in staging to match variation in demands.<br>Virtually limitless and permanent supply<br>Relatively flat topography | Ongoing energy usage for this type of treatment is high but potentially can be offset by employing renewable resources at additional cost.<br>Low lying areas are flood prone<br>Pipeline to coast passes through Tyagarah Nature Reserve<br>Byron Bay Marine Park is located offshore and the marine feedwater intake and brine disposal and could be contrary to the objects of the Marine Park.<br>Potential conflict with tourism industry of Byron Bay |

| Option | Benefits | Constraints |
|---|---|---|
| | | (temporary offshore rig may decrease amenity of Byron/ Belongil Beach)<br>High ongoing operations cost. |
| G2. South Ballina | Flexibility in staging to match variation in demands.<br>Virtually limitless and permanent supply<br>Relatively flat topography | Ongoing energy usage for this type of treatment is high but potentially can be offset by employing renewable resources at additional cost.<br>Potential quality issues due to proximity to Richmond River mouth.<br>Known habitat of threatened species in in the district (Pied Oystercatcher)<br>Low lying areas are flood prone<br>Need for major river crossing of the Richmond River. Has been allowed for in option configuration and costing.<br>High ongoing operations cost. |

## 5.8 Proposed Dunoon Dam

Rous Water has resolved to build Dunoon Dam if and when it is needed to secure supply. The new dam would located downstream of the existing Rocky Creek dam and provide up to 50,000 ML storage. Water would be transferred to Nightcap WTP for treatment. Infrastructure required includes dam construction, transfer pumping station and mains, roads and land acquisition.

Studies indicate that Dunoon Dam is technically viable, but with significant environmental and social constraints associated with threatened and endangered terrestrial ecology and cultural significant Aboriginal heritage. State significant infrastructure with State Minister approval required and Rous Water is currently conducting detailed investigations of Dunoon Dam.

### 5.8.1 Location

An aerial photo showing the full water level of the proposed Dunoon Dam relative to Rocky Creek Dam is shown in Figure 5-12.

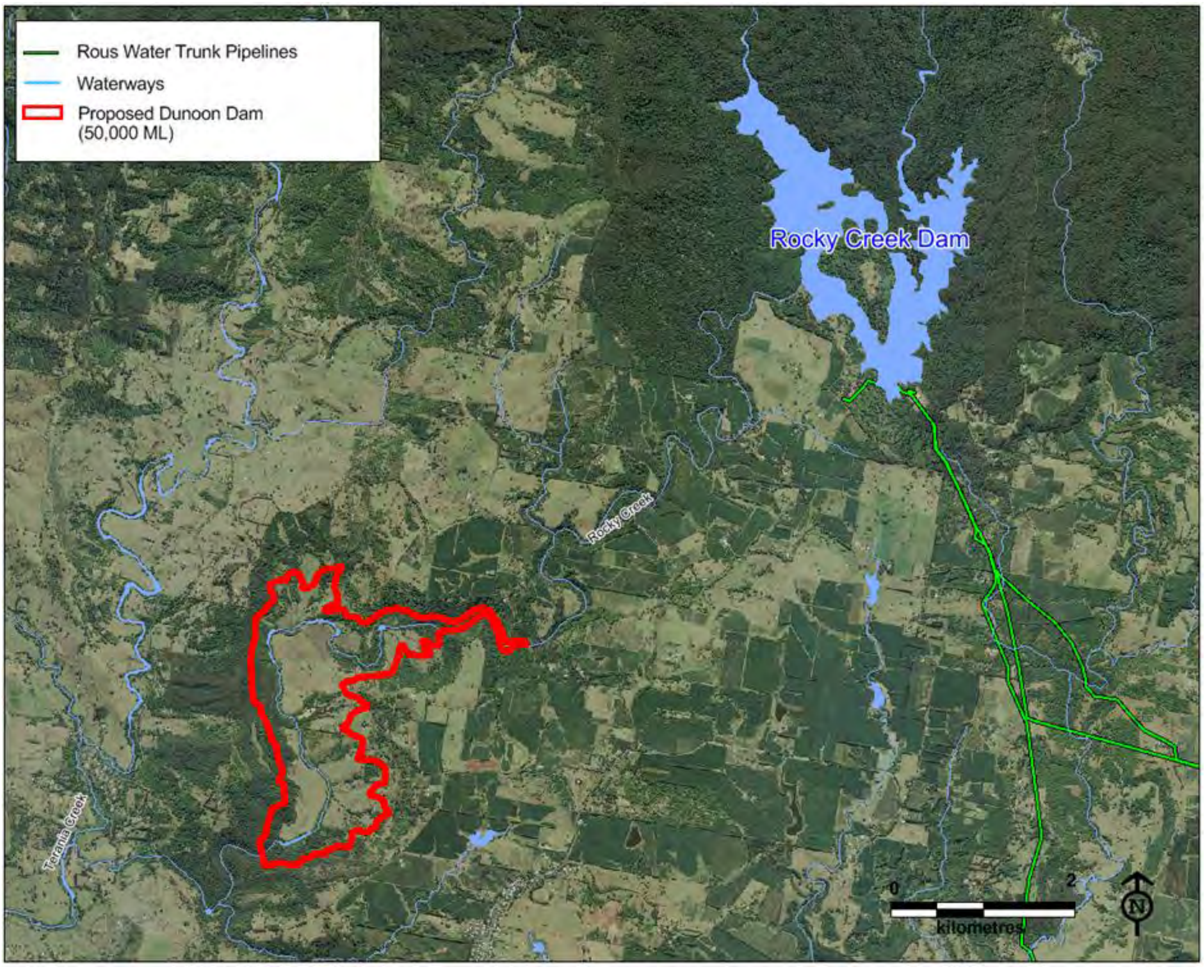



**Figure 5-12: Dunoon Dam location**

### 5.8.2 Additional yield

The results of the secure yield modelling including climate change impacts for the 50,000 ML dam is shown in Table 5-12.

**Table 5-12: Dunoon Dam additional yield**

| Additional yield (ML/a) | | |
|---|---|---|
| Current | 2030 | 2060 |
| 20,000 | 17,500 | 11,300 |

### 5.8.3 Benefits and constraints

The constraints and benefits associated with Dunoon Dam are shown in Table 5-13.

**Table 5-13: Dunoon Dam constraints and benefits**

| Benefits | Constraints |
|---|---|
| Estimated to exceed supply deficit in 2060 – no need to rely on multiple water sources | High capital cost |

| Benefits | Constraints |
|---|---|
| Many detailed investigations and robust costing estimates<br>High level of understanding about option. Numerous studies have been undertaken<br>Council resolved approach – has achieved a certain level of acceptance at both a Council and PRG level<br>Can utilise Nightcap WTP<br>Most of the land required is under Rous Water ownership | Significant environmental and social impacts<br>Highly climate influenced (up to 45% reduction in secure yield in 2060 predicted) |

## 5.9 Regional interconnections – Toonumbar Dam

This option involves the gradual purchase of general security licences from Toonumbar Dam supply area within the Richmond River Regulated Source. Rous Water would then seek conversion to town supply licence with review of the WSP when permitted (post Dec 2020). Raw water would be piped to the augmented Casino WTP. Treated supply would then be pumped to the Rous Water system at South Lismore.

### 5.9.1 Additional supply

Little information is available on secure yield. An early study (NSW Public Works, 1994) provides limited information on the 5/10/20 case but does not allow for current users (including environmental flows). To allow consideration of this approach in this study a number of significant assumptions are made (Table 5-14):

- 10% and 25% of the total volumetric allocation is purchased by Rous Water in 2030 and 2060, respectively.
- All allocations are converted to high security (town supply).
- No environmental flow allowance is required.
- The 5/10/20 secure yield to 5/10/10 (historic and future) secure yield ratios is the same as Rocky Creek Dam system.

**Table 5-14: Secure yield estimate Toonumbar Dam – modify WSP**

| Additional yield (ML/a) | | |
|---|---|---|
| Current | 2030 | 2060 |
| N/A<br>(2020 licence conversion) | 500 | 1,000 |

### 5.9.2 Benefits and constraints

The benefits and constraints associated with this option are shown in Table 5-15.

**Table 5-15: Benefits and constraints**

| Benefits | Constraints |
|---|---|
| Makes use of an existing high quality water source | Dependent on sale of existing irrigation licences. Potential to impact local livelihoods.<br>Available secure yield unknown.<br>Dependent on conversion of licence types |

| Benefits | Constraints |
|---|---|
| | and regulator approval.<br>Changes to the WSP are only permitted after 2020. |

## 5.10 Regional water supply options

Regional issues and opportunities were considered through alignment with the *Northern Rivers Regional Bulk Water Supply Study* that is under development at the same time as the FWS. The Regional Bulk Water Supply Study was developed by the Northern Rivers Regional Organisation of Councils to consider a 50 year water supply strategy for the wider region comprising local water supplies for:

The two studies are complementary, with each strategy identifying demand management, water loss management, wastewater re-use, groundwater, surface water and desalination as key opportunities for securing water supplies within the region.

Ongoing collaborative development of both strategies will ensure that future supply augmentation can occur in a considered and appropriate manner.

Marine water desalination was recommended as the most viable augmentation option in the draft report (Hydrosphere, 2013). The proposed scheme relies on existing surface water storages and minor groundwater supplies and would be supplemented by treated water from a new marine desalination facility (staged up to 70 ML/day), potentially located between Ocean Shores and Pottsville. This option is considered in this report as a potential regional supply option. Other options identified are considered as being complementary and have not been separately analysed.

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.

### 5.10.1 Locations and interconnections

The location and interconnections with the existing network are shown in Figure 5-13. This figure has been sourced from the draft NOROC Regional Supply report (Hydrosphere, 2013).

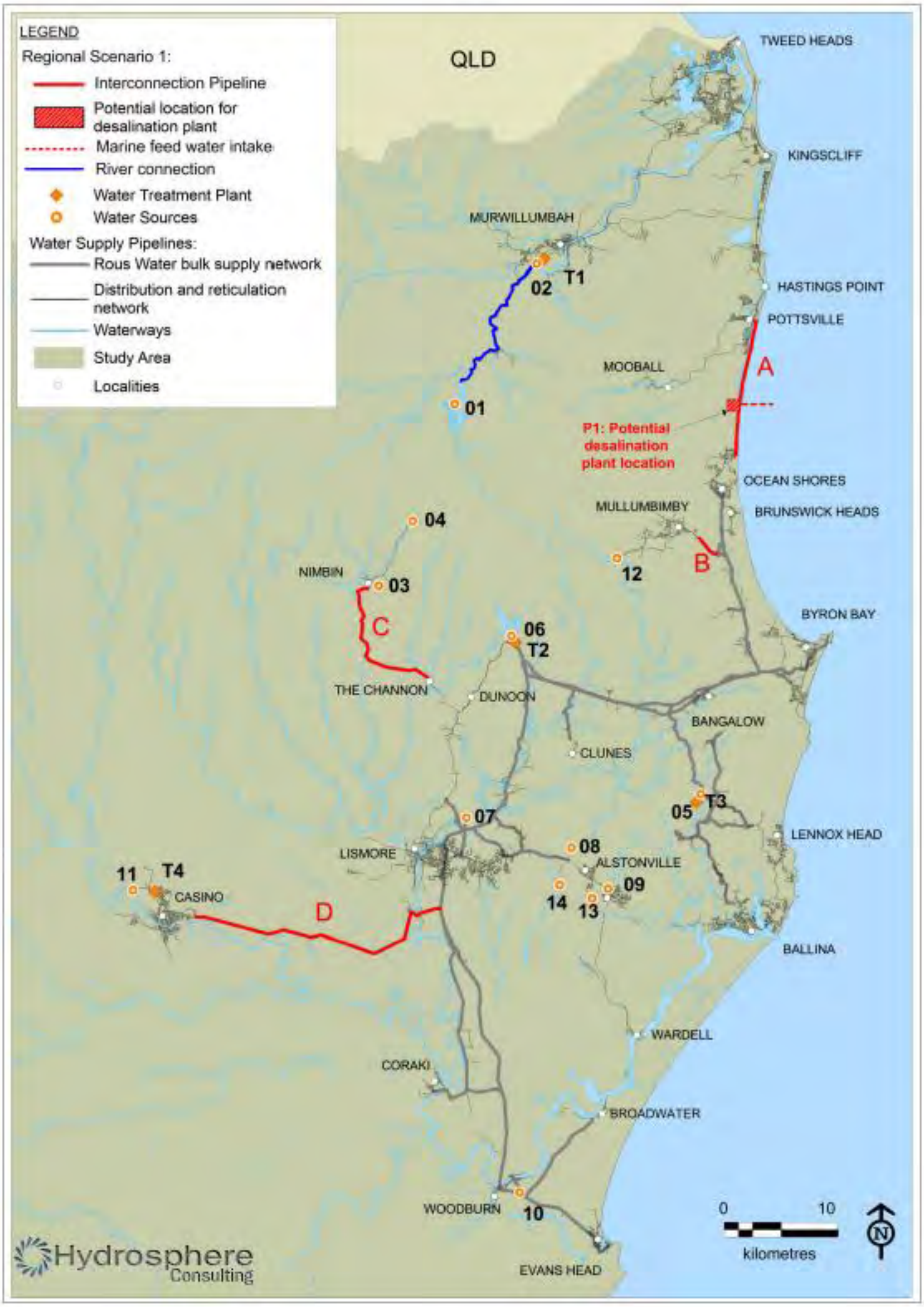



**Figure 5-13: Regional desalination option**

### 5.10.2 Additional yield

To enable comparison with other water local water supply options, the size and additional supply from the regional desalination plant has only considered the component of demand servicing the Rous Water supply area based on the average day demand (16.5 ML/day). The yield from the desalination plant is therefore 6,000 ML/a.

### 5.10.3 Benefits and constraints

The constraints and benefits associated with regional desalination are discussed in Table 5-16.

**Table 5-16: Regional desalination benefits and constraints**[5]

| | Benefits | Constraints |
|---|---|---|
| Regional desalination | Multiple stages are possible: A desalination facility is easily constructed in stages to meet demand.<br>Significant initial infrastructure cost but highly scalable thereafter.<br>The desalination facility provides a new source that is drought resistant and independent of existing sources.<br>Potential to minimise impacts and approval requirements at a single site in the region. | High capital costs<br>High energy consumption<br>Potential to trigger Commonwealth EIS requirements (EPBC) and complicated approvals.<br>Relies on joint management and financing arrangements.<br>Specialised personnel skills required for plant operation. |

## 5.11 Revised water restrictions

This option considers the adoption of a reduced security of supply level of service (LoS) compared to the agreed NOW guideline of 5/10/10. This is estimated to result in increased frequency, duration and severity of enforced water supply restrictions. Two reduced LoS are considered: 10/15/15 and 10/20/40 (Table 5-17). The reduced LoS represent a 20% and 40% reduction in consumption in during drought periods, respectively. Refer to Appendix C for detailed modelling outputs.

**Table 5-17: Revised water restrictions**

| LoS | Extra yield (ML/a) | Average duration (months) |
|---|---|---|
| 5/10/10 | 0 | 2.7 |
| 5/15/15 | 1,100 | 2.7 |
| 10/20/40 | 3,300 | 3.3 |

### 5.11.1 Benefits and constraints

Increased restrictions allow for the deferral and downsizing of supply infrastructure. However these options will impact to the local economy, user amenity and water utility costs. Extended societal costs are likely but remain difficult to estimate.

Table 5-18 describes some of the benefits and constraints.

[5] Adapted from (Hydrosphere, 2013)

**Table 5-18: Benefits and constraints associated with revised restrictions**

| Levels of service | Benefits | Constraints |
|---|---|---|
| 5/15/15 | The reduced *level of service* may delay and potentially downsize infrastructure requirements | The secure yield *level of service* falls short of the NSW government recommendation (i.e. is a lower level of service than provided elsewhere).<br>Restrictions - more frequent, longer duration and increased level (similar to restriction level 2).<br>Increased cost of enforcement and advertising, loss of revenue (to utility) and community impacts (economic and amenity). |
| 10/20/40 | The reduced *level of service* may delay and potentially downsize infrastructure requirements | Difficulty/risk is achieving such a high reduction.<br>Same as for 5/15/15 plus:<br>Loss of amenity, recreation and health benefits from public parks and sportsgrounds<br>Decreased sales/employment from goods or services that are restricted<br>Increased financial cost to outdoor water using businesses whose core activities are restricted<br>Cost to restore public and private gardens after restrictions. |

## 5.12 Raising Rocky Creek Dam

The potential for raising the existing Rocky Creek Dam was identified and assessed as part of the coarse screening exercise. It was initially found to be unviable by the PRG during the coarse screening phase however has been reconsidered in this study at the request of Rous Water.

Rocky Creek Dam was completed in 1953 and predates current requirements for environmental flow releases. If Rous Water were to undertake augmentation works to increase the capacity of the existing dam, the need for environmental flow releases would be triggered. This significantly reduces the secure yield of the augmented dam.

### 5.12.1 Sizing and additional yield

Table 5-19 compares the existing Rocky Creek Dam with an 8 m raising of the existing dam wall. This is the highest possible raising without the need to extend the existing dam wall across the existing spillway (NSW Public Works, 1994) and develop a new spillway. The 8 m raising was chosen in an effort to offset the impact of environmental flow releases.

**Table 5-19: Statistics for existing and raised Rocky Creek Dam**

| Statistic | Existing | Raised | Variance |
|---|---|---|---|
| Height of dam wall | 28 m | 36 m | 8 m |
| Surface area | 194 ha | 284 ha | 90 ha |
| Storage volume | 14,000 ML | 33,600 ML | 19,600 ML |

| Statistic | Existing | Raised | Variance |
|---|---|---|---|
| Proposed Environmental flow requirement | Nil | Fully transparent releases up to 110 ML/d | |

Table 5-20 shows the additional yield from raising Rocky Creek by 8 m.

**Table 5-20: Additional yield including climate change impacts**

| Option | Current | 2030 | 2060 |
|---|---|---|---|
| Raise Rocky Creek Dam | 1,500 ML | 1,700 ML | 0 (due to combined impact of climate change environmental flow releases) |

### 5.12.2 Benefits and constraints

An 8 m rising would increase the surface area of Rocky Creek Dam by approximately 90 ha (Table 5-19). This is likely to impact a large portion of high conservation value ecological communities and would require significant clearing within the Whian Whian State Conservation Area and the World Heritage Listed Nightcap National Park as well as rehabilitated Rous Water land surrounding the dam.

In addition to this, the potential raising of Rocky Creek Dam provides only a small increase in secure yield at a high cost. Rocky Creek Dam was not designed with a future raising in mind. Accordingly, engineering work to raise the wall is considered to be similar to that required to construct a new dam in terms of cost, complexity and risk.

## 5.13 Summary of options

High level estimates of the energy use, lead time, capital cost, annualise cost and future yield are summarised in Table 5-21 for each assessed water supply option.

**Table 5-21: Evaluation summary for each water supply option**

| # | Option | Energy use (kWh/kL) | Lead time | Capital cost $M | Annualised $/kL | Future yield (2060) ML/a |
|---|---|---|---|---|---|---|
| A1 | Existing Demand Management* | NA | Short | Shared | 4.00 | - |
| A2 | Enhanced Demand Management (including water loss management)* | NA | Short | Shared | 3.00 | 400 |
| B1 | Stormwater harvesting - indirect potable -Goonellabah Catchments | 1.7 | Medium | 9 | 2.60 | 400 |
| B2 | Stormwater harvesting - indirect potable - Alstonville Catchments | 1.0 | Medium | 8 | 2.00 | 400 |
| B3 | Roofwater harvesting - indirect potable - Cumbalum Ridge development | 0.9 | Long | 27 | 6.70 | 300 |
| C | Stormwater harvesting - non-potable | NA | Short | TBA | Variable | Minor |
| D1 | Wastewater reuse - indirect potable - East and South | 2.0 | Long | 20 | 1.70 | 1,900 |

| # | Option | Energy use (kWh/kL) | Lead time | Capital cost $M | Annualised $/kL | Future yield (2060) ML/a |
|---|---|---|---|---|---|---|
| | Lismore STPs | | | | | |
| D2 | Wastewater reuse - indirect potable - Alstonville STP | 1.0 | Long | 9 | 1.90 | 600 |
| D3 | Wastewater reuse/stormwater harvesting - indirect potable - Alstonville | 1.0 | Long | 12 | 1.80 | 1,000 |
| D4 | Wastewater reuse - indirect potable - Ballina and Lennox Head STPs | 1.1 | Long | 14 | 1.80 | 1,000 |
| E | Wastewater reuse - non-potable | NA | Short | TBA | Variable | Minor |
| F1 | Groundwater - maximise existing sources (Woodburn) | 0.3 | Short | 4 | 2.20 | 200 |
| F2 | Groundwater - new sources (Coastal Sands) | 0.4 | Medium | 18 | 1.50 | 1,300 |
| F3 | Groundwater - new sources (Fractured Basalt) | 0.7 | Medium | 13 | 1.70 | 800 |
| G1 | Desalination - Tyagarah (marine feed water) | 4.2 | Medium to Long | 103 | 3.20 | 6,000 |
| G2 | Desalination - South Ballina (marine feed water) | 4.3 | Medium to Long | 107 | 3.30 | 6,000 |
| H1 | Dunoon Dam | 1.6 | Medium to Long | 111 | 1.80 | 11,300 |
| I1 | Toonumbar Dam - modify water sharing plan (2020) | 0.6 | Medium (after 2020) | 34 | 2.90 | 1,000 |
| J1 | Regional desalination (NOROC) | 4.2 | Long | 101 | 3.00 | 5,900 |
| K1 | Revised water restrictions - accept reduced supply security | NA | Short | NA | NA | 3,300 |
| L1 | Raise Rocky Creek Dam 8m. | 1.3 | Long | 74 | 5.00 | Minor |

## 5.14 Option assessment

The outcomes of the water supply and demand management option assessment were presented to the stakeholders (both PRG and Rous Water Council) during Workshop 2. Participants examined the benefits and constraints associated with each of the water supply options. Participants were also invited to develop a series of potential water supply scenarios by bundling suitable options together to meet the following themes based on project assessment objectives:

1. Resilience, adaptation and risk management.
2. Water use efficiency.
3. Acceptability.
4. Cost and affordability.

In addition, participants were invited to bundle options based on what they intuitively felt was the 'best case'.

The one pre-requisite for scenario development was that the combination of options would meet the supply deficit in 2060 of 6,500 ML/a. This exercise enabled discussion on the advantages and disadvantages of each option. Options were ranked based on the number of times they appeared in the scenarios. Stakeholder preferences showed most support for:

1. Enhanced demand management.
2. Groundwater options – particularly those located in coastal sands.
3. IPR options.
4. Restrictions, albeit only at the 5/15/15 level.
5. Dunoon Dam.

There was also clear indication that the following options need not be pursued further:

3. Toonumbar Dam – modified WSP: displaces existing users, with high risks and low yield.
4. Raising Rocky Dam - high capital cost and environmental impact for low future yield.

Refer to Appendix A for more information on the stakeholder process and outcomes from each meeting.

# 6 Scenario development

This section describes potential future scenarios and the process used to develop the concepts for selection of a preferred option. Scenarios are a mix of water supply options which seek to address the water supply issues identified in Section 4.1. The options used in the scenarios are based on the options assessment in the previous section.

## 6.1 Process

Drawing on the options assessment and stakeholder feedback, five scenarios were recommended by MWH and accepted by Rous Water for characterisation and assessment (Table 6-1). The scenario titles indicate the key theme of each scenario. Suitable contingency supply options, in alignment with the scenario theme, are also identified.

Each scenario is developed to meet the following *must do* objectives over the entire planning scenario (section 4.2):

- Comply with WSPs.
- Plan for option implementation lead times.
- Protect public health.
- Provide adequate secure yield.
- Effectively utilise existing assets into the future.

**Table 6-1: Assessed FWS scenarios**

| Scenario | Scenario components (options) | |
|---|---|---|
| 1. Business as usual | A1. | Existing demand management program |
| | H1. | The currently proposed Dunoon Dam (50,000 ML storage) |
| 2. Staged Dunoon Dam | A2. | Enhanced demand management |
| | H2. | Dunoon Dam (20,000 ML storage) |
| | *Contingency* - ability to increase capacity to 50,000 ML storage | |
| 3. Extended groundwater | A2. | Enhanced demand management |
| | F2. | Groundwater supply (Coastal Sands Aquifer) |
| | F3. | Groundwater supply (Fractured Basalt Aquifer) |
| | F1. | Groundwater supply (Existing Woodburn source) |
| | *Contingency* - managed aquifer recharge | |
| 4. Indirect potable reuse | A2. | Enhanced demand management |
| | F2. | Groundwater supply (Coastal Sands Aquifer) |
| | F1. | Groundwater supply (Existing Woodburn source) |
| | D4. | Wastewater IPR (Ballina and Lennox Head STPs) |
| | D3. | Wastewater and stormwater harvest IPR (Alstonville STP and catchment) |
| | *Contingency* – wastewater IPR (South and West Lismore STPs) | |
| 5. Desalination | A2. | Enhanced demand management |
| | F2. | Groundwater supply (Coastal Sands Aquifer) |
| | F1. | Groundwater supply (Existing Woodburn source) |

| Scenario | Scenario components (options) |
|---|---|
| | G2. Desalination of marine water (South Ballina)<br>*Contingency* – ability to increase desalination capacity |

## 6.2 Scenario estimates

For each scenario, estimates of performance in terms of costs (community and Rous Water), greenhouse gas emissions and secure yield are made. It is noted that all scenarios are at an indicative level of development to enable comparison against project objectives, and remain subject to finalisation of source locations, staging options, approvals and design including associated cost elements.

### 6.2.1 Costing

Key cost estimates are described in Section 5.1.3. Capital cost estimates for new works are combined with Rous Water's existing capital works planning budget (Rous Water, 2013). The costs shown are the additional costs (capital and operating) to implement the scenario compared to the current capital works budget and operating costs.

Key peak demand bulk supply augmentations are also considered in each scenario e.g. Nightcap WTP augmentation.

Operating costs include additional operating costs for options which make use of existing infrastructure.

### 6.2.2 Greenhouse gas emissions

The greenhouse gas emissions (GHG) are estimated for each scenario based on ongoing operational costs as well as embodied energy. Details on how embodied energy was calculated are provided in Appendix H.

### 6.2.3 Secure yield

The secure yield for each scenario is determined using the secure yield model (Section 3.3.2) for the combined options. Modelling indicates overall system secure yields slightly greater than the individual contributions of each source in some of the options. Refer to Appendix C for details.

### 6.2.4 Transfer rules

The general rules for transferring bulk water from the major sources in the system include:

1. Maximum transfer from Emigrant Creek Dam was 8 ML/d.
2. If Rocky Creek Dam >= 95 % full, no Wilsons River pumping/Lismore transfer and no Emigrant Creek Dam transfer and no Dunoon Transfer.
3. If Rocky Creek Dam < 95% full, then use Emigrant Creek Dam for Ballina and use Wilsons River source to maximum allowed and Rocky Creek Dam for shortfall.
4. And for the options with Dunoon Dam the following additional rules were used:
    a. If Rocky Creek Dam < 50% full then use Dunoon Dam instead of Rocky Ck.
    b. If Dunoon Dam < 20% full then use Rocky Creek Dam instead of Dunoon Dam.
    c. If Rocky Creek Dam 0% full then use Dunoon Dam.

Future refinement of operational rules to maximise system yields and optimise overall costs and energy is envisaged.

## 6.3 Scenario 1: Business as usual (BAU)

### 6.3.1 Description

Scenario 1 is the current Rous Water resolved approach to meeting the water supply needs of the Rous Area. It includes the current (existing) level of demand management effort.

A 50,000 ML roller compacted concrete (RCC) type dam is proposed at Dunoon. An intake structure would be attached to the upstream of the dam while an outlet/ valve house arrangement would be located at the downstream end.

A new raw water pumping station is proposed next to the outlet valve house at Dunoon Dam. Water is to be pumped from Dunoon Dam to connect to the Wilsons River Source pipeline at Dorroughby, a distance of some 8 km. Each pump will have the capacity to pump against a head of 120 m (allowing for losses in the rising main) and have a motor power rating of about 300 kW.

Studies indicate Dunoon Dam is technically viable, but with significant environmental and social constraints. State significant infrastructure with State Minister approval required.

The results of the secure yield modelling including climate change impacts for the 50,000 ML dam is shown in Table 5-12.

### 6.3.2 Schematic

Figure 6-1 shows the location of Dunoon Dam.


**Figure 6-1: Scenario 1 - location of proposed Dunoon Dam**

### 6.3.3 Sizing and staging

The characteristics of the 50,000 ML storage dam are shown in Table 6-4.

**Table 6-2: Characteristics of 50,000 ML storage**

| Dam Storage Full Supply Level (AHD) | Dam Crest (AHD) | Spillway width (m) |
|---|---|---|
| 82.85 | 90.6 | 30 |

A dam with a total storage volume of 50,000 ML has a secure yield which exceeds the demand in 2060 by approximately 5,000 ML/a under the BAU scenario. The dam would be required to be fully operational by 2023.

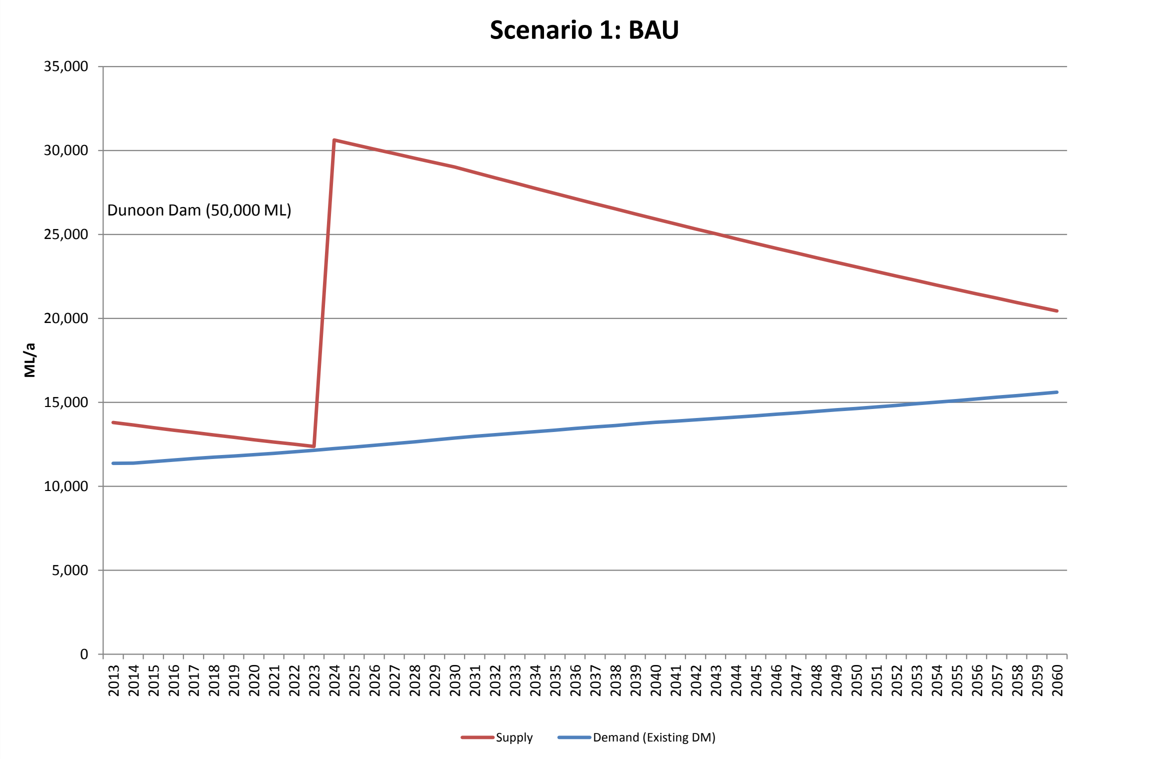



**Figure 6-2: Scenario 1 supply/demand graph**

### 6.3.4 Operational needs

Water from the dam would be pumped using a dedicated rising main to Dorroughby and then to the existing Nightcap WTP for treatment. The Nightcap WTP would need to be upgraded in 2023 based on an assessment of peak day demands.

For the scenarios that included the proposed Dunoon Dam the environmental flow requirements were based on the recent Dunoon Environmental Flows Assessment (Eco Logical, 2012) that investigated and developed different environmental flows towards meeting ecological objectives. The environmental flow requirements used were:

- Transparent Release from Dunoon Dam for 100 ML/d, but if inflow is less than 0.7 ML/d release 0.7 ML/d from Dunoon Dam.
- From 31 Dec to 28 Feb (within the 60 days) if no 3 days with transparent release of 100 ML/d then release up to 100 ML/d for 3 consecutive days from Dunoon Dam.
- From 2 June to 31 July (within the 60 days) if no 3 days with transparent release of 100 ML/d then release up to 100 ML/d for 3 consecutive days from Dunoon Dam.
- From 12 August to 30 September (within the 50 days) if no 3 days with transparent release of 100 ML/d then release up to 100 ML/d for 3 consecutive days from Dunoon Dam.

### 6.3.5 Capital, operating costs and energy requirements

Capital costs for new works associated with the scenario, average additional operating cost over the planning horizon and average annual energy consumption over the planning horizon are shown in Table 6-3.

**Table 6-3: Scenario 1 - capital, operating and energy consumption**

| Capital ($M) | Average annual operating cost ($M/a) | Average annual energy consumption (MWh/a) |
|---|---|---|
| 158 | 1.95 | 6,100 |

## 6.4 Scenario 2: Staged Dunoon Dam

### 6.4.1 Description

The current 50,000 ML proposal provides a far greater yield than is envisaged to be required for the 2060 planning horizon. A 20,000 ML storage is optimised to meet this planning horizon and make it comparable with the yields provided in scenarios 3 to 5.

The dam could be raised to provide 50,000 ML storage at a later date, if required. A roller compacted concrete type dam is again assumed for costing.

Studies indicate Dunoon Dam is technically viable, but with significant environmental and social constraints. State significant infrastructure with State Minister approval required. Significant aboriginal areas are unlikely to be affected by the smaller inundation area.

### 6.4.2 Schematic

Figure 6-3 shows a schematic showing the location of the proposed 20,000 ML Dunoon dam.


**Figure 6-3: Scenario 2 – location of the proposed Dunoon Dam (20,000 ML)**

### 6.4.3 Sizing and staging

As for the 50,000 ML arrangement, the 20,000 ML dam option would incorporate a concrete gravity structure with a 30 metre wide spillway at the centre of the dam and plunge pool at the downstream toe. A diversion tunnel would be located at creek bed level, just left of the spillway through the dam wall. This would be converted to an outlet tunnel once construction of the dam has been completed. An intake structure would be attached to the back of the wall while an outlet/ valve house would be located at the downstream end together with an associated pumping station

Design features are incorporated in the 20,000 ML arrangement to facilitate future raising of the dam. These design features include:

- The positions of the valve house and pumping station are located downstream of the dam to suit a larger dam.

- Sizing of the pumping station, valve house, pipework and associated equipment has been determined to suit a larger dam.
- The section dimensions for the intake tower allow for possible future raising of the storage to 50,000 ML.

The characteristics of the 20,000 ML storage dam are shown in Table 6-4.

**Table 6-4: Characteristics of 20,000 ML storage**

| Dam Storage FSL (AHD) | Dam Crest (AHD) | Spillway width (m) |
|---|---|---|
| 67.20 | 74.96 | 30 |

The timing and yield for the staged Dunoon Dam is shown in Figure 6-4. Enhanced demand management defers the need for the dam by approximately 5 years (to 2028) and provides an estimated supply buffer of approximately 900 ML/a in 2060.

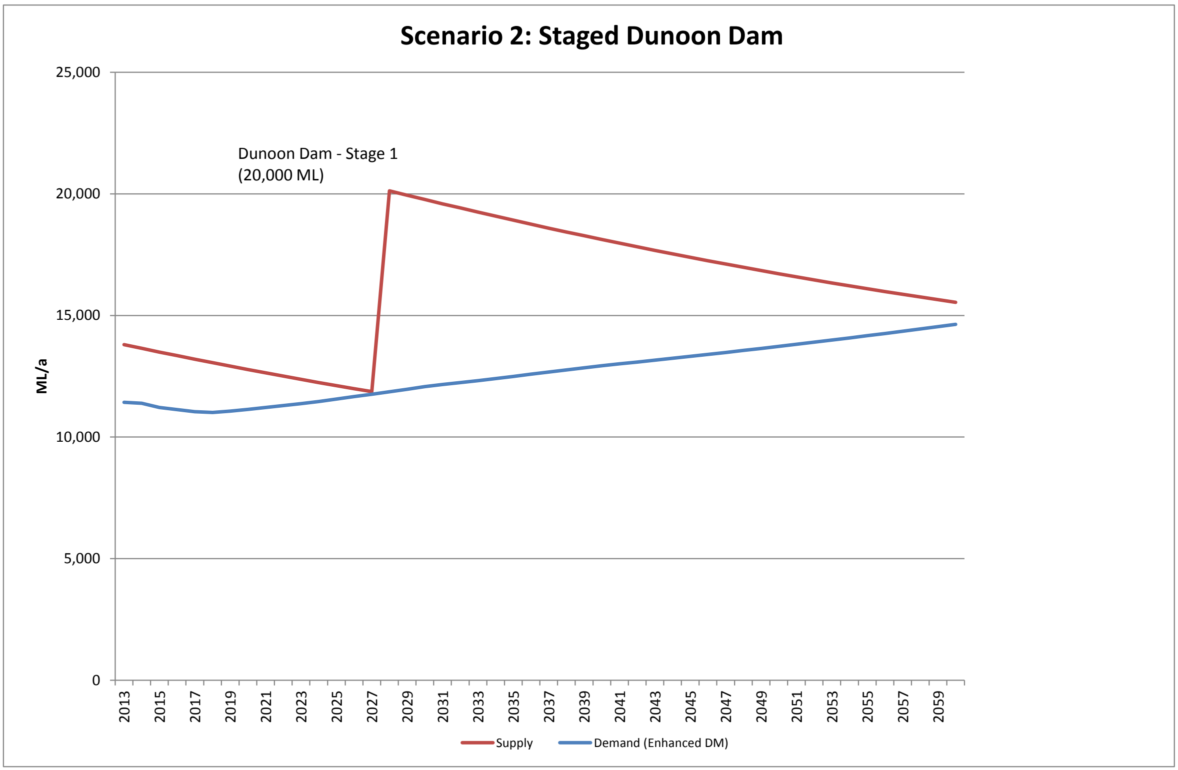



**Figure 6-4: Scenario 2 supply/demand**

## 6.4.4 Operational needs

The dam would operate in the same way as Scenario 1. Water would be pumped from the toe of the dam to the Dorroughby Tanks and then to the existing Nightcap WTP for treatment. This scenario would require an upgrade to Nightcap WTP in 2028. This upgrade is delayed compared to Scenario 1 due to the implementation of enhanced demand management.

## 6.4.5 Capital, operating costs and energy requirements

The estimate costs for the outlet works/valve house/pumping station are similar to those for the 50,000 ML storage. Costs for the dam wall and the intake tower reflect the lower 20,000 ML storage level. Capital costs for new works, average additional operating cost over the planning horizon and average annual energy consumption over the planning horizon are shown in Table 6-5. Detailed cost breakdowns for the dam were provided by PWD (NSW Public Works, 2013).

**Table 6-5: Scenario 2 capital, operating costs and energy consumption**

| Capital ($M) | Average annual operating cost ($M/a) | Average annual energy consumption (MWh/a) |
|---|---|---|
| 130 | 1.8 | 5,700 |

## 6.5 Scenario 3: Extended Groundwater

### 6.5.1 Description

This scenario aims to fulfil the 2060 supply deficit through potential groundwater sources (Woodburn Bores, Coastal Sands and Fractured Basalt). Maximum sustainable yields from each of the sources are sought. Groundwater is a supply source with relatively low capital investment, low running costs and high stakeholder support. However, the scenario has significant unknowns (quantity, quality and licencing) that will need to be assessed through an exploratory drilling and monitoring program.

Woodburn Bores and treatment facilities would be relocated owing to the Pacific Highway upgrade. New borefields would be developed in the Coastal Sands (assumed as 3 borefields) and Fractured Basalt aquifers (assumed as 2 borefields). Relatively high yields from the aquifers are sought. New groundwater treatment facilities, storage and transfer systems, to the existing supply network is assumed.

The success of this scenario depends on achieving the required supply yield, whilst protecting impacted Groundwater Dependent Ecosystems and complying with relevant WSP and approvals processes.

Enhanced demand management would be implemented which off-sets the need for capital infrastructure upgrades and reduces the overall supply deficit.

### 6.5.2 Schematic

Figure 6-5 shows the indicative location of prospective groundwater sources for Scenario 3.

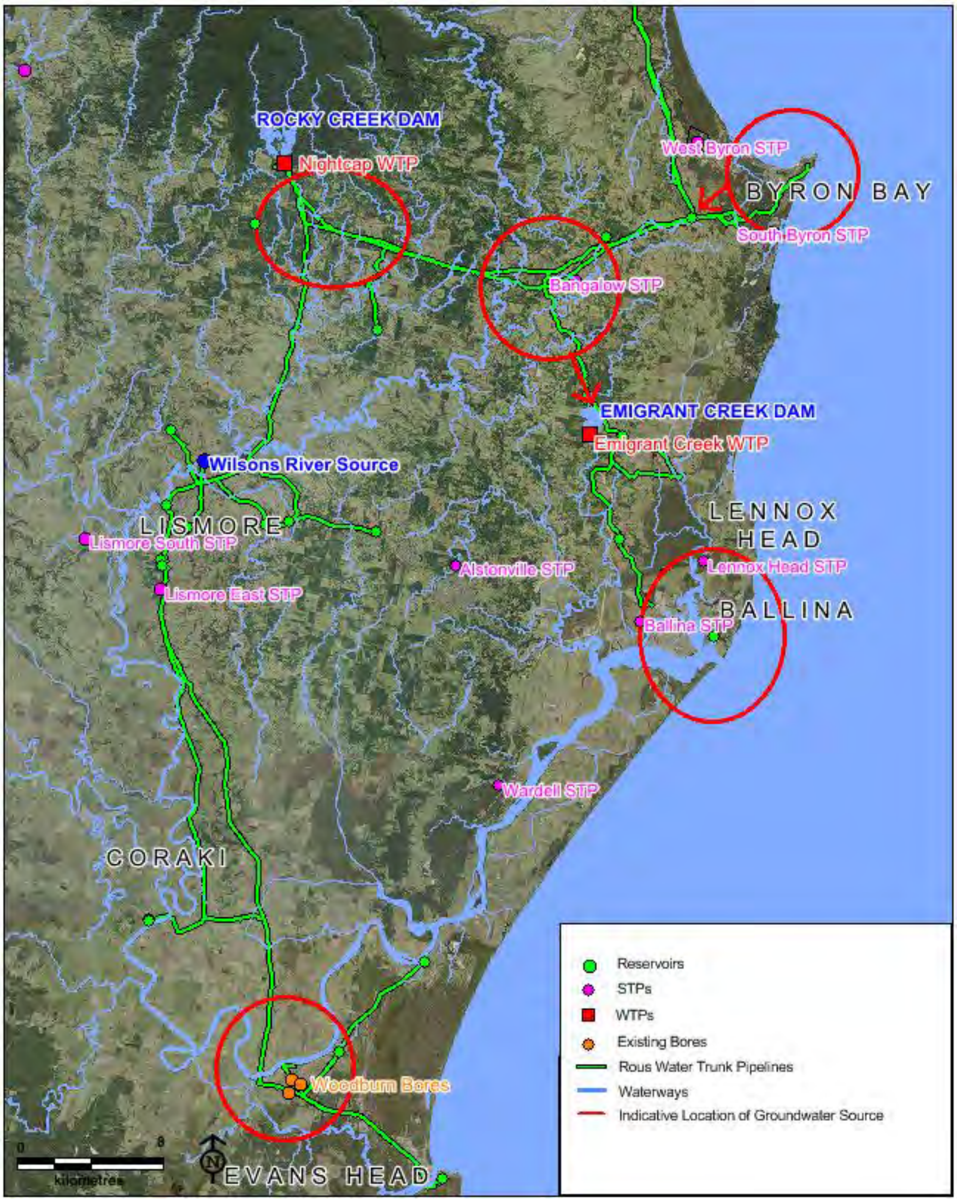



**Figure 6-5: Scenario 3 – prospective location of groundwater sources**

### 6.5.3 Sizing and staging

The assumed contributions and timing for the development of each source are shown in Table 6-6. Final borefield locations and aquifers to contribute to supply will be dependent on outcomes of exploratory work and approvals. The decline rate of each source is based on assumed climate change impacts.

**Table 6-6: Assumed timing and contribution from each new source**

| Source | Year | Contribution in 2060 (ML/a) |
|---|---|---|
| Maximise existing sources | 2027 | 576 |
| New sources (coastal sands) | 2030 | 1,800 |
| New sources (fractured basalt) | 2046 | 1,350 |

The timing and yield from each new supply source is shown in Figure 6-6.

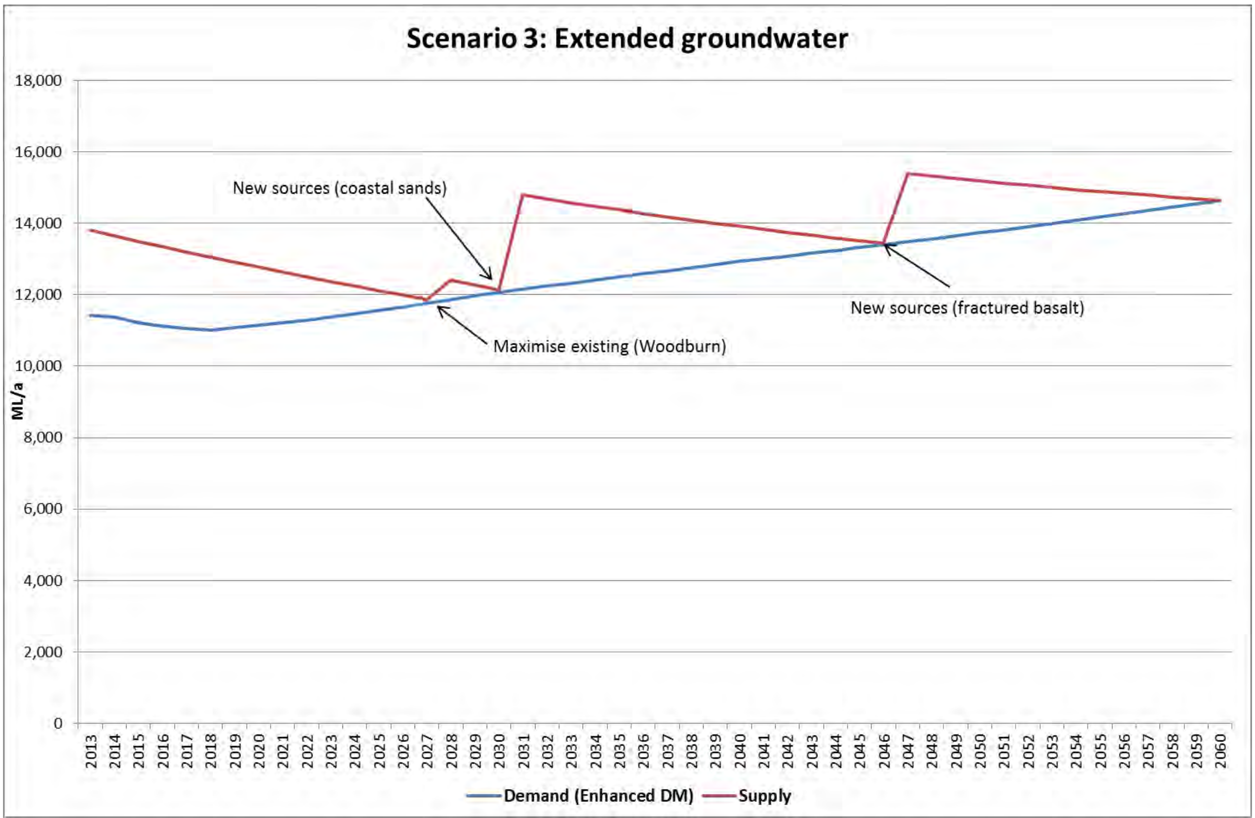



**Figure 6-6: Scenario 3 supply/demand graph**

In the event that supply from the groundwater sources is insufficient, a suitable MAR scheme could be developed using either stormwater of treated wastewater. The coastal sands aquifer includes locations close to existing STPs (which could be used for future MAR schemes) and demand centres. The yield of potential MAR sources has not been quantified at this stage.

### 6.5.4 Operational needs

Groundwater would be treated to a potable water standard before entering the existing water supply system. The water quality is expected to vary by location and as such the treatment needs would vary as well. Treatment facility design is to include the ability to provide potable water quality to the network following shut down periods. At this stage it is assumed full conventional water treatment is provided at each borefield as agreed with Rous Water operations staff.

### 6.5.5 Capital, operating costs and energy requirements

Capital costs for new works, average additional operating cost over the planning horizon and average annual energy consumption over the planning horizon are shown in Table 6-7.

**Table 6-7: Scenario 3- capital, operating and energy consumption**

| Capital ($M) | Average annual operating cost ($M/a) | Average annual energy consumption (MWh/a) |
|---|---|---|
| 62 | 2.7 | 5,700 |

## 6.6 Scenario 4: Indirect potable reuse

### 6.6.1 Description

Scenario 4 makes use of groundwater sources to off-set and delay the need for IPR options. More conservative groundwater extraction yields have been assumed for this scenario (compared to scenario 3) necessitating the need for alternative water supply options later in the scenario.

Woodburn Bores and treatment facilities would be relocated and new borefields developed providing relatively low yields. New groundwater treatment facilities, storage and transfer systems to the existing distribution network/storages would be provided. Exploratory drilling would define the borefield locations. It is assumed that climate change impacts to groundwater supply yields will be in line with worst case surface yield reductions (refer to section 3.3.3).

STP effluent from Ballina and Lennox Head would be treated using advanced treatment and stored before being transferred to Emigrant Creek Dam to augment water supply. Further treatment would occur at the existing Emigrant Creek WTP for indirect potable reuse.

Alstonville STP effluent and stormwater collected from the Alstonville area would be treated using advanced treatment processes and stored before being transferred to Emigrant Creek Dam for indirect potable reuse. Public health and environmental risk management procedures are required including community consultation.

Enhanced demand management would be implemented which off-sets the need for capital infrastructure upgrades and reduces the overall supply deficit.

### 6.6.2 Schematic

Figure 6-7 shows a schematic and location of key infrastructure required for Scenario 4.

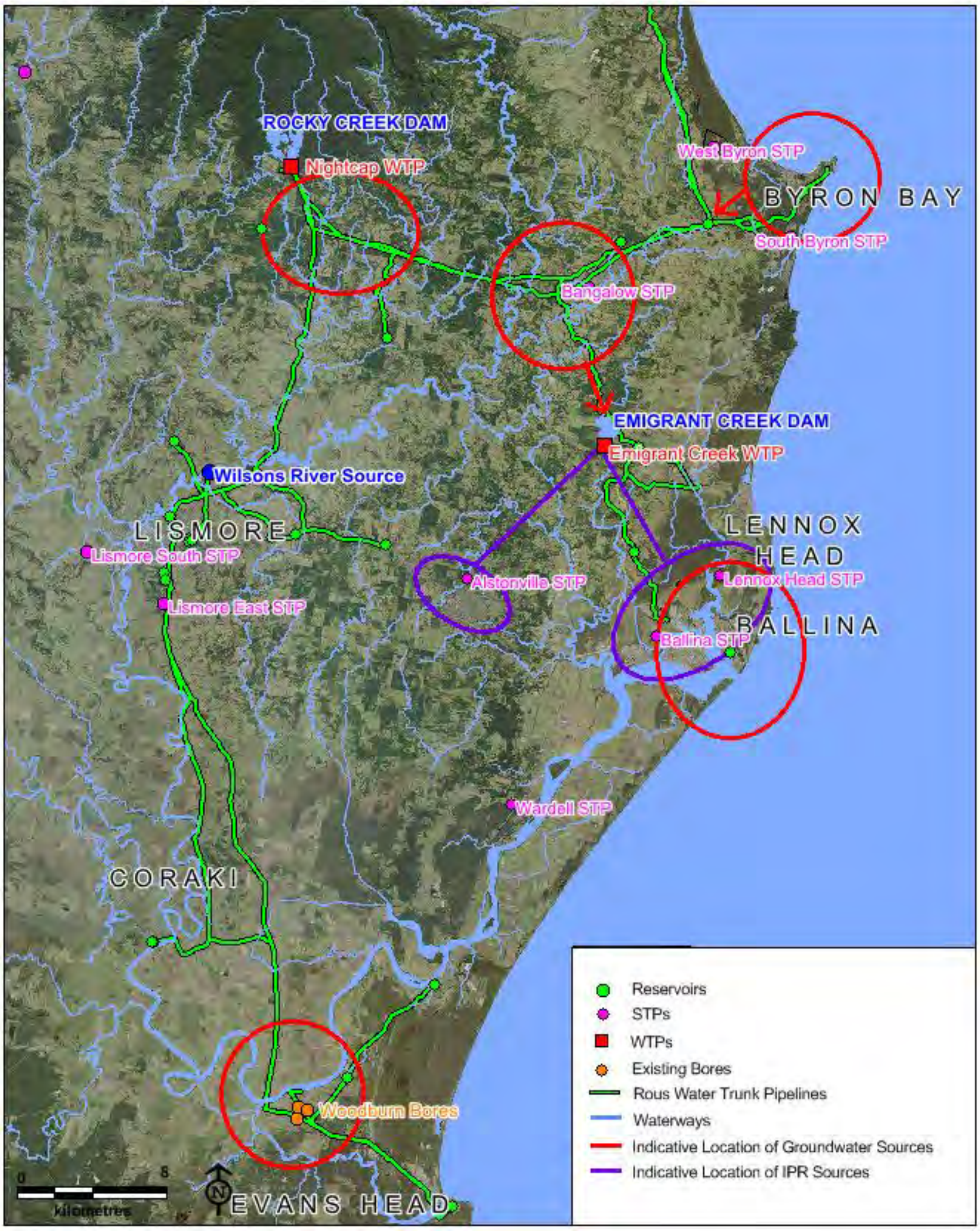



**Figure 6-7: Scenario 4 – location of water sources and main transfers**

### 6.6.3 Sizing and staging

This scenario has prioritised the use groundwater supplemented by IPR when required thereby delaying the need for IPR until approximately 2037. The assumed contributions and timing from each source are shown in Table 6-8.

**Table 6-8: Scenario 4 – sizing and staging**

| Source | Year | Contribution in 2060 (ML/a) |
|---|---|---|
| Maximise existing groundwater sources | 2028 | 325 |
| New sources (coastal sands) | 2030 | 650 |
| Ballina and Lennox Head STPs | 2037 | 1,260 |
| Alstonville STP plus stormwater harvesting | 2050 | 840 |

The indicative timing and additional supply for each new supply source is shown in Figure 6-8.

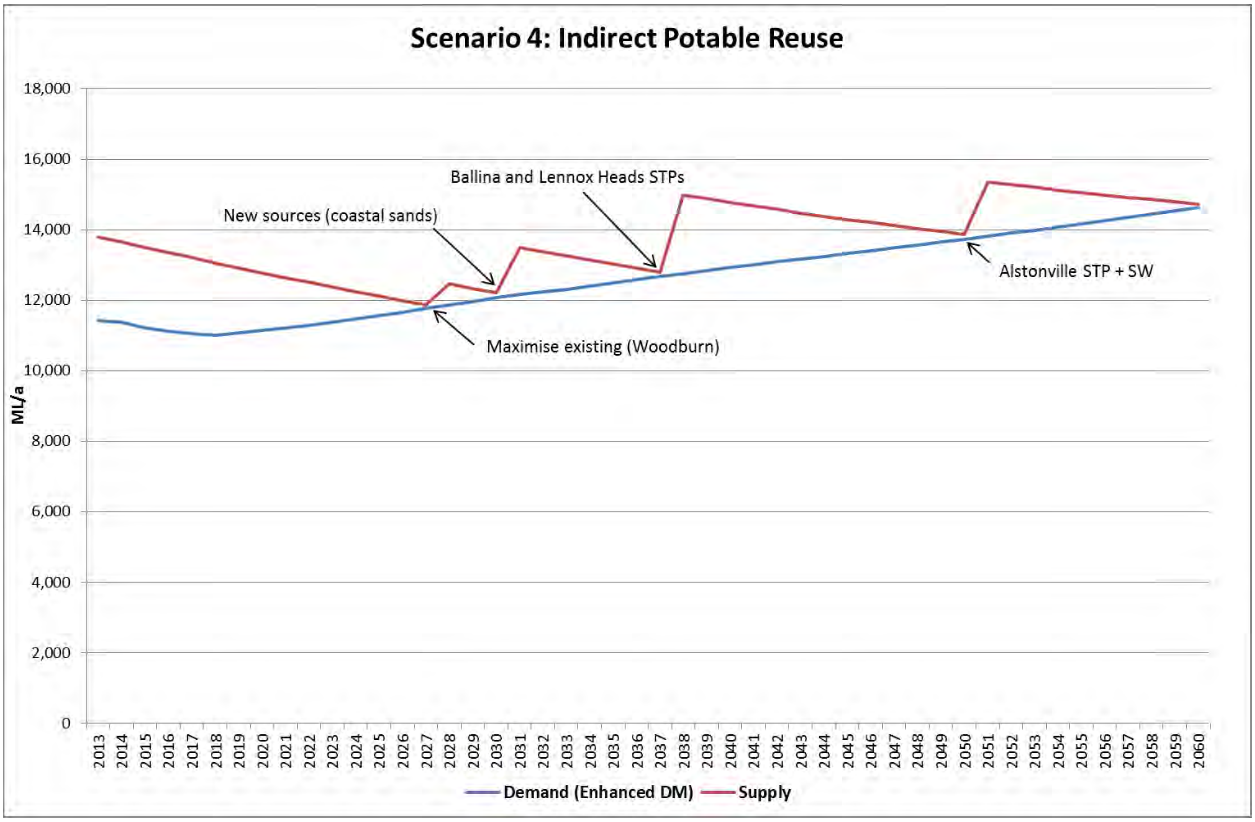



**Figure 6-8: Scenario 4 supply/demand graph**

### 6.6.4 Operational needs

The capacity of the Emigrant Creek WTP would need to be upgraded in 2037 to manage the increased inflow from the IPR schemes. Augmentation of Nightcap WTP is not required under this scenario.

In the event that the supply from the nominated sources is insufficient additional IPR supply from East and South Lismore STPs (Option D1) could be considered but is not included in the scenario evaluation.

The implementation of this scenario would require an updated drinking water quality management plan with new monitoring conditions.

### 6.6.5 Capital, operating costs and energy requirements

Capital costs for new works, average additional operating cost over the planning horizon and average annual energy consumption over the planning horizon are shown in Table 6-9.

**Table 6-9: Scenario 4 – capital, operating and energy consumption**

| Capital ($M) | Average annual operating cost ($M/a) | Average annual energy consumption (MWh/a) |
|---|---|---|
| 105 | 3.7 | 7,000 |

## 6.7 Scenario 5: Deferred desalination

### 6.7.1 Description

Like Scenario 4, this scenario makes use of groundwater sources with priority to defer costs but uses desalinated water instead of IPR to meet the potential demand shortfall in the future.

Woodburn Bores and treatment facilities would be relocated and new borefields developed providing relatively low yields. New groundwater treatment facilities, storage and transfer systems to the existing distribution network/storages would be provided.

Desalination of ocean water extracted via a sub-surface beach well system will augment supply. At this stage South Ballina is the assumed location for the plant however other options should not be ruled out at this strategy stage. The plant would be staged with brine discharge via a new ocean outfall. A renewable power source is assumed to be sourced from the local power authority. There is potential to trigger Federal EIS requirements (EPBC) and complicated approvals (refer to Appendix E for more information on environmental constraints).

Enhanced demand management would be implemented which off-sets the need for capital infrastructure upgrades and reduces the overall supply deficit.

### 6.7.2 Schematic

Figure 6-9 shows the location of key infrastructure required for Scenario 5. It includes 3 groundwater sources and one desalination plant.


**Figure 6-9: Scenario 5 – indicative location of water sources**

### 6.7.3 Sizing and staging

The need for desalination would be deferred by prioritising the use of groundwater. Development of the desalination plant would be staged in modules of approximately 5 ML/day to meet future average demand increases. The assumed contributions and timing from each source are shown in Table 6-10.

**Table 6-10: Scenario 5 – staging and sizing**

| Option | Year | Contribution in 2060 (ML/a) |
|---|---|---|
| F1. Maximise existing groundwater sources | 2028 | 325 |
| F2. New groundwater sources (coastal sands) | 2031 | 650 |
| Desalination – stage 1 | 2037 | 1,100 |
| Desalination – stage 2 | 2048 | 1,100 |

The timing and available supply for each new supply source is shown in Figure 6-10.

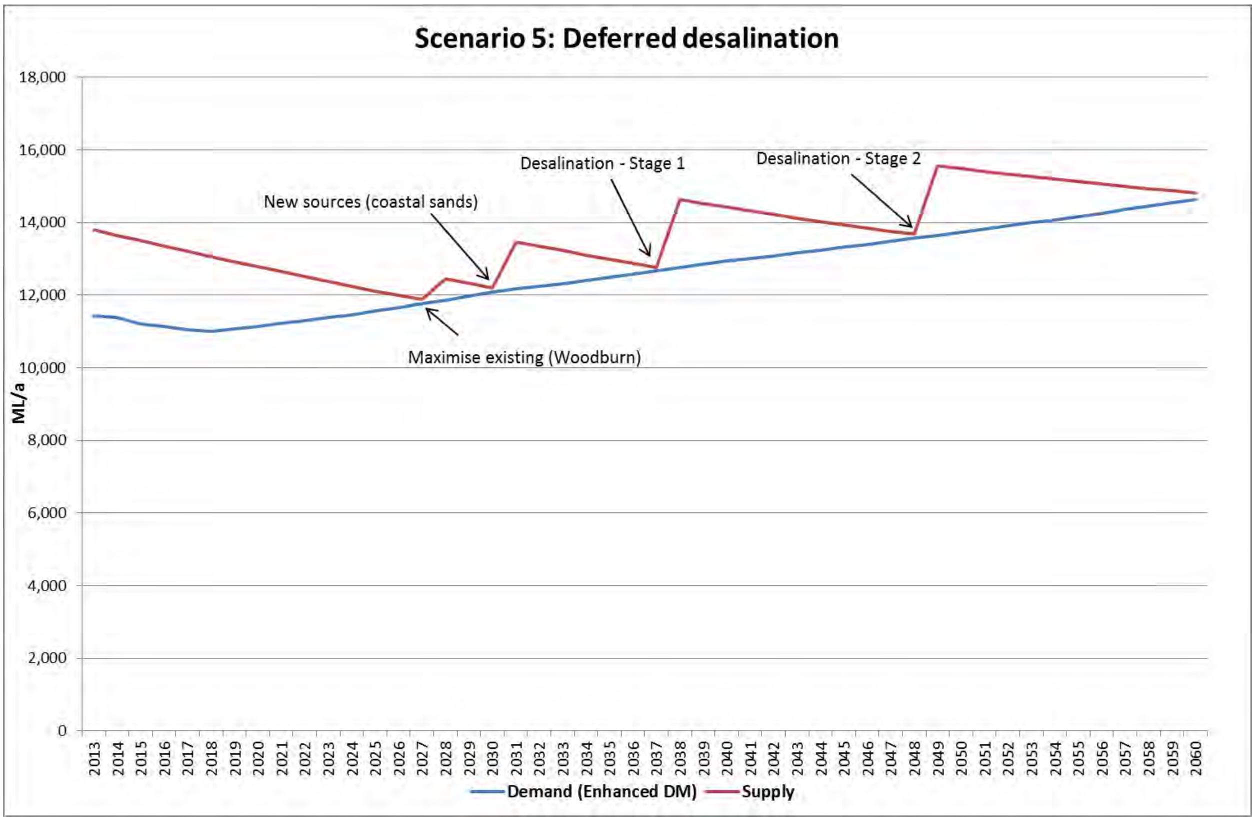



**Figure 6-10: Scenario 5 supply/demand graph**

### 6.7.4 Operational needs

The desalination plant is assumed to operate continuously, to provide a stable base component to the supply system. Operational rules regarding the operation of Rocky Creek and Emigrant Creek would need to be refined on this basis.

### 6.7.5 Capital, operating costs and energy requirements

Capital costs for new works, average additional operating cost over the planning horizon and average annual energy consumption over the planning horizon are shown in Table 6-11.

**Table 6-11: Scenario 5 – capital and operating costs and energy consumption**

| Capital ($M) | Average annual operating cost ($M/a) | Average annual energy consumption (MWh/a) |
|---|---|---|
| 103 | 3.7 | 11,500 |

## 6.8 Increased restrictions

Initial stakeholder feedback indicated that planning infrastructure upgrades for increased duration, frequency and intensity of enforced restrictions is worth consideration at the 5/15/15 supply yield LoS (Section 5.14). The adoption of a reduced LoS is possible for all of the scenarios. *NSW Best Practice Management of Water and Sewerage Guidelines* (Department of Energy and Water, 2007) allows for changes to LoS through a consultation process included in the review of strategic business plans.

Generally the adoption of a reduced LoS is expected to defer the need for infrastructure upgrades by approximately 7 to 8 years and reduce net capital expenditure by around 9% in the scenarios. However the harsher restriction regime is also expected to:

- Result in more frequent, longer duration and increased level of restrictions (similar to L2+).
- Increase cost of enforcement and advertising, loss of revenue (to utility) and community impacts (economic and amenity).

At this stage, reduced LoS is carried forward as a possibility to be included with the preferred scenario. Increased water restrictions could be implemented to further reduce capital expenditure and delay the need for new water supply options, however, this would need to be fully tested against the communities willingness to accept a lower level of service (compared to the remainder of NSW). There are no known cases in NSW where the supply yield level of service has been reduced for strategic planning purposes.

# 7 Scenario comparison

The future water scenarios described in section 6 are ranked against the project objectives in this section. An outline of the multi-criteria comparison process and outcomes is provided together with outcomes of sensitivity analysis on assessment objective weightings.

## 7.1 Multi-criteria assessment framework

Scenarios are compared based a range of criteria including environmental, social and economic (TBL) objectives developed for this study. To assist in balancing the sometimes conflicting considerations and to understand the trade-offs in meeting study objectives, a multi-criteria analysis decision tool was used to assist compare the scenarios.

Estimated potable water usage and community net present value costs provide direct input to the multi-criteria analysis scores. All other scores are subjective and based on stakeholder input. Supporting material and advice provided to the stakeholders to assist them in scoring the criteria, is discussed below.

Scores range between -3 (representing a poor outcome for the criteria assessed) and +3 (representing an excellent outcome for the criteria assessed). A score of zero represents essentially no change when compared to the baseline option. All individual scores are tallied and averaged for assessment of the scenarios. Also, the sensitivity to changes in weightings for the objectives is tested.

Each of the criteria is described below in Table 7-1. The weightings shown were determined in consultation with Rous Water.

**Table 7-1: MCA criteria and preliminary weightings**

| Criteria | Description | Weighting |
|---|---|---|
| Scenario enables adaptive management | Adaptive management considers effective back-up supply options, as well as the flexibility of the scenario to scaling and staging. Stakeholders were informed of the back-up (contingency) options and staging for each scenario to assist scoring this criterion. | 5% |
| Increased system resilience through supply diversity | Resilience through supply diversity considers the number and type of water sources utilised in a scenario, as well as its resilience to potential climate change impacts. Stakeholders were provided with the number of water sources associated with each scenario to assist scoring this criterion | 10% |
| Effectively utilise demand management | The predicted average potable per capita water for each scenario was provided (refer to Appendix B). However, as there are only two demand management cases the scenarios were scored as +3 if they incorporated *Enhanced Demand Management,* and zero if not. | 7% |
| Minimise ecological and cultural heritage impacts | Appendix E outlines the initial desktop environmental constraints assessment. To assist with scenario scoring a combined ecological/cultural heritage score was developed with specialist input considering: likely triggers for federal approvals; mapped protected areas, groundwater dependent ecosystems and acid sulphate soils; new source footprint (ha); and, registered cultural heritage sites. The score was provided as a guide to assist stakeholders in discussion of the objective. It was not necessarily accepted by stakeholders. | 7% |
| Reduce | Reducing greenhouse gas emissions considers both | 5% |

| Criteria | Description | Weighting |
|---|---|---|
| greenhouse gas emissions | operational and embodied carbon estimated and the use of green power in a scenario. A high level assessment of embodied energy is provided for each scenario. The annual estimated greenhouse gas emissions for each scenario were presented to each stakeholder for consideration when scoring this criterion (see Appendix H). | |
| Scenario is affordable to consumers | Financial analysis considers future revenue, loans and costs associated for each scenario is modelled. It assists to understand the impact of the proposed expenditure program on the required revenue to be recovered through bulk supply charges. The score will provide an indication of the relative increase in rates for each scenario assuming these costs are then reflected in the retail cost of water (which is set by LWUs). The full outcomes of the financial analysis are provided in Appendix G.<br>Stakeholders were asked to consider the outcomes of the financial analysis when scoring the 'Affordability' criteria. | 11% |
| Supported by constituent Councils | Stakeholders were asked to consider whether the constituent Councils would likely support the scenario. The PRG included representatives from each Council area and group discussion facilitated sharing of ideas. | 15% |
| Maximises community acceptance | Stakeholders were asked to consider community concerns about any of the options, including equity issues, social values and perceived risks. | 7% |
| Minimise community costs | Each scenario has been assessed on basis of community (utility plus customer) NPV. | 33% |

A summary of the technical information that was provided to each of the stakeholder groups is provided below in Table 7-2.

**Table 7-2: Technical information for assessing scenarios**

| Scenario | Description | Potable Water Demand (L/p/d) | Community NPV ($M)[6] | Back-up Options | No. of Water Sources | Ecological/ Cultural Heritage Score | Average GHG Emissions (2013-2060) (T CO2e/ year) |
|---|---|---|---|---|---|---|---|
| 1. Business as Usual | Existing demand management<br>50,000 ML Dunoon dam (2024) | 315 | 102<br>(315) | Excess capacity included | 4 | -3.0 | 9,200 |
| 2. Staged Dunoon Dam | Enhanced demand management<br>20,000 ML Dunoon dam, raised at a later date if required (2028) | 295 | 69<br>(282) | Ability to raise dam | 4 | -2.2 | 7,200 |
| 3. Extended Groundwater | Enhanced demand management<br>Woodburn Bores (2027)<br>Coastal Sands aquifers (2030)<br>Fractured Basalt aquifers (2046) | 295 | 26<br>(240) | Managed Aquifer Recharge | 9 | -0.8 | 6,200 |
| 4. Indirect Potable Reuse | Enhanced demand management<br>Woodburn Bores (2027)<br>Coastal Sands aquifers | 295 | 36<br>(249) | East & South Lismore STPs reuse | 9 | -1.4 | 8,000 |

[6] The value in brackets is the total NPV including all current capital works and operating costs.

| Scenario | Description | Potable Water Demand (L/p/d) | Community NPV ($M)[6] | Back-up Options | No. of Water Sources | Ecological/ Cultural Heritage Score | Average GHG Emissions (2013-2060) (T CO2e/ year) |
|---|---|---|---|---|---|---|---|
| | (2030)<br>Ballina & Lennox Head STPs reuse (2037)<br>Alstonville STP reuse and stormwater harvesting (2050) | | | | | | |
| 5. Deferred Desalination | Enhanced demand management<br>Woodburn Bores (2027)<br>Coastal Sands aquifers (2030)<br>South Ballina marine feed desalination (staged) | 295 | 36<br>(249) | Additional desalination | 6 | -2.8 | 5,400 (using green power)<br>12,400 (without green power) |

## 7.2 Scenario scoring and ranking

Both stakeholder groups (PRG and Councillor) both scored each scenario against the assessment objectives. The scenarios were initially ranked against Rous Water staff weightings for each objective which were derived in consultation with Rous Water prior to the workshops. During the meeting, each group was asked to allocate weightings to each of the individual objectives.

Sensitivity to changing the objective weightings was also tested. The results of the scenario ranking using each of the various weightings are shown in Table 7-3.

**Table 7-3: Sensitivity testing of scenarios**

| Scenario | Equal across MCA categories | Equal across individual objectives | Councillor nominated weightings | PRG nominated weightings |
|---|---|---|---|---|
| 1. Business as usual | 5 | 5 | 5 | 5 |
| 2. Staged Dunoon Dam | 4 | 4 | 4 | 4 |
| 3. Extended groundwater | 1 | 1 | 1 | 1 |
| 4. Indirect potable reuse | 2 | 2 | 2 | 2 |
| 5. Deferred desalination | 3 | 3 | 3 | 3 |

The scoring and sensitivity exercise showed that:

- Scenario 3, *extended groundwater*, performed the best against the combined project objectives in the multi-criteria analysis. It remained the highest ranking scenario in all sensitivity testing. This was driven by the low NPV, low environmental impact, low GHG emissions, the ability to adapt requirements to future changes as the FWS proceeds, and general acceptance across the community, councils and Rous Water.
- Scenario 4, *indirect potable reuse*, consistently ranked the next highest scenario. Closely followed by Deferred desalination.

## 7.3 Sensitivity of community NPV

Rous Water, LWU and retail water customer capital and on-going costs are combined to provide *community costs*. A discount rate of 7% (in accordance with state treasury guidelines) is adopted for NPV analysis. A sensitivity of the NPV against discount rates of 3% and 10% is also provided. These costs include all of Rous Water current capital works budgeting and operating costs not just the cost of the FWS elements.

**Table 7-4: Community NPV by scenario**

| Scenario | Community NPV ($M) | | |
|---|---|---|---|
| | 7% | 3% | 10% |
| 1. Business as usual | 315 | 240 | 515 |
| 2. Staged Dunoon Dam | 282 | 210 | 475 |
| 3. Extended groundwater | 240 | 175 | 430 |
| 4. Indirect potable reuse | 249 | 180 | 460 |
| 5. Deferred desalination | 249 | 180 | 460 |

## 7.4 Scenario selection

Each scenario has merit for consideration and each meets the compulsory objectives. All scenarios are developed to meet the *must-do objectives*. The best balance of triple bottom outcomes as defined by the multi-criteria assessment objectives favours Scenario 3 (Extended groundwater). Scenario 3 provides the following advantages:

1. The ability to adapt requirements to future changes as the FWS proceeds. The number and location of borefields can be modified over the planning horizon to suit changing needs such as supply deficit. Groundwater is also likely to fit into any future regional approaches adopted.
2. System resilience is increased through overall supply system diversity. The borefields can be located near to the major development areas and isolated supply zones. It is also likely to be more resilient than surface water to climate change.
3. Power usage and greenhouse gas emissions are anticipated to be relatively low compared to the other supply options, through low material needs and the ability to locate borefields near development areas.
4. Groundwater is the most widely used drinking water source in the world. It is likely to receive broad community and constituent council support once the approach to ensure water quality and environmental concerns is understood.
5. Groundwater is expected to be relatively cost effective.
6. The ability to reduce environmental impacts and costs through well investigated borefield site selection.

The key concerns related to Scenario 3 include:

1. The quantity, quality and reliability of each borefield requires proving. Groundwater quality problems (predominately aesthetics related) have occurred at sites within the region. The problems can vary with changing aquifer levels and with increased extraction. Sustainable yields can vary, as well as treatment requirements.
2. Recognition of existing users and environmental dependencies. Modification of aquifer levels with groundwater extraction can impede existing uses. In addition groundwater resources support ecological communities (GDEs). Sustainable yield assessment will require in-field assessment of environmental constraints and consideration in dry and wet years.
3. A high level of investment has been made to support the development of Dunoon Dam. There is also high current community expectation for the dam.

Recognising the benefits and trade-offs associated with Scenario 3, a step by step strategy is proposed. Exploratory drilling and monitoring work in the short term will assist improve understanding of the groundwater resources and potential impacts. At the same time, parallel supporting investigations and ongoing community consultation will continue to allow a contingency approach to be adopted, if required.

Scenario 4 (Indirect potable reuse) represents the second highest ranking approach. It could be brought into the FWS, if required. However, IPR may not have a high level of support in the community, as shown in the South East Queensland (SEQ) case. The education process is therefore likely to increase the required lead time.

In addition, a decision to abandon Scenario 2 (Staged Dunoon Dam) is not required for several years, based on current understanding.

In several years' time, groundwater resources and indirect potable reuse views will be better understood to assist the decision.

The next section outlines the preferred FWS with an extended groundwater approach supported by an exploratory program, and backed-up by contingency approaches in indirect potable reuse, Dunoon Dam and possibly desalination.

# 8 Recommended strategy

This section outlines the recommended strategy as developed through the study's integrated planning process. An implementation plan is provided supported by identification of implementation risks, funding, costs and monitoring requirements.

## 8.1 Strategy overview

The FWS identifies the following new water sources for further investigations. The strategy aims to establish the project viability between 2014 and 2018, and to allow staged implementation, as required, to maintain water security. The strategy will include the following:

1. Enhanced demand management to maximise existing water uses, promote greater water efficiency while minimising costs and off-set the need for new water sources. Key features of the enhanced program include greater community engagement, open space water efficiency, business water reduction, residential rebate programs and water loss management.
2. Existing groundwater sources at Woodburn and on the Alstonville Plateau will be assessed and reviewed to maximise their reliability and contribution to water supply security. Investigations will determine whether these existing sources should be maintained, upgraded or abandoned in favour of more prospective sites.
3. New groundwater sources will be considered, commencing with desktop investigations, and progressed through field based exploratory drilling and testing. New sources investigation would seek to find new sites within both the coastal sand aquifers and fractured basalt. Likely yields are to be assessed as soon as possible to ascertain the likely volume, quality and reliability of the groundwater sources. This will assist in determining whether additional measures such as MAR, IPR or desalination are required.

Contingencies will need to be employed if groundwater proves unsuitable. Contingency measures include:

1. IPR could be used in conjunction with groundwater augmentation if groundwater is not able to provide the required volume of water. It is unlikely that IPR would be required before the mid to late 2030s based on current projections and taking into account a conservative groundwater allowance. Community acceptance would be critical to the viability of this options and early engagement with community and stakeholder groups is proposed to test support for this option,
2. Technical investigations into Dunoon Dam show that it is viable despite some specific ecological and cultural heritage concerns. A staged approach to the construction of the dam may be viable, enabling a progressive approach and off-setting upfront capital costs. Compared with both groundwater and IPR the viability of the Dunoon Dam proposal is well understood. Rous Water will retain the option of the Dunoon Dam should the other sources prove unviable or insufficient.
3. Desalination is a potential new water source, however should only be considered as a safeguard should other sources prove unviable or insufficient.
4. Increased water restrictions could be implemented to further reduce capital expenditure and delay the need for new water supply options, however, this would need to be fully tested against the communities willingness to accept a lower level of service (compared to the remainder of NSW).

### 8.1.1 Risk assessment

A qualitative risk assessment was undertaken to identify key risks associated with the implementation of the strategy and to identify the required management actions to be included in the implementation plan (Table 8-1). The full risk assessment outcomes are shown in Appendix I.

**Table 8-1: Implementation risks and mitigation**

| Category | Risk | Consequence | Management |
|---|---|---|---|
| General | Forecast supply deficit is too high or low (changed growth, consumer behaviour, climate impact/yield forecast) | Change to supply/demand approaches required. Could incur significant cost and service implications. Investment timing changes. | Adopt monitoring plan. Include triggers for change in the strategy. Regularly review demand management plans (every 2 years). Regularly review strategy (every 6 years). Contingency supply options identified. |
| | Changed infrastructure sizing and locations as the strategy develops | Change to timing and size of infrastructure. Changes in peak day demand forecasting approach impacts on design factors. Cost and revenue implications. | Regularly review the strategy and demand management plans including definition of peak day design requirements. Update financial planning as infrastructure requirements are developed. |
| Scenario 3<br>Extended groundwater | Extended period for licence approvals | Need additional supplies earlier than anticipated and perhaps at additional cost. | Early investigation studies, exploratory work in more than one site, stay involved in the Water Sharing Plan process. Scenario 4 is a backup. |
| | Absence of political support, continued commitment to council resolved approach | May need to revert to the dam as preferred strategy against the project objectives. | Political engagement, community engagement, capacity building. Maintain current investments in Dunoon site (not further investment) |
| | Inadequate available supply (poor quality/quantity/reliability) | Need additional supplies earlier than anticipated and perhaps at additional cost. | Scenario 4 is the back-up |
| | The impact of groundwater extraction on downstream environments and GDEs are not yet known. | Cannot develop the particular site, additional supplies required elsewhere. | Multiple sites with appropriate environmental investigations, commence investigations for exploratory work early on |
| | Water Sharing Plans are being developed for a number of potential groundwater sources. The limitations imposed | Need additional supplies earlier than anticipated and perhaps at additional cost. | Early investigation studies, exploratory work in more than one site, stay involved in the water sharing plan process. |

| Category | Risk | Consequence | Management |
|---|---|---|---|
| | by the plans are therefore not yet known. | | Scenario 4 is a backup |
| Scenario 4<br>IPR | Low acceptance (perceived issues, costs) | Delayed investment, lower levels of service for a period. | Recycled water management plan, community engagement and capacity building, pilots plants and process proving, media management |
| | Absence of political support | Revert to the Dunoon dam or desalination as preferred strategy against the project objectives. | Political engagement, community engagement, capacity building. Maintain current investments in Dunoon site. |
| Scenario 2<br>Staged Dunoon Dam | Community opposition to construction of new dam | Another supply would be required | Lobbying, monitor situation, develop other strategies. |
| | Unable to achieve approval requirements | Another supply would be required. | Engage with the regulators. |
| | Inundation of Aboriginal grave sites, threatened flora and fauna habitat and transport routes inundated | Loss of those environmental and heritage values. | 20,000 ML dam does not have the cultural heritage impacts, compensation, environmental offsets. |

## 8.2 Implementation plan

The recommended strategy provides the framework for sustainable management of Rous Water water supply into the future. The implementation plan described in this section outlines the key FWS activities and their timing, based on the assumptions made in this report. The plan allows for exploratory groundwater investigations to confirm suitable resources, with a parallel communications program and supporting studies for IPR and Dunoon Dam. Ongoing monitoring and evaluation forms an integral part of the FWS, which combined with the supporting investigations, will lead to revision of timeframes as improved information becomes available. Initial critical decision dates for the contingency approaches are suggested based on potential lead times.

There are a number of aspects of the current institutional, legislative and policy framework for the management of water resources that will need to be considered on an ongoing basis over the life of the FWS. Considerations include, but are not limited to:

1. Water Sharing Plans: these are legal instruments under the Water Management Act 2000, with a 10 year statutory review period. The plans currently in place will be revised prior to the planned groundwater installations.
2. Quality of Water Products: the Australian Drinking Water Guidelines 2011 (NHMRC, 2011), and similar guidelines for recycled water products, set a risk-based approach to water quality to ensure products supplied are fit for their intended purpose. These guidelines are regularly updated, and can be expected to be altered again, prior to the installation of treatment for the groundwater, MAR or recycled water options are developed.

3. Regional approaches: both the Draft NOROC Regional Bulk Water Supply and the Rous Water Future Water Strategy are in development. Although independent, the studies are fully aligned and consistent with each other, both from a data and strategic point of view. The recommended FWS does not in any way preclude future regional bulk water supply opportunities; rather it increases these opportunities through improving the baseline supply and demand characteristics.
4. Water Reform: State and national governments have continued to encourage competition to ensure monopoly water supplies are efficient and effective. New models for water service provision have been encouraged as well as market-oriented project delivery vehicles which appropriately apportion risk. There will be a need to ensure current approaches are adopted when capital is acquired.
5. Groundwater Resource Management: particular State and Commonwealth policies are in place around both the abstraction of groundwater and the recharge of groundwater. These are also subject to change as knowledge of this resource, which is less well understood than surface water, improves. Maintaining knowledge of the current, and any proposed changes, to groundwater management will be important in supporting strategy implementation. It would also be reasonable to expect, with a period of more than 10 years between the adoption of the FWS, and the proposed groundwater works, that other institutional, legislative and policy frameworks may be introduced in NSW, or at a Commonwealth level. Ongoing monitoring of changes in this framework by Rous Water will be necessary.

Ongoing review and update of NSW best practice management for water supply requirements is assumed as an integral component of the FWS framework.

Table 8-2 summarises the key implementation steps with currently estimated timing.

**Table 8-2: Implementation initiative description**

| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| 1 | FWS community consultation | Community engageme nt | Public display and invitation for feedback from draft FWS | 2013 - 2014 |
| 2 | NOROC Regional Bulk Water Supply Strategy | | Review report and consider key recommendations. Align documents where feasible. | 2013-2014 |
| 3 | Engage in Coastal Sands Water Sharing Plan process | | Engage with NOW in the development process | 2013-2014 |
| 4 | Council acceptance of FWS | | Council adoption of FWS following community consultation | Early to mid-2014 |
| 5 | Revise Water Supply Agreement | | Update and implement the water supply agreement with constituent councils to reflect the FWS and enhanced demand management plan | 2014 |
| 6 | Supply system review | | Detailed supply system review – confirmed design criteria and optimised operational management in line with proposed supply sources | 2014 |

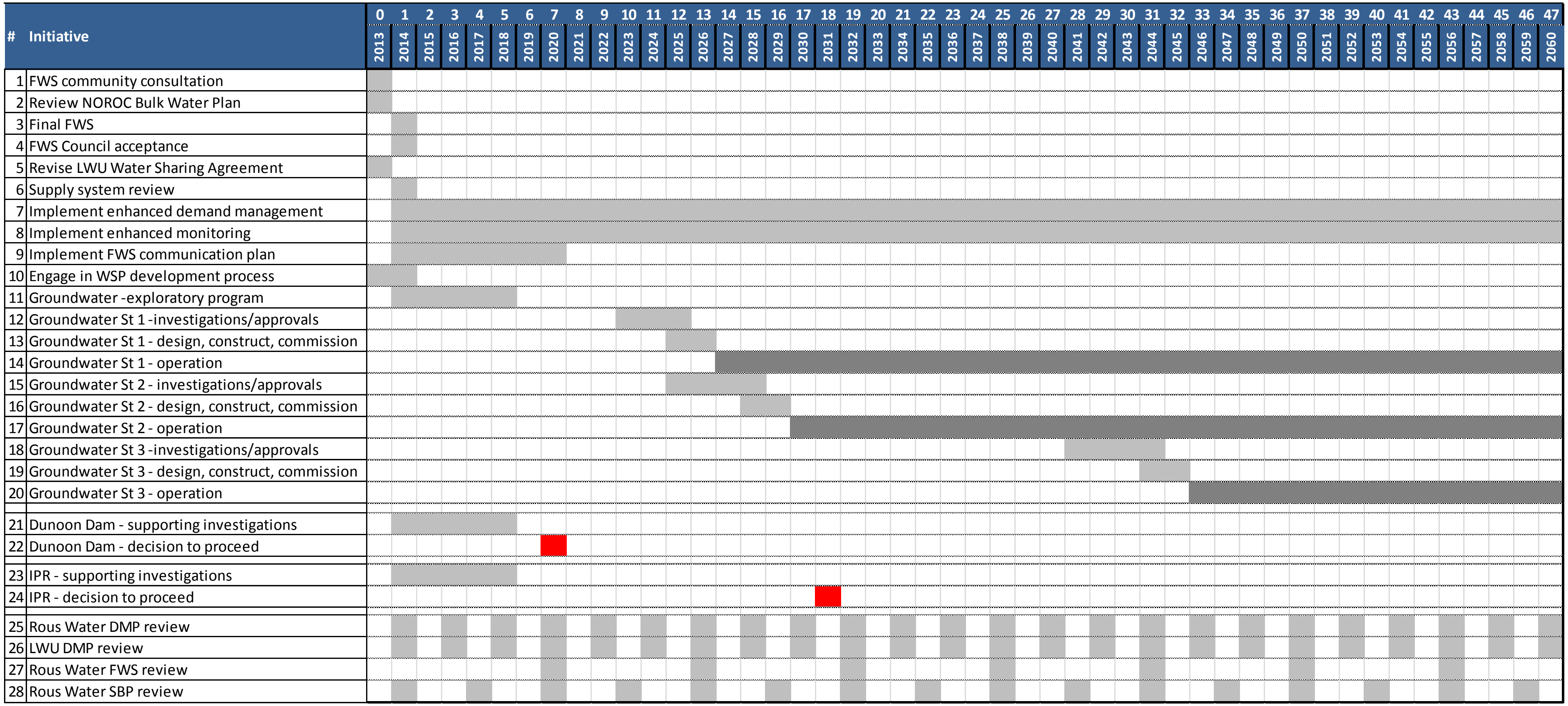
| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| 7 | Implement enhanced demand management and monitoring | Improved information for ongoing FWS evaluation | Rous Water and LWU implementation of demand management programs and FWS monitoring (refer to Appendix B for specifics) | 2014 onwards |
| 8 | FWS Communications Program | Community capacity building | Ongoing community education and survey including groundwater, IPR, increased restrictions messages | 2014 - 2018 |
| 9 | Groundwater exploratory program | Improved understanding of groundwater resources | 6. Undertake detailed desk studies to locate most prospective and convenient bore locations.<br>7. Identify several exploratory sites (additional to anticipated needs).<br>8. Investigate relationship of each well-field with GDEs and other environmental aspects e.g. saline waters and acid-sulfate soils.<br>9. Pump testing to confirm sustainable yield and water quality. Likely to require multi-day testing programmes at each location.<br>10. Apply for licence for each source, based on interpretation of pump testing results. Interpretation will need to include numerical modelling to determine interactions with GDEs, coastal salinity and acid-sulphate soil deposits. | 2014-2018 |
| 10 | Dunoon Dam supporting investigations | Ability to timely proceed, if required | Much of the base investigation work has been completed. However refinements to the concept maybe required with further community input and any changes to policies. | 2014-2018 |

| No. | Initiative | Outcome | Actions | Timing |
|---|---|---|---|---|
| 11 | IPR supporting investigations | Ability to timely proceed, if required | Ongoing studies and discussions with LWUs to confirm requirements for IPR approaches. Refinements maybe required with further community input and any changes to policies.<br>Consider MAR opportunities | 2014-2018 |
| 12 | Groundwater Stage 1 | New water source – Woodburn | 1. Budgeting, funding allocation, subsidy and any applicable grant approvals.<br>2. Land acquisition and environmental approvals.<br>3. Design and documentation.<br>4. Development of procurement and operational arrangements.<br>5. Construction and commissioning.<br>6. System management, operation and monitoring. | 2022-2026 |
| 13 | Groundwater Stage 2 (coastal sands) | New water sources | As above | 2025-2029 |
| 14 | Groundwater Stage 3 (fractured basalt) | New water sources | As above | 2040-2045 |
| 15 | Review of demand management program every 2 years | Enhanced demand manageme nt program | Review and update. LWUs to develop and regularly update their own plans also. | Every 2 years (next due 2014) |
| 16 | Review of FWS every six years | Allows for FWS to be adapted | Review of FWS | Every 6 years (in line with IWCM best practice) |
| 17 | Review of Strategic Business Plan (SBP) | | Review and update including financial modelling with revenue considerations. | Every 3 years |

Table 8-3 outlines the preliminary program for implementation of the FWS initiatives. Critical decision dates for the two contingency approaches, Dunoon Dam and IPR (Stage 1), are based on operational status by 2028 and 2037, respectively, with estimated lead times allowing for detailed planning, approvals, design, construction and commissioning of six years for each initiative. An additional two years is allowed for the new dam to fill with adequate water to meet demand requirements. It is recognised that the initiatives and timeframes presented will be changed as improved information becomes available.

FWS implementation is an on-going process involving formal review every six years to allow key assumptions made during the development of the FWS to be updated. Implementation of the FWS will require ongoing support by Rous Water, the constituent Councils, the community and relevant government agencies.

## Table 8-3: Implementation plan



### 8.2.1 Investment plan

Table 8-4 outlines the FWS's indicative level investment plan. The plan is based on:

1. New groundwater supply works and enhanced demand management capital and ongoing cost estimates (Scenario 3: extended groundwater, Section 6.5).
2. Existing Rous Water system growth works, renewals, management and other ongoing costs (Rous Water, 2013).
3. Parallel supporting investigations for contingency approaches (IPR and Dunoon Dam) combined with an ongoing communications program.

At this stage the cost estimates are not suitable for budgeting purposes. Budget cost estimates are to be prepared as design activities proceed. There is also opportunity to even out major capital investments as development of the works proceeds.

The annual capital investment (excluding renewals and O&M costs) required over the planning horizon is shown in Figure 8-1.

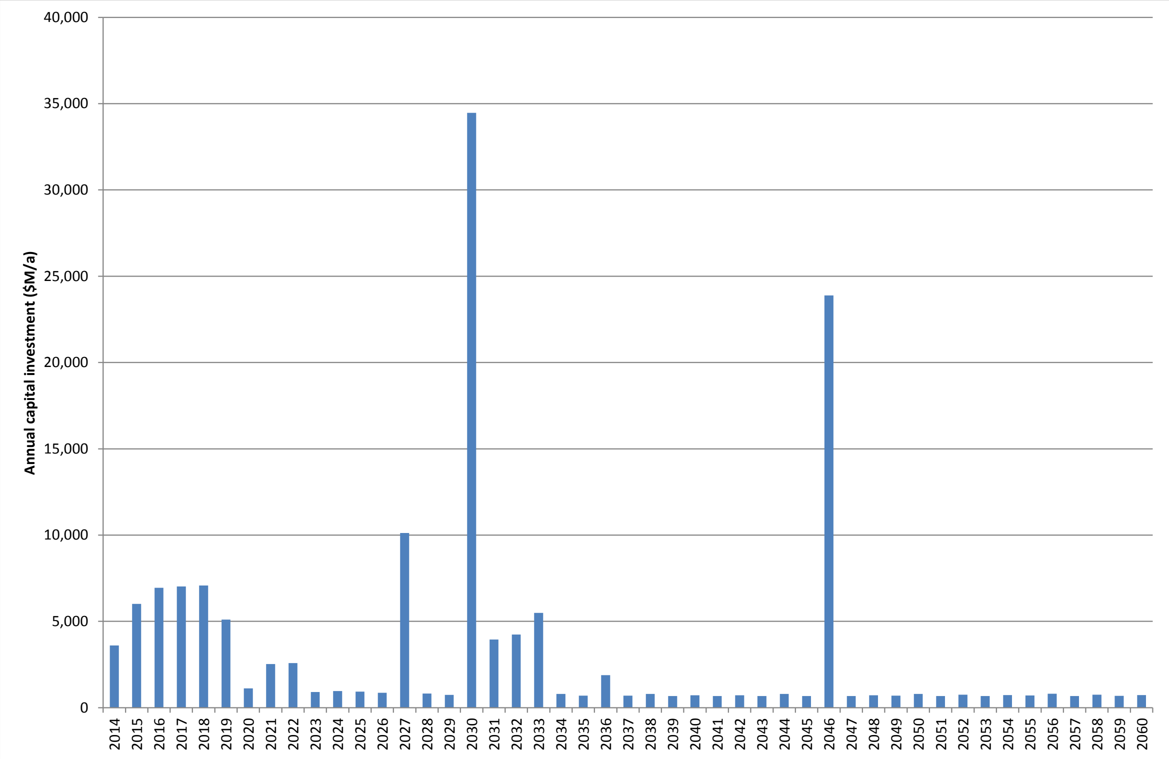



**Figure 8-1: Capital investment plan for FWS implementation**

Full financial planning of the FWS considering revenue (including funding opportunities) and costs (including loans) will be included in the strategic business planning process.

Opportunities for grant and subsidy funding should be reviewed as detailed planning commences. There may be opportunity for external funding to support the relocation of Woodburn Bores (associated with highway upgrade). If so, a business case should be prepared to bring forward the *Groundwater - Stage 1* (Woodburn Bore) activities to attract the funding.

However, in the current environment, there are relatively few grant and subsidy opportunities for the funding of urban water infrastructure. Utilities are actively encouraged to be self-funding. It is also unlikely that any current grant and subsidy programs for capital will be in place at the time of the proposed new works (post 2025).

## Table 8-4: Rous Water FWS investment plan (2013 dollars '000)

| # | Activity | Total | 1<br>2014 | 2<br>2015 | 3<br>2016 | 4<br>2017 | 5<br>2018 | 6<br>2019 | 7<br>2020 | 8<br>2021 | 9<br>2022 | 10<br>2023 | 11<br>2024 | 12<br>2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Extended groundwater** | | | | | | | | | | | | | |
| 1 | Catchment | 13,481 | 292 | 443 | 323 | 448 | 268 | 308 | 268 | 278 | 268 | 268 | 268 | 293 |
| 2 | Treatment and source | 763 | 28 | 264 | 20 | 12 | 10 | 12 | 10 | 10 | 14 | 10 | 12 | 11 |
| 3 | Distribution | 41,702 | 1,820 | 2,746 | 4,048 | 4,048 | 4,048 | 4,048 | 130 | 1,652 | 1,652 | 30 | 30 | 201 |
| 4 | Ballina Dual Supply | 1,756 | | | | | 1,611 | 145 | | | | | | |
| 5 | Depot | 12,230 | 270 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 |
| 6 | Demand management | 13,204 | 621 | 1,804 | 1,744 | 1,754 | 331 | 335 | 329 | 334 | 338 | 342 | 347 | 169 |
| 7 | Best practice planning | 1,750 | 75 | | 50 | | 50 | | 125 | | 50 | | 50 | |
| 8 | FWS communications | 500 | 100 | 100 | 100 | 100 | 100 | | | | | | | |
| 9 | Groundwater exploratory program | 2,000 | 400 | 400 | 400 | 400 | 400 | | | | | | | |
| 10 | Groundwater - Stage 1 | 9,329 | | | | | | | | | | | | |
| 11 | Groundwater - Stage 2 | 29,378 | | | | | | | | | | | | |
| 12 | Groundwater - Stage 3 | 23,141 | | | | | | | | | | | | |
| 13 | Renewals | 54,763 | 2,662 | 2,930 | 1,653 | 1,660 | 2,000 | 1,112 | 211 | 2,127 | 3,918 | 2,224 | 1,898 | 2,844 |
| 14 | Operation and maintenance | 558,214 | 9,245 | 9,249 | 9,249 | 9,248 | 9,247 | 9,246 | 9,255 | 9,254 | 9,253 | 9,252 | 9,251 | 9,250 |
| | **Contingency approaches** | | | | | | | | | | | | | |
| 1 | IPR supporting investigations, incl. MAR | 250 | 50 | 50 | 50 | 50 | 50 | | | | | | | |
| 2 | Dunoon Dam supporting investigations | 250 | 50 | 50 | 50 | 50 | 50 | | | | | | | |

| # | Activity | 13<br>2026 | 14<br>2027 | 15<br>2028 | 16<br>2029 | 17<br>2030 | 18<br>2031 | 19<br>2032 | 20<br>2033 | 21<br>2034 | 22<br>2035 | 23<br>2036 | 24<br>2037 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Extended groundwater** | | | | | | | | | | | | |
| 1 | Catchment | 268 | 318 | 293 | 268 | 268 | 353 | 268 | 268 | 343 | 268 | 268 | 293 |
| 2 | Treatment and source | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3 | Distribution | 30 | 30 | 30 | 30 | 4,332 | 3,152 | 3,402 | 4,780 | 10 | 38 | 1,175 | 10 |
| 4 | Ballina Dual Supply | | | | | | | | | | | | |
| 5 | Depot | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 |
| 6 | Demand management | 169 | 170 | 170 | 171 | 169 | 169 | 170 | 170 | 121 | 121 | 121 | 122 |
| 7 | Best practice planning | 125 | | 50 | | 50 | | 125 | | 50 | | 50 | |
| 8 | FWS communications | | | | | | | | | | | | |
| 9 | Groundwater exploratory program | | | | | | | | | | | | |
| 10 | Groundwater - Stage 1 | | 9,329 | | | | | | | | | | |
| 11 | Groundwater - Stage 2 | | | | | 29,378 | | | | | | | |
| 12 | Groundwater - Stage 3 | | | | | | | | | | | | |
| 13 | Renewals | 1,651 | 532 | 1,321 | 965 | 464 | 1,487 | 467 | 2,628 | 1,263 | 556 | 4,671 | 482 |
| 14 | Operation and maintenance | 9,249 | 9,248 | 9,993 | 9,827 | 9,679 | 11,195 | 11,326 | 11,457 | 11,629 | 11,765 | 11,902 | 12,031 |
| | **Contingency approaches** | | | | | | | | | | | | |
| 1 | IPR supporting investigations, incl. MAR | | | | | | | | | | | | |
| 2 | Dunoon Dam supporting investigations | | | | | | | | | | | | |

| # | Activity | 25<br>2038 | 26<br>2039 | 27<br>2040 | 28<br>2041 | 29<br>2042 | 30<br>2043 | 31<br>2044 | 32<br>2045 | 33<br>2046 | 34<br>2047 | 35<br>2048 | 36<br>2049 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Extended groundwater** | | | | | | | | | | | | |
| 1 | Catchment | 268 | 268 | 268 | 268 | 268 | 268 | 268 | 268 | 293 | 268 | 268 | 293 |
| 2 | Treatment and source | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3 | Distribution | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 4 | Ballina Dual Supply | | | | | | | | | | | | |
| 5 | Depot | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 |
| 6 | Demand management | 122 | 122 | 123 | 123 | 123 | 124 | 124 | 125 | 125 | 126 | 126 | 126 |
| 7 | Best practice planning | 125 | | 50 | | 50 | | 125 | | 50 | | 50 | |
| 8 | FWS communications | | | | | | | | | | | | |
| 9 | Groundwater exploratory program | | | | | | | | | | | | |
| 10 | Groundwater - Stage 1 | | | | | | | | | | | | |
| 11 | Groundwater - Stage 2 | | | | | | | | | | | | |
| 12 | Groundwater - Stage 3 | | | | | | | | | 23,141 | | | |
| 13 | Renewals | 3,083 | 1,352 | 1,693 | 96 | 1,478 | 177 | 136 | 110 | 561 | 180 | 1,161 | 95 |
| 14 | Operation and maintenance | 12,160 | 12,289 | 12,417 | 12,533 | 12,648 | 12,763 | 12,876 | 12,988 | 13,099 | 13,888 | 13,998 | 14,107 |
| | **Contingency approaches** | | | | | | | | | | | | |
| 1 | IPR supporting investigations, incl. MAR | | | | | | | | | | | | |
| 2 | Dunoon Dam supporting investigations | | | | | | | | | | | | |

| # | Activity | 37<br>2050 | 38<br>2051 | 39<br>2052 | 40<br>2053 | 41<br>2054 | 42<br>2055 | 43<br>2056 | 44<br>2057 | 45<br>2058 | 46<br>2059 | 47<br>2060 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Extended groundwater** | | | | | | | | | | | |
| 1 | Catchment | 268 | 268 | 293 | 268 | 268 | 293 | 268 | 268 | 293 | 268 | 268 |
| 2 | Treatment and source | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 3 | Distribution | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 4 | Ballina Dual Supply | | | | | | | | | | | |
| 5 | Depot | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 | 260 |
| 6 | Demand management | 127 | 127 | 128 | 128 | 129 | 129 | 130 | 131 | 131 | 132 | 132 |
| 7 | Best practice planning | 125 | | 50 | | 50 | | 125 | | 50 | | 50 |
| 8 | FWS communications | | | | | | | | | | | |
| 9 | Groundwater exploratory program | | | | | | | | | | | |
| 10 | Groundwater - Stage 1 | | | | | | | | | | | |
| 11 | Groundwater - Stage 2 | | | | | | | | | | | |
| 12 | Groundwater - Stage 3 | | | | | | | | | | | |
| 13 | Renewals | 111 | 95 | 116 | 130 | 511 | 110 | 376 | 100 | 1,161 | 95 | 111 |
| 14 | Operation and maintenance | 14,216 | 14,324 | 14,430 | 14,537 | 14,641 | 14,745 | 14,848 | 14,950 | 15,052 | 15,152 | 15,252 |
| | **Contingency approaches** | | | | | | | | | | | |
| 1 | IPR supporting investigations, incl. MAR | | | | | | | | | | | |
| 2 | Dunoon Dam supporting investigations | | | | | | | | | | | |

### 8.2.2 Monitoring and evaluation

The FWS assumes on-going monitoring to address areas of uncertainty and to confirm strategy actions. The FWS should be reviewed every six years to incorporate improved information and processes, as available. Table 8-5 outlines key monitoring recommendations identified in this study.

**Table 8-5: Monitoring and evaluation plan**

| Outcomes | Actions | Timing |
|---|---|---|
| Monitoring of trends in bulk per capita water production | Updated daily water tracking model | Monthly |
| Monitoring trends in customer consumption per account by customer type | Establish and update consumption tracking model | Quarterly |
| Monitoring trends in the level of NRW | Reconciliation of customer consumption and bulk supply by supply system | Quarterly |
| Monitor and update secure yield estimates (current and predicted) | Review the secure yield as understanding of climate change science and secure yield estimation processes improve. | Every 6 years |
| Monitoring trends in population growth | Review Census and total connection growth | Every 5 years |
| Monitoring changing household size | Review Census and total connection growth | Every 5 years |
| Monitoring formation of MFR accounts | Review number of connections by account type. | Quarterly |
| Monitoring of peak day factors | Review peak day factors using daily water tracking model. | Annually |
| Monitoring of non-residential connections and demand | Review number of connections by account type. | Quarterly |
| Monitoring of demand measures assumptions e.g. costs, uptake, sizes/types, stock/fixtures. | Review uptake rates, costs, savings and changing stock assumptions<br>Update the demand forecast if any significant drivers in demands are observed | Annually |

# 9 Conclusions and recommendations

This report documents the outcome of the IWP process. The process included:

1. Identification of Rous Water's future water management issues over a long term planning horizon.
2. Development of strategy assessment triple bottom line objectives and criteria in response to the water management issues.
3. Multiple options assessment and scenario development in order to address the water management issues.
4. A participatory approach with stakeholder feedback to help Rous Water on the choices faced.
5. Technical assurance and development of recommended strategy in consultation with Rous Water staff.
6. Recognition of future uncertainties and implementation risks, requiring on-going monitoring and review.

The process drew together information previously developed as part of the FWS process and incorporated input from stakeholders (PRG and councillors) to identify a number of new water supply options. Water supply options were individually assessed before being bundled into 'scenarios' aimed at meeting the water supply objectives. The option and scenarios were developed technically by the project team including Rous Water staff and considering opinions and input from technical experts. The options and subsequently scenarios were presented to the stakeholders who gave input into the preferred scenario by ranking against the project objectives.

Based on the study the following outcomes are drawn:

1. Future supply-demand deficit in the order of 6,500 ML/a by 2060. The adopted existing supply and demand scenario (which takes into account climate change impacts) suggests that existing supplies will be sufficient to meet the existing demand until 2024.
2. Potential climate change impacts are uncertain, however best available information suggests reduction in supply yield and increased extreme weather events leading to water quality issues and potential infrastructure damage. Secure yield modelling based on climate change predictions shows a 34% decrease in secure yield from 13,800 ML/a currently to 9,100 ML/a in 2060.
3. Stakeholder feedback supported through triple bottom line multi-criteria analysis, indicates that the highest ranked scenario is extended groundwater (Scenario 3) with enhanced demand management. This extended groundwater scenario is the basis of the recommended FWS.
4. Groundwater supply sources rank well in the balance of assessment objectives (Table 7-1). They do, however, include relatively high implementation risks, including variable water quality and quantity, potential environmental issues and approvals in a changing legislative environment. As such, the recommended FWS allows for on-going monitoring to enable adaptive management and consideration of contingency approaches if required.
5. If groundwater sources prove inadequate Indirect potable reuse (Scenario 4) the second highest ranking scenario allows for mid planning horizon implementation. IPR is not proposed as a standalone solution rather it is proposed as a complementary approach that could be used in conjunction with groundwater augmentation, to ensure long-term water security.
6. Compared with groundwater and indirect potable re-use of wastewater, the viability of the Dunoon Dam proposal is well understood. Accordingly, Rous Water will retain the option of the Dunoon Dam proposal, to be developed only should combined groundwater and indirect potable re-use of wastewater prove unviable or insufficient.

7. Desalination of seawater provides an unlimited, climate independent and reliable new water supply. The FWS identifies desalination as a potential new source to be considered as a safeguard should other sources prove unviable and insufficient.
8. Increased water restrictions could be implemented to further reduce capital expenditure and delay the need for new water supply options, however, this would need to be fully tested against the communities willingness to accept a lower level of service (compared to the remainder of NSW).

The recommended FWS is expected to address the future water supply deficit needs, whilst maintaining the best balance in environmental, social and economic objectives identified through this study. A FWS incorporating the following actions be implemented based on the preferred FWS from this study:

1. Adopt enhanced demand management to efficiently maximise the potable demand savings.
2. Adopt a stepped approach for development of groundwater sources to meet future supply needs.
3. Co-develop IPR and staged Dunoon Dam sources until the suitability of groundwater sources is fully understood.
4. Implement an on-going monitoring and review process in line with NSW best practice requirements.

It is recommended that Rous Water adopts the strategy outlined in this report and use it as the basis of the FWS for the next steps:

1. Documenting the FWS for public exhibition and comment.
2. Finalising the FWS for Rous Water Council adoption.
3. Continuing to engage in FWS Implementation Plan initiatives timed for current activity.

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# A Stakeholder engagement plan and outcomes

## Introduction

Stakeholder engagement was a key input to the development of the Rous Water Future Water Strategy (FWS).

The objective of the project was to develop an acceptable balance of water supply and demand options to meet forecast requirements to 2060. The scope of the project was to assess demand management and new water supply options. Supply and demand forecasting, and detailed examination of the proposed Dunoon Dam option, were carried out in separate studies completed prior to this project. In addition, coarse filtering of the potential new water supply options had already been undertaken by Rous Water prior to the commencement of this phase of the project.

A stakeholder engagement plan was put in place to identify the stakeholders to be engaged during the project and the consultation activities for each stage to help determine the balance of water supply and demand options to meet future water needs. The plan built upon the engagement of key stakeholders already undertaken through the Rous Water Project Reference Group (PRG), to continue to develop project understanding and trust.

This appendix documents the plan for engagement as it was delivered and the outcomes achieved at each point in the planning process.

## Stakeholder Engagement

A stakeholder engagement plan (SEP) was developed to provide a clear and consistent framework for stakeholder involvement at an appropriate level for each of the stakeholder groups. This plan provided a specific process for consultation with key stakeholders.

### Purpose

The purpose of SEP was:

- To supplement The Comms Team SEP for the overall engagement of the PRG with the specific consultation aspects of the MWH scope of works.
- To demonstrate the commitment of the project team to considering that feedback and informing stakeholders how it has been taken into account in the strategy.
- To continue to build and maintain trusted relationships with stakeholders to improve project outcomes.
- To provide a clear framework, process and protocols for engagement and capturing and integrating feedback.
- To provide a process for monitoring and evaluating engagement activities such that engagement activities can be improved over the life of this project as required.

### Objectives

The objectives of the stakeholder engagement process were:

- To provide defined stakeholders with an opportunity to raise issues and provide feedback relevant to the strategy.
- To obtain a better understanding of water management issues and potential solutions through stakeholder input, to improve project outcomes.
- To engender a sense of stakeholder involvement and ownership of the project outcomes.
- To assist in the proactive management of water resources by taking into account community values and the available scientific and engineering information in decision-making.

- To build relationship and a common understanding of issues and management responses with defined stakeholders.
- To increase study credibility.

## Approach

The options for water management will have economic, social and environmental impacts and the potential trade-offs of each need to be considered by stakeholders. Early and inclusive consultation with the appropriate stakeholders was viewed as a vital element to the success of the project.

As the study was a high level, regionally focussed, feasibility type study, it was appropriate to undertake consultation to seek the views of particular stakeholders (in this case, the already constituted PRG and Council Technical Directors) in order to improve study outcomes.

The consultation approach had the following characteristics:

- Goal: to obtain stakeholder feedback on analysis, alternatives and/or decisions.
- Commitment: defined stakeholders will be kept informed, listened to and their concerns and aspirations acknowledged and feedback provided on how public input influenced the decision.

The consultation approach provided stakeholders with opportunities to participate in the planning process.

The broader community (public) was not directly engaged during this project, although it is understood that Rous Water intends to engage more broadly now that this project has been concluded.

Ultimate decision-making authority in relation to the adopted Future Water Strategy will sit with the Rous Water Council and this was communicated to other stakeholders engaged in the planning process (i.e. that they would be providing feedback which would be collated and summarised for presentation to the Rous Water Board).

## Guiding Principles

The stakeholder consultation process for this project was guided by the following principles:

- Be proactive. Engage the stakeholders early in the process.
- Be open and honest in any communications.
- Be inclusive. Ensure stakeholders have access to the process and information about the study.
- Be responsive. Respond to stakeholder contact in a timely manner.
- Honour commitments made.

## Key Messages

The Comms Team developed a series of key messages for stakeholders that were utilised during the project. These are set out below.

### Background

- To maintain a reliable and sustainable water supply for the region, Rous Water is preparing the Future Water Strategy (FWS), a long-term water resource plan.
- The Future Water Strategy will assess how best to secure the region's long-term water needs and will take into account climatic conditions and rainfall, future water demand and demand management measures.
- The strategy will have a 50 year planning horizon and factor the staging of new water sources to meet expected increased demand for potable water.
- A project reference group, drawn from business, community and government, is supporting Rous Water with the development of the Future Water Strategy.
- Work on the Future Water Strategy will continue throughout 2013 and is expected to be completed by the end of the year.
- The draft strategy will be released for public comment prior to being finalised.

- Further information and Future Water Strategy documents are available on the Rous Water website, www.rouswater.nsw.gov.au.

**Project description**

- A range of technical studies and investigations have been undertaken to inform the FWS, including identifying potential new water sources, supply and demand investigations and environmental and social studies.
- The FWS will assess the outcomes of these investigations to draw together an integrated picture of how Rous Water will meet further supply and demand needs within the region.
- The FWS involves four components:
    - Supply and demand forecasting – to accurately estimate the expected future demand for water, taking into account factors such as population and economic growth and climate change and the expected yield of current and future water sources.
    - Demand management –long-term initiatives to maintain or reduce demand for potable water. The integrated water planning process has considered a range of additional demand management measures to increase water efficiency while minimising costs.
    - Dunoon Dam investigations – determining what if any role the proposed Dunoon Dam should play in meeting the future water needs of the region by investigating its technical and environmental viability.
    - New supplies – investigate whether new water sources or supplies are required and determining the most appropriate and suitable new supply. As well as Dunoon Dam, five other options are being investigated:
        - increased groundwater harvesting
        - desalination
        - regional water sharing, particularly the possibility of linking to Toonumbar Dam
        - potable and non-potable use of urban stormwater
        - non-potable and indirect potable wastewater reuse.
- These options will be the subject of detailed evaluation against a range of criteria. The evaluation will involve assessing the costs associated with each proposal (economic, social and environmental) against the benefits they will provide.
- A more extensive set of water supply options was considered earlier in the preparation of the strategy and following professional assessment, the above were considered to be most viable.

**Dunoon Dam investigations**

- Rous Water has previously resolved to be in a position to build Dunoon Dam if and when it is needed to ensure the region's water security.
- The Dunoon Dam proposal was identified by Rous Water as a potential future water source in 1995, and involves the construction of a new dam on Rocky Creek, downstream of the existing Rocky Creek Dam.
- As part of the development of the Future Water Strategy, Rous Water is undertaking a range of technical studies to determine whether the Dunoon Dam proposal is viable in technical, environmental, social and economic terms.
- If the Dunoon Dam proposal is determined to be viable, the Future Water Strategy will determine whether it is required, when compared to other water supply and management options.
- Rous Water does not yet have an expectation as to whether the Dunoon Dam will be included in the Future Water Strategy, or not.
- Raising of the wall at Rocky Creek Dam has been assessed and would not provide meaningful new quantities of water.

- Several separate studies have been commissioned to help determine the viability of the proposed Dunoon Dam. The studies include:
  - Terrestrial ecology assessment
  - Aquatic ecology and environmental flow assessment
  - Cultural heritage assessment
  - Dam concept design and preliminary costing
  - Geology and soil profile investigation

## Stakeholder Analysis

This section sets out the stakeholders relevant to the delivery of this project. Detailed stakeholder analysis is not conducted as this forms part of the overarching SEP developed and implemented by The Comms Team.

## Internal Stakeholders

The following table documents the internal stakeholders relevant to this project (Table A-1).

**Table A-1: Rous Water Council and Constituent Council technical directors**

| Stakeholder | Organisation | Title | Outcomes |
|---|---|---|---|
| Cr Keith Johnson | Rous Water - Ballina Shire Council | Councillor | Sense of ownership of process and outcomes |
| Cr Susan Meehan | Rous Water - Ballina Shire | Councillor and Deputy Chair | Empowered with reference group feedback, technical director feedback and independent technical advice in order to resolve a FWS for Rous Water. |
| Cr Duncan Dey | Rous Water – Byron Shire Council | Councillor | |
| Cr Diane Woods | Rous Water – Byron Shire Council | Councillor | |
| Cr Simon Clough | Rous Water – Lismore Council | Councillor | |
| Cr Vanessa Ekins | Rous Water – Lismore Council | Councillor | |
| Cr Robert Mustow | Rous Water – Richmond Valley Council | Councillor | |
| Cr Col Sullivan | Rous Water – Richmond Valley Council | Councillor and Chair | |
| John Truman | Ballina Shire Council | Civil Services Group Manager | Sense of ownership of process and outcomes |
| Phil Warner | Byron Shire Council | Executive Manager Water & Recycling | |
| Phil Holloway | Byron Shire Council | Executive Manager  Community Infrastructure | Ownership of responsibilities in relation to implementing aspects of the |
| Garry Hemsworth | Lismore Council | Executive Director Infrastructure Services | |

| Stakeholder | Organisation | Title | Outcomes |
| --- | --- | --- | --- |
| Gary Murphy | Richmond Valley Council | Executive Manager Infrastructure and Environment | adopted strategy |

## External Stakeholders

The following table documents the external stakeholders relevant to this project (Table A-2).

**Table A-2: Project Reference Group**

| Stakeholder | Organisation | Title | Outcomes |
| --- | --- | --- | --- |
| George Bell | Not supplied | Not supplied | As set out in the engagement charter for the PRG and The Comms Team SEP |
| Andrew Braid | Not supplied | Not supplied | |
| John Cade | NSW Farmers Association | Not supplied | |
| Leigh Davison | Southern Cross University | Not supplied | |
| Ian Drinkwater | Evans Head District Water Committee | Not supplied | |
| Jill Garsden | Not supplied | Not supplied | |
| Chris Hennessy | NSW Office of Water | Not supplied | |
| Rod Haig | Lismore City Council | Not supplied | |
| Tim Mackney | Department of Services, Technology and Administration | Not supplied | |
| Paul Muldoon | Not supplied | Not supplied | |
| Paula Newman | Lismore City Council | Not supplied | |
| Nanette Nicholson | Not supplied | Not supplied | |
| Monica Pimm | Not supplied | Not supplied | |
| Tim Rabbidge | NSW office of Water | Not supplied | |
| Terry Seymour | Richmond Valley Council | Not supplied | |
| Andi Simpson | Not supplied | Not supplied | |
| Caroline Sullivan | Southern Cross University | Not supplied | |
| Richard Swinton | Not supplied | Not supplied | |
| Duncan Thomson | Geolink | Not supplied | |
| John Truman | Ballina Shire Council | Not supplied | |
| Todd Westgate | Northern Cooperative Meat Company | Not supplied | |

## Consultation

This section sets out the consultation activities undertaken at each stage in the planning process.

## Engagement in the Planning Process

The key stakeholder input points in the planning process are highlighted in Figure A-1.

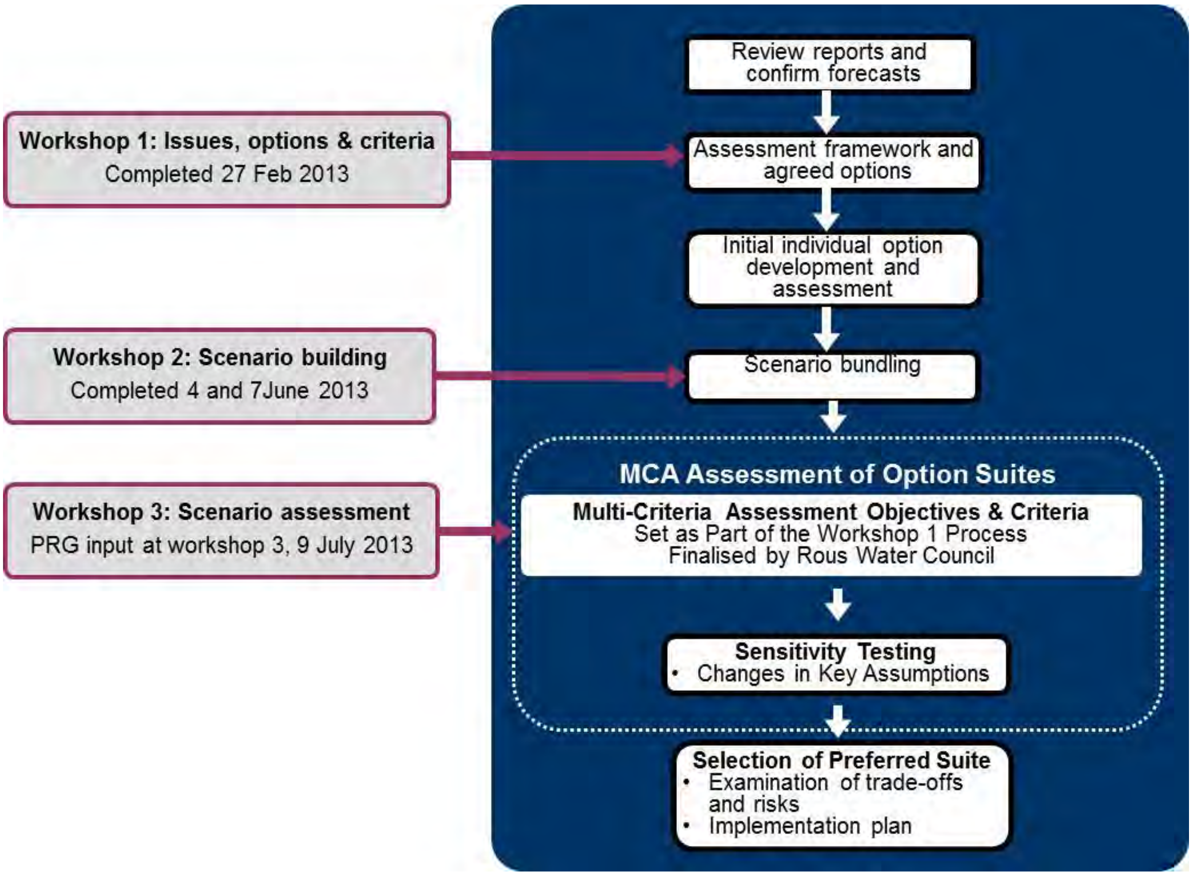


**Figure A-1: Engagement throughout the planning process**

## Consultation Activities

Table A-3 sets out the consultation activities delivered for this project. Other activities, including media management etc, were implemented by The Comms Team.

**Table A-3: Planned Consultation Activities**

| Date (2013) | Activity | Reason/Outcomes | Responsibility | Stakeholders |
|---|---|---|---|---|
| 23 Jan | Develop a stakeholder consultation plan | Stakeholder Engagement Plan | MWH | Rous Water |
| 23 Jan | Initial contact made with external stakeholders | Confirm dates<br>Discuss involvement | The Comms Team (TCT) | PRG |
| 27 Feb | Workshop 1 PRG: Issues and Options. A 2.5hr facilitated workshop to confirm project objectives and identify options and the potential requirements/issues relating to each option (e.g. environmental, social and economic constraints). | Develop an understanding of the planning process<br>Determine the triple bottom line assessment framework<br>Foster a shared understanding of issues | The Comms Team – Facilitation and management of workshop<br>MWH – Technical content | PRG |

| Date (2013) | Activity | Reason/Outcomes | Responsibility | Stakeholders |
|---|---|---|---|---|
| 27 Feb | | and Rous Water's situation.<br>Gain a sense of the types of management options available<br>Workshop Briefing and Summary Papers | | Rous Water Council<br>Directors |
| 4 June | Workshop 2 PRG: Scenario Building. A 2.5hr facilitated workshop to assist in determining actions to achieve sustainable water management outcomes and bundling those together in response to particular drivers. | Review of the assessment of individual options<br>Agreed bundling of options into scenarios for short and long terms<br>Workshop Briefing and Summary Papers | The Comms Team – Facilitation and management of workshop<br>MWH – Technical content | PRG |
| 7 June | Workshop 2 Rous Water: Scenario Building. A 2.5hr facilitated workshop to assist in determining actions to achieve sustainable water management outcomes and bundling those together in response to particular drivers. | | | Rous Water Council<br>Directors |
| 3 July | Workshop 3 PRG: Scenario Assessment: Stakeholders will be presented with a number of scenarios and be asked to undertake a triple bottom line assessment of each option. The workshop briefing paper will outline the results of the analyses undertaken for the project and the different scenarios. | Transparent and objective decision making process<br>Assessment of strategic options and identification of PRG preferred option<br>Workshop Briefing and Summary Papers | The Comms Team – Facilitation and management of workshop<br>MWH – Technical content | PRG |
| 9 July | Workshop 3 Rous Water: Scenario Assessment | | | Rous Water Council<br>Directors |
| Yet to be set | Final Presentation to PRG | An endorsement meeting to confirm the study outcomes<br>Presentation | MWH | PRG |
| Yet to be set | Final Presentation to Rous Water | A presentation of the study process and outcomes to Rous Water<br>Presentation | MWH | Rous Water Council<br>Directors |

## Outcomes

This section sets out the outcomes from the stakeholder engagement processes.

The workshop processes for the PRG and Rous Water Council and Directors were the same. The outcomes presented below are combined outputs from the two groups of stakeholders.

### Workshop 1: Issues, Options and Criteria

The purpose of these workshops was to:

- Provide an update about the FWS methodology.
- Introduce the project team who will prepare the draft FWS.
- Confirm the values and objectives which will frame the FWS.
- Workshop the criteria which will be used to assess new water supply options (from 2012 shortlist).

The short-listed water supply options confirmed at this workshop are presented in Table A-4. The participants were also presented with background information on the supply and demand forecasts and the key issues and proposed objectives identified by the project team through desktop review of previous planning studies and policy documents.

**Table A-4: Short-listed water supply options**

| FWS – Short-listed water supply options |
|---|
| **A.** Demand Management |
| **B.** Potable use of stormwater |
| **C.** Urban stormwater for non-potable urban use and urban irrigation |
| **D.** Indirect potable reuse |
| **E.** Recycling of reclaimed water for non-potable urban use |
| **F.** Groundwater |
| **G.** Desalination |
| **H.** Dunoon Dam |
| **I.** Regional connections –Establish new Town Water Supply licence for Toonumbar Dam |
| **J.** Regional water supply options identified through NOROC study |
| **K.** Revised water supply restrictions |
| **L.** Raising Rocky Creek Dam |

During each workshop participants were invited to:

- Confirm short-listed water supply options.
- Reflect on preliminary water management issues and objectives developed prior to the meeting.
- Consider potential criteria which could be used to assess each water supply option, and
- Identify and rank their highest priority objectives.

The principles of setting objectives that the workshop participants were asked to consider were:

- Environmental, social & economic option assessment criteria.
- Assigning of weightings and normalised scores to each criteria.
- Comparison of options using aggregated index/s for ranking.

- Sensitivity testing of weightings.
- Selection of criteria which value the project goals and objectives, and which minimise double-counting.
- A participatory approach – stakeholder input and transparency of assumptions, trade-offs and decisions.

Minutes and records of the workshop, including ranked objectives, were recorded by staff from The Comms Team.

This information was then used by the project team and staff from Rous Water to refine and reconsider the preliminary water management objectives and to recommend appropriate criteria by which each objective could be measured.

As an outcome of this process, the following objectives and criteria were recommended to, and adopted by, Rous Water Council for use in the multi-criteria assessment of short-listed water supply options (Table A-5).

**Table A-5: Multi-criteria assessment objectives**

| Category | Objectives | Criteria |
|---|---|---|
| Environmental | Scenario enables adaptive management | Qualitative assessment score |
| | Increased system resilience through supply diversity | Qualitative assessment score |
| | Effectively utilise demand management | Per capita potable usage |
| | Minimise ecological& cultural heritage impacts | Qualitative assessment score |
| | Minimise greenhouse gas emissions | Qualitative assessment score |
| Social | Scenario is affordable to consumers | Qualitative assessment score |
| | Supported by constituent Councils | Qualitative assessment score |
| | Maximises community acceptance | Qualitative assessment score |
| Economic | Minimise community costs | Community (utility + customer) net present value |

In addition to the above, the following objectives (Table A-6) were identified as "must do" objectives (i.e. minimum criteria which all scenarios must meet).

**Table A-6: Must do objectives**

| Must Do Objectives | Criteria |
|---|---|
| Comply with water sharing plans | Water sharing plans establish rules for sharing water between the environmental needs of the river or aquifer and water users, and also between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation. Water |

| | |
|---|---|
| | sharing plans are being progressively developed for rivers and groundwater systems across New South Wales following the introduction of the *Water Management Act 2000*. |
| Plan for option lead times | Allow sufficient lead time to ensure approvals, design, construction can be completed before augmentation required |
| Protect public health | Meet Australian guidelines for drinking water or recycled water |
| Provide adequate secure yield | Meets secure yield level of service targeted |
| Effectively utilise existing assets into the future | Do as part of scenario development |

## Workshop 2: Scenario Building

The purpose of these workshops was to:

- Provide an update about the FWS methodology.
- Examine the benefits and identify the constraints associated with each of the water supply options.
- Workshop a series of bundles (scenarios) of water supply options to meet the demand forecast.

The participants were presented with detailed technical, environmental and financial information on each of the 21 sub options developed from the short-listed water supply options as set out in Table A-7.

**Table A-7: Detailed short-listed options**

| Short-listed water supply options | Sub-options |
|---|---|
| A. Demand Management | A1. Existing Demand Management<br>A2. Enhanced Demand Management (including Loss Management) |
| B. Stormwater harvesting for potable | B1. Goonellabah Catchment<br>B2. Alstonville Catchments<br>B3. Cumbalum Ridge Development |
| C. Stormwater harvesting for non-potable | None identified. Consider in demand management programs (BASIX) |
| D. Indirect potable reuse of wastewater | D1. East and South Lismore STP<br>D2. Alstonville STP<br>D3. Alstonville STP plus stormwater harvesting<br>D4. Ballina and Lennox STP |
| E. Non-potable wastewater reuse | None identified. Consider in demand management programs (Ballina Recycled Water Scheme) |
| F. Groundwater supply augmentation | F1. Maximise existing sources (Woodburn, Lumley Park)<br>F2. New sources (Coastal Sands)<br>F3. New sources (Fractured basalt) |

| Short-listed water supply options | Sub-options |
|---|---|
| G. Desalination supply augmentation | G1. Tyagarah (marine feed water)<br>G2. South Ballina (marine feed water) |
| H. The proposed Dunoon Dam | H1. Dunoon Dam (50,000 ML) |
| I. Access regulated water associated with Toonumbar Dam | I1. Modified water sharing plan (2020) |
| J. Regional water supply options identified through the NOROC study | J1. Regional desalination |
| K. Application of revised water restrictions | K1. Accept reduced supply security (5/15/15) |
| L. Raise existing Rocky Creek Dam (resolution of Rous Water Council, February 2013) | L1. Raise Rocky Creek Dam (8 m) |

To assist in the development of bundles of water supply options (scenarios), participants were asked to work with a series of themes, related to the project objectives. These themes were:

1. Resilience, adaptation and risk management: this theme is included to explore options that diversify supply, are climate independent and conscious of carbon emissions
2. Water resource efficiency: this theme is included to consider options that ensure water demands are efficient and water conservation is considered.
3. Acceptability: this theme is included to capture options that are acceptable to the community from environmental, cultural and other social value perspectives.
4. Minimise cost and ensure affordability: this theme is included to ensure options that result in minimal costs are considered.

Based on the bundles of options compiled, stakeholder preferences showed best support for:

- Enhanced demand management
- Groundwater options – particularly coastal sands
- Wastewater reuse options
- Restrictions, albeit only at the 5/15/15 level
- Dunoon Dam.

The results of these bundling exercises were reviewed and compiled into five scenarios by the project team. These were then reviewed by Rous Water staff and presented to Rous Water Councillors. The scenarios set out in Table A-8 were agreed to be the scenarios for assessment.

**Table A-8: Scenarios**

| Scenario | Description |
|---|---|
| 1. Business as usual | A1. Demand Management , Existing Demand Management<br>H1. The proposed Dunoon Dam, Currently planned Dunoon Dam (50,000 ML) |
| 2. Staged Dunoon Dam | A2. Demand Management, Enhanced Demand Management (including water loss management)<br>H2 The proposed Dunoon Dam, Staged Dunoon Dam (20,000 ML) |
| 3. Extended groundwater | A2. Demand Management, Enhanced Demand Management (including water loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands) |

| Scenario | Description |
|---|---|
| | F3. Groundwater supply augmentation, New sources (Fractured Basalt)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>Backup option<br>F4. Groundwater supply augmentation, Managed aquifer recharge (stormwater or wastewater reuse) and new additional sources |
| 4. Indirect potable reuse | A2. Demand Management, enhanced Demand Management (including water loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands)<br>F3. Groundwater supply augmentation, New sources (Fractured Basalt)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>D4. Indirect potable reuse of wastewater, Ballina and Lennox Head STPs<br>D3. Indirect potable reuse of wastewater, Alstonville STP plus stormwater harvesting<br>Backup option<br>D1. Indirect potable reuse of wastewater, East Lismore and Sth Lismore STPs |
| 5. Deferred desalination | A2. Demand Management, Enhanced Demand Management (including water loss management)<br>F2. Groundwater supply augmentation, New sources (Coastal Sands)<br>F3. Groundwater supply augmentation, New sources (Fractured Basalt)<br>F1. Groundwater supply augmentation, Maximise existing sources (Woodburn)<br>G2. Desalination supply augmentation, South Ballina (marine feed water) |

## Workshop 3: Scenario Assessment

The purpose of these workshops was to:

- Provide an update on the progress of the Future Water Strategy (FWS), including presenting the water supply scenarios developed
- Workshop the assessment of a series of water supply scenarios against the project objectives agreed in Workshop 1
- To provide feedback on the strategic choices facing Rous Water

At the workshop participants were presented detailed information on each of the scenarios that had been developed, considering its environmental, social and economic impacts.

Participants were then asked to assess each scenario against each of the project objectives by applying the multi-criteria assessment framework developed in Workshop 1 and set out in Table A-5.

The assessment was achieved by each participant assigning each of the scenarios a relative score from -3 to +3 for each project objective, where -3 represented the worst possible outcome for the criterion and +3 represented the most favourable.

+3 Significant positive contribution to achieving the objective

+2 Moderate positive contribution to achieving the objective

+1 Minimal positive contribution to achieving the objective

0 No influence on achieving the objective

-1 Minimal negative contribution to achieving the objective

-2 Moderate negative contribution to achieving the objective

-3 Significant negative contribution to achieving the objective

A more detailed explanation of the scoring process, as well as support staff from MWH and Rous Water to assist, was provided at the workshop.

Following scoring, participants from both workshop processes were provided an opportunity to develop a set of weightings for each of the project objectives in Table A-5. In addition, the Rous Water staff participated in a pairwise analysis of the project objectives to derive a third set of possible weightings. Pairwise analysis is a process of comparing stated objectives in pairs in order to determine the relative preference for each objective. It is a systematic and forced-choice comparison of objectives, and results in participants specifically considering and weighing each objective before determining their relative preferences. Hence, it is more deliberate than other processes, such as the assignment of simple votes against each objective. It is a widely used tool in the study of social preferences and attitudes for policy and planning processes.

The results of the multi criteria assessment as it was conducted at the workshops are set out below.

The results in were derived using the PRG project objectives, the scores for each objective as assessed by the PRG, the weightings for each objective, as determined by Rous Water, and an equal weighting for the categories of environment, social and economic. As shown in the graph, Scenario 3 is ranked first, followed by Scenario 4 and then Scenario 5.

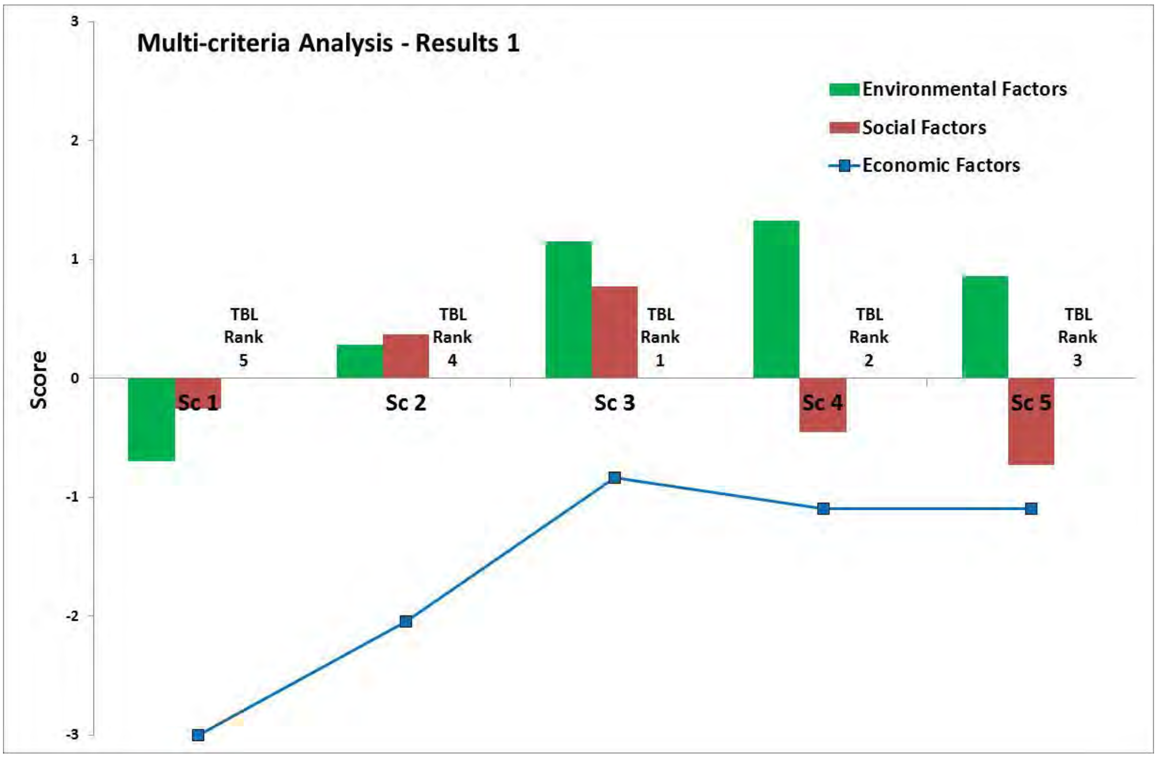


**Figure A-2: MCA Results using PRG Objectives, PRG Scores, Rous Water Weightings, TBL Categories**

Following the workshop, the PRG was invited to provide their own weightings for the project objectives. The results of the same MCA process, applied using the PRG project objectives, the scores for each objective as assessed by the PRG at the workshop, the weightings for each objective as determined by the PRG after the workshop, and without any categorisation of the objectives, are set out in Figure A-3. As shown in the graph, the results are identical in terms of ranking, with Scenario 3 ranked first, followed by Scenario 4 and then Scenario 5.

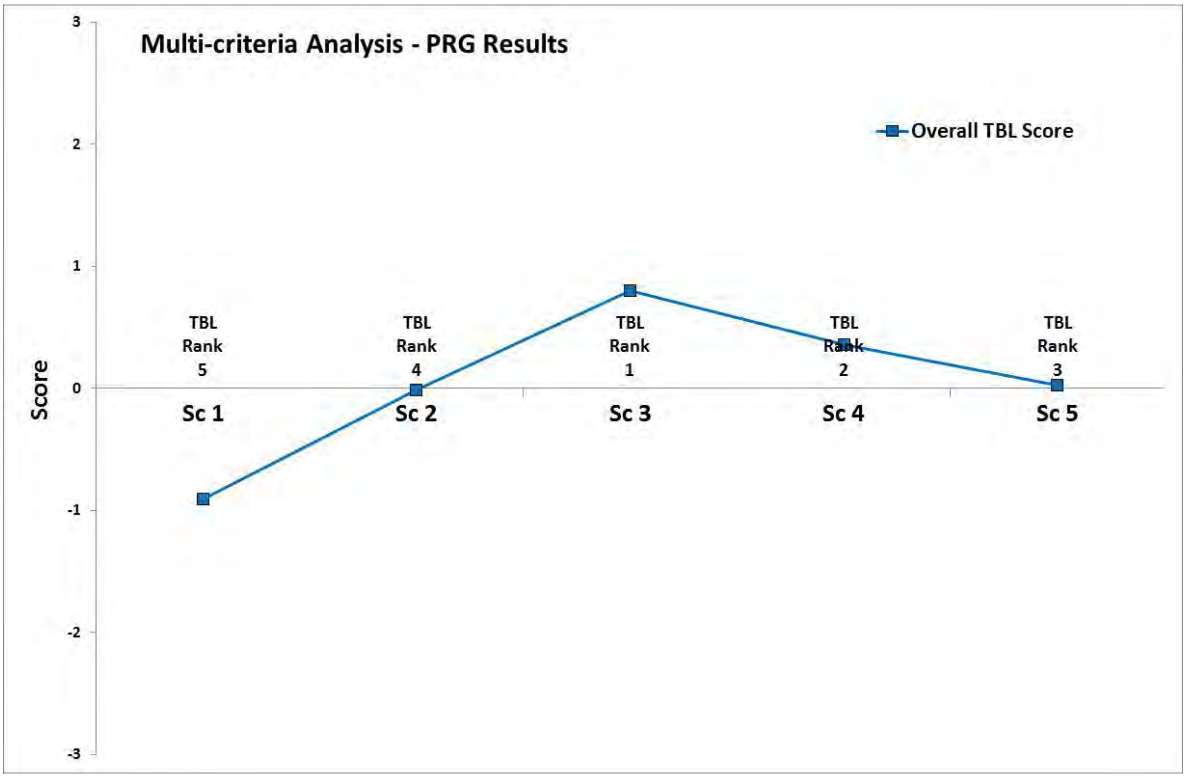


**Figure A-3: MCA Results using PRG Objectives, PRG Scores, PRG Weightings, No TBL Categories**

A similar process was followed with the Rous Water Councillors. The results are set out in Figure A-4 and Figure A-5.

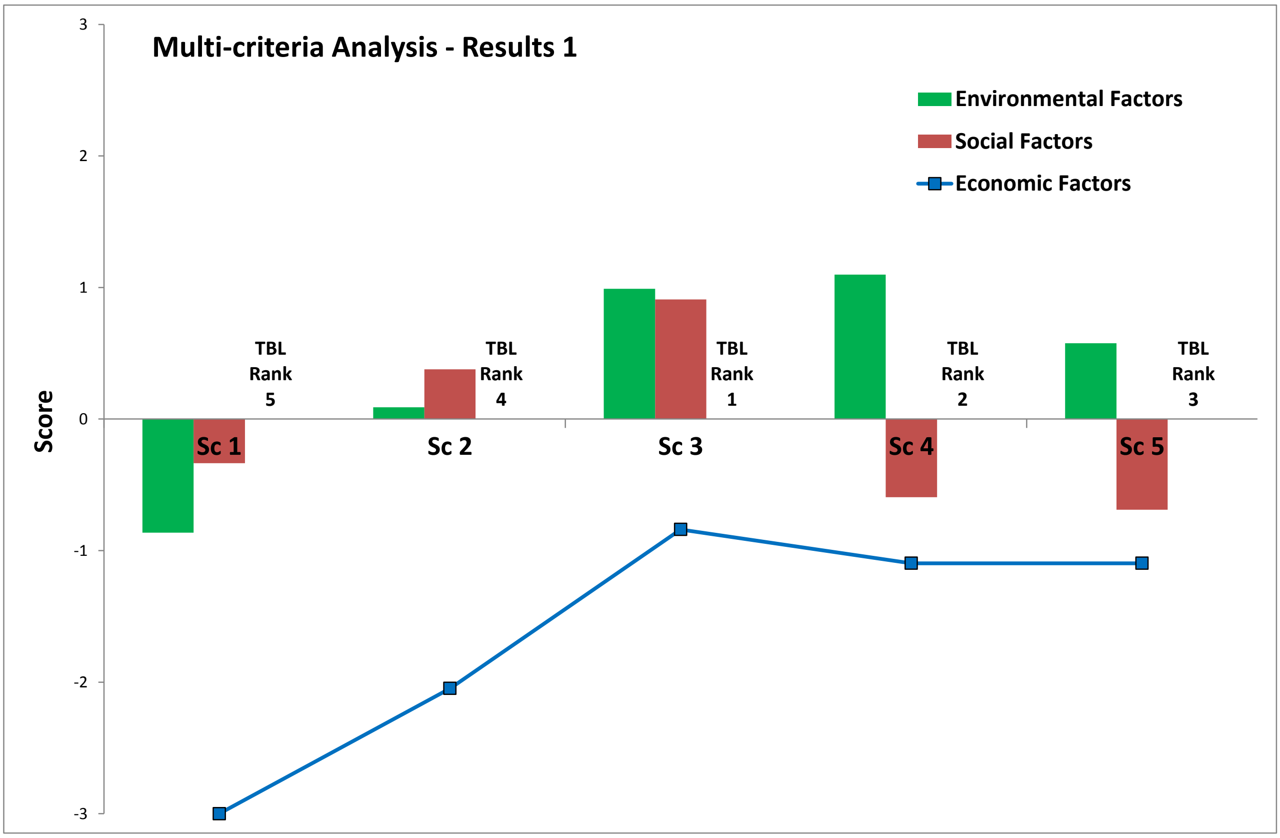


**Figure A-4: MCA Results using PRG Objectives, Council and Director Scores, Rous Water Weightings, TBL Categories**

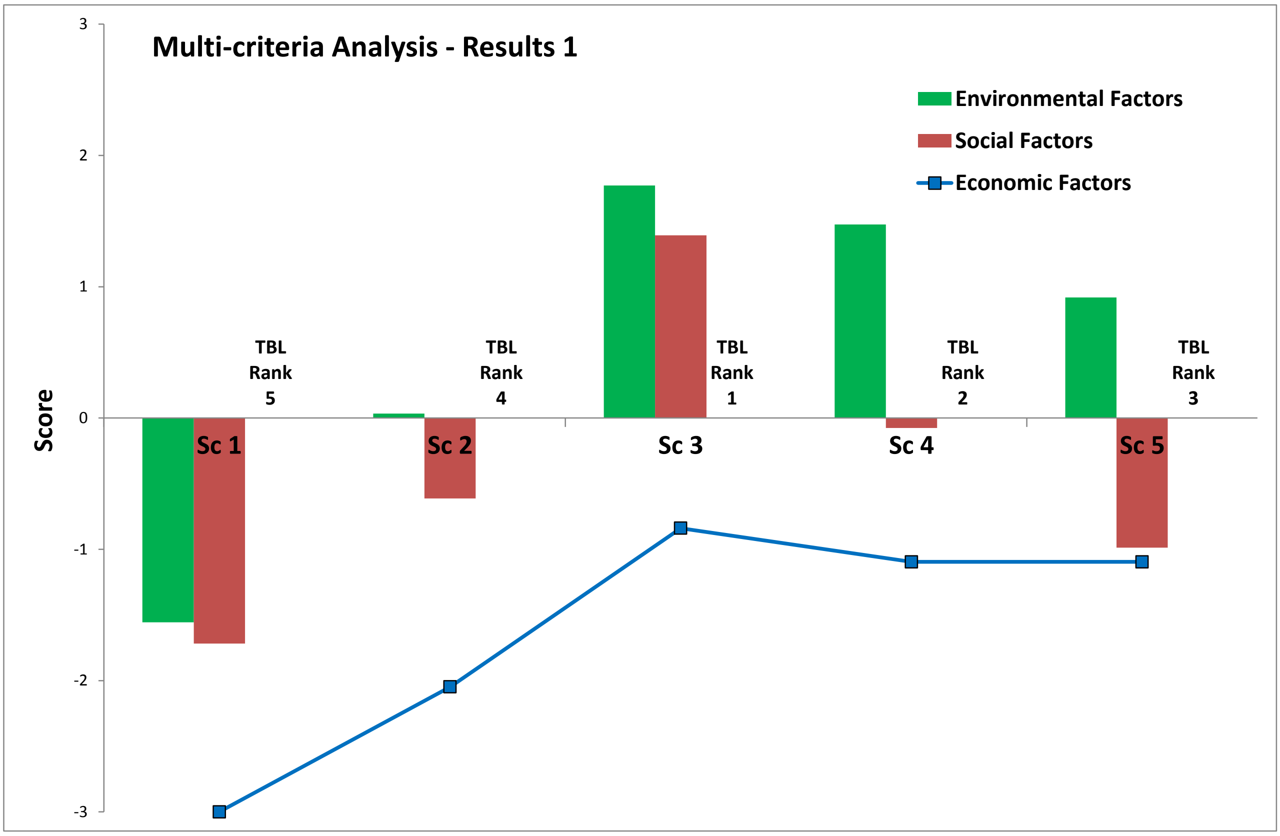


**Figure A-5: MCA Results, PRG Objectives, Council and Director Scores, Council and Director Weightings, TBL Categories**

# B Evaluation of demand management measures

# EVALUATION OF DEMAND MANAGEMENT MEASURES TECHNICAL NOTE

## Future Water Strategy

Prepared for Rous Water

July 2014

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## REVISION SCHEDULE

| Rev No | Date | Description | Signature or Typed Name (documentation on file). | | | |
|---|---|---|---|---|---|---|
| | | | Prepared by | Checked by | Reviewed by | Approved by |
| A | April 13 | Technical note | TM | AJ | AJ | AJ |
| B | July 13 | Revised technical note | TM/JB | TM | AJ | AJ |
| C | Jan 14 | Final draft | TM | SOB | SOB | EP |
| D | July 14 | Final | TM | SOB | SOB | EP |

# Rous Water

## Demand Management Evaluation

## CONTENTS


Glossary of terms ........ 1
1 Introduction ........ 3
1.1 Purpose ........ 3
1.2 Scope ........ 3
1.3 Layout ........ 3
2 Context ........ 4
3 Demand analysis ........ 4
3.1 Water production ........ 4
3.1.1 Bulk water production model ........ 5
3.1.2 Monthly WaterTrac model by LWU ........ 6
3.1.3 Production by LWU ........ 7
3.1.4 Peak day factors ........ 8
3.2 Consumption breakdown ........ 8
3.3 Major users ........ 9
3.4 Non-revenue water ........ 10
4 Demand forecast ........ 10
4.1 Drivers ........ 10
4.2 Population ........ 10
4.2.1 Household size ........ 12
4.2.2 Population growth ........ 12
4.2.3 Non-residential growth ........ 13
4.2.4 Household income and lifestyle ........ 13
4.2.5 Water efficient appliances and fixtures ........ 14
4.3 Customer consumption ........ 14
4.3.1 Current breakdown in end use ........ 14
4.4 Baseline forecast ........ 16
5 Options identification ........ 17
5.1 Current demand management measures ........ 17
5.2 Additional demand management measures ........ 24
6 Options evaluation ........ 27
6.1 Overview ........ 27
6.2 Benefit-cost analysis ........ 28
6.2.1 Individual measures ........ 28
6.3 Demand management cases ........ 29

7 NSW best practice management .... 32
8 Monitoring and reporting .... 32
8.1 Demand targets .... 33
9 Recommendations .... 34
10 References .... 34

## LIST OF TABLES

Table 3-1: Representative climate site used for each water supply area .... 5
Table 3-2: Top 20 non-residential water users (2010) .... 9
Table 3-3: Historical NRW assessment .... 10
Table 4-1: Assumed serviced population by LGA .... 11
Table 4-2: Non-residential connection growth .... 13
Table 4-3: Baseline demand for each customer type (Hydrosphere Consulting, 2013) .... 14
Table 4-4: End use breakdown by customer type (L/connection/day) .... 15
Table 5-1: Current and historical demand management measures .... 17
Table 5-2: Additional demand management measures .... 24
Table 6-1: Benefit-cost assessment for each stand-alone demand management measure .... 28
Table 6-2: Demand management cases .... 29
Table 6-3: Summary of Costs and Savings for each Demand Management Case .... 30
Table 8-1: Monitoring and reporting plan .... 33
Table 8-2: Water Demand Targets .... 33
Table C-1: Showers Fixture Assumptions .... 2
Table C-2: Currently Installed Stock Assumptions - 2010 .... 2
Table C-3: Types of Washing Machines Assumptions .... 3
Table C-4: WELS Star Rating – Volume per Use for Washing Machines .... 4
Table C-5: Currently Installed Stock Assumptions .... 5
Table C-6: Toilet Fixture Assumptions .... 5
Table C-7: Currently Installed Stock Assumptions .... 5

## LIST OF FIGURES

Figure 3-1: Observed and climate corrected bulk water production per head of population served (L/p/day) 6
Figure 3-2: Climate corrected bulk supply by LWU (L/p/day) .... 7
Figure 3-3: Average consumption by LWU (2007-2010) .... 7
Figure 3-4: Historical peak day factor .... 8
Figure 3-5: Average demand by customer sector (2007-2010) .... 9
Figure 4-1: Assumed decrease in household size for SFR and MFR accounts .... 12
Figure 4-2: Serviced population forecast for Rous Water supply area .... 13
Figure 4-3: Assumed water use breakdown for an existing SFR account .... 15

Figure 4-4: Rous Water baseline demand forecast using end use model and connection based method 16
Figure 6-1: Forecast water demand for each demand management case (ML/a) .................................. 31
Figure 6-2: Forecast water demand for each demand management case (L/head of serviced population) 31
Figure 6-3: Peak day demand forecast ........................................................................................ 32

## APPENDICES

Appendix A Measure assumptions ........................................................................................ 1
Appendix B Demand management plan checklist - status.................................................................. 1
Appendix C Fixture and appliance assumptions ................................................................................ 1
C.1 Showers........................................................................................................................ 1
C.2 Washing Machines ........................................................................................................ 2
C.3 Toilets........................................................................................................................... 5
C.4 Taps.............................................................................................................................. 5
C.5 Dishwasher.................................................................................................................... 6
C.6 Bath use ........................................................................................................................ 6
C.7 Internal leakage ............................................................................................................. 6

# Glossary of terms

| Word/Acronym | Definition |
|---|---|
| ADD | Average day demand (water supply) |
| ADWF | Average dry weather flow (sewage) |
| ADWG | Australian Drinking Water Guidelines |
| AGWR | Australian Guidelines for Water Recycling |
| Annualised cost | The present value of the cost of a program converted to an annual cost divided by the average annual reduction in demand resulting from that program. Presented as $/kL. |
| BASIX | Building and Sustainability Index |
| BOM | Bureau of Meteorology |
| Constituent Council | Councils provided with bulk water from Rous Water |
| DECCW | NSW Department of Environment, Climate Change and Water (formerly DECC and EPA) |
| DSM DSS | Demand Side Management Decision Support System - a spreadsheet based *end use model* which allows development of water and sewage forecasts and benefit cost analysis of demand management measures (through least cost planning). |
| DOH | NSW Department of Health |
| DOP | NSW Department of Planning |
| End Use Model | A model that looks to take account of the impact of different water conservation and source substitution programs on the volume of water used at the end use level to provide aggregated water demand and savings forecasts. |
| Environmental flows | River flows, or characteristics of the river flow pattern that are either protected or created for an environmental purpose, usually the protection of habitat or an ecological process. |
| IWCM | Integrated Water Cycle Management – The principal planning tool used in NSW best practice management of water and sewerage systems by which all urban water uses are considered within a catchment and policy framework to seek balanced environmental, economic and social outcomes. |
| LGA | Local government area |
| LWU | Local water utility |
| MFR | Multi-family residential |
| NOW | NSW Office of Water (formerly DWE and DEUS) |
| NPV | Net present value |
| NRW | Non-revenue water (water supply) |
| PDD | Peak day demand (water supply) |
| PPA | Person per account |
| PRG | Project reference group |
| PWWF | Peak wet weather flow (sewage) |

| Word/Acronym | Definition |
|---|---|
| Recycled water | Water generated from sewage, grey water or stormwater systems and treated to a standard that is appropriate for its intended use. |
| Reliability of supply | The percentage of time with an uninterrupted water supply (i.e. no restrictions on use). |
| Secure yield | An estimate of the annual demand which can be supplied by a water source and its associated storage, based on an assessment of historical drought flows and acceptable restriction guidelines. |
| Security of supply | The percentage of time with an uninterrupted water supply (i.e. no restrictions on use). |
| Sewage | Wastewater from homes, offices, shops, factories and other premises discharged to the sewer. About 99 percent of sewage is water. |
| SFR | Single family residential |
| SMI | Soil moisture index |
| SPS | Sewage pumping station |
| Stormwater | Rainfall that flows over hard surfaces in urban areas and is collected in drainage systems for disposal. |
| STP | Sewage treatment plant (or wastewater treatment plant) |
| Targets | The legislation, licence conditions, contracts and levels of service requirements that the utility or service must comply with or has agreed to achieve. |
| TBL analysis | Triple bottom line analysis. Consideration of the economic, social and environmental outcomes in decision-making. |
| WELS | Water Efficiency Labelling and Standards Scheme introduced by the Australian Government. |
| WSUD | Water sensitive urban design |
| WPS | Water pumping station |
| WTP | Water treatment plant (or water filtration plant) |

# 1 Introduction

## 1.1 Purpose

The purpose of this technical note is to prepare demand management cases for consideration in the Future Water Strategy (FWS); provide strategic level cost-benefit assessment for the existing and enhanced demand management cases; and assist in review of future Demand Management Plans and related discussions with Rous Water's local water utility customers (LWUs). It forms an input to the FWS and associated demand management planning and implementation.

## 1.2 Scope

This assessment considers the following:

- Analysis of the historical observed and climate corrected water records to understand the influence of climate, demand management activities and other related factors on demand. This assists in determining an appropriate baseline demand for demand forecasting.
- Analysis of the current water production records and metered water consumption records to estimate customer category demands and non-revenue water (NRW).
- Consolidation of historical, current and forecast serviced population of the supply area.
- Development of a baseline demand forecast in an end-use model for cost benefit analysis. The forecast will take into account the Future Water Strategy's current demand forecast and mandatory measures such as BASIX and WELS as well as the planned recycled water scheme in Ballina.
- Description of the current suite of demand management measures.
- Consideration of additional demand management measures (not already identified as FWS options) that will enhance the current demand management measures.
- Consultation with Rous Water representatives, including a workshop to assist with development of the forecasts and assumptions associated with each measure. Outcomes of the workshop are incorporated in this technical note.
- Analysis of the water demand management cases. The following aspects have been assessed:
    - preliminary cost-benefit ratios, annualised costs and water savings for the individual water demand management.
    - preliminary cost-benefit, annualised costs and water savings for demand management cases.
    - water demand forecasts to 2060 for each of the cases.
- Recommendations for on-going monitoring and review.

## 1.3 Layout

This report is divided into the following sections:

1. *Introduction* – outlines the purpose and background of the study.
2. *Context* – context of demand management in the region.
3. *Demand analysis* – presents the results of the historic demand analysis of water production records, customer consumption and NRW.
4. *Demand forecasting* – discusses the demand forecasting approach and presents the baseline forecasts.
5. *Options identification* – describes the current demand management measures and additional measures which have been considered.
6. *Options evaluation* - presents the outcomes of the benefit-cost assessment and the demand forecast for each case.
7. *NSW best practice* – an assessment of current performance against the NSW Best Practice requirements for Demand Management Plans.
8. *Monitoring and reporting* – recommended monitoring and reporting and water use targets under the enhanced demand management case.
9. *Recommendations.*

# 2 Context

Demand management has been an integral part of Rous Water's approach to planning and management of regional water assets and ongoing supply management. Demand management programs in the Rous region are part of a wider strategy seeking to ensure an adequate and secure water supply that meets the needs of the community. Since 1995 Rous Water has implemented an ongoing program of demand management.

The Rous Water Demand Management Plan (2012-2016) represents the latest evolution in Rous Water's demand management initiatives. Utilising the current suite of programs as a foundation, this document outlines the future for demand management for Rous Water, with an implementation plan for 2012 to 2016.

Rous Water provides bulk water to four LWUs on the far north coast of NSW, servicing the urban areas of the following Local Government Areas (LGA):

- Ballina Shire Council, excluding Wardell and surrounds.
- Byron Shire Council, excluding Mullumbimby.
- Lismore City Council, excluding Nimbin.
- Richmond Valley Council, excluding Casino and all land west of Coraki.

Rous Water also provides water supply services to approximately 2,000 rural and urban connections direct from the bulk supply trunk main system.

This structure presents some challenges to Rous Water in the effective delivery of demand management programs and the ability of Rous Water to directly influence all aspects of demand management policy. As a bulk supplier Rous Water is limited in its ability to:

- Influence State or local government planning and policy.
- Set pricing signals to retail customers of LWUs.
- Interact and engage with LWUs.
- Monitor ongoing trends in demand at customer level.

Under the current water delivery and retailing arrangements in the region (formalised in the Water Supply Agreement), Rous Water is reliant on a cooperative and positive working relationship with each LWU to deliver a comprehensive and effective demand management program..

In 2012, a demand forecast for the supply area to 2060 was developed for Rous Water (Hydrosphere Consulting, 2013) for the FWS. The demand forecast used a connection based approach. Key assumptions from this report are used in this technical note.

# 3 Demand analysis

This section presents the results of the historical demand analysis of water production records, customer consumption and NRW.

## 3.1 Water production

Historical water production data for the Rous Water supply area was modelled using the production trend-tracking model Water-Trac. WaterTrac is a purpose-built multi-variable regression analysis model which facilitates a detailed understanding of the influence of climate and other influences on daily water demand. The climate correction of historical demand records is important as it removes the influence of short term climatic events on the current level of demand and recent demand trends.

The WaterTrac analysis uses four basic steps:

- A soil moisture index is generated from the climate data and is included as one of four climate variables.
- Calibration - The model is calibrated over a period of time using four climate variables and recognised statistical techniques. The calibration is undertaken over a period of relatively 'normal' water consumption (e.g. free from restrictions) with a reasonable range of climatic conditions.

- Hindcasting - The available climate record is used to project the calibrated model through the full climate record to obtain a statistical understanding of the mean or climate normalised baseline year consumption.
- Trend Tracking and Climate Correction - The observed demands are compared with those predicted by the baseline-calibrated model and changes in the demand relative to the baseline are estimated.
- Peaking Factor Assessment – The observed and climate corrected trends are assessed to determine the peak day demands, peak hour demands and mean day per month demands and peaking factors.

Rous Water provided the following bulk water production for this analysis:

- Daily bulk water production (all production sources) from January, 1991 to December, 2012
- Monthly bulk water supply to each LWU in the Rous Water supply area from June, 2001 to December, 2012.

A daily WaterTrac model was created using historical bulk water production for the Rous water system (i.e. bulk water supplied to all LWUs plus Rous Retail customers). Separate monthly models were also created for each LWU and Rous Retail customers using local climate data derived from the Queensland State Governments 'SILO' service. The data is interpolated between defined climate measurement stations. Climate derived for Alstonville was used to represent climate for the Rous water supply region. Alstonville is located between the major centres of Ballina and Lismore and has been used historically to represent climate for the Rous supply area.

**Table 3-1: Representative climate site used for each water supply area**

| Location | Representative site | Latitude and Longitude |
|---|---|---|
| Whole of system | Alstonville | -28.85, 153.45 |
| Ballina | Ballina | -28.85, 153.55 |
| Byron Shire | Byron Bay | -28.65, 151,10 |
| Lismore | Lismore | -28.80, 153.30 |
| Richmond Valley | Evans Head | -28.10, 153.45 |
| Rous Retail | Alstonville | -28.85, 153.45 |

### 3.1.1 Bulk water production model

The bulk water production model was calibrated during a time of relatively stable demand (January, 2009 to December, 2011) and reasonable correlation was achieved ($R^2$=0.83) demonstrating a strong relationship between demand and the climate variables (maximum temperature, rainfall, evaporation and soil moisture).

Figure 3-1 presents observed and climate corrected historical water production trends. The climate corrected demand is a 12 month moving average. Key factors influencing the demands over this time are also shown.

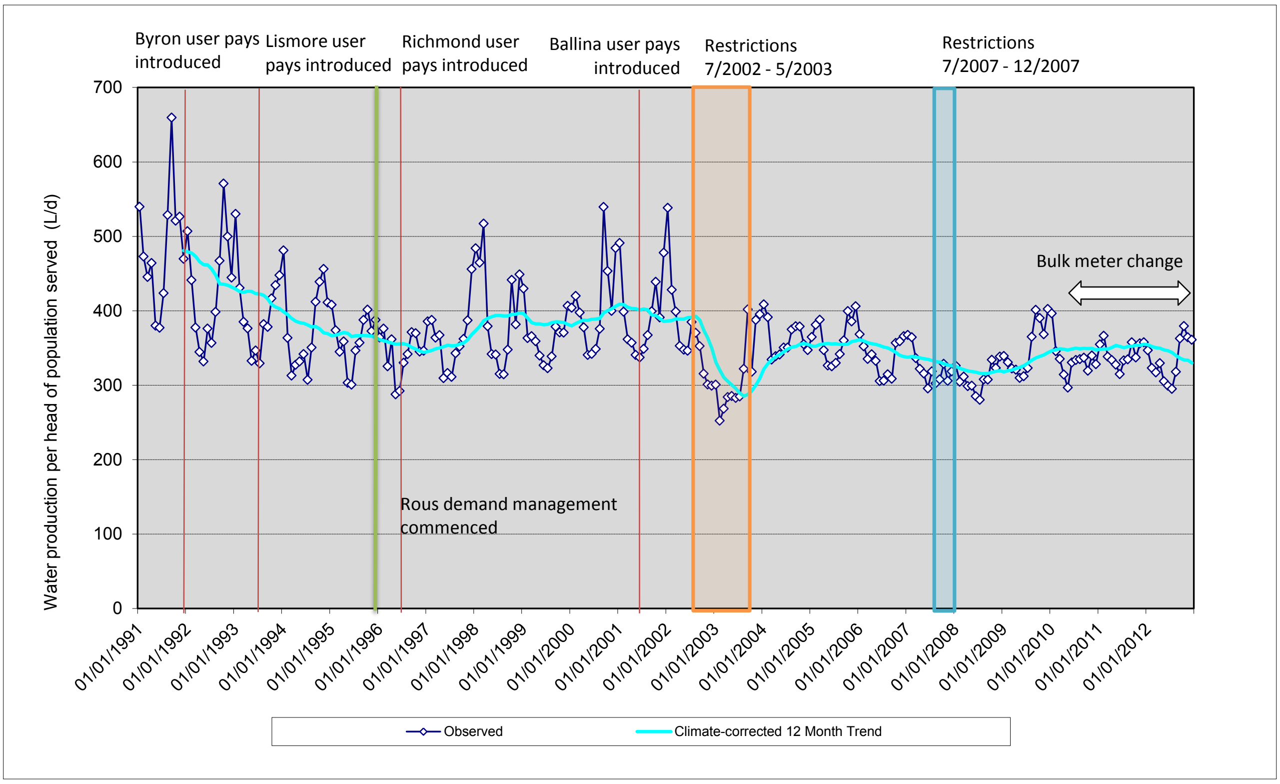


**Figure 3-1: Observed and climate corrected bulk water production per head of population served (L/p/day)**

Figure 3-1 indicates:

- The progressive implementation of 'user pays' (i.e. volumetric charging) billing system by each LWU appears to have reduced demand.
- The implementation of the Rous Demand Management Plan in 1996 has formed part of integrated demand management framework which in combination with the introduction of user pays and restrictions has resulted in a steady decline in water usage.
- Between 1998 and 2002 demand was relatively stable (demand around 400 L/p/day) but decreased significantly during the severe drought and associated restrictions period in 2002/03.
- The demand 'bounced back' following the drought to around 360 L/p/day and remained relatively stable until a shorter restrictions period in 2007. Most of the country was also in drought during this time which may have amplified the decrease (associated with consumer behaviour) in this period.
- The climate-corrected demand has remained relatively stable since 2009 at around 350 L/p/day although it has decreased to 335 L/p/day in 2012.

### 3.1.2 Monthly WaterTrac model by LWU

A monthly Water-Trac model was created for each LGA using local climate data obtained from SILO and monthly bulk water supplied to each LWU. The demand patterns and overall production per person across each of the LWUs are very similar (see Figure 3-2).

In addition to providing bulk water supply to each LGA, Rous Water directly supplies water to approximately 2,000 rural and urban customers (Rous Retail customers). The monthly bulk production minus the bulk supply to each of the LWUs was used to calculate the combined volume of losses in the bulk water supply network and consumption by retail customers.

The production per person for 'Retail customers and bulk losses' are relatively high as the majority of customers are rural type customers who are typically characterised by larger lot sizes and farms. A leak was discovered in the bulk production network following a bulk meter change out in 2009 (as observed in the figure below). This has since been fixed and it is anticipated that the production per person will return to pre-2009 levels.

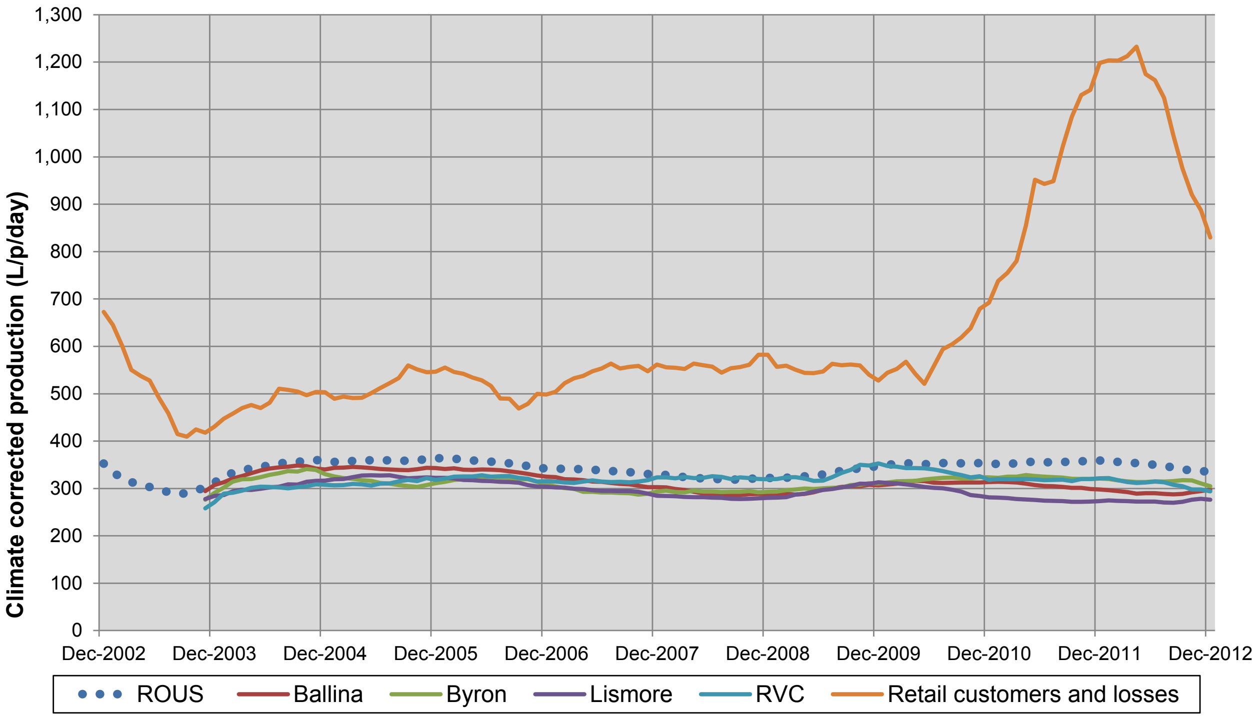


**Figure 3-2: Climate corrected bulk supply by LWU (L/p/day)**

### 3.1.3 Production by LWU

The bulk water supplied to each of the LWUs was also provided for this assessment. Figure 3-2 shows their climate corrected supply. The overall breakdown in supply by LWU is shown in Figure 3-3.

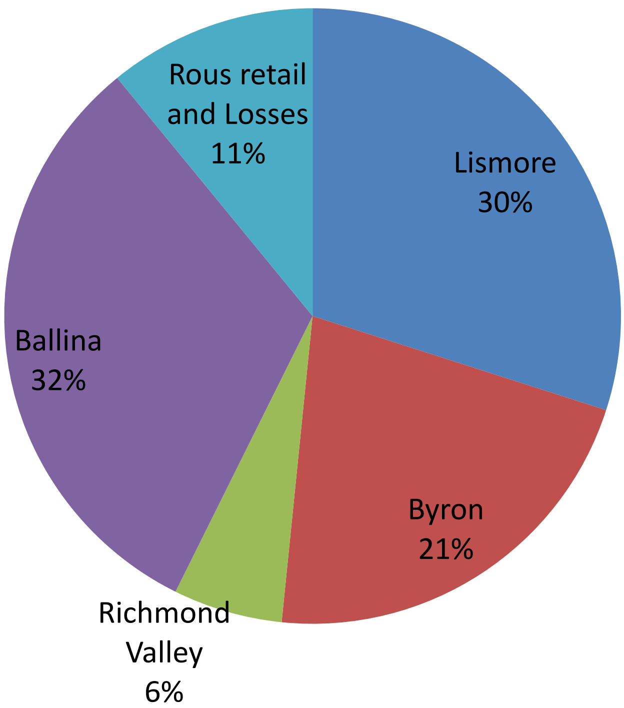


**Figure 3-3: Average consumption by LWU (2007-2010)**

### 3.1.4 Peak day factors

In the traditional approach to estimating peak demand factors, peak demands are compared with raw demand on an annual basis. There are a number of problems with this approach. Firstly, the arbitrary use of discrete years of data results in large amounts of data being effectively discarded and secondly, the climate influence in any one year can bias the result. Peak demand periods typically occur once every three to five years. They almost always occur during prolonged periods of hot and dry weather, and may not necessarily occur in a hot or dry year. A relatively minor peak demand period occurring in a cool, wet year will result in a high peak to average ratio. Likewise, a high peak demand occurring in a hot, dry year will result in a low peak to average ratio. Thus it is important to compare peak demands with the climate-corrected demand for a useful comparison.

The historical daily bulk water production data has been climate corrected in order to understand the changing Peak Day Factor (PDF) trends. The historical peak to climate corrected average is shown in Figure 3-4. Prior to the 2002/03 restrictions the PDF was around 2. Since the restrictions, the PDF has steadily decreased from around 1.7 to 1.4. For forecasting purposes a PDF of 1.7 has been adopted (with a 20% safety factor). This should be monitored as higher levels have historically been observed.

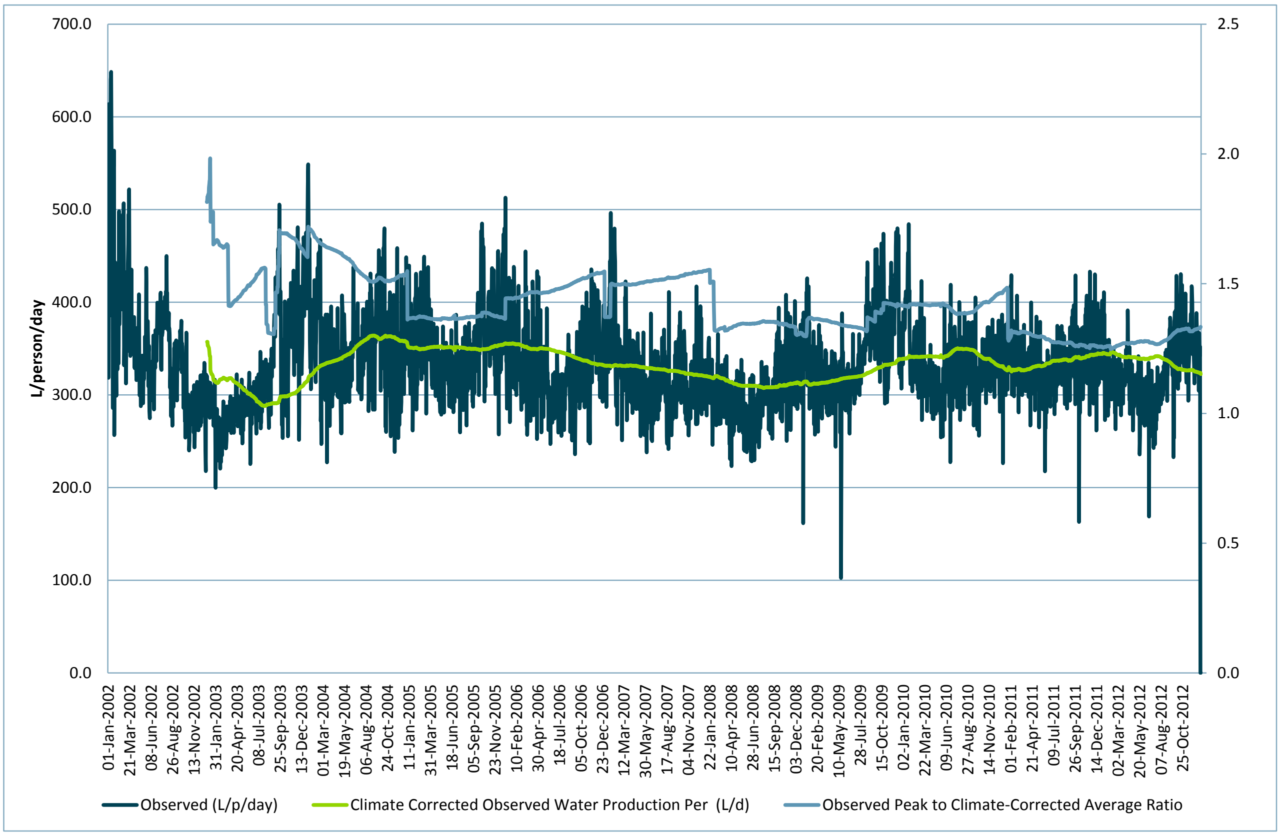


**Figure 3-4: Historical peak day factor**

## 3.2 Consumption breakdown

Each of the LWUs and Rous Water provided water consumption (billing) data and the number of customer accounts for 2007 to 2010 during the development of *Future Water Strategy: Demand Forecast Report* (Hydrosphere Consulting, 2013). This data has been used to inform this technical report.

The metered data was split into four customer categories:

- Single family residential (SFR) – detached residential dwellings.
- Multi-family residential (MFR) – semi-detached and multi-unit dwellings.
- Non-residential – all non-residential customers.
- Rous retail – customers supplied directly by Rous Water.

The average demand by each customer sector between 2007 and 2010 is shown in Figure 3-5. Water consumption is predominantly for residential users (58%), followed by non-residential users (19%), non-revenue water (16%) and Rous Retail customers (7%).

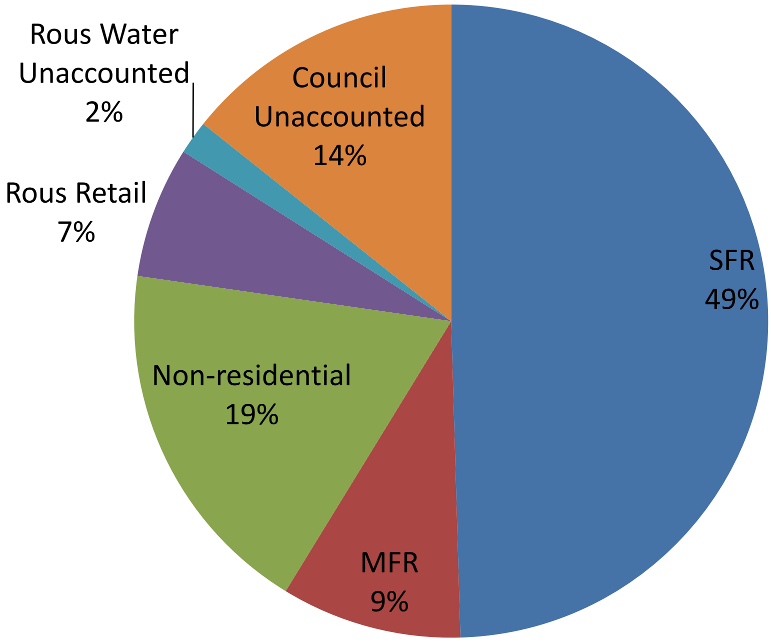


**Figure 3-5: Average demand by customer sector (2007-2010)**

## 3.3 Major users

The top 10 water users in 2010, estimate from LWU water billing databases, are show in Table 3-2. The average daily demand for the top ten users is approximately 1.4 ML/day. There are no major industrial type users in the Rous Water supply area.

**Table 3-2: Top 20 non-residential water users (2010)**

| Business | Industry | Demand (ML/a) | LWU |
|---|---|---|---|
| Ingham Chickens | Food processing | 123 | Byron |
| Norco | Food processing | 114 | Lismore |
| Lismore Base Hospital | Health | 74 | Lismore |
| Southern Cross University | Tertiary Education | 45 | Lismore |
| St Vincent's Hospital | Health | 32 | Lismore |
| Linclean | Commercial Laundry | 25 | Lismore |
| Ballina RSL | Club | 20 | Ballina |
| Caroona Village | Health (ageing) | 20 | Lismore |
| Arts Factory Lodge | Hostel | 20 | Byron |
| Crowley Village | Health (ageing) | 18 | Ballina |

**Source:** (Rous Water, 2012)

## 3.4 Non-revenue water

NRW was calculated based on the difference between the annual production data and the annual consumed (billed) water data. The annual production data was obtained directly from Rous Water while the consumption figures were obtained from the *Future Water Strategy: Demand Forecast Report* (Hydrosphere Consulting, 2013). The percentage of NRW for Rous Water supply area and within the LWU supply areas is shown in Table 3-3.

**Table 3-3: Historical NRW assessment**

| | 2006/07 | 2007/08 | 2008/09 | 2009/10 | Average |
|---|---|---|---|---|---|
| Rous Water NRW (%) | 1.6% | 1.9% | 1.3% | 2.0% | 2% |
| LWU NRW (%) | 12.7% | 9.8% | 15.4% | 18.6% | 14% |
| Total NRW (%) | 14.3% | 11.7% | 16.8% | 20.6% | 15.9% |

The majority of NRW occurs within the individual LWU reticulation networks as opposed to Rous Water's bulk distribution system. This represents an opportunity for demand reduction through pressure management and leakage reduction in the LWU reticulation network. The average NRW of 16% has been used as the basis for use in future water demand forecasting.

Water loss and pressure management opportunities within each of the LWUs were considered in the Regional Water Loss Management report (Water Loss and Pressure Management , 2012). The study demonstrates that there are potential water savings in Ballina and Byron Councils.

In the case of Ballina, it is recommended to conduct a leak detection/repair program and a pressure management program to achieve the expected savings of 406 ML at the end of a 5 years period time.

Byron Council has a quite low average pressure of 30 m so it is not recommended for a general pressure management program but to study the different areas in a case-by-case analysis. However the Council can expect a saving of 259 ML from a leak detection and repair program.

The levels of losses and hence potential for water loss reductions for Lismore City Council could not be determined due to data inaccuracies. Until the information can be further verified it will not be possible to estimate the actual level of losses and any further reduction on them.

There is potential for water loss reduction in Evan's Head following subsequent Minimum Night Flow (MNF) studies.

# 4 Demand forecast

This section discusses the demand forecasting approach and demand drivers, and presents the results of the baseline forecasts.

## 4.1 Drivers

The process taken in the development of water demand forecasts is as follows:

- Estimation of historical and future population, dwellings and accounts served with potable water.
- Assessment of the influence of climate on historical production records, including historical peak to average day demand factors.
- Assessment of water consumption (metered accounts) by consumption category.
- Assessment of unaccounted-for-water (the difference between production and consumption records).
- Identification of future demand drivers, including on-going conservation measures and recent restrictions.

## 4.2 Population

One of the key elements in urban water demand analysis is the estimation of the population serviced, both historically and in the future, by reticulated potable water. An assessment of population serviced was last undertaken as part of the *Dunoon Dam: Population and Demand* Projections (Geolink, 2005) report using Census data from 2001 as the basis. More recent studies have used connection based methods as the means for assessing historical and future demands.

To estimate current population served per LGA the following approach was adopted for this study:

1. **Estimate served population:** The initial proportion of population served was assumed to be consistent with the Geolink (2005) report. This split was applied to the total population for each Local Government Area (LGA) using the most recent Census data for 2006 and 2011 (ABS, 2011).

2. **Estimate population per SFR connections**: The average household size taken from ABS Census data sheets for separate houses was adopted as an initial estimate for population per billing connection for SFR.

3. **Estimate populations represented by SFR connections:** The persons per connection estimated for SFR was then multiplied by the number of connections recorded in Council billing data for 2010 for each of these sectors to obtain population estimates for all SFR accounts.

4. **Check per person connections for MFR sector**: The population represented by SFR connections was then subtracted from the forecast population for 2010, and the remainder of the forecast population was allocated to the MFR sector. This population was then divided by the number of MFR connections to ensure that the persons per connection (PPC) for this sector were reasonable.

5. **Check water use per person**: As an additional check, the water use per person was calculated based upon the populations estimated for each sector. These were compared to ensure that they were within a reasonable range of each other.

6. **Increase serviced population percentage**: For Byron and Lismore it was necessary to increase the serviced percentage in order to provide a reasonable MFR persons per connection.

Where:

- MFR – Multi-family residential
- SFR – Single family residential

The modified persons per connection for MFR accounts (2.4) was approximately 1.3 times that given in ABS data, implying an average of 1 to 2 dwellings per MFR account. This is due to multiple connections being associated with the one meter in multi-residential dwellings. This was considered reasonable at this stage although review of these assumptions should be included in future monitoring.

The outcomes of the serviced population assessment for each LGA are shown below in Table 4-1.

**Table 4-1: Assumed serviced population by LGA**

| LGA | Serviced by Rous (%) | Total LGA Population | | | Serviced Population | | |
|---|---|---|---|---|---|---|---|
| | | 2001 | 2006 | 2011 | 2001 | 2006 | 2011 |
| Byron | 69% | 30,245 | 30,326 | 30,964 | 20,869 | 20,925 | 21,365 |
| Ballina | 82% | 37,218 | 38,977 | 39,645 | 30,346 | 31,780 | 32,325 |
| Lismore | 74% | 41,883 | 42,613 | 42,907 | 30,993 | 31,534 | 31,751 |
| Richmond Valley | 25% | 20,554 | 21,828 | 22,312 | 5,237 | 5,562 | 5,685 |
| **Total** | **65%** | **134,400** | **138,365** | **140,517** | **87,446** | **89,801** | **91,126** |

### 4.2.1 Household size

The rate of account formation in the residential sector is a product of both the rate of population growth and the overall household size. Historical household sizes have been falling in most areas of Australia for some time. Across each of the LGAs the household size has dropped from an average of 2.52 to 2.42 persons per household between 2001 and 2011. It is assumed that the household size will continue to decrease asymptotically as shown in Figure 4-1.

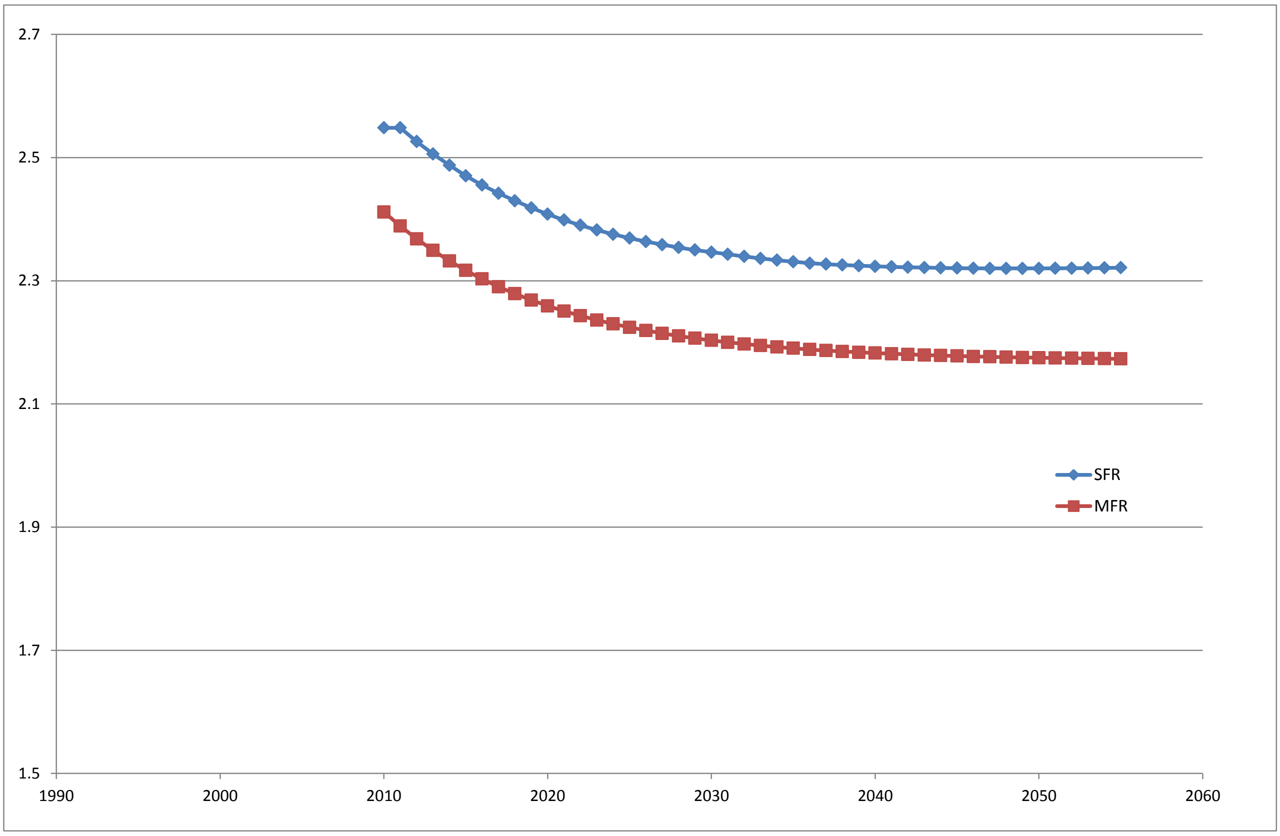


**Figure 4-1: Assumed decrease in household size for SFR and MFR accounts**

### 4.2.2 Population growth

Connection growth figures adopted in the *Future Water Strategy: Demand Forecast* (Hydrosphere Consulting, 2013) has been used as the basis of the population growth estimate. The connection based forecast relied on the assumptions developed as part of *Future Water Strategy: Demand Forecast* for each LWU data set including:

- The rate of development infill.
- The availability, demand and timing of greenfield development (new release areas).
- The density of future development (e.g. dual occupancy or flats).
- The future proportion of multi-residential developments (compared to single residential in new release areas).
- The rate of conversion of inefficient houses to efficient (BASIX compliant) houses through renovations and uptake of efficient appliances.
- The extension of recycled water supplies to new release areas in Ballina.
- The rate of non-residential development.

The growth in residential connections was multiplied by the assumed persons per connection for each residential customer type to arrive at a total population served for each year until 2060. Population projections for Rous have also been estimated using the NSW Department of Planning (DoP) projected growth rates for each LGA (DoP, 2010) as shown in Figure 4-2.

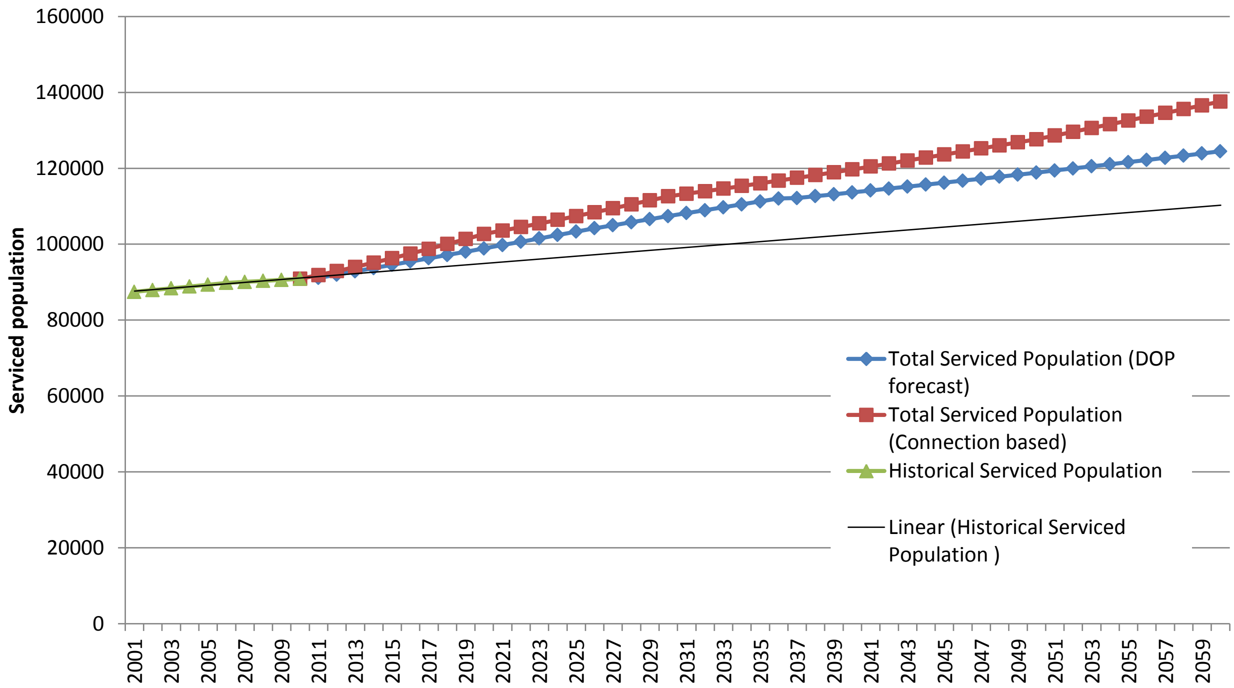


**Figure 4-2: Serviced population forecast for Rous Water supply area**

The serviced population forecast using a connection based approach produced a growth rate in excess of the Department of Planning (2010) figures. A trend showing the population growth if the current trend continues has been shown for comparison sake. Both the DoP and connection based forecast exceed the historical growth trend. The connection based approach has been adopted in this assessment as this is consistent with the current demand forecast produced and is based on the best available information.

### 4.2.3 Non-residential growth

Non-residential connection growth is based on the figures adopted in the *Future Water Strategy: Demand Forecast* (Hydrosphere Consulting, 2013). The non-residential account growth is shown in Table 4-2.

**Table 4-2: Non-residential connection growth**

| LWU | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Ballina | 1,088 | 1,317 | 1,546 | 1,661 | 1,661 | 1,661 |
| Byron | 1,365 | 1,987 | 2,609 | 3,231 | 3,853 | 4,475 |
| Lismore | 1,190 | 1,581 | 1,972 | 2,168 | 2,168 | 2,168 |
| Richmond Valley (ex Casino) | 267 | 300 | 334 | 334 | 334 | 334 |
| Ballina | 1,088 | 1,317 | 1,546 | 1,661 | 1,661 | 1,661 |

### 4.2.4 Household income and lifestyle

It is generally agreed that, without demand management measures, people tend to use more water with increasing wealth and associated lifestyle choices (SEQWRSS, 2006). In cross sectional analysis work, clear income elasticities of demand have been identified as a driver in residential household demands (Montgomery Watson, 2005). The forecasts allows for this influence through discretionary per capita water usage. To cater for these impacts, it has been assumed that water uses in certain end uses (those discretionary in nature) will increase by 15% over the 50 year planning period. These discretionary uses include baths, dishwashers, irrigation and leakage. Leakage is considered to have discretionary use impacts because as the number of water uses and appliances increases (such as toilets for example), there are more opportunities for leakage to occur.

### 4.2.5 Water efficient appliances and fixtures

Appliance ownership figures for dishwashers, washing machines and toilets show that there is a natural tendency for more water efficient fixtures and appliances to increase in popularity. This trend towards increasing appliance efficiency is anticipated to continue into the future and will result in changes in household water use per account.

The DSM DSS[1] has in-built appliance and stock models which develop forecasts of these impacts on the basis of assumed replacement rates, growth and market share for fixtures and appliances or different levels of efficiency.

In addition, the implementation of the national Water Efficiency Labelling Scheme, for the mandatory labelling of appliances and the BASIX for new developments is anticipated to further increase the market uptake of water efficient fixtures and appliances, particularly showerheads and washing machines.

The assumptions associated with current fixture and appliance ownership and usage are provided in Appendix C.

## 4.3 Customer consumption

The average demand between 2007 and 2010 for each customer type has been used the basis for demand forecasting which is in line with the assumptions in the *Future Water Strategy: Demand Forecast* report. As shown in section 3.1, demand during this time was relatively stable and continues to be representative of current demands.

**Table 4-3: Baseline demand for each customer type (Hydrosphere Consulting, 2013)**

| LGA | SFR | | | MFR | | | Non-residential | Rous Retail |
|---|---|---|---|---|---|---|---|---|
| | L/acc/day | PPC | L/p/day | L/acc/day | PPC | L/p/day | L/acc/day | L/acc/day |
| Ballina | 537 | 2.7 | 199 | 371 | 2.3 | 158 | 907 | - |
| Byron | 578 | 2.5 | 231 | 443 | 2.4 | 184 | 1,748 | - |
| Lismore | 500 | 2.6 | 194 | 424 | 2.7 | 158 | 1,841 | - |
| Richmond Valley | 479 | 2.5 | 192 | 352 | 2.4 | 149 | 1,788 | - |
| Rous Retail | - | - | - | - | - | - | | 929 |
| *Rous Area* | *529* | *2.6* | *204* | *394* | *2.4* | *163* | *1,488* | *929* |

### 4.3.1 Current breakdown in end use

The DSM DSS model uses detailed estimates of the volume of water use against each end use to estimate demand management impacts. For the residential sector, these have been developed based on work undertaken by Yarra Valley Water Melbourne (Roberts, 2012) and in South East Queensland (Beal & Stewart, 2011) . For the non-residential sector, breakdowns have been adapted from the study into the commercial and institutional end uses of water (AWWARF, 2000). Accurately determining end use consumption requires sub-metering of all water uses, which complex and costly. Accordingly, Rous Water takes information from other studies for guidance in lieu of undertaking detailed end-use studies.

The DSS DSM utilises both 'top down' and 'bottom up' information to arrive at a current breakdown in water use. Using the 'bottom up' approach, assumptions regarding currently installed stock and frequency of use of fixtures are used to estimate internal use per SFR connection, for both existing and

[1] The Demand Side Management Decision Support System (DSM DSS) is an end use based model (refer to Glossary).

new (Greenfield/Infill) connections. New accounts use less water internally due to increased efficiency of new appliances and fixtures compared to existing dwellings.

External use is then calculated by subtracting the assumed internal use from the total consumption per connection. Table 4-4 lists the internal/external end use breakdown assumed for customer sectors. Figure 4-3 illustrates the internal/external breakdown for an existing SFR connection.

**Table 4-4: End use breakdown by customer type (L/connection/day)**

| End Use | SFR | | MFR | | Rous Retail |
|---|---|---|---|---|---|
| | Existing | New | Existing | New | |
| Toilets | 58 | 38 | 54 | 38 | 58 |
| Baths | 8 | 8 | 8 | 8 | 8 |
| Showers | 134 | 101 | 125 | 101 | 134 |
| Taps/Sinks | 67 | 66 | 63 | 66 | 67 |
| Dishwashers | 6 | 6 | 6 | 6 | 6 |
| Washing Machines | 78 | 68 | 73 | 68 | 78 |
| Int. Leakage | 16 | 8 | 15 | 8 | 16 |
| Irrigation | 129 | 129 | 41 | 41 | 449 |
| Ext. Other | 24 | 24 | 8 | 8 | 84 |
| Ext. Leakage | 8 | 8 | 3 | 3 | 28 |
| **Total** | **529** | **458** | **394** | **347** | **929** |

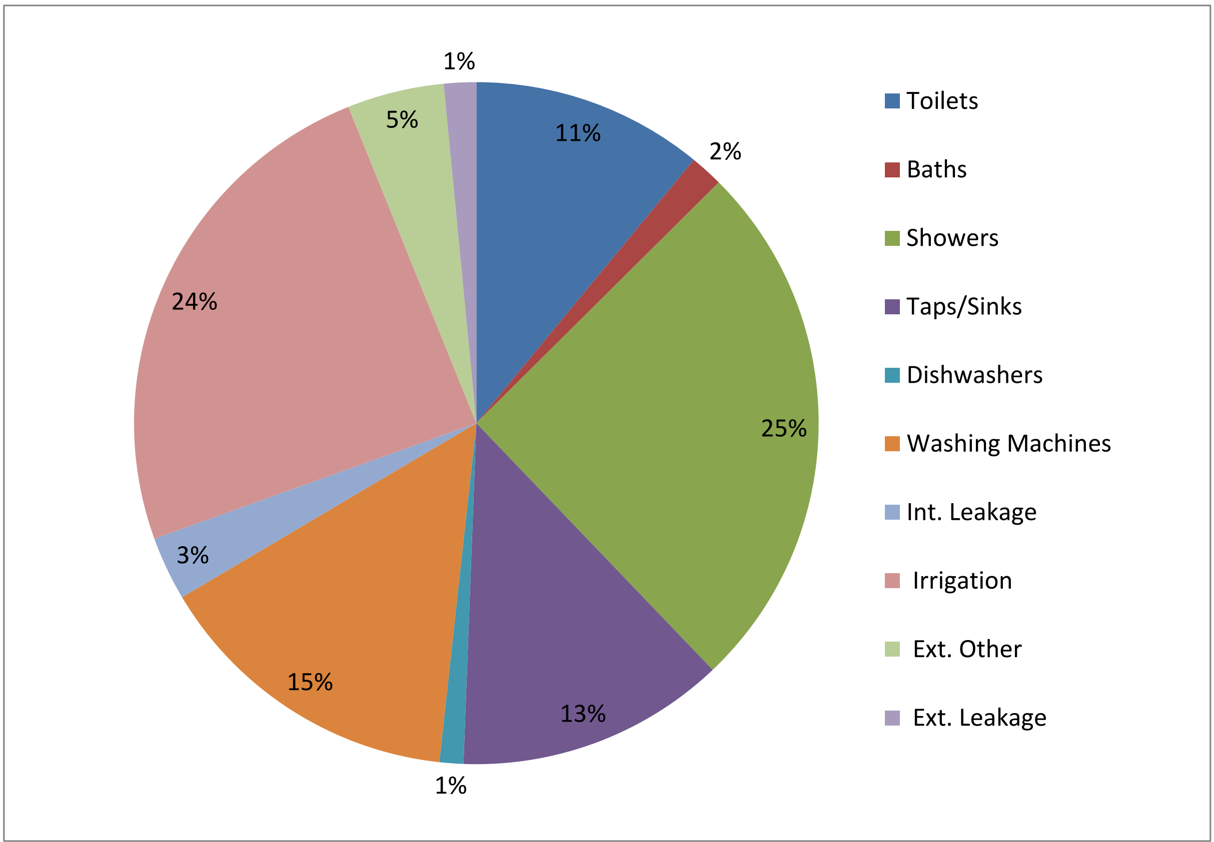


**Figure 4-3: Assumed water use breakdown for an existing SFR account**

The internal use breakdown correlates well with other recent end use studies such as the South East Queensland Residential End Use Study (2011). The irrigation demand of 129 L/account/day is equivalent to garden watering an area of 125 $m^2$ [2].

## 4.4 Baseline forecast

The baseline forecast quantifies the impacts of population growth, associated non-residential growth, changing customer account size, water using fixture stock numbers and discretionary water use on water demands. Baseline forecasts have been prepared using the DSM DSS.

The baseline water demand is based on a starting per capita value of 335 L/p/day. This was the climate corrected per capita production in 2012. The baseline forecast includes:

- WELS - National Mandatory Water Efficiency Labelling Scheme.
- BASIX – Fixture efficiency with dual reticulation to new dwellings as part of the Ballina-Lennox Head Recycled Water Master Plan (dual supply commences in 2014).
- BASIX - Fixture efficiency with rainwater tank use for new dwellings outside of recycled water supply areas in Ballina.

The assumptions adopted in determining the water savings from BASIX and WELS are presented in the following sections.

The baseline demand forecast to 2060 in shown in Figure 4-4. For comparison the baseline demand produced in the *FWS: Demand Forecast* (Hydrosphere Consulting, 2013) is also shown Figure 4-4. The forecasts produced are very similar.

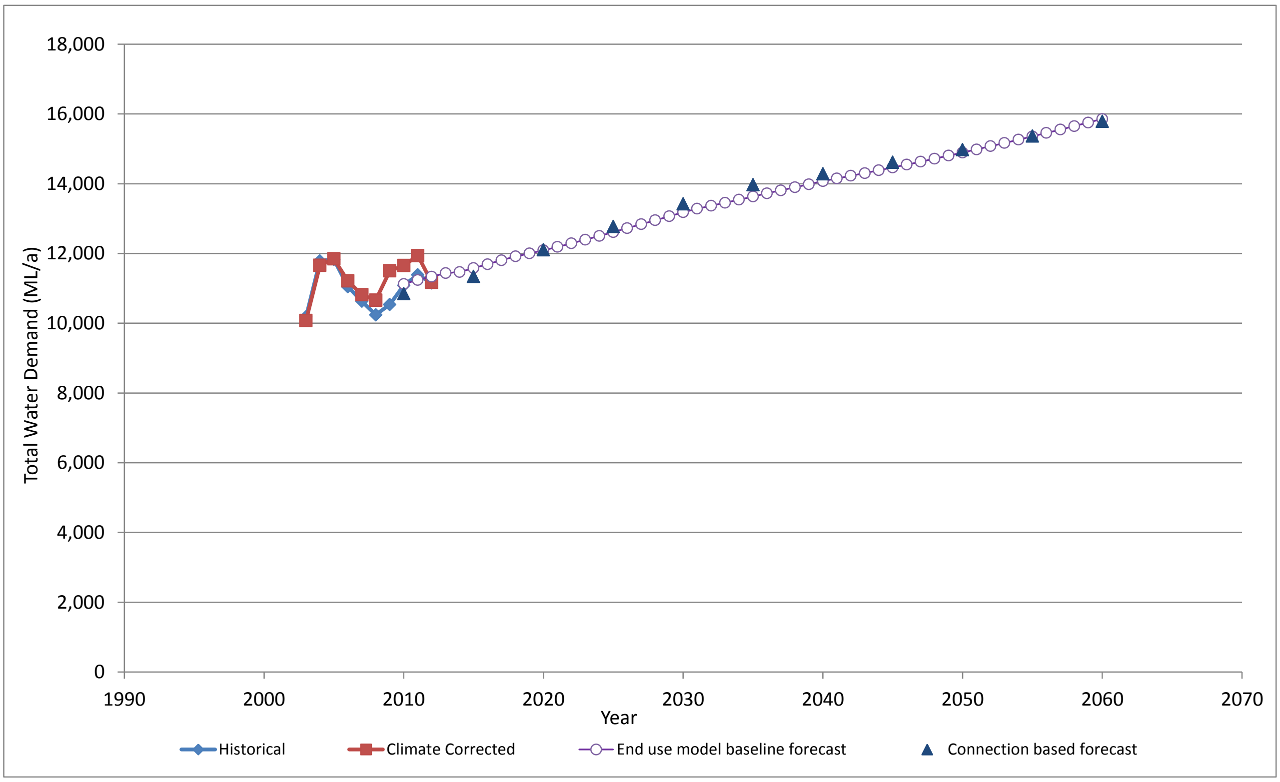


**Figure 4-4: Rous Water baseline demand forecast using end use model and connection based method**

[2] The average daily irrigation demand of 3.7 ML/ha/year (1.03 L/$m^2$/day) was calculated using a deficit irrigation model with climate data representing the Alstonville weather station location.

# 5 Options identification

This section describes current demand management measures and identifies additional measures which could be implemented by Rous Water to enhance the current suite of measures.

## 5.1 Current demand management measures

A description of Rous Water's current and previously implemented demand management measures is presented in Table 5-1.

**Table 5-1: Current and historical demand management measures**

| Measure | Description | Target | Status/comments |
|---|---|---|---|
| Residential Home Retro-fit Program | The home tune-up involved a visit by a plumber to a household.<br>Program 1 from December 1997 to March 1999 at 1,874 participants. Program 2 from June 2001 to April 2008 had 3,902 participants. By early 2008 the cost of an average tune-up was about $112.<br>The first program included:<br>• Check the household water pressure.<br>• Read the water meter.<br>• Record the number of occupants in the household.<br>• Record the type and temperature of the hot water system.<br>• Adjust the hot water thermostat to 60$^{o}$C.<br>• Measures water flows through the showers before and after installing water efficient shower heads.<br>• Measure water flows at bathroom basins and kitchen sinks before and after installing aerators.<br>• Install one of four types of aerators, depending on the basin or sink.<br>• Record the number and location/s of leaking taps and replace washers.<br>• Check the toilet cistern/s for leaks, record the type/s of toilet cisterns installed and adjust to 9 L/min if possible.<br>The second program was a streamlined version of the first and required the plumber to:<br>• Replace old shower heads with new water efficient shower heads.<br>• Install aerators on faucets at all basins, if possible.<br>• Install aerators on faucets at all sinks, if possible.<br>• Check all toilet cisterns for leaks and adjust the flush volume, if possible. | Residential shower/taps, kitchen and toilet/cistern end uses. | There are no current plans to reintroduce this program. |

| Measure | Description | Target | Status/comments |
| --- | --- | --- | --- |
| | • Check for leaking taps and replace washers.<br><br>Then delivered through Enviro Saver program where only cost to Rous Water was for aerators. In December 2008 the NSW Government withdrew funding of the Greenhouse Gas Abatement Certificates Scheme and the Enviro Saver program concluded. | | |
| Rainwater Tank Rebate | Customers are offered a rebate for the installation of a rainwater tank. Between Feb, 2003 and March, 2013 1,357 rebates were paid. 154 of the rebates paid have been outside of the Rous Water supply area. The majority of rebates (1,065) were provided between 2008 and 2011 when the NSW Government were also offering a rebate for installation of rainwater tanks. The average number of rebates provided between 2008 and 2011 were almost 10 times the average outside of these years. This was also a time of heightened drought awareness and national focus on water conservation.<br><br>Varying funding levels since program inception. Additional rebates are offered for larger tank sizes and if connected to toilets and washing machine. | Residential clothes washing, toilet and outdoor end uses | The uptake of this program has diminished significantly since the state government rebate ended. Increasing rebate may improve uptake. Although numbers have dropped, most applicants[3] report that the existence of the rebate influences their decision to install a tank. |
| Dual Flush Toilet Rebate | Rebates of $50 have been offered to customers for the replacement of a single flush toilet or cistern with a dual flush model since 2004. The average cost of toilet and installation is $287. Between 2004 and March, 2013 1,762 rebates have been paid. | Residential toilet/cistern end uses | Evidence collected from rebate applicants suggest that only about half are influenced by the rebate. Generally, other influences (e.g. toilet repair, renovation) trigger replacement of a |

[3] 70% of applicants out of a sample of 40 in 2013

| Measure | Description | Target | Status/comments |
|---|---|---|---|
| | | | toilet. |
| Washing Machine Rebate | Between October 2003 and July 2008, 1,921 washing machine rebates were given out to residential customers. The rebate amount was $50.<br><br>The rebate was stopped in July 2008 due to budget constraints and the fact that a majority of new machines on the market are now water efficient front or top loaders. The NSW government offered a similar rebate until June, 2011. | Residential clothes washing water use | The Rous Water Washing Machine Rebate will not be continued. Majority of washing machines on the market already water efficient. |
| Mulch rebate | A rebate on garden mulch was offered between October 2007- January 2008 and December 2008-January 2009. The rebate offered was $20 rebate for each full $50 spent on mulch, up to $100 rebate per household. | Residential outdoor water use | The rebate was very popular and had good publicity.<br><br>A program like this also provides an important link between water efficient behaviour, particularly outdoor uses. It also provides a good link between voluntary permanent water saving measures and incentives. |
| Outdoor Water Efficiency Packs | On occasion, Rous Water produced water saving garden packs and sold them at a reduced cost to town water customers in the region. The packs contain a range of products that encourage water saving in the garden.<br><br>The most recent packs were sold between October 2007 and April 2008. The pack contents cost approximately $30 each and the packs were sold for $10 each. A total of 1,000 packs were sold making a net cost to Rous Water of about $20,000. | Residential outdoor water use | As above |
| Showerhead Rebate | The rebate has been offered since 2004. 50% of the combined cost of the showerhead and installation up to a maximum rebate of $50 is offered. The average rebate amount is $40. The average purchase price for the customer is $130 (not including installation | Residential shower use | Less than half of the rebate recipients stated the rebate |

| Measure | Description | Target | Status/comments |
|---|---|---|---|
| | costs). Since 2011 there have been 147 rebates provided. | | influenced their decision to replace their showerhead. The cost-effectiveness of the program should be considered before deciding whether to continue the program. |
| Water Saving Products Rebate | Rous Water has introduced a rebate for specific new water saving products, to further encourage their use and household water conservation. The products that are currently eligible for such a rebate are: Every Drop Shower Saver, Cisternlink Aquasaver, outdoor swimming pool and spa covers and Aquadivert. This rebate provides a high water saving per dollar spent, however, uptake is low as it will take time for the community to feel comfortable with some of these products given they have not had the promotion of products such as rainwater tanks or showerheads.<br>Since 2011, rebates have been given for 29 Every Drop Water Savers, 18 swimming pool covers and 2 Cisternlink Aquasavers.<br>No rebates have been paid for the Composting (Waterless) toilet or the Aquadivert. Based on the results of this rebate program to date, the highest interest has been shown in the Every Drop Shower Saver and the Swimming Pool Cover. | All end uses | Program has not been as successful as other rebate programs and may be due to a lack of understanding or acceptance of these products in the community. Consider changing to focus on a specific product such as pool covers only or consider alternative products. |
| Water Loss Reduction | Some level of planning and implementation of water loss programs has been undertaken by LWUs as part of strategic asset management as opposed to dedicated water loss management effort. A Regional Water Loss Management report (Water Loss and Pressure Management , 2012) has been prepared on behalf of Rous Water to identify opportunities for pressure and leakage management in each of the Rous region LWUs. | Non-revenue Water reduction | Excellent opportunity to reduce water use at a LWU level.<br>Will require LWUs to implement Water Loss Program |
| Blue and Green Business Program | In 2007, Rous Water received funding for its project: “Engaging business to save potable water in the Rous Water region of North East NSW”. The project had two stages designed to develop partnerships with non-residential water users and result in on-ground works to reduce potable water demand. The project built on Rous Water’s | Top Non-residential customers | There is scope to add elements to this program that don’t currently exist that |

| Measure | Description | Target | Status/comments |
|---|---|---|---|
| | existing funding program for non-residential water customers.<br><br>Stage 1, carried out by Naturally Resourceful Pty Ltd, involved a series of in-depth interviews to engage businesses to identify their specific needs, the barriers and opportunities for water saving actions and works. The results identified the need to focus on the top water users and the accommodation sector. Stage 2 has involved the implementation of on-ground works to save water, with Rous Water providing rebates for part of the works.<br><br>The rebates offered under this program are:<br><br>• $150 per water efficient toilet/cistern/urinal<br>• $50 per water efficient showerhead<br>• $75 per tap/tap set<br>• $1,500 for a rainwater tank with 2 kL to 10 kL capacity<br>• $3,500 per ML/a of water saved up to 50% of total project cost for water recycling, leaks and other water efficiency projects and devices. Other includes rainwater tanks with capacity > 10 kL.<br>• 15% of cost for water meters.<br><br>A maximum rebate of $25,000 is available per business. This can come from one or more projects.<br><br>The Blue and Green Business Program has cost Rous Water and the NSW Climate Change Fund $161,559 to provide savings of 55 ML/year over 3 years. Up to May 2012, 48 businesses had participated in the program. | | have potential to deliver more savings (e.g. smart metering and effective auditing) Increased involvement from LWUs will be required to facilitate better direct engagement with customers. Program should focus on major users as these are where the most significant savings can be achieved. |
| School and Community Education | There are a number of existing education programs undertaken by Rous Water targeting early childhood, primary school students, secondary school students, tertiary students and the general community.<br><br>Rous Water undertakes a range of media activities. Current media programs are generally focussed on the promotion of rebate schemes. Promotion of rebate schemes has been undertaken through:<br>• Newspaper/print. | | Continues to be essential part of DM program and evolves to suit changing curriculum and technology. Future community |

| Measure | Description | Target | Status/comments |
| --- | --- | --- | --- |
| | • Television.<br>• Radio.<br>• Internet-website.<br>• Attending events (face to face).<br><br>Approximate numbers participating in 2011-12 for school education activities:<br><br>(see table below)<br><br>In addition to these education programs, Rous Water also participates in major community events reaching approximately 1,800 people. | | education/engagement must better integrate behaviour related messages with other programs and look for more effective technological solutions to deliver the messages to more specific target audiences. |
| Voluntary Permanent Water Savings (VPMS) | The Regional Demand Management Steering Committee recommended that Permanent Water Saving Measures be voluntary because there was not a current legal framework for such measures unless they were required by water shortage.<br><br>The measures are designed to promote water efficient behaviours. The measures include:<br>• Set times for outdoor watering, on/off nozzle for all hand held hoses.<br>• Ban on using water to clean driveways, paths, paved areas and other impervious | | On-going.<br><br>Examine the implementation of mandatory measures in accordance with best practice requirements. |

| Program | Number of Centres/Schools Visited | Estimated Number of Participants/Students |
| --- | --- | --- |
| Early Childhood | 29 | 1,867 |
| Primary | 46 | 2,577 |
| Secondary | 29 | 1,090 |
| Tertiary | 6 | 249 |
| Other | 5 | 1,040 |
| **TOTAL** | **115** | **6,823** |

| Measure | Description | Target | Status/comments |
| --- | --- | --- | --- |
| | surfaces unless using a high pressure water cleaner.<br>• Use of hand held hoses with on/off nozzle or a high pressure cleaner for all construction activities and private and commercial cleaning. | | |

## 5.2 Additional demand management measures

A review of Rous Water's current approach to demand management shows:

- Rous Water has had long term residential and non-residential programs largely backed by rebate programs.
- Residential programs may have a limited remaining life given the level of investment to date and that, for some water efficiency devices, are reaching saturation (e.g. toilets, washing machines).
- Given the gains in the residential sector through introduction of pricing and application of restrictions along with extended drought conditions across much of Australia, the current set of rebate programs will not give further significant savings, therefore need to transition to new delivery of demand management.
- Non-Residential program to date has been "selling" the rebate program for water efficiency work. There is a need to focus programs on major water users and focus on engagement between LWUs and customers.

In general, the emerging trends in demand management are:

- "Smart" technologies so consumers can better manage their own water consumption rather than through application of bans on certain water uses.
- Move away from generic water saving information delivered in a broad-brush approach to more specific advice to consumers to enable them to make effective choices.
- Better integration between information collected on water consumption and information provided back to customers.
- Higher level of customer focus and greater level of collaboration with customers.
- More targeted focus on particular groups or activities (e.g. open space irrigation, large non-residential users).

Additional demand management measures have been identified by considering the above points. The list of additional demand management measures to be evaluated is shown in Table 5-2.

**Table 5-2: Additional demand management measures**

| Measure | Description | Target |
|---|---|---|
| LWU Demand Management Plans | Encourage LWU's to develop individual Demand Management Plans and liaise with Rous Water on a regular basis. The plans would be developed under the overarching Rous Water Demand Management Plan. LWUs have direct access to their customer base and therefore have greater ability to influence major water users, open space irrigation, Council and LWU facilities as well as managing leakage within the LWU reticulation network. | Major water users, open space irrigation, Council facilities and NRW |
| Enhanced Blue and Green Business Program | Audit and smart metering targeting top 61 (>5 ML/year). Rebates provided for up to 50% of water efficiency measures implemented as a result of the audit. | High water using non-residential customers |
| Pool Cover Rebate | Would essentially replace the Water Saving Products Rebate focussing solely on pool cover rebates. Provide rebate of up to $100 for pool covers for residential customers. Rebate increased from current value of $50 to $100 to promote additional uptake. | Outdoor water use |
| Enhanced School and Community | Community engagement efforts in the future will need to focus on:<br>• Closing any gaps between perceived water use and actual | General |

| Measure | Description | Target |
|---|---|---|
| Education | water use in the community (i.e. those community members who think they have a low or average water use, yet are actually high).<br>• Enabling customers to understand how their household /personal water use compares to a community average and/or water efficiency target.<br>• Providing greater connection between information collected by LWU regarding household water use (i.e. metered consumption data) and the information provided to the consumer.<br>• Move away from generic water efficiency information in the forms of "tips" and provide practical tools that allow consumers to identify specific actions they can undertake that are relevant to their own personal circumstances.<br>• Provide more active assistance to customers where there is a history of consistently high water use.<br>Specific activities may include:<br>• Development of a benchmark for the long term maintenance and/or improvement of per household or per capita demand.<br>• Brand development and marketing campaign of target based program.<br>• Better information to customers on water bills of their consumption against target or community average in accordance with the National Guidelines for Residential Customers' Water Accounts<br>• Online resources (e.g. home water audit tools) that allow people to input information about their household and provide specific actions, estimated costs and suggested timeframes for improved water efficiency.<br>• Introduction of social media or other online tools that show water consumption and allow people to compare against a target.<br>• Identify high water users (e.g. greater than 1,000 L/day) and provided them with tailored water efficiency advice (pilot program is currently underway).<br>• More effective use of community based social marketing methods for target groups of interest (e.g. high residential water users). | |
| Outdoor Water Efficiency Packs | Produce water saving packs and sell them at a reduced cost to customers in the region. The packs contain a range of products that encourage water saving in the garden. The pack contents cost approximately $30 each and are sold for $10 each.<br>Program also includes a $20 rebate for every $50 spent on mulch, up to $100 rebate per household. | External irrigation |
| Water Loss Reduction | Losses represent approximately 16% of the total water production. The majority of this is through the local reticulation networks that are owned and operated by LWUs.<br>LWU's to carry out recommendations from Regional Water Loss Management Report (Water Loss and Pressure Management , 2012):<br>• Implementation of pressure management zones.<br>• Leakage reduction programs.<br>• Regular ongoing maintenance and leak repair.<br>• Identification of unmetered water consumption. | Water loss (NRW) |

| Measure | Description | Target |
|---|---|---|
| | Rous Water will work with LWUs to develop targets related to best practice based on either NRW (%) or Infrastructure Leakage Index (ILI). These will then be agreed by LWUs as part of the Service Level Agreement.<br><br>Water loss reduction is more of an operational issue and should be considered separately from the demand management measures in the future. | |
| Open Space Water Efficiency | Provide an irrigation audit of all open space sites and sporting ovals/fields. The auditor would examine the potential for water savings through water efficient landscaping, evapo-transpiration (ET) controllers and/or rain sensors and provide rebate for measures.<br><br>The program will also include training for landscape managers and monthly irrigation budgets. | Open space irrigation |
| Conservation based pricing | Three of the four LWUs already have a two-tier water pricing scheme in place which is in accordance with the NOW Best Practice Guidelines. The pricing structures and threshold for the second tier all vary between the LWUs. Rous Retail and Lismore City have a single tier pricing system. It is recommended that LWUs should review their pricing structures as part of their individual Demand Management Plans. | External water use |
| Permanent Low Level Restrictions | Introduction of mandatory permanent low level restrictions. Would replace the current voluntary measures. | |
| Enhanced Rainwater Tank Rebate | The following Enhanced Rainwater Tank Rebate is designed to offer the same level of funding that was offered when Rous Water experienced the highest level of rainwater tank rebate applications. This occurred in the same time period that the State government offered between 2008 and 2011. | Residential clothes washing, toilet and outdoor end uses |

| **Rous Water Rebates 2007-2011** | | **State Government 2007-2011** | | **Enhanced Rainwater Tank Rebate** | |
|---|---|---|---|---|---|
| Rebate Level | Rebate amount | Rebate Level | Rebate amount | Rebate Level | Rebate amount |
| 1 (2000-4,499 Litres) | $100 | 1 (2000-3,999 Litres) | $100 | 1 (2000-4,499 Litres) | $200 |
| 2 (4,500 – 8,999 Litres) | $400 | 2 (4,000 – 6,999 Litres) | $400 | 2 (4,500 – 8,999 Litres) | $800 |
| 3 (9,000+ Litres) | $500 | 3 (7,000+ Litres) | $500 | 3 (9,000+ Litres) | $1,000 |
| Plus connection to Washing Machine | $120 | Plus connection to Washing Machine | $500 | Plus connection to Washing Machine | $620 |
| Plus connection to toilet/s | $50 | Plus connection to toilet/s | $500 | Plus connection to toilet/s | $550 |

# 6 Options evaluation

This section presents the outcomes of the measure evaluation, including:

- preliminary benefit-cost ratios and water savings for the individual water demand management.
- measures that were included in the demand management cases.
- water demand forecasts for the next 30 years for each of the scenarios.

## 6.1 Overview

The financial benefit-cost analysis of each option has been undertaken using the DSM DSS model. The benefit-cost analysis of the demand management options examined weighs the cost of investment in demand management initiatives against the benefits accrued from three perspectives, the utility, the customer and the community (where the community combines both the utility and the customer).

**Note:** For the purposes of this technical note and the FWS in general, Utility costs include costs to both Rous Water and the LWUs while customer costs refer to costs incurred by retail water customers.

Utility costs include:

- Setup costs.
- Administration and enforcement costs (e.g. education).
- Capital costs and operations and maintenance costs for measures requiring new infrastructure (e.g. effluent reuse).
- Leak detection and repair costs.
- Rebate costs for efficient fixtures and appliances.

Utility benefits include:

- Delays and downsizing of capital expenditure.
- Reduction in treatment and energy costs.

Customer costs include:

- Purchase costs for rainwater tanks and associated equipment, efficient fixtures and appliances (minus utility rebate if applicable).
- Additional pumping costs for rainwater tanks.

Customer benefits include:

- Reductions in hot water use by customers.
- Reduced water bills.

Benefit-cost ratios were calculated for each stand-alone measure, the ratio of the net present value (NPV) of the financial benefits to the NPV of the financial costs. Annualised costs were also developed. Demand management cases comprising a bundle of individual options have been developed and assessed in the DSS using the same benefit-cost ratio approach.

The demand management measure benefit-cost analysis is dependent on multiple assumptions including customer uptake rate, end-use water saving, customer and utility cost estimates. Where available, information from existing Rous Water demand management activities and studies has been adopted. Otherwise, assumptions typically used by NOW in the development of NSW demand management plans have been used (NOW (formerly DEUS), 2006). Cost estimates are high level, for strategic level comparison purposes only. Actual costs will vary. Appendix A presents a summary table of the measure description and the assumptions for market penetration, water savings and implementation costs that were used in the forecasts.

## 6.2 Benefit-cost analysis

### 6.2.1 Individual measures

Table 6-1 presents the benefit-cost ratio for each demand management measure, the NPV, the annualised cost ($/kL) and the projected average annual water savings (ML/a).

**Table 6-1: Benefit-cost assessment for each stand-alone demand management measure**

| Measure Name | Present Value of Water Utility Costs | Water Utility Benefit Cost Ratio | Present Value of Total Community Costs | Total Community Benefit Cost Ratio | Total Community Annualised Costs ($/kL) | Average Water Savings (ML/a) |
|---|---|---|---|---|---|---|
| BASIX | $31,840,000 | 0.7 | $54,580,000 | 0.4 | $4.5 | 880 |
| WELS | $0 | - | $1,020,000 | 3.7 | $0.7 | 100 |
| Showerhead Rebate | $30,000 | 14.2 | $70,000 | 10.3 | $0.6 | 10 |
| Dual Flush Toilets Rebate | $170,000 | 6.8 | $1,000,000 | 1.2 | $2.7 | 30 |
| Rainwater Tank Rebate | $530,000 | 3.8 | $5,470,000 | 0.4 | $5.8 | 70 |
| School and Community Education | $430,000 | 3.0 | $430,000 | 3.7 | $1.7 | 20 |
| Blue and Green Business Program | $700,000 | 2.7 | $1,840,000 | 1.1 | $1.8 | 70 |
| Voluntary Permanent Water Saving Measures | $40,000 | 46.0 | $40,000 | 46.0 | $0.1 | 50 |
| Enhanced Rainwater Tank Rebate | $1,940,000 | 2.0 | $10,840,000 | 0.4 | $5.7 | 140 |
| Enhanced School and Community Education | $630,000 | 3.1 | $630,000 | 4.0 | $0.7 | 70 |
| Enhanced Blue and Green Business Program | $630,000 | 11.4 | $1,090,000 | 7.0 | $0.4 | 190 |
| Open Space Water Efficiency Program | $1,010,000 | 3.6 | $1,610,000 | 2.2 | $1.4 | 80 |
| Permanent Low Level Restrictions | $43,000 | 46.0 | $40,000 | 46.0 | $0.1 | 50 |
| Pool Covers Rebate | $44,000 | 1.4 | $150,000 | 0.4 | $9.1 | 1 |
| Outdoor Water Efficiency Pack | $170,000 | 3.6 | $320,000 | 1.9 | $4.3 | 5 |
| LWU Demand Management Plans | $190,000 | 0.0 | $190,000 | - | - | - |

| Measure Name | Present Value of Water Utility Costs | Water Utility Benefit Cost Ratio | Present Value of Total Community Costs | Total Community Benefit Cost Ratio | Total Community Annualised Costs ($/kL) | Average Water Savings (ML/a) |
|---|---|---|---|---|---|---|
| Water Loss Reduction | $3,920,000 | 4.3 | $3,920,000 | 4.3 | $0.48 | 591 |

Rous Water is currently resolved to construct the new Dunoon Dam to meet future supply requirements, and forms the baseline case for this study. The long term marginal cost of supply (assumes Dunoon Dam) is in the order $2.35 (Rous Water, 2012). From a high level financial perspective, any demand management with marginal cost less than this figure is worth consideration, particularly if significant water savings are gained. Higher volumetric cost measures may be justified where other benefits are gained e.g. greenhouse gas emission reduction and enhanced community engagement.

## 6.3 Demand management cases

Demand management cases comprising bundled individual options were developed in consultation with Rous Water representatives. Current demand management includes the mandated measures (BASIX and WELS) plus the current suite of Rous Water demand management initiatives; while enhanced demand management includes the mandatory measures and all measures which are 'cost-effective' i.e. have an annualised cost less than $2.35/kL. The measures included in each demand management case are shown in Table 6-2.

**Table 6-2: Demand management cases**

| Demand Management Measure | Current Demand Management | Enhanced Demand Management |
|---|---|---|
| WELS | ● | ● |
| BASIX | ● | ● |
| Showerhead Rebate | ● | ● |
| Dual Flush Toilet Rebate | ● | |
| Rainwater Tank Rebate | ● | |
| School and Community Education | ● | |
| Blue and Green Business Program | ● | |
| Voluntary Permanent Water Saving Measures | ● | |
| Enhanced Rainwater Tank Rebate | | ○ |
| Enhanced School and Community Education | | ● |
| Enhanced Blue and Green Business Program | | ● |
| Open Space Water Efficiency | | ● |
| Permanent Low Level Restrictions | | ● |
| Pool Covers Rebate | | ○ |
| Outdoor Water Efficiency Pack | | ○ |

| Demand Management Measure | Current Demand Management | Enhanced Demand Management |
|---|---|---|
| LWU Demand Management Plans | | • |
| Water Loss Reduction | | • |

**Note:**
A clear circle (○) indicates that the program is not considered 'cost effective' and hence has not been included in the Enhanced Demand Management case. Rous Water should consider, in consultation with stakeholders, whether there are other reasons to continue these programs.

The DSM DSS model provides an inbuilt capacity to estimate the reduced impact that occurs when multiple demand management measures target the same end use. Thus, the water savings achieved by a bundle of measures will generally be less than the sum of the individual water savings.

The individual measures included in each case and the overall benefit-cost, annualised cost ($/kL) and average water savings (ML/a) are provided in Table 6-3. The enhanced demand management case only includes those measures deemed to be cost-effective.

**Table 6-3: Summary of Costs and Savings for each Demand Management Case**

| Case | Present Value of Rous Water Costs | Rous Benefit Cost Ratio | Present Value of Total Community Costs | Total Community Benefit Cost Ratio | Total Community Annualised Costs ($/kL)[4] | Average Water Savings (ML/a) |
|---|---|---|---|---|---|---|
| Existing Demand Management Measures | $33.7M | 0.9 | $64M | 0.58 | $3.87 | 1,204 |
| Enhanced Demand Management | $38.1M | 1.4 | $63M | 0.94 | 2.34 | 1,950 |

The demand forecast for each of the cases is shown in Figure 6-1. The peak day demand forecast is also shown in Figure 6-3. It has been assumed that all of the cost effective enhanced demand management programs will commence in 2014. This is to show indicatively the impact of the enhanced program compared to the current program.

[4] $Annualised\ Cost = \frac{\sum C_t/(1+r)^t \times r/(1-(1+r)^t)}{\sum W_t/t}$
Where C is the cost (capital and operating) at time t, Wt is the water demand conserved or supplied or in year t and r is the discount rate.

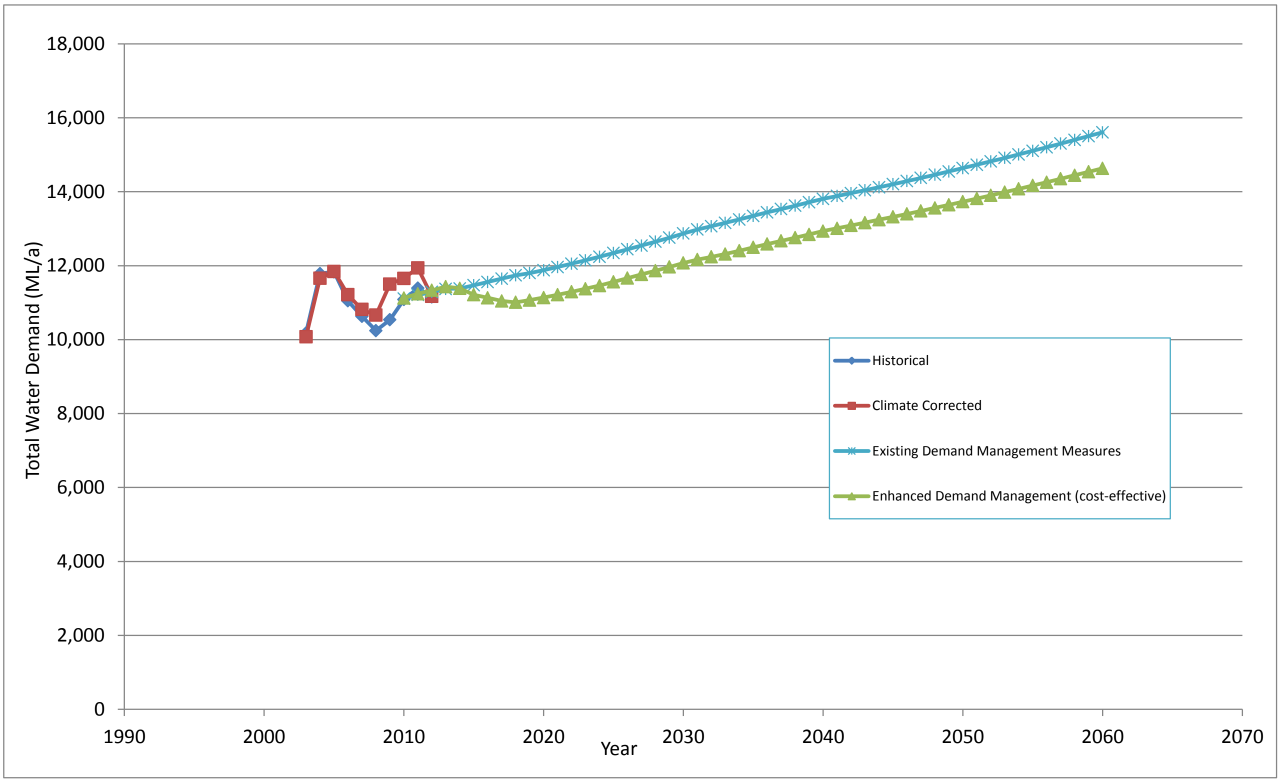


**Figure 6-1: Forecast water demand for each demand management case (ML/a)**

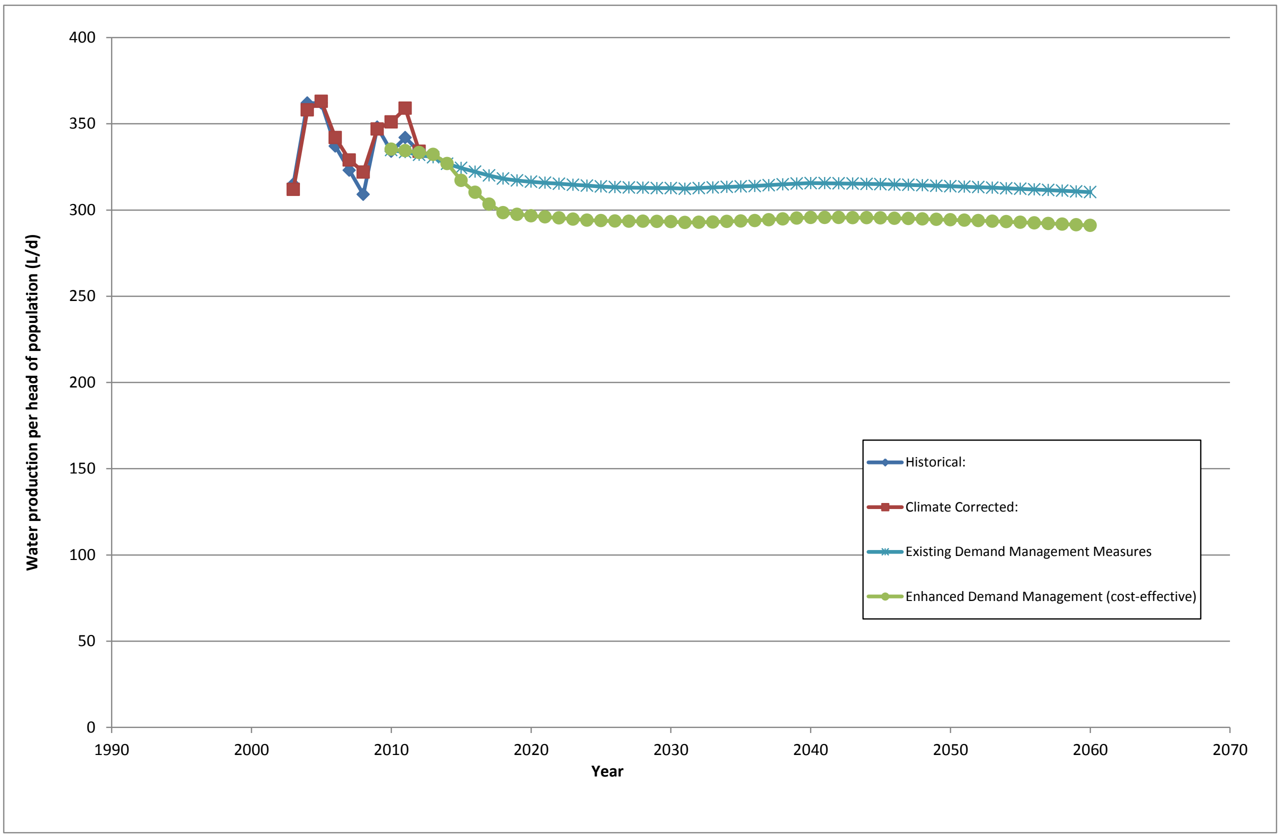


**Figure 6-2: Forecast water demand for each demand management case (L/head of serviced population)**

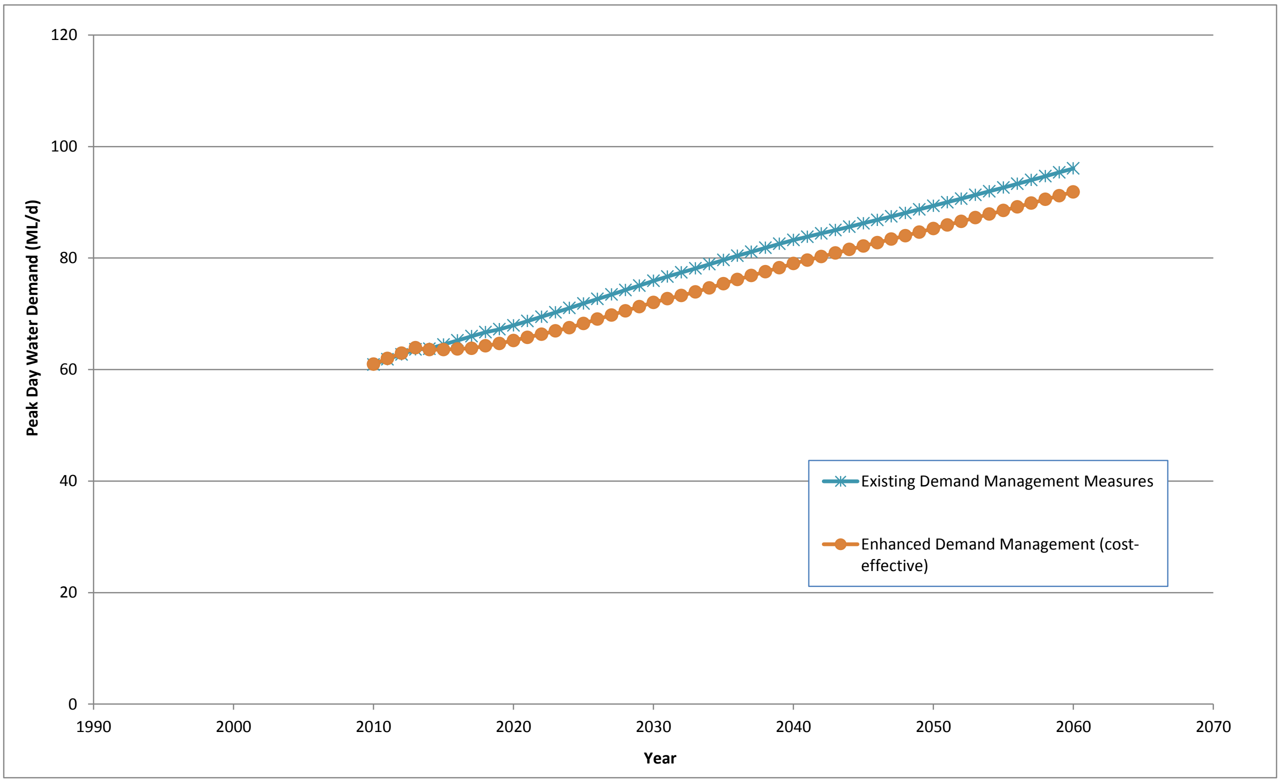


**Figure 6-3: Peak day demand forecast**

# 7 NSW best practice management

The NSW Office of Water defines best practice management of water and sewerage systems for local water utilities. Based on the information available for this study, the best practice demand management checklist has been assessed for Rous Water and the LWUs (Appendix B). Gaps in meeting checklist requirements provide basic elements for consideration in developing future demand management plans.

Rous Water is generally performing well against the best practice check-list, area for improvement include:

- Improved customer classification and reporting.
- Improved involvement by LWUs in the development of localised demand management measures.
- The need to implementation a cost-effective leakage (loss) management program, particularly aimed at the LWU level.
- Improved monitoring to review the effectiveness of the demand management measures.

# 8 Monitoring and reporting

It is recommended that Rous Water develop a reporting program to track water consumption and monitor the impacts of demand management activities. This requires working with the LWUs to develop and implement a standardised program to incorporate monitoring reports that include:

- Bulk water production.
- Bulk metered water consumption.
- Number of connections by customer/connection type.
- Total consumption by connection type.
- Total volume of metered water use by connection type.
- Per connection volume of metered water use by connection type.

Customers should be classified in accordance with the categories defined in the latest NSW Water Supply and Sewerage Performance Monitoring Report - Residential, Commercial, Industrial, Rural, Institutional, Bulk Sales, Public Parks and Unbilled.

A consistent definition of connection types across all constituent councils, and consistent reporting of water consumption within these types, is required to provide comparable and useful consumption based water use data to Rous Water.

The major assumptions used in the report should be monitored and reviewed. To facilitate this, the following data should be collected and reported on at the intervals shown in Table 8-1.

**Table 8-1: Monitoring and reporting plan**

| Indicator | Source | Reporting frequency |
|---|---|---|
| Production forecasts | Production data | Annually |
| Population growth forecasts | Census | Every 5 years |
| Residential consumption | Billing data (consumption) | Annually |
| Connections growth | Billing data (consumption) | Annually |
| Changing household size | Census | Every 5 years |
| MFR formation | Billing data (consumption) | Annually |
| Peak day factors | Production records | Annually |
| Non-residential connections and demand | Billing data (consumption) | Annually |
| Measures assumptions e.g. costs, uptake, sizes/types, stock/fixtures. | Rous Water/LWU program data | Annually |
| Climate influence | Climate correction of bulk water production and customer consumption demands | Annually |
| Demand management measures | Take-up of rebates and impact of water saving measures on demand | Annually |

## 8.1 Demand targets

Demand targets have been determined for the enhanced demand management case. These are derived based on the assumed demand forecast shown in Figure 6-1. Targets for overall water use per person and residential water use are shown in Table 8-2.

**Table 8-2: Water Demand Targets**

| Target (L/p/day) | Current | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Total production | 335 | 297 | 293 | 296 | 294 | 291 |
| Residential consumption | 195 | 168 | 154 | 148 | 143 | 138 |

These residential consumption targets can be used to:

- Set residential consumption targets for future demand management planning.

- Be used to as part of education and awareness campaigns.
- Inform residential customers of their performance against the target (e.g. on water bills).

# 9 Recommendations

Assessment of long term demand regime changes and demand trends has been used to develop demand forecasts. The end-use model is established and ready for use in developing Future Water Strategy scenarios. Forecasts for the current demand management measures and additional measures have been prepared and indicative cost-benefits for each case have been assessed. This assessment will assist Rous Water in the review of future demand management programs, including involvement of the LWUs.

The following recommendations are provided for consideration to improve demand management planning and facilitate adaptation in the future:

1. The Regional Demand Management Plan be revised to continue compliance with NSW best practice and consider the proposed enhanced demand management measures, providing appropriate regional targets and establish objectives for programs. Also give consideration to the roles and responsibilities of Rous Water as bulk supplier and LWUs in delivery of program.
2. LWU's to prepare local DM Plans to comply with NSW best practice and also look to achieve consistency with regional targets but also reflect the unique characteristics of their customer base.
3. Implement a monitoring program between Rous Water and LWUs to inform ongoing changes in demand in accordance with the Monitoring and Reporting recommendations listed in Section 8.
4. Review the Demand Management Plan in an ongoing basis as agreed between Rous Water and LWUs in future iterations of DM Plans.

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# Appendix A Measure assumptions

| Option Description | Assumed Market Penetration | Assumed Water Savings | Assumed Implementation Costs | Comments |
|---|---|---|---|---|
| **Mandatory Measures** | | | | |
| **National Mandatory Water Efficiency Labelling Scheme (WELS)**<br>2005 saw the introduction of a mandatory Water Efficiency Labelling Scheme (WELS) for toilets, washing machines, shower roses, taps, urinals and dishwashers. | Assumed to impact residential customers only; Increase the uptake of efficient washing machine by 5% and low flow showerheads by 5%. | Based on average use reductions of:<br>• 20% for taps;<br>• 30% for dishwashers;<br>• 30% for washing machines; and<br>• 30% for efficient showerheads. | Zero cost to utility to enhance and promote scheme.<br>Customer costs:<br>• $10 per tap<br>• $200 per dishwasher<br>• $10 per showerhead<br>• $700-$800/washing machine | Costs and savings adopted from *DSM-DSS Simplified Manual* (NOW (formerly DEUS), 2006) |
| **BASIX – Fixture Efficiency Component** | 90% of new residential accounts complying. | 20% reduction in use in showers, taps and sinks and outdoor use. | Nominal utility costs to support BASIX:<br>• Annual administration– $3,750 plus 5 cents for each person in the service area (assume setup cost no longer needed).<br>Cost to community (excluding rainwater tank and/or dual reticulation costs which are listed below):<br>• $10 additional for low flow showerhead.<br>• $10 for tap flow regulators.<br>• $50 application fee | Administration cost from *DSM-DSS Simplified Manual* (NOW (formerly DEUS), 2006), adjusted for 2012.<br>It has been assumed that each account purchases 1 low flow showerhead and 2 tap flow regulators.<br>Take-up rate based on BASIX assessment undertaken by McBeth (2011). |
| **BASIX- Rainwater Tanks on all new Residential Development** | 95% of new residential customers (excluding those connected to dual | Savings determined from rainwater tank modelling based on assumed | • Cost of installation is $3,750 per account.<br>• $40 per year per customer for | It has been assumed that setup costs are no longer required. |

| | | | | |
|---|---|---|---|---|
| Majority of new residential development will fit a rainwater tank. | reticulation in Ballina) | rainwater tank connected end uses, roof area and rainwater tank volume. House connected to toilets, washing machine and external can save approximately 65 kL/year. House connected to toilet and irrigation can save 50 kL/year. House connected to irrigation only can save 40 kL/year.<br><br>Zero savings under peak conditions. | operation. | Annual operating cost taken from *DSM-DSS Simplified Manual* (NOW (formerly DEUS), 2006), but adjusted for 2012 costs.<br><br>Take-up rate based on BASIX assessment undertaken by McBeth (2011).<br><br>Rainwater tank modelling has been used to determine water savings.<br><br>Assumptions:<br>End use breakdown for each customer type based on account usage and assumed fixture types and usage figures.<br><br>Three scenarios modelled:<br>• Irrigation only<br>• Irrigation and toilet flushing<br>• Irrigation, toilet flushing and cold water tap of washing machine<br><br>Majority (80%) are connected to irrigation, toilet flushing and washing machines. 3% are connected to irrigation and toilet flushing and 10% are |

| | | | | |
|---|---|---|---|---|
| | | | | connected to irrigation only. It is assumed that 7% of households will not connect to rainwater tanks.<br><br><u>SFR Greenfield/Infill</u><br>Roof area of 150 $m^2$ and tank volume of 4.5 kL.<br><br>Savings vary between 38-60 kL/year depending on end uses connected. Average saving of 47 kL/year.<br><br><u>MFR Greenfield/Infill</u><br>Roof area of 75 $m^2$ and tank volume of 1 kL.<br><br>Savings vary between 12-27kL/year depending on end uses connected. Average saving of 21 kL/year. |
| **<u>BASIX- Dual Reticulation for new residential accounts in Ballina</u>**<br>All new Greenfield development to be fitted with dual reticulation systems with recycled water to be used for toilet flushing, outdoor use (irrigation) and cold washing machine tap. | 264 existing accounts (to be connected to recycle water supply in 2014).<br>All new MFR/SFR Greenfield developments in Ballina from 2014 | 100% reduction in toilets and outdoor end uses, 75% reduction in washing machine end uses assuming 25% is hot water use.<br>Additional urban open space irrigation savings proposed have not been allowed for in this assessment.<br>No saving due to irrigation of coastal revegetation as this is currently not | Costs to Customer:<br>• $15M developer contribution for distribution network<br>• Equates to $2,070 per account<br>Costs to utility:<br>• Setup - $35M (cost of recycled water recycling treatment plants - $16M and distribution - $18M)<br>• Operating and maintenance costs of $3,000/ML assumed | Costs obtained from *Ballina-Lennox Head Recycled Water Masterplan* (Ballina Shire Council, n.d) and *Report for Ballina and Lennox*<br>*Head Reclaimed Water Reuse*<br>*Masterplan Project* (GHD, 2007) |

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| | | irrigated with potable water – in addition recycled water may not be used for this purpose anymore (pers comm A. Swan, 2013) | | |
| **Existing Measures** | | | | |
| **Rainwater Tank Rebate**<br>Existing residential properties are offered a rebate to fit a rainwater tank. | 100 accounts/year (previous target) | Savings determined from rainwater tank modelling based on assumed rainwater tank connected end uses, roof area and rainwater tank volume. | Costs to customer:<br>• Cost of installation is $5,000 per account (minus $492 rebate).<br>• $40 per year per customer for operation.<br>Costs to utility – to enhance and promote rebates:<br>• $3,000 annual administration cost<br>• Rebate is $600 per household participating | Rainwater tank modelling has been used to determine water savings.<br><br>Assumptions:<br>End use breakdown for each customer type based on account usage and assumed fixture types and usage figures.<br><br>Three scenarios modelled:<br>• Irrigation only<br>• Irrigation and toilet flushing<br>• Irrigation, toilet flushing and cold water tap of washing machine<br><br>Majority (70%) are connected to irrigation, toilet flushing and washing machines. 3% are connected to irrigation and toilet flushing and 10% are connected to irrigation only.<br><br><u>SFR Existing</u><br>Roof area of 150 $m^2$ and tank volume of 4.5 kL.<br><br>Savings vary between 38-66 kL/year depending on end uses connected. Average saving of |

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| | | | | 52 kL/year.<br><br>MFR Existing<br>Roof area of 75 $m^2$ and tank volume of 1 kL.<br><br>Savings vary between 12-29 kL/year depending on end uses connected. Average saving of 22 kL/year.<br><br>In addition McBeth 2011 was reviewed- Average water savings as a result of rainwater tank installation in the Rous Water supply area are calculated at 50kL/ house/annum; external use connections saved an average of 43kL/house/year; external, laundry and toilet connections saved 27kL/house/year; and all-of-house connections saved 107kL/house/year (McBeth 2011). The savings predicted from rainwater tank modelling are in the range determined by McBeth. |
| **Showerhead Rebate**<br>50% of the combined cost of the showerhead and installation up to a maximum rebate of $50 is offered. | 50 accounts/year<br>(previous target) | Based on average use volumes for each type of shower (calculated in DSS –DSM) | Costs to customer:<br>• Cost of showerhead is $130 per account (minus $50 rebate) including installation.<br>Costs to utility – to enhance and promote rebates:<br>• Rebate is $50 per account | Costs based on average of previous rebate and project costs provided by Rous Water. |
| **Dual Flush Toilet Rebate** | 400 accounts/year | Based on average use volumes for each type of | Costs to customer: | Costs based on average of previous rebate and project |

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| Rebates of $50 have been offered to customers for the replacement of a single flush toilet with a dual flush model. | (previous target) | toilet (calculated in DSS – DSM) | • Cost of toilet is $287 per account (minus $50 rebate) including installation.<br>Costs to utility – to enhance and promote rebates:<br>Rebate is $50 per account | costs. |
| **Blue and Green Business Program**<br>This measure allows for water audits for non-residential customers. | 10 accounts/year | 15% reduction in total demand | Costs to customer:<br>• Project cost is $11,020 per account (minus $3,297 rebate).<br>Costs to utility:<br>• $3,297 rebate per account<br>• Annual administration cost of $18,500 | Water savings based on previous total water savings (2009 onwards)<br>Costs based on average of previous rebate and project costs from blue and green program (2009 onwards)<br>Costs to utility based on demand budget costs provided by Rous Water. |
| **Community and School Education** | 15% of all new accounts<br>2% per year of existing accounts (total 40%) | Residential:<br>2% of all end uses and 5% during peak conditions.<br>Non-residential:<br>1% of all end uses | Costs to utility :<br>• Annual Administration Costs $35,000 | Average cost is $35,000 per year for School and Community Education & Awareness. |
| **Planned Measures** | | | | |
| **LWU Demand Management Plans** | All accounts | Council will have biggest influence on:<br>• Major users (including Council properties)<br>• Irrigation of parks and gardens<br>• Leakage<br>No savings directly attributable to Demand Management Plans. | Costs to utility :<br>• $30,000 for each council to set up a DM plan ($120,000 in total)<br>• 20 person days per year per council for on-going liaison with Rous | Cost for typical Demand Management Plan based on MWH cost estimate for similar projects. |

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| **Enhanced Blue and Green Business Program**<br>Audit and smart metering targeting top 61 (>5ML/year). Rebates provided for up to 50% of water efficiency measures implemented as a result of the audit | 10 accounts/year over 4 years (40 in total) | 20% of total use | Costs to customer:<br>• $20,500 cost of water efficiency measures (minus $6,000 rebate-30%).<br>Costs to utility :<br>• Audit cost $10,000 per account<br>• Rebate is $6,000 per account<br>• Program Setup costs of $12,000<br>• Annual Administration Costs are $18,500 | Rebate and measure implementation costs adopted as average from Blue and Green Program for >5ML customers which have participated to date<br><br>Have assumed 33% of customers have already been targeted based on data provided.<br><br>Annual administration cost as per Blue and Green program costs |
| **Open Space Water Efficiency**<br>Provide an irrigation audit of all open space sites and sporting ovals/fields. The auditor would examine the potential for water savings through water efficient landscaping, evapo-transpiration (ET) controllers and/or rain sensors and provide rebate for measures up to 50%.<br>The program will also include training for landscape managers and monthly irrigation budgets. | 10 per year over 11 years (110 total) | 30% of outdoor end uses based on savings achieved from similar programs | Costs to customer:<br>• $20,000 cost of water efficiency measures (minus $10,000 rebate).<br>Costs to utility:<br>• Audit cost $4,000 per account<br>• Landscape manager training of $980 for two day course<br>• Rebate is $10,000 per account<br>• Program Setup costs of $20,000<br>• Annual Administration Costs are $8,000 | Have assumed 10% of non-res customers are will be targeted based on Hunter large customers (218 customers) and 50% participation<br><br>Assumed 30% savings for outdoor end uses for relevant customers based on Hunter Water program Non-residential Demand Assessment (MWH, 2013). However scaled up so that each participating customer would save around 1 ML/year (assumed value). Savings of 3 ML/year were made by Hunter large open space customers through a similar program. |
| **Residential High Water Users Program** | 150 in total (program trial) | 20% of reduction in discretionary uses | Costs to utility :<br>• $5,000 budget to cover | Assumed all existing residential accounts greater than 1,000 |

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| High water users (e.g. greater than 1,000 L/day) are notified by their Council and provided with water saving tips.<br>Note: The costs and water savings are absorbed into Enhanced Community and School Education | | | interpretive materials, survey administration etc. | L/day (scaled up demand per customer by factor of 2 to represent this)<br><br>Budget costs and uptake rates advised by E. Hunter (17/4/2013).<br><br>Savings based on savings from similar One to One program undertaken in SEQ. |
| **Pool Cover Rebates**<br>Provide 50% rebate for pool covers for residential customers. | 70 accounts/ year or 0.2% per year | 80% of external outdoor 'other' (i.e. non-irrigation and non-external use) use for participating customers | Costs to customer:<br>• Cost of pool cover is $800 per account (minus $100 rebate) including installation.<br>Costs to utility:<br>• Rebate is $400 per account<br>• Program Setup costs of $12,000<br>• Annual Administration Costs are $3,500 | SEQ RWSS (MWH, 2006) assumption- 20 L/day saving per customer participating - scaled usage up by factor of 1.2 to account for extra outdoor usage for customers with pool (and to achieve 20 L/day reduction)<br><br>Uptake and duration of program based on SEQ RWSS assumption that 0.2% of all residential customers will be targeted over a 3 year period |
| **Enhanced School and Community Education (included High Water Users Trial Program)** | 25% of all new accounts<br>3% per year of existing accounts (total 60%) | Residential:<br>2% of all end uses and 5% during peak conditions.<br>Non-residential:<br>1% of all end uses | Costs to utility :<br>• Annual Administration Costs $50,000 | Uptake rate spread out over 20 years |
| **Permanent low level restrictions**<br>Permanent restrictions with | 72% of accounts | 2% of irrigation and other external use | Costs to utility :<br>• Set up costs of $5,000<br>• Annual Administration costs | Uptake rate is spread out over 6 years, 12% each year (so that in total 72% participate) |

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| various requirements relating the use of town water for filling of pools and other water bodies, cleaning of external surfaces, vehicle washing and irrigation. | | | of $10,000 | Annual administration cost is current budget allocation for advertising of Voluntary Permanent Water Saving Measures obtained from Rous Water Annual administration cost is current cost for advertising of restrictions obtained from Rous Water Demand Management Budget. |
| **Outdoor Water Efficiency Packs**<br>Produce water saving packs and sells them at a reduced cost to customers in the region. The packs contain a range of products that encourage water saving in the garden. The pack contents cost approximately $30 each and are sold for $10 each.<br>Program also includes a $20 rebate for every $50 spent on mulch, up to $100 rebate per household. | 500 accounts per year over 5 years | 10% of outdoor uses | Cost to customer:<br>• Cost of water savings pack $30 per account (minus $10 rebate).<br>• Cost of mulch $100 per account (minus $40 rebate).<br>Costs to utility :<br>• Rebates are $60 per account<br>• Program Setup costs of $8,000<br>• Annual Administration Costs are $5,000 | All assumptions based on previously run programs- assumed water savings based on previous saving of 6 kL/year/household (water savings pack and mulch rebate program combined). |
| **Water Loss Reduction**<br>Reduce water losses through leakage detection | | Achievable savings of 670 ML based on Regional Water Loss Management Report (70% reduction in avoidable losses). | Worst case setup costs are $3.7M based on Regional Water Loss Management Report (Water Loss and Pressure Management Pty Ltd, 2012). Continued investment to maintain savings Inspection and repair costs per km. Assumed 50,000 for administration and management. | Savings and costs obtained from Regional Water Loss Management Report (Water Loss and Pressure Management Pty Ltd, 2012) |

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|---|---|---|---|---|
| **<u>Enhanced Rainwater Tank Rebate</u>**<br>Existing residential properties are offered a rebate to fit a rainwater tank. | 200 accounts/year | Savings determined from rainwater tank modelling based on assumed rainwater tank connected end uses, roof area and rainwater tank volume. | Costs to customer:<br>• Cost of installation is $5,000 per account (minus $492 rebate).<br>• $40 per year per customer for operation.<br>Costs to utility – to enhance and promote rebates:<br>Rebate is $1,200 per household participating (double the current average) | As per existing Rainwater Tank rebate assumptions |

<u>Baseline Assumptions</u>

- Treatment and operating costs for current water sources were provided by Rous Water. An operating cost for the current water sources is $90/ML for treatment and $30/ML for distribution has been assumed. This distribution costs allows for increased transfer from Lismore River Source between 2018 and 2022.
- Rous Water's planning for the Dunoon Dam augmentation assumes the dam will be completed by 2023 in order to maintain water se curity.
- Costs have been adjusted to reflect 2012/13 dollar values.
- Discount rate of 7% has been assumed for NPV calculations.

# Appendix B Demand management plan checklist - status

| Area | | Item | Rous Water | LWU |
|---|---|---|---|---|
| **Demand Monitoring** | A | Bulk water production metered and recorded on a daily basis. | Yes | Yes |
| | B | All new free standing and multi-unit residential developments (both strata and non-strata) approved after 1 July 2004 must be separately metered. | Billing data not provided | Billing data not provided |
| | C | All free standing residential premises must be separately metered by 1 July 2007. | Billing data not provided | Billing data not provided |
| | D | LWUs should encourage separate metering of existing multi-unit residential developments, where cost-effective. | Unclear | Unclear |
| | E | Customer water consumption billed at least three times a year (and preferably quarterly). | Yes | Yes |
| | F | Customers classified in accordance with the categories defined in the latest NSW Water Supply and Sewerage Performance Monitoring Report (2009/10 categories: Residential, Commercial, Industrial, Rural, Institutional, Bulk Sales, Public Parks and Unbilled) and consumptions reported annually. | No | No |
| | G | If facing augmentation of the peak day capacity of your system, monitor and record service reservoir levels on a daily basis in high demand periods. | Unclear | Unclear |
| **Demand Forecasting** | A | Historical records corrected for influence of climate. | Yes, as part of this study | Yes, as part of this study |
| | B | Data records screened for errors. | Yes | Yes |
| | C | Demand forecasts prepared for each customer category as well as for leakage and unaccounted for water (UFW). | Main categories part of this study | Main categories part of this study |
| **Demand Management Planning** | A | Examined a range of long-term demand management measures including:<br>- retrofit programs<br>- rebates for water efficient appliances<br>- rebates for rainwater tanks<br>- rebates for garden mulch<br>- effluent and stormwater re-use programs. | Yes, as part of this study and the Future Water Strategy | Partly covered by this study |
| | B | Completed benefit/cost analysis of demand management measures that includes benefits from reduced capital works and lower operating costs. | Yes, as part of this study and the Future Water Strategy | Partly covered by this study |
| | C | Completed investment schedule/plan for implementing cost-effective demand management measures. | To be done as part of FWS | No |

| Area | | Item | Rous Water | LWU |
|---|---|---|---|---|
| **Implementation** | A | Subsidised and promoted at least two of the identified demand management initiatives, referred to in Demand Management Planning (A) above. | Yes | No |
| | B | Examined the implementation of permanent water saving measures to minimise wastage, in accordance with Item 91 (iii) of the National Water Initiative. | Yes, as part of this study | Yes, as part of this study |
| | C | Implemented a cost-effective leakage reduction program to reduce system water losses. | No, investigation commenced | No, investigation commenced |
| | D | Ongoing customer education campaign focussing on the importance of conserving our valuable water resources. | Yes | Partly |
| | E | If average residential water use per property exceeds that for the median NSW utility (290 kL/a in 2002/03) by over 20%, the LWU must show progress towards achieving a reduction in average residential use by 1 July 2007. | N/A | N/A |
| | F | Monitoring program for reviewing the effectiveness of the implemented demand management measures. | No | No |

# Appendix C Fixture and appliance assumptions

The residential end use profile for internal consumption is broken down into seven end uses:

1. Showers
2. Washing Machines
3. Toilets
4. Taps
5. Dishwashers
6. Bath
7. Internal Leakage.

For each of these end uses, the following key assumptions have been determined from the latest available information:

- Volume per Use
- Localised installed stock and fixture information (Currently Installed Stock)
- Market availability information (Market Share)
- Cost per Installation
- Annual Replacement Rate.

## C.1 Showers

For the end use modelling in the Rous FWS, four different types of showerheads have been assumed:

1. Water Miser <7.5 L/min
2. Low flow >7.5, < 9 L/min
3. Medium flow >9L/min,<12 L/min
4. High flow >12 L/min.

**Table C-1: Showers Fixture Assumptions**

| TYPE | AVERAGE SHOWER TIME (MIN) [5] | AVERAGE FLOW RATE (L/MIN)[6] | VOLUME PER USE (L/USER) | BASELINE MEAN NO. OF USES/ USER/ DAY[7] | REPLACE-MENT RATE[8] | FIXTURE INSTALL-ATION COST |
|---|---|---|---|---|---|---|
| Water Miser | 6.3 | 6.6 | 34.0 | 0.85 | Every 20 years | $75 |
| Low Flow | 6.3 | 8.4 | 41.6 | 0.85 | Every 20 years | $60 |
| Medium Flow | 6.3 | 10.8 | 52.9 | 0.85 | Every 20 years | $40 |
| High Flow | 6.3 | 13.2 | 90.3 | 0.85 | Every 20 years | $40 |

In determining the current proportion of installations data 'Environmental Issues - People's Views and Practices' (ABS, 2010) indicated that 64.9% of households had reduced flow showerheads in NSW. Reduced flow is assumed to be <12 L/min. The proportions for existing showerheads within each category are based on a survey of shower types undertaken by Yarra Valley Water (2011). It has been assumed that new build housing will contain a much higher proportion of water efficient showers (90%) given the more efficient stock available on the market currently.

**Table C-2: Currently Installed Stock Assumptions - 2010**

| CONSUMER CATEGORY | INITIAL PROPORTION | | | | TOTAL |
|---|---|---|---|---|---|
| | WATER MISER | LOW FLOW | MEDIUM FLOW | HIGH FLOW | |
| Existing Residential | 18% | 25% | 19% | 38% | 100% |
| New Residential | 22.8% | 45.6% | 22.8% | 9% | 100% |

## C.2 Washing Machines

The best available information available regarding the proportion of installed washing machines and current behavioural use are:

- Yarra Valley Future Water, 2011 Appliance Stock and Usage Patterns Survey
- Sales data from the 2006 report from the Australian Greenhouse Office's Equipment Energy Efficiency Committee - Greening Whitegoods – A Report into the Energy Efficiency Trends of Major Household Appliances in Australia from 1993 to 2005.
- Installed stock data from the ABS Report – Environmental Issues, People's Views and Practices, March 2010.

### C.2.1 Forecasting Future Markets

The forecasting of future washing machine water use is a difficult exercise, because there are a number of factors that need to be considered. These include:

- Falling economies of scale associated with falling household sizes;
- The tendency of consumers to purchase larger washing machines;

[5] Average shower time taken from overall average duration time in YVW (2011) Appliance Stock and Usage Pattern Survey.
[6] Average flow rate determined by applying a reduction factor of 80% to the capacity flow rate
[7] Baseline mean number of uses taken from YVW (2011) Appliance Stock and Usage Pattern Survey.
[8] 5% replacement rate. MWH assumption

- The increasing water efficiency of top loading machines; and
- The increasing purchasing of front loading machines.

The broad assumptions made in the preparation of forecasts:

- There will always be a residual market for top loading machines, in spite of their inherent lower efficiency levels relative to front loaders;
- There will be a natural increase in the efficiency of both top and front loaders;
- The impacts of changes in economies of scale due to falling household sizes will be minor in comparison to changes in the type of machines and will be ignored;
- The impacts of consumers purchasing larger machines will be offset to some extent by reduced frequency of washing and for the purposes of our modelling will be ignored;
- Twin tubs will continue to be a minor player in the market and will not specifically be modelled – but will be assumed to be included in the efficient top-loader category of machine.

To forecast these impacts, four different types of washing machines have been assumed:

1. Efficient Front Loader – 4 star assumed
2. Inefficient Front Loader – 2.5 star assumed
3. Efficient Top Loader – 3 star assumed
4. Inefficient Top Loader – 1.5 star assumed.

The mean number of uses was derived using the formulae developed in the YVW study.

$$\text{No. Loads/Week} = 2.25 * (\text{Household Size})^{0.69}$$

$$= 2.25 * 2.59^{0.69} = 4.34 \text{ Loads/Week/Household}$$

$$= 0.24 \text{ Loads/Day/Person}$$

Table C-3 indicates the assumptions used in the end use forecasting of the washing machine end use for each of the different types of washing machines. The assumed volume per use figures quoted are taken from WELS assumptions, see Table C-4 and the average load capacity is assumed as 7 kg which is consistent with sales data.

**Table C-3: Types of Washing Machines Assumptions**

| TYPE | WELS STAR RATING | LOAD CAPACITY (KG)[9] | VOLUME PER USE (L/USE)[10] | BASELINE MEAN USES PER USER PER DAY | REPLACEMENT RATE[11] | FIXTURE INSTALLATION COST |
|---|---|---|---|---|---|---|
| Efficient Front Loader | 4 star | 7 | 72 | 0.24 | Every 15 years | $800 |
| Inefficient Front Loader | 2.5 star | 7 | 123 | 0.24 | Every 15 years | $775 |

[9] Average capacity for front and top loaders in NSW - Greening White Goods - A Report into the Energy Efficiency Trends of Major Household Appliances in Australia from 1993 – 2005, Energy Efficient Strategies (June 2006)

[10] Calculated based on the assumed WELS rating

[11] Based on Bern Clothes Washer Study, Final Report, US Dept. of Energy (Mar 1998)

| TYPE | WELS STAR RATING | LOAD CAPA CITY (KG)[9] | VOLUME PER USE (L/USE)[10] | BASELINE MEAN USES PER USER PER DAY | REPLACE-MENT RATE[11] | FIXTURE INSTALL-ATION COST |
|---|---|---|---|---|---|---|
| Efficient Top Loader | 3 star | 7 | 103 | 0.24 | Every 15 years | $750 |
| Inefficient Top Loader | 1.5 star | 7 | 176 | 0.24 | Every 15 years | $700 |

**Table C-4: WELS Star Rating – Volume per Use for Washing Machines**

| LOAD CAP-ACITY (KG) | STAR RATING | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 STAR | 1.5 STAR | 2 STAR | 2.5 STAR | 3 STAR | 3.5 STAR | 4 STAR | 4.5 STAR | 5 STAR | 5.5 STAR | 6 STAR |
| | VOLUME PER USE (L) | | | | | | | | | | |
| 1 | 30 | 25.1 | 21 | 17.6 | 14.7 | 12.3 | 10.3 | 8.6 | 7.2 | 6 | 5 |
| 1.5 | 45 | 37.6 | 32.5 | 26.4 | 22.1 | 18.4 | 15.4 | 12.9 | 10.8 | 9 | 7.6 |
| 2 | 60 | 50.2 | 42 | 35.1 | 29.4 | 24.6 | 20.6 | 17.2 | 14.4 | 12.1 | 10.1 |
| 2.5 | 75 | 62.7 | 52.5 | 43.9 | 36.8 | 30.7 | 25.7 | 21.5 | 18 | 15.1 | 12.6 |
| 3 | 90 | 75.3 | 63 | 52.7 | 44.1 | 36.9 | 30.9 | 25.8 | 21.6 | 18.1 | 15.1 |
| 3.5 | 105 | 87.8 | 73.5 | 61.5 | 51.5 | 43 | 36 | 30.1 | 25.2 | 21.1 | 17.6 |
| 4 | 120 | 100.4 | 84 | 70.3 | 58.8 | 49.2 | 41.2 | 34.4 | 28.8 | 24.1 | 20.2 |
| 4.5 | 135 | 112.9 | 94.5 | 79.1 | 66.2 | 55.3 | 46.3 | 38.7 | 32.4 | 27.1 | 22.7 |
| 5 | 150 | 125.5 | 105 | 87.8 | 73.5 | 61.5 | 51.5 | 43 | 36 | 30.1 | 25.2 |
| 5.5 | 165 | 138 | 115.5 | 96.6 | 80.9 | 67.6 | 56.6 | 47.4 | 39.6 | 33.1 | 27.7 |
| 6 | 180 | 150.6 | 126 | 105.4 | 88.2 | 73.8 | 61.7 | 51.7 | 43.2 | 36.2 | 30.3 |
| 6.5 | 195 | 163.1 | 136.5 | 114.2 | 95.6 | 79.9 | 66.9 | 56 | 46.8 | 39.2 | 32.8 |
| 7 | 210 | 175.7 | 147 | 123 | 102.9 | 86.1 | 72 | 60.3 | 50.4 | 42.2 | 35.3 |
| 7.5 | 225 | 188.2 | 157.5 | 131.8 | 110.3 | 92.2 | 77.2 | 64.6 | 54 | 45.2 | 37.8 |
| 8 | 240 | 200.8 | 168 | 140.6 | 117.6 | 98.4 | 82.3 | 68.9 | 57.6 | 48.2 | 40.3 |
| 8.5 | 255 | 213.3 | 178.5 | 149.3 | 125 | 104.5 | 87.5 | 73.2 | 61.2 | 51.2 | 42.9 |
| 9 | 270 | 225.9 | 189 | 158.1 | 132.3 | 110.7 | 92.6 | 77.5 | 64.8 | 54.2 | 45.4 |
| 9.5 | 285 | 238.4 | 199.5 | 166.9 | 139.7 | 116.8 | 97.8 | 81.8 | 68.4 | 57.3 | 47.9 |
| 10 | 300 | 251 | 210 | 175.7 | 147 | 123 | 102.9 | 86.1 | 72 | 60.3 | 50.4 |

Sales data from NSW shows a significant increase in the number of front loading machines over the last few years. Based on the Yarra Valley Water survey (2011) there is a 52% to 48% split between Top Loaders and Front Loaders. This split has been used to apportion between efficient and in-efficient model types with each washing machine type.

**Table C-5: Currently Installed Stock Assumptions**

| CONSUMER CATEGORY | INITIAL PROPORTION | | | | TOTAL |
|---|---|---|---|---|---|
| | EFFICIENT FRONT LOADER | FRONT LOADER | EFFICIENT TOP LOADER | IN-EFFICIENT TOP LOADER | |
| Existing Residential | 24.00% | 24.00% | 17.00% | 34.00% | 100.0% |
| New Residential | 40.00% | 4.50% | 28.00% | 28.00% | 100.0% |

## C.3 Toilets

The following tables indicate the assumptions used in the end use forecasting of the toilet end use.

**Table C-6: Toilet Fixture Assumptions**

| TYPE | VOLUME PER USE (L/USER)[12] | BASELINE MEAN NO. OF USES PER USER PER DAY[13] | REPLACEMENT RATE[14] | FIXTURE INSTALLATION COST |
|---|---|---|---|---|
| 4.5/3 Dual Flush | 3.28 | 4.2 | Every 25 yrs | $350 |
| 6/3 Dual Flush | 4.04 | 4.2 | Every 25 yrs | $350 |
| 9/4.5 Dual Flush | 5.88 | 4.2 | Every 25 yrs | $350 |
| High Flush | 9.80 | 4.2 | Every 25 yrs | $350 |

Historical ABS ownership data does not differentiate between different types of dual flush toilets. Yarra Valley Water identified specific breakdown of toilet types as part of their survey in 2011. For currently installed stock numbers, it has been assumed that 12% are of the 4.5/3 dual-flush type, 44% are of the 6/3 dual-flush type, 28% are 9/4.5 dual-flush type and the remainder are single flush. The current breakdown is shown in Table C-7.

**Table C-7: Currently Installed Stock Assumptions**

| CONSUMER CATEGORY | INITIAL PROPORTION | | | | TOTAL |
|---|---|---|---|---|---|
| | 4.5/3 DUAL FLUSH | 6/3 DUAL FLUSH | 9/4.5 DUAL FLUSH | HIGH FLUSH | |
| Existing Residential | 12.00% | 45.00% | 28.00% | 15.00% | 100% |
| New Residential | 60.00% | 40.00% | 0.00% | 0.00% | 100% |

## C.4 Taps

Tap use is considered as an indoor use but in reality could be outdoor as well, as it is very difficult to distinguish between internal and external use with the data logging from an end use study. Therefore it is assumed to be predominantly bathroom basin, kitchen sink and laundry trough use.

On average, it is assumed that each person in the household uses a tap 20 times per day and the average volume of each use is just 1.4 litres for an unregulated tap, or 1.2 litres per use for a flow regulated tap, resulting in an average usage of 26 L/person/day in line with the YVW study.

[12] Average volume per use based on 4 full flushes and 1 half flush per day (WELS methodology).
[13] Based on average dual flush frequency (YVW, 2011)
[14] Based on California Urban Water Conservation Council adopted rate

## C.5 Dishwasher

Dishwasher use is assumed as 2.3 L/person/day which is the average water use from recent Australian studies (Beal & Stewart, 2011).

## C.6 Bath use

For the bath end use component, the demand forecasting model adopts the outcomes of the YVW study which estimated a use of 3.2 L/person/day. This figure is used for both Existing and New residential properties and is assumed to remain constant over time.

## C.7 Internal leakage

For the internal leakage end use, the demand forecasting model adopts 16 L/household/day for a residential property. This figure aligns to the YVW Study findings of 15.9 L/household/day. This figure is used for both Existing and New residential properties and is assumed to remain constant over time.

# C Yield modelling

# ROUS WATER REGIONAL WATER SUPPLY FUTURE WATER STRATEGY

## Yield Modelling Report

Prepared for Rous Water

Report No. 13004 DRAFT 1.2

16 August 2013
NSW Urban Water Services Pty Ltd

# Summary

This Report to be provided as an Appendix to the Main Future Water Strategy report provides requested secure yield estimates from modelling various augmentation options for Rous Regional Water Supply Headworks system as part of developing strategies to meet future water demands.

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# Contents


SUMMARY 1

CONTENTS 2

1 INTRODUCTION: 4

1.1 BACKGROUND 4
1.2 SCOPE OF WORK 4
1.3 OBJECTIVES 4
1.4 METHODOLOGY 4
1.5 CLIMATE CHANGE 5
1.6 QUALIFICATIONS 5
1.7 MODEL DEVELOPMENT 5

2 HYDROMETEOROLOGICAL DATA 9

2.1 INTRODUCTION 9
2.2 DATA 9

3 SYSTEM BEHAVIOUR MODELLING 10

3.1 INTRODUCTION 10
3.2 HEADWORK SYSTEMS 10
3.3 DEMAND PATTERNS 10
3.4 MAJOR DAM STORAGES 14
3.5 OTHER STORAGES 14
3.6 ENVIRONMENTAL FLOWS 14
3.7 TRANSFER RULES 15

4 MODELLING RESULTS 17

4.1 INTRODUCTION 17
4.2 RESULTS TABLES 17

5 CLIMATE CHANGE 32

5.1 BACKGROUND 32
5.2 DATA 32
5.3 MODELLING 32
5.4 RESULTS 32

6 RECOMMENDATIONS 49


DRAFT

7 REFERENCES 50

8 FIGURES 52

9 APPENDICES 56

APPENDIX A – MODELLED TRANSFERS 56

APPENDIX B – CLIMATE CHANGE PAPER 79

## Tables

Table 3.1: Demand Patterns 11
Table 3.2: Revised Demand Patterns 12
Table 3.3: Year 2060 Demand Patterns 13
Table 3.4: Major Storages 14
Table 3.5: Wilsons River Pumping Rules 14
Table 4.1: Rocky Creek Dam System Results 20
Table 4.2: Dunoon Dam System with no Wilsons Pumping Results 21
Table 4.3: Dunoon Dam System with Wilsons pumping Results
Table 4.4: Results from varying restrictions to attempt to offset effects of Climate Change 22
Table 4.5: Results for Stormwater Options B1,B2, and Roofwater Harvesting Option B3 23
Table 4.6: Results for Wastewater Reuse Optionsd D1,D2,D3,D4 24
Table 4.7: Results for Reduced Dunoon Dam Storage with Wilsons Pumping 25
Table 4.8: Results for Dunoon Dam Storage with Wilsons Pumping 26
Table 4.9: Results for Scenario 3 (Extended Groundwater) & Scenario 5 (Deferred Desalination) 27
Table 4.10: Results for Scenario 4 (Indirect Potable Reuse) 28
Table 4.11: Results for Revised Scenario 3 (Extended Groundwater)(Historic Climate) 29
Table 4.12: Results for Revised Scenario 4 ( Indirect Potable Reuse)(Historic Climate) 30
Table 4.13: Results for Revised Scenario 2B (Delayed/Staged Dunoon Dam) 31
Tables A1-P1: Climate Change Factors 33-48
Tables A2-P2: Secure Yield Adjusted for Climate Change 33-48

## Figures

Figure 1: Duration and Frequency of Restrictions 52
Figure 2: Severity of Restrictions 53
Figure 3: Rous Regional Water Supply Existing Headworks System Schematic 54
Figure 4: Emigrant Creek Environmental Flow Plan 55

DRAFT

# 1. Introduction

## 1.1 Background

Over the last 30 years numerous yield assessments have been undertaken for Rous Water Supply headworks system and proposed augmentation options. These assessments led to the development of Rous Waters Regional Water Supply headworks system model for undertaking yield analysis and related aspects.

The first yield assessment using the *security of supply* basis was undertaken in 1984 (Ref 1) however the basis of the current model traces back to the 1994 Rous regional Water Supply Strategy study (Ref 2) .

The core team that developed the current Rous Water Headworks System model and undertook many of the yield assessments are now part of NSW Urban Water Services Pty Ltd.

Section 1.7 provides an outline of the history of the development of the model and its basis.

## 1.2 Scope of Work

Rous Water engaged NSW Urban Water Services to use and modify the provided headworkõs system model previously developed for Rous Water to:

- Estimate the *Secure Yield* of various proposed augmentation options to meet projected future demand scenarios with and without climate change impacts.

It is noted *Secure Yield* is a defined term as provided by NSW Office of Water (NOW) *Best-Practice Management of Water Supply and Sewerage Guidelines* (Ref 3) and the *NSW Water Supply Investigation Manual* (Ref 4). Use of Secure Yield provides a practical consistent basis for assessing the yield of a system on a security of supply basis. Details of Secure Yield are provided in Section 1.7 and Appendix B.

## 1.3 Objectives

This report contains a summary of the modelling undertaken to provide secure yield estimates for specified operating and streamflow conditions for proposed Rous Water Regional Water Supply Headworks systems.

The outcomes from this modelling were required to assist with developing strategies to meet Rous Watersô future water demand.

## 1.4 Methodology

Estimating the yield of a headworks system involves two important stages:

- Streamflow estimation:

  *Developing an appropriate sequence of streamflows*

- System Behaviour Modelling:

  *Modelling the behaviour of the headworks system subject to operating constraints using the streamflows to assess what demand subject to reliability or security criteria can be satisfied.*

For this study, the required streamflows were provided by NOWs predecessors using their Sacramento (Ref 5) rainfall runoff models previously set up for the catchments. In addition daily runoff sequences were provided by MWH for input to the model for examining particular augmentation options.

For the behaviour modelling the purposely developed system behaviour model to determine yield in terms of 'secure yield' for the Rous Water headworks system was used. The model has been developed and tested through many uses over the years. Furthermore the underlying methodology used in the model that arises from the definition of *Secure Yield* has been successfully used on many other water supply headworks systems.

## 1.5 Climate Change

While secure yield allows for meeting demand with restrictions through a much worse drought than has occurred since about 1890, consideration needs to be given to possible changes from Climate Change.

For this study additional consideration was given by using the approach proposed in NSW Office of Water's (NOW) Draft Proposed Policy for assessing the impact of climate change on non-metropolitan water supplies as given in (Samra and Cloke, 2010) and provided in Appendix B.

## 1.6 Qualifications

This Report should be read in conjunction with the Main Future Water Strategy report prepared by MWH for Rous Water.

The work contained in this Report is considered valid within the context of the study purposes, but caution should be exercised if aspects of this report, including data and estimates, are abstracted out of context or are to be used for some other purpose. Hydrology is not an exact science and necessarily involves some uncertainty and the results should be regarded as estimates within the limitations of the study and available data to be used as indications in a much larger decision making process.

The yield of a headworks system is dependent on the assumed streamflows and operating constraints. For this study the streamflows were provided by others and the operating constraints are as specified. While the yield estimates are based on established methodology, NSW Urban Water Services Pty Ltd does not warrant or accept any liability in relation to the quality or accuracy of the yield estimates and no responsibility is accepted by NSW Urban Water Services Pty Ltd for the accuracy, currency, reliability and correctness of any information in this publication provided by the client or third parties.

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## 1.7 Model Development

### *Secure Yield*

For the past 25 years or so most urban water supply headworks in country NSW have been sized on a robust Security of Supply basis. This security of supply basis was developed to cost-effectively provide sufficient dam storage capacity to allow the water utility to effectively manage its water supply in future droughts of greater severity than experienced over the past 100 or more years. ‘*Secure Yield*’ is the water demand that can be expected to be supplied with only moderate restrictions during a significantly more severe drought than had been experienced since about 1895 (from when generally reliable rainfall records are available). The required water restrictions must not be too severe, not too frequent, nor of excessive duration. It has beens argued that the definition of *Secure Yield* in effect allows meeting demand with moderate restrictions through a severe drought akin to a ‘1 in 1000 year’ drought.

Under the NSW Security of Supply basis ( commonly referred to as the ‘5/10/20 rule’), water supply headworks system were normally sized so that:

a) Duration of restrictions does not exceed 5% of the time; and
b) Frequency of restrictions does not exceed 10% of years ( ie 1 year in 10 on average)
c) Severity of restrictions does not exceed 20%. Systems must be able to meet 80% of the unrestricted water demand (ie 20% average reduction in consumption due to water restrictions) through a repetition of the worst recorded drought, commencing with the storage drawn down to the level at which restrictions need to be imposed to satisfy a) and b) above.

‘Secure Yield’ is defined as the highest annual water demand that can be supplied from a water supply headworks system while meeting the above ‘5/10/20’ rule.

Over the last 20 years there has been a significant reduction in residential water consumption per property and thus it is considered it will be difficult to achieve a 20% reduction in consumption as implied by the earlier ‘5/10/20’ rule . Consequently NSW Office of Water (NOW) recommends that future planning should be based on a 10% reduction in consumption through a repetition of the worst drought commencing with the storage already drawn down to satisfy the 5% duration and 10% frequency criteria. Thus the ‘5/10/20’ rule has now become a ‘5/10/10’ rule.

It is also noted that more recently the 10% frequency rule has been slightly refined by NOW from frequency of restrictions occurring 1 in 10 years on average to only being applied in 10% of years. For a sample of test cases this was of little consequence, and was desired to fit in with NOWs requirements for Performance Reporting of restrictions and thus was also based on the financial year.

The current procedures to determine secure yield are illustrated in Figures 1 and 2 which have been taken from material provided by NOW.

### *Model*

The Rous Water Headworks System Model has been developed and modified over the last 20 years and used to determine the secure yield of various options and to examine the behaviour of various components of the water supply system.

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Essentially the model is a computer program that balances continuity equations between all the water sources and demands while incorporating the procedures (as illustrated in Figures 1 and 2) to determine secure yield. The model simulates the behaviour of the system by

accounting for and balancing the available water. The hydrological cycle is modelled external to the model and the required hydrometeorological data is provided as input to the system behaviour model. In essence the system model is driven by operating conditions such as the need to meet a particular demand while satisfying constraints such as environmental flow objectives and available flow.

Apart from the consideration of additional options, other significant changes that have been made to the system behaviour model through modified computer programs include:

1. The original system behaviour model used a monthly time step commiserate with the means of estimating the required hydrometeorological data and the issues to be modelled. However as it become important to simulate the daily interactions and with the improvement in ease of estimating daily hydrometeorological data, the model was changed to simulate the system behaviour on a daily time step.

2. Incorporation of meeting various environmental flow objectives.

3. Modifying the security of supply criteria (eg 5/10/20 to 5/10/10).

Studies that the system behaviour model has been used with include:

1. The 1994 Rous Regional Water Supply Strategy Study (Ref 2).
2. In 1997 assessing the system yield for proposed Federal Dam options.
3. In 1998 assessing Rocky Creek dam storage levels and restriction conditions.
4. The 2000 Knockrow Water Treatment Plant Capacity Assessment and Regional Water Supply Assessment (Ref 6).
5. The 2001 Emigrant Creek Dam Environmental Flows Investigation (Ref 7).
6. In 2002 assessing the transfer capacity from Emigrant Creek Dam.
7. In 2002 assessing secure yield of Rous Water supply system.
8. In 2002 assessing Rocky Creek Dam drought security (Ref 8).
9. In 2002 as part of assessing the impacts of rainwater tanks on the headworks system yield.
10. In 2003 developing a drought management strategy for Rocky Creek Dam (Ref 9).
11. The 2008 Rous Water Operational Rules for Energy and Greenhouse Gas Reduction study (Ref 10).
12. In 2008 assessing secure yield of Rous Water Supply system (Ref 11).
13. In 2010 assessing the secure yield of Dunoon Dam and environmental flows (Ref 12).
14. In 2011 assessing the yield of a proposed 8 m raising of Rocky Creek Dam.
15. In 2011 assessing the yield of Jabour weir on the Richmond River as part of the Rous Regional water supply system.

In 2002 and over the next few years a different model was also used to assess the secure yield of the Rous Water supply system. This model was developed by NSW Department of Infrastructure, Planning and Natural Resources (DIPNR) and was based on their IQQM model (Ref 12). The model was developed as part of investigating the Lismore source option (pumping from Wilsons River) and obtaining licensing approval for the Lismore source. This model and the Rous Water headworks system model were cross validated with each other by obtaining similar results when modelling the same cases.

In 2007 the Wilsons River IQQM model was extended by the NSW Department of Natural Resources (DNR) to include the proposed Dunoon Dam (Ref 13). Subsequently the proposed Dunoon Dam was included in the Rous Water headworks system model and was cross validated by obtaining similar results to the IQQM model with Dunoon Dam.

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# 2. Hydrometeorological Data

## 2.1 Introduction

In general estimates of daily rainfalls, streamflows and daily evaporation for as long a historical period as possible is desirable.

Satisfying the “5,10,10” rule for determining secure yield requires more than 100 years of daily streamflows to be a sufficiently long data sample for testing the rules and so as to include the significant Federation drought (1895-1902) and other known significant droughts.

In addition to daily streamflows, accompanying daily rainfalls and evaporation are required for input to the system behaviour model for determining the net loss or gain from or to storage’s water surface area due to evaporation or rainfall.

All three types of data were required for the major dam storages and Wilsons River streamflows were required for the Lismore source.

## 2.2 Data

The above required hydrometeorological data for inputting into the system behaviour models were available from the earlier yield studies (Ref 12 and 13) and were agreed to be used for this study. The period of data available and used was from 01/01/1892 to 31/12/2003. It is noted that the Rous Water Supply system had recovered from the *Millennium* drought by 2003 and thus using data to December 2003 was considered appropriate for the study purposes. Furthermore for previous studies the yield was controlled by the droughts around the early 1900’s. To extend the streamflows to 2013 would have involved a relatively major rainfall-runoff modelling study in itself and was not considered warranted.

In addition to the above data, daily inflows were provided by MWH for the additional water sources identified as part of the main Future Water Strategy study.

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# 3. System Behaviour Modelling

### 3.1 Introduction

Modelling of the behaviour of the water supply headworks system is required to determine the *secure yield* of that system. The aim of the modelling is to determine the maximum annual demand that satisfies the ô5/10/10ô rules. This is done using a computer storage and system behaviour model using an iterative process to satisfy all the requirements implied by the rules and available water from the various sources.

Rous Watersô previous system behaviour model developed and used and tested over many years was updated for this study to incorporate the various proposed augmentation options to be examined.

The model is essentially driven by operating conditions such as the need to meet a specified demand whilst satisfying constraints such as available water from streamflows and meeting environmental flow objectives.

In addition to the hydrometeorological data that has to be input into the computer simulation model, other data has to be incorporated into the model. These additional data are detailed in the following sections.

### 3.2 Headworks Systems

The existing headworks system modelled is shown in Figure 3 . This system was then varied as detailed in the results section (see 4.1) to include the various proposed augmentation options.

### 3.3 Demand Patterns

Whilst secure yield provides the system annual demand that can be met, the annual demand needs to be broken down into monthly patterns to reflect seasonality and also broken down to the various demand centres. Three demand patterns were modelled depending on the augmentation option being modelled:

- The demand patterns that were used for the previous studies and these are referred to as ñExisting (Old) Ratioò.
- As part of the Future Strategy study MWH updated the demand ratios based on additional demand data not available for the earlier studies. These ratios are referred to as ñRevised (New) Ratioò. Initially both sets of ratios were used but there was no significant difference in the secure yields and thus the ñRevised (New)ò demand ratios were only used.
- For some augmentation options the ratios were varied by MWH to reflect expected changes in demands by the year 2060 and these are referred to as ñMWH Predicted Bulk Monthly Demand Pattern (Year 2060 Forecast)ò.

The three demand patterns are provided in Tables 3.1, 3.2 and 3.3.

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## Table 3.1: Demand Patterns

**Existing (Old) Ratio of Monthly Demand Pattern and Ratio of Annual Demand**

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ratio of annual Demand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(A) Ballina** | **0.121** | **0.080** | **0.081** | **0.072** | **0.074** | **0.070** | **0.072** | **0.073** | **0.082** | **0.092** | **0.081** | **0.102** | **0.267** |
| Ballina | | | | | | | | | | | | | |
| **(B) Byron Bay** | **0.117** | **0.080** | **0.080** | **0.072** | **0.073** | **0.068** | **0.071** | **0.073** | **0.080** | **0.095** | **0.086** | **0.103** | **0.221** |
| Byron Bay | | | | | | | | | | | | | |
| Ocean Shores | | | | | | | | | | | | | |
| **(C) Lismore** | **0.096** | **0.077** | **0.081** | **0.070** | **0.073** | **0.075** | **0.076** | **0.081** | **0.089** | **0.097** | **0.086** | **0.100** | **0.295** |
| Lismore (Holland St) | | | | | | | | | | | | | |
| Lismore Urban | | | | | | | | | | | | | |
| **(D) Richmond River** | **0.120** | **0.083** | **0.082** | **0.072** | **0.070** | **0.066** | **0.072** | **0.073** | **0.082** | **0.096** | **0.079** | **0.106** | **0.074** |
| Coraki | | | | | | | | | | | | | |
| Lower River | | | | | | | | | | | | | |
| **(E) Rural & Losses** | **0.111** | **0.088** | **0.098** | **0.081** | **0.080** | **0.082** | **0.075** | **0.069** | **0.077** | **0.084** | **0.072** | **0.083** | **0.145** |
| Clunes Rural | | | | | | | | | | | | | |
| Bangalow | | | | | | | | | | | | | |
| Dunoon | | | | | | | | | | | | | |
| Alstonville | | | | | | | | | | | | | |

Daily demand is equal to Annual demand * Ratio of Annual Demand * monthly demand pattern divided by the number of days in the month

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## Table 3.2 Revised Demand Patterns

**Revised (New) Ratio of Monthly Demand Pattern and Ratio of Annual Demand**

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ratio of annual Demand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(A) Ballina** | **0.088** | **0.076** | **0.078** | **0.074** | **0.076** | **0.071** | **0.082** | **0.088** | **0.089** | **0.093** | **0.090** | **0.097** | **0.325** |
| Ballina | | | | | | | | | | | | | |
| **(B) Byron Bay** | **0.092** | **0.077** | **0.081** | **0.078** | **0.074** | **0.069** | **0.080** | **0.083** | **0.086** | **0.091** | **0.089** | **0.099** | **0.217** |
| Byron Bay | | | | | | | | | | | | | |
| Ocean Shores | | | | | | | | | | | | | |
| **(C) Lismore** | **0.081** | **0.076** | **0.081** | **0.074** | **0.078** | **0.074** | **0.084** | **0.089** | **0.090** | **0.093** | **0.090** | **0.090** | **0.306** |
| Lismore (Holland St) | | | | | | | | | | | | | |
| Lismore Urban | | | | | | | | | | | | | |
| **(D) Richmond River** | **0.092** | **0.071** | **0.075** | **0.072** | **0.071** | **0.070** | **0.087** | **0.088** | **0.091** | **0.096** | **0.088** | **0.101** | **0.056** |
| Coraki | | | | | | | | | | | | | |
| Lower River | | | | | | | | | | | | | |
| **(E) Rural & Losses** | **0.078** | **0.074** | **0.078** | **0.077** | **0.068** | **0.074** | **0.085** | **0.085** | **0.096** | **0.095** | **0.095** | **0.093** | **0.097** |
| Clunes Rural | | | | | | | | | | | | | |
| Bangalow | | | | | | | | | | | | | |
| Dunoon | | | | | | | | | | | | | |
| Alstonville | | | | | | | | | | | | | |

Daily demand is equal to Annual demand * Ratio of Annual Demand * monthly demand pattern divided by the number of days in the month

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## Table 3.3: Year 2060 Demand Patterns

**MWH Predicted Bulk Monthly Demand Pattern (Year 2060 Forecast)**

| Location | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Ratio of annual Demand |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(A) Ballina**<br>Ballina | **0.088** | **0.076** | **0.078** | **0.074** | **0.076** | **0.071** | **0.082** | **0.088** | **0.089** | **0.093** | **0.090** | **0.097** | **0.389** |
| **(B) Byron Bay**<br>Byron Bay<br>Ocean Shores | **0.092** | **0.077** | **0.081** | **0.078** | **0.074** | **0.069** | **0.080** | **0.083** | **0.086** | **0.091** | **0.089** | **0.099** | **0.194** |
| **(C) Lismore**<br>Lismore (Holland St)<br>Lismore Urban | **0.081** | **0.076** | **0.081** | **0.074** | **0.078** | **0.074** | **0.084** | **0.089** | **0.090** | **0.093** | **0.090** | **0.090** | **0.290** |
| **(D) Richmond River**<br>Coraki<br>Lower River | **0.092** | **0.071** | **0.075** | **0.072** | **0.071** | **0.070** | **0.087** | **0.088** | **0.091** | **0.096** | **0.088** | **0.101** | **0.045** |
| **(E) Rural & Losses**<br>Clunes Rural<br>Bangalow<br>Dunoon<br>Alstonville | **0.071** | **0.074** | **0.078** | **0.077** | **0.068** | **0.074** | **0.085** | **0.085** | **0.096** | **0.095** | **0.095** | **0.093** | **0.082** |

Daily demand is equal to Annual demand * Ratio of Annual Demand * monthly demand pattern divided by the number of days in the month

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## 3.4 Major Dam Storages

Depending on the option, three major storages were modelled as part of the headworks system. All the systems modelled included the existing Emigrant Creek Dam and the existing Rocky Creek Dam or with the Rocky Creek Dam raised by 8m. Some options included the proposed Dunoon Dam located downstream of Rocky Creek Dam. Data taken from the earlier studies and used for the storages are provided in Table 3.4.

### Table 3.4: Major Storages

| Storage | Full Storage ML | Dead Storage ML | Assumed Leakage ML/d |
|---|---|---|---|
| Existing Emigrant Ck Dam | 820 | 50 | 0.23 |
| Existing Rocky Ck Dam | 14000 | 150 | 1.15 |
| Raised 8m Rocky Ck Dam | 33600 | 150 | 1.15 |
| Proposed Dunoon Dam | 10000 to 50000 | 4800 | 0.263 |

## 3.5 Other Storages

Some of the options involved relatively small off-creek storages to collect additional water such as stormwater, wastewater reuse and roofwater harvesting. For these storages it was assumed dead storage and leakage was negligibly small and thus zero values were used for all these storages.

## 3.6 Environmental Flows

As required in the model before water can be pumped from the river sources (Wilsons River) or inflows stored in the Dam storages environmental flow requirements have to be satisfied. These environmental flow requirements have been developed from earlier studies or part of the existing licensing requirements.

### *Wilsons River*

For pumping from the Wilsons River the environmental flow requirements are built into the pumping rules that are based on Wilsons River flows as given in Table 3.5.

### Table 3.5: Wilsons River Pumping Rules

| Summer (September – February) | | Winter (March – August) | |
|---|---|---|---|
| **River Flow (ML/d)** | **Maximum Pump Capacity (ML/d)** | **River Flow (ML/d)** | **Maximum Pump Capacity (ML/d)** |
| <107 | 0 | <61 | 0 |
| 107 | 5 | 61 | 5 |
| 132 | 11.25 | 82 | 10.25 |
| 181 | 23.5 | >=161 | 30 |
| 196 | 27.25 | | |
| >=207 | 30.0 | | |

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### *Rocky Creek Dam*

For the existing Rocky Creek Dam there were no environmental flow requirements (EFR) however for the Rocky Creek Dam raised it was assumed as for earlier studies that an environmental flow would be required. The target EFR was 109.5 ML/d based on the ecological work done for developing environmental flows for Dunoon Dam. Only that part of the daily inflow greater than the target value could be stored.

### *Emigrant Creek Dam*

For Emigrant Creek Dam the EFR was “Bishop’s modified low flow protection” as detailed in Ref 7 and illustrated in Figure 4.

### *Dunoon Dam*

For the options that included the proposed Dunoon Dam the EFR were based on the recent Environmental Flows Assessment Study (Ref 12) that investigated and developed EFR towards meeting ecological objectives. The EFR used were:

- Transparency of daily inflows up to 100 ML/d at Dunoon Dam,
- If daily inflow to Dunoon Dam exceeds 100 ML/d, then release 100 ML/d
- If daily inflow is less than 0.7 ML/d then release 0.7 ML/d from Dunoon Dam and also
- From 31 Dec to 28 Feb (within the 60 days) if there has not been a total of 3 days or more with a release of 100 ML/d or more, then release 100 ML/d for 3 consecutive days from Dunoon Dam
- From 2 June to 31 July (within the 60 days) if there has not been a total of 3 days or more with a release of 100 ML/d or more, then release 100 ML/d for 3 consecutive days from Dunoon Dam
- From 12 August to 30 September (within the 50 days) if there has not been a total 3 days or more with a release of 100 ML/d, then release 100 ML/d for 3 consecutive days from Dunoon Dam.

Inflows to Dunoon Dam arise from any spills from the upstream Rocky Creek Dam plus natural occurring runoff from the catchment area downstream of Rocky Creek Dam to the Dunoon Dam.

## 3.7 Transfer Rules

The general rules for transferring water from the major sources in the system were:

- Maximum transfer from Emigrant Creek Dam was 8 ML/d.
- If Rocky Creek Dam was greater than or equal to 95 % full, then no Wilsons River pumping/Lismore transfer and no Emigrant Creek Dam transfer (and no Dunoon transfer) was allowed.

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- If Rocky Creek Dam was less than 95% full, then use Emigrant Creek Dam for Ballina and use Lismore source to maximum allowed and use Rocky Creek Dam to meet any shortfall.

And for the options with Dunoon Dam the following additional rules were used:

- If Rocky Creek Dam was less than 50% full then use Dunoon Dam instead of Rocky Creek Dam
- If Dunoon Dam was less than 20% full then use Rocky Creek Dam instead of Dunoon Dam
- If Rocky Creek Dam was empty then use Dunoon Dam

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# 4. Modelling Results

## 4.1 Introduction

The secure yield estimates determined from the behaviour modelling for the requested specified cases are presented in this chapter. The cases modelled were a reflection of the development and refinement of proposed augmentation options as the Future Water Strategy study progressed towards preferred options which in turn were informed by the secure yield estimates of the modelled options.

Secure Yield determination is based on a defined methodology (see Appendix B) and uses historic climate data and allows for supply to be met through a much more severe drought than has occurred in the last 120 years or so. The results presented in this chapter are based on historic climate. Adjustments to these results can be made to allow for projected climate change scenarios using defined methodology and these results are presented in Chapter 5.

While secure yield is reliant on the available streamflows, it is also dependent on transfer capacities, environmental flow conditions, annual demands and their daily distribution, level of security expected and the schemes operating rules. The main conditions used have been described in Chapter 3. Other conditions related to the particular case are included with that particular case results table. Summary tables of transfers between nodes and demand centres are provided in Appendix A.

The expected level of security arises from the 5/10/10 rules which provides for 10% restrictions occurring in 10% of the years for 5% of the time. For some cases the expected levels of security were varied to examine their sensitivity.

## 4.1 Results Tables

### *Table 4.1*

Results in Table 4.1 are for the existing system ( ie Rocky Ck Dam/ Emigrant Ck Dam and pumping from Wilsons River/Lismore Source) and with Rocky Creek dam raised by 8m to provide an additional 19600 ML of storage. The results are for 5/10/10 security. Previous studies were based on 5/10/20 security that is allowing for 20% restrictions rather than 10% restrictions. Results are compared for the new and old demand patterns. The results show relatively little increase in secure yield from raising Rocky Creek Dam. This is because there are no environmental flow requirements for the existing dam but it was considered that if the dam was raised then there would be a need for environmental flow requirements.

### *Tables 4.2 and 4.3*

Results in Table 4.2 are for the proposed 50,000 ML Dunoon Dam storage that was considered as part of the recent Dunoon Dam Environmental Flows Assessment Study ( Ref 12) for without the Lismore source (ie Wilsons River pumping) and Table 4.3 is the same but with the Lismore source. Both the new and old demand patterns were tested but the results were not sensitive to the differences in the patterns. The results show that the Lismore source and the proposed Dunoon Dam provides significant increase in secure yield.

*Table 4.4*

Results in Table 4.4 are for the existing system with the new demand pattern. The frequency, duration and severity of restrictions as given by the expected level of security in the 5/10/10 rule was varied in order to find a restriction regime that would increase the secure yield to attempt to offset effects of climate change.

*Table 4.5*

Results in Table 4.5 are for the existing system but with options to supplement the available water from utilising stormwater and harvesting roofwater that are in effect stored in small off-creek storages that feed into the system at nominated locations. Results are for the new demand pattern and expected security level of 5/10/10.

*Table 4.6*

Results in Table 4.6 are for the existing system but with options to supplement the available water from reusing wastewater that feeds into the system at nominated locations. Results are for the new demand pattern and expected security level of 5/10/10.

*Table 4.7*

Results in Table 4.7 are for the existing system with the addition of the proposed Dunoon Dam but with reduced storage size with Wilsons River pumping. Results are for the new demand pattern and expected security levels of 5/10/10.

*Table 4.8*

Results in Table 4.8 and 4.8a are for the existing system with the addition of the proposed Dunoon Dam with storage sizes of 50000 ML and 20000 ML with Wilsons River pumping and using the year 2060 demand patterns and 5/15/15 and 5/10/10 levels of security.

*Table 4.9*

Results in Table 4.9 and 4.9a are for the existing system supplemented with additional sources feeding into the system at nominated locations and referred to by MWH as Scenarios 3 and 5. The results are for the year 2060 demand patterns and 5/10/10 and 5/15/15 levels of security.

*Table 4.10*

Results in Table 4.10 and 4.10a are for the existing system supplemented with additional sources feeding into the system at nominated locations and referred to by MWH as Scenario 4. The results are for the year 2060 demand patterns and 5/10/10 and 5/15/15 levels of security.

*Table 4.11*

Results in Table 4.11 and 4.11a are for the existing system supplemented with additional sources feeding into the system at nominated locations and referred to by MWH as Revised Scenario 3. The results are for the year 2060 demand patterns and 5/10/10 and 5/15/15

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levels of security. Since it was proposed that the additional sources would be staged, systems were modelled for year 2030 and year 2060 system sources.

*Table 4.12*

Results in Table 4.12 and 4.12a are for the existing system supplemented with additional sources feeding into the system at nominated locations and referred to by MWH as Revised Scenario 4. The results are for the year 2060 demand patterns and 5/10/10 and 5/15/15 levels of security. Since it was proposed that the additional sources would be staged, systems were modelled for year 2030 and year 2060 system sources.

*Table 4.13*

Results in Table 4.13 and 4.13a are for the existing system with different sized Dunoon Dam storages supplemented with additional sources feeding into the system at nominated locations and referred to by MWH as Revised Scenario 2B. The results are for the year 2060 demand patterns and 5/10/10 and 5/15/15 levels of security.

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## Table 4.1: Rocky Creek Dam System Results

| Run No. | Rocky Creek Dam | Emigrant Creek Dam | Transfer from Wilsons River | | Demand Pattern | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | Applied at Storage (%) | Duration (%) | % of year | From | To |
| **Existing System** (5/10/10) Program:JOUS6A28.BAS | | | | | | | | | | | |
| YX1 | 14000 | 820 | 95 | 30 | Old | 13800 | 60 | 1.96 | 9.82 | 01/11/1914 | 30/01/1916 |
| YX2 | 14000 | 820 | 95 | 30 | New | 13800 | 60 | 1.74 | 8.93 | 30/10/1914 | 30/01/1916 |
| | | | | | | | | | | | |
| **Rocky Creek Dam Raised 8m** (5/10/10) Program: ROUSRR8M.BAS | | | | | | | | | | | |
| YR1 | 33600 | 820 | 95 | 30 | Old | 14900 | 50 | 2.60 | 5.36 | 06/03/1911 | 27/02/1919 |
| YR2 | 33600 | 820 | 95 | 30 | New | 15300 | 50 | 2.91 | 6.25 | 03/06/1910 | 27/02/1919 |

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### Table 4.2: Dunoon Dam System with no Wilsons Pumping Results

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No. | Demand Pattern | Rocky Creek Dam | Emigrant Creek Dam | Minimum release From Dunoon Dam ML/d | Dunoon Dam Transparency Target Release (ML/d) | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Dn11 | Old | Yes | Yes | 0.7 | **100** | 19900 | 60 | 3.45 | 5.36 | 06/08/1913 | 05/11/1917 |
| Dn21 | New | Yes | Yes | 0.7 | **100** | 19800 | 60 | 3.39 | 5.36 | 05/08/1913 | 05/11/1917 |

Program: JOUS7DN8.BAS

### Table 4.3: Dunoon Dam with Wilsons Pumping Results

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restrictions 10% of years and demand reduced by 10%

| Run No | Demand Pattern | Rocky Creek Dam | Emigrant Creek Dam | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum ML/d | Target ML/d | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Dw11 | Old | Yes | Yes | 95 | 30 | 0.7 | 100 | 33600 | 60 | 3.15 | 8.04 | 15/07/1901 | 26/02/1903 |
| Dw21 | New | Yes | Yes | 95 | 30 | 0.7 | 100 | 33800 | 60 | 3.34 | 8.04 | 13/07/1901 | 26/02/1903 |

Program: JOUS7DN4.BAS

### Table 4.4: Results from varying restrictions to attempt to offset effects of Climate Change

Operating Rule x/y/z applied ï Duration of Restriction x%, Frequency of Restriction y% of years and demand reduced by z%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | Operating Rule (x/y/z) | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| | | | | | | | | | | | |
| Y10 | 14000 | 820 | 95 | 30 | 5/15/10 | 14000 | 60 | 1.88 | 10.71 | 30/10/1914 | 30/01/1916 |
| Y11 | 14000 | 820 | 95 | 30 | 5/15/15 | 14900 | 60 | 2.81 | 14.29 | 26/08/1914 | 30/01/1916 |
| Y12 | 14000 | 820 | 95 | 30 | 5/15/20 | 15000 | 60 | 2.71 | 14.29 | 26/08/1914 | 30/01/1916 |
| Y13 | 14000 | 820 | 95 | 30 | 10/15/10 | 14000 | 60 | 1.88 | 10.71 | 31/10/1914 | 30/01/1916 |
| Y14 | 14000 | 820 | 95 | 30 | 5/10/15 | 13900 | 55 | 1.14 | 6.15 | 31/10/1914 | 30/01/1916 |
| **Y18** | **14000** | **820** | **95** | **30** | **10/20/25** | **15600** | **60** | **3.34** | **18.75** | **15/08/1914** | **30/01/1916** |
| Y15 | 14000 | 820 | 95 | 30 | 10/20/30 | 16900 | 55 | 3.30 | 16.07 | 14/08/1914 | 30/01/1916 |
| Y16 | 14000 | 820 | 95 | 30 | 10/20/40 | 17100 | 55 | 3.15 | 16.07 | 13/08/1914 | 30/01/1916 |
| Y17 | 14000 | 820 | 95 | 30 | 10/50/60 | 17100 | 55 | 5.35 | 33.04 | 13/08/1914 | 30/01/1916 |

Program: JOUS6A29.BAS

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## Table 4.5: Results for Stormwater Options B1, B2, and Roofwater Harvesting Option B3

| Run No. | Rocky Creek Dam | Emigrant Creek Dam | Transfer from Wilsons River | | Off-Creek Storage Size ML | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : JOUS6B28.BAS | | | | | | | | | | | |
| Bx1 | 14000 | 820 | 95 | 30 | 47.5 (Option **B1**) | 14400 | 60 | 1.76 | 8.93 | 30/10/1914 | 30/01/1916 |
| Program : JOUS6C28.BAS | | | | | | | | | | | |
| Cx1 | 14000 | 820 | 95 | 30 | 30.0 (Option **B2**) | 14400 | 60 | 1.78 | 8.93 | 30/10/1914 | 30/01/1916 |
| Cx2 | 14000 | 820 | 95 | 30 | 23.4 (Option **B3**) | 14200 | 60 | 1.82 | 9.82 | 31/10/1914 | 30/01/1916 |

NOTES

Option B1 ï Daily stormwater inflows provided by MWH. Off-creek storage supplies up to 3.6 ML/d to Wilsons River source pumping pipeline. Flow used whenever Wilsons River source used and in addition to that allowed by Wilsons River source pumping rules.

Option B2 ï Daily stormwater inflows provided by MWH. Off-creek storage supplies up to 2.3ML/d to Emigrant Creek Dam.

Option B3 ï Daily roofwater harvesting inflows provided by MWH. Off-Creek storage supplies up to 3.46ML/d to Emigrant Creek Dam.

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## Table 4.6: Results for Wastewater Reuse Options D1, D2, D3, D4

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | Option | Waste Water Reuse Transfer ML/d | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : JOUS6B29.BAS | | | | | | | | | | | | |
| B29-1 | 14000 | 820 | 95 | 30 | D1 | 8.3 | 16500 | 60 | 1.66 | 7.14 | 14/08/1914 | 30/01/1916 |
| Program : JOUS6C29.BAS | | | | | | | | | | | | |
| C29-1 | 14000 | 820 | 95 | 30 | D2 | 1.8 | 14500 | 60 | 1.77 | 8.93 | 30/10/1914 | 30/01/1916 |
| Program : JOUS6C30.BAS | | | | | | | | | | | | |
| C30-1 | 14000 | 820 | 95 | 30 | D3 | 1.8 | 15100 | 60 | 1.85 | 9.82 | 26/08/1914 | 30/01/1916 |
| Program : JOUS6C29.BAS | | | | | | | | | | | | |
| C29-2 | 14000 | 820 | 95 | 30 | D4 | 3.5 | 15100 | 60 | 1.80 | 9.82 | 26/08/1914 | 30/01/1916 |

**NOTES**

Option D1- Up to 8.3 ML/d available whenever and in addition to when Wilsons River pumping source used.
Option D2- 1.8 ML/d provided to Emigrant Ck Dam everyday
Option D3- 1.8 ML/d provided to Emigrant Ck Dam everyday plus that available from stormwater option B2 with 30 ML storage
Option D4- 3.5 ML/d provided to Emigrant Ck Dam everyday

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## Table 4.7: Results for Reduced Dunoon Dam Storage with Wilsons Pumping

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No | Demand Pattern | Rocky/ Emigrant Creek Dams | Dunoon Dam Storage (ML) | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum ML/d | Target ML/d | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Dv21 | New | Yes | 25000 | 95 | 30 | 0.7 | 100 | 25200 | 65 | 2.50 | 9.82 | 18/07/1901 | 26/02/1903 |
| Du21 | New | Yes | 20000 | 95 | 30 | 0.7 | 100 | 23100 | 65 | 2.52 | 9.82 | 20/07/1901 | 31/12/1903 |

Program: JOUS7DN4.BAS

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### Table 4.8: Results for Dunoon Dam Storage with Wilsons Pumping

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| Run No | Demand Pattern | Rocky/ Emigrant Creek Dams | Dunoon Dam Storage (ML) | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum (ML/d) | Target (ML/d) | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Dt21 | 2060 | Yes | 50000 | 95 | 30 | 0.7 | 100 | 34300 | 60 | 3.32 | 8.04 | 13/07/1901 | 26/02/1903 |
| Dy21 | 2060 | Yes | 20000 | 95 | 30 | 0.7 | 100 | 24300 | 65 | 3.13 | 14.29 | 19/07/1901 | 26/02/1903 |

Program: KOUS7DN5.BAS

### Table 4.8a: Results for Dunoon Dam Storage with Wilsons Pumping

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No | Demand Pattern | Rocky/ Emigrant Creek Dam | Dunoon Dam Storage (ML) | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum (ML/d) | Target (ML/d) | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Dp21 | 2060 | Yes | 50000 | 95 | 30 | 0.7 | 100 | 33900 | 60 | 3.38 | 8.04 | 31/07/1913 | 28/11/1916 |
| Dq21 | 2060 | Yes | 20000 | 95 | 30 | 0.7 | 100 | 23100 | 65 | 2.52 | 9.82 | 20/07/1901 | 26/02/1903 |

Program: KOUS7DN5.BAS

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## Table 4.9: Results for Scenario 3 (Extended Groundwater) & Scenario 5 (Deferred Desalination)

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | Scenario | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : KOUS6A29.BAS | | | | | | | | | | | | |
| K01 | 14000 | 820 | 95 | 30 | 3 | See Notes | 20600 | 55 | 1.23 | 6.25 | 31/10/1914 | 30/01/1916 |
| K02 | 14000 | 820 | 95 | 30 | 5 | See Notes | 21200 | 55 | 1.35 | 7.14 | 30/10/1914 | 30/01/1916 |

## Table 4.9a: Results for Scenario 3 (Extended Groundwater) & Scenario 5 (Deferred Desalination)

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam | Transfer from Wilsons River | | Scenario | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : KOUS6A29.BAS | | | | | | | | | | | | |
| K51 | 14000 | 820 | 95 | 30 | 3 | See Notes | 21800 | 55 | 1.74 | 8.04 | 26/08/1914 | 30/01/1916 |
| K52 | 14000 | 820 | 95 | 30 | 5 | See Notes | 22500 | 55 | 1.95 | 11.61 | 26/08/1914 | 30/01/1916 |

**NOTES**

**Additional Sources at specified centres (assumed available each day and used before other sources)**

| **Additional Water Sources** | **Transfer (ML/d)** Scenario 3 | Scenario 5 |
|---|---|---|
| Ballina | 7.71 (5.48 +2.23) | 12.74 (2.74 + 10.09) |
| Byron Bay | 3.84 (2.74 +1.11) | 2.74 |
| Richmond | 1.75 | 1.686 |
| Node 2 | 2.74 | 1.37 |
| Node 4 | 2.74 | 1.37 |

## Table 4.10: Results for Scenario 4 (Indirect Potable Reuse)

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | Scenario | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : KOUS6C28.BAS | | | | | | | | | | | | |
| K03 | 14000 | 820 | 95 | 30 | 4 | See Notes | 21000 | 55 | 1.49 | 7.14 | 25/07/1901 | 26/02/1903 |

## Table 4.10a: Results for Scenario 4 (Indirect Potable Use)

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| un No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | Scenario | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : KOUS6C28.BAS | | | | | | | | | | | | |
| K53 | 14000 | 820 | 95 | 30 | 4 | See Notes | 22300 | 55 | 2.38 | 13.39 | 24/07/1901 | 26/02/1903 |

**<u>NOTES</u>**

**Additional Sources at specified centres (assumed available each day and used before other sources)**

| Additional Water Sources | Transfer (ML/d) | |
|---|---|---|
| Ballina | 2.74 | |
| Byron Bay | 2.74 | |
| Richmond | 1.686 | |
| Node 2 | 1.64 | |
| Node 4 | 1.64 | |
| Node 8 (ECD) | 3.45 | |
| Lismore Source | 3.34 | |
| 30ML Off-Creek Storage to ECD | 2.30 | (Daily inflows to storage provided by MWH) |

## Table 4.11: Results for Revised Scenario 3 (Extended Groundwater)

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | System Conditions Year | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : S6A29.BAS | | | | | | | | | | | | |
| 3A | 14000 | 820 | 95 | 30 | 2060 | See Notes | 18200 | 60 | 1.75 | 9.82 | 31/10/1914 | 30/01/1916 |
| 3C | 14000 | 820 | 95 | 30 | 2030 | See Notes | 17200 | 60 | 1.71 | 9.82 | 30/10/1914 | 30/01/1916 |

## Table 4.11a: Results for Revised Scenario 3 (Extended Groundwater)

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | System Conditions Year | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : S6A29.BAS | | | | | | | | | | | | |
| 3B | 14000 | 820 | 95 | 30 | 2060 | See Notes | 19300 | 60 | 2.59 | 14.29 | 26/08/1914 | 30/01/1916 |
| 3D | 14000 | 820 | 95 | 30 | 2030 | See Notes | 18400 | 60 | 2.66 | 14.29 | 26/08/1914 | 30/01/1916 |

**NOTES**

**Additional Sources at specified centres (assumed available each day and used before other sources)**

| **Additional Water Sources** | **Transfer (ML/d)** | |
|---|---|---|
| | **Year 2060** | **Year 2030** |
| Ballina | 5.48 | 5.48 |
| Byron Bay | 2.74 | 2.74 |
| Richmond | 1.75 | 1.75 |
| Node 2 | 1.37 | 0 |
| Node 4 | 1.37 | 0 |

## Table 4.12: Results for Revised Scenario 4 (Indirect Potable Reuse)

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | System Conditions Year | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program :S6C28.BAS | | | | | | | | | | | | |
| 4A | 14000 | 820 | 95 | 30 | 2060 | See Notes | 18400 | 55 | 1.33 | 7.14 | 11/09/1901 | 26/02/1903 |
| 4C | 14000 | 820 | 95 | 30 | 2030 | See Notes | 16300 | 60 | 1.75 | 9.82 | 31/10/1914 | 30/01/1916 |

## Table 4.12a: Results for Revised Scenario 4 (Indirect Potable Use)

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| Run No. | Rocky Creek Dam ML | Emigrant Creek Dam ML | Transfer from Wilsons River | | System Conditions Year | Additional Sources | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | | | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| Program : S6C28.BAS | | | | | | | | | | | | |
| 4B | 14000 | 820 | 95 | 30 | 2060 | See Notes | 19500 | 55 | 1.87 | 9.82 | 25/07/1901 | 26/02/1903 |
| 4D | 14000 | 820 | 95 | 30 | 2030 | See Notes | 17400 | 60 | 2.64 | 13.39 | 26/08/1914 | 30/01/1916 |

**NOTES**

**Additional Sources at specified centres (assumed available each day and used before other sources)**

| Additional Water Sources | Transfer (ML/d) Year 2060 | Transfer (ML/d) Year 2030 |
|---|---|---|
| Ballina | 2.74 | 2.74 |
| Byron Bay | 2.74 | 2.74 |
| Richmond | 1.686 | 1.686 |
| Node 8 (ECD) | 3.45 | 0 |
| 30ML Off-Creek Storage to ECD | 2.30 | 0 (n/a) (Daily inflows to storage provided by MWH) |

## Table 4.13: Results for Revised Scenario 2B (Delayed/Staged Dunoon Dam)

Operating Rule 5/10/10% applied ï Restriction duration 5%, Frequency of Restriction 10% of years and demand reduced by 10%

| Run No | Additional Sources | Rocky Creek/ Emigrant Creek Dams | Dunoon Dam Storage (ML) | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum (ML/d) | Target (ML/d) | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| 1 | See Notes | Yes | 20000 | 95 | 30 | 0.7 | 100 | 25100 | 60 | 2.27 | 8.93 | 18/07/1901 | 26/02/1903 |
| 3 | See Notes | Yes | 15000 | 95 | 30 | 0.7 | 100 | 22800 | 60 | 2.24 | 9.82 | 20/07/1901 | 26/02/1903 |
| 5 | See Notes | Yes | 10000 | 97 | 30 | 0.7 | 100 | 20400 | 55 | 1.22 | 5.36 | 11/08/1914 | 30/01/1916 |

Program: S7DN5.BAS

## Table 4.13a: Results for Revised Scenario 2B (Delayed/Staged Dunoon Dam)

Operating Rule 5/15/15% applied ï Restriction duration 5%, Frequency of Restriction 15% of years and demand reduced by 15%

| Run No | Additional Sources | Rocky Creek/ Emigrant Creek Dams | Dunoon Dam Storage (ML) | Transfer from Wilsons River | | Dunoon Dam Environmental Flow Releases | | Secure Yield ML/a | Restrictions | | | Critical Drought | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | When RCD is less than % full | Transfer Capacity Max. (ML/d) | Minimum (ML/d) | Target (ML/d) | | Applied at Storage (%) | Duration (%) | % of years | From | To |
| 2 | See Notes | Yes | 20000 | 95 | 30 | 0.7 | 100 | 25900 | 55 | 1.76 | 4.46 | 18/07/1901 | 26/02/1903 |
| 4 | See Notes | Yes | 15000 | 95 | 30 | 0.7 | 100 | 24100 | 60 | 2.94 | 14.29 | 19/07/1901 | 26/02/1903 |
| 6 | See Notes | Yes | 10000 | 97 | 30 | 0.7 | 100 | 21800 | 60 | 2.94 | 14.29 | 10/08/1914 | 30/01/1916 |

Program: S7DN5.BAS

**NOTES**

**Additional Sources at specified centres (assumed available each day and used before other sources):**

Ballina (Node 7) 2.74 ML/d
Byron Bay (Node 5) 2.74 ML/d
Richmond (Node 9) 1.75 ML/d

# 5. Climate Change

## 5.1 Background

While secure yield allows for meeting demand with restrictions through a much worse drought than has occurred since about 1890, consideration needs to be given to possible changes from Climate Change.

For this study additional consideration was given by using the approach proposed in NSW Office of Water's (NOW) Draft Proposed Policy for assessing the impact of climate change on non-metropolitan water supplies as given in (Samra and Cloke, 2010) and provided in Appendix B. However for this study data for projections based on 2$^{o}$C warming scenario, about Year 2060 for A1B mid-range emissions, were mainly used. Some cases were also examined for a 1$^{o}$C warming scenario, about Year 2030 for A1B mid-range emissions. The Pilot Study was based on 0.9$^{o}$C warming, for A1B mid-range emissions scenario, at the time thought to be about a Year 2030 projection but now considered to be some years earlier.

## 5.2 Data

The required Climate Change data to follow the proposed approach were provided by NOW. Daily values of rainfall and evapotranspiration were provided by NOW using the methodology developed for their 2008 data sets (Vaze et al, 2008) (Ref 15) for the 15 global climate models (GCMs) and the corresponding historic data for the nominated catchment locations. The climate change data are for projected ~2060 and ~2030 and were obtained by Vaze et al (Ref 15) by scaling the historical 1894-2008 daily rainfall and evapotranspiration data using the methods detailed in Chiew et al, 2008 (Ref 16). The climate change data were based on the Years 2030 and 2060 A1B warming scenarios, mid-range emissions scenarios.

The daily data from the 15 GCMs and the corresponding historic base data were used by NOW with their rainfall-runoff models to produce 16 series of flows at the relevant locations for the two warming scenarios.

## 5.3 Modelling

The modelling essentially involved:

- The 16 series of daily inflows, (and daily rainfalls and daily evaporation) provided by NOW were input into the headworks storage behaviour model to determine 16 corresponding secure yield estimates. (*The required daily evaporation was obtained from relations developed between historic evapotranspiration and historic evaporation and then applied to the climate change evapotranspiration daily values*).

It is noted the modelling period was 1/1/1895 to 31/12/2003 which was slightly shorter to that used for the secure yield modelling without climate change.

## 5.4 Results

The following tables summarises the key results for determining the factors to apply to the *traditional* secure yield estimates for the nominated cases modelled to allow for Climate Change using the same approach as provided by NOWs draft policy as given in "NSW Response for Addressing the Impact of Climate Change on the Water Supply Security of Country Towns" (Samra & Cloke, 2010).



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### *A. Existing Rocky Creek Dam with Wilsons River Pumping*

Table A1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table A1: Climate Change Factors**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 1°C (~2030) | Old | 13000 | 12500 | 9400 | 10900 | D/A | 0.838 |
| | New | 13300 | 12500 | 9700 | 11100 | D/A | 0.835 |
| 2°C (~2060) | Old | 13000 | 10800 | 7800 | 8600 | D/A | 0.662 |
| | New | 13300 | 11000 | 7900 | 8800 | D/A | 0.662 |

** Subsequent to Samra & Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table A2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table A2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | |
|---|---|---|---|---|---|
| | | Run No for Original Historic Case* | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 1°C (~2030) | Old | YX1 | 13800 | 0.838 | 11600 |
| | New | YX2 | 13800 | 0.835 | 11500 |
| 2°C (~2060) | Old | YX1 | 13800 | 0.662 | 9100 |
| | New | YX2 | 13800 | 0.662 | 9100 |

* *see Table 4.1*

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### *B. Rocky Creek Dam Raised 8 m with Wilsons River Pumping*

Table B1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table B1: Climate Change Factors**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 1°C (~2030) | Old | 14400 | 14300 | 10200 | 12300 | D/A | 0.854 |
| | New | 14600 | 14500 | 10300 | 12600 | D/A | 0.863 |
| 2°C (~2060) | Old | 14400 | 11900 | 5000 | 6500 | D/A | 0.451 |
| | New | 14600 | 12200 | 5000 | 6500 | D/A | 0.445 |

** Subsequent to Samra & Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table B2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table B2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | |
|---|---|---|---|---|---|
| | | Run No for Original Historic Case* | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 1°C (~2030) | Old | YR1 | 14900 | 0.854 | 12700 |
| | New | YR2 | 15300 | 0.863 | 13200 |
| 2°C (~2060) | Old | YR1 | 14900 | 0.451 | 6700 |
| | New | YR2 | 15300 | 0.445 | 6800? |

* *see Table 4.1*

It is noted the results for 2°C warming appear inconsistent with results without the raising of Rocky Creek Dam. However the raised dam has an environmental flow of 109.5 ML/d imposed. The inconsistency is only apparent for the 2 GCMs that resulted in the two lowest secure yields and was considered to be possibly due to an interaction of flows being reduced by 2°C warming and environmental flow providing long periods of unusable inflow.

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### *C. Dunoon Dam without Wilsons River Pumping*

Table C1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table C1: Climate Change Factors**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 1°C (~2030) | Old | 19200 | 18800 | 14900 | 16800 | D/A | 0.875 |
| | New | 19200 | 18700 | 14900 | 16800 | D/A | 0.875 |
| 2°C (~2060) | Old | 19200 | 16800 | 9900 | 11700 | D/A | 0.609 |
| | New | 19200 | 16800 | 10000 | 11700 | D/A | 0.609 |

** Subsequent to Samra & Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table C2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table C2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | |
|---|---|---|---|---|---|
| | | Run No for Original Historic Case* | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 1°C (~2030) | Old | Dn11 | 19900 | 0.875 | 17400 |
| | New | Dn21 | 19800 | 0.875 | 17300 |
| 2°C (~2060) | Old | Dn11 | 19900 | 0.609 | 12100 |
| | New | Dn21 | 19800 | 0.609 | 12000 |

* *see Table 4.2*

### *D. Dunoon Dam with Wilsons River Pumping*

Table D1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table D1: Climate Change Factors**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 1°C (~2030) | Old | 26900 | 24900 | 21000 | 21900 | D/A | 0.814 |
| | New | 26800 | 24800 | 20900 | 23000 | D/A | 0.858 |
| 2°C (~2060) | Old | 26900 | 23000 | 14400 | 16200 | D/A | 0.602 |
| | New | 26800 | 23000 | 14400 | 16200 | D/A | 0.604 |

** Subsequent to Samra & Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table D 2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table D2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | |
|---|---|---|---|---|---|
| | | Run No for Original Historic Case* | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 1°C (~2030) | Old | Dw11 | 33600 | 0.814 | 27300 |
| | New | Dw21 | 33800 | 0.858 | 29000 |
| 2°C (~2060) | Old | Dw11 | 33600 | 0.602 | 20200 |
| | New | Dw21 | 33800 | 0.604 | 20400 |

* *see Table 4.3*

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### *E. Existing Rocky Creek Dam with Wilsons River Pumping and wastewater reuse option D4*

Table E1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table E1: Climate Change Factors**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 1°C (~2030) | New | 14300 | 14000 | 11000 | 12500 | D/A | 0.874 |
| 2°C (~2060) | New | 14300 | 12400 | 9400 | 9600 | D/A | 0.671 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table E2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table E2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) RunC29-2* | Adjustment factor for Climate Change | With Climate Change |
| 1°C (~2030) | New | 15100 | 0.874 | 13200 |
| 2°C (~2060) | New | 15100 | 0.671 | 10100 |

**see Table 4.6*

DRAFT

## *F. Dunoon Dam (25000 ML storage) with Wilsons River Pumping*

Table F1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

### Table F1: Climate Change Factors

| Case | Dunoon Dam Storage ML | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2°C (~2060) | 25000 | 20000 | 17000 | 12000 | 13500 | D/A | 0.675 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table F2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

### Table F2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) Run Dv21* | Adjustment factor for Climate Change | With Climate Change |
| 2°C (~2060) | New | 25200 | 0.675 | 17000 |

* *see Table 4.7*

DRAFT

### *G. Dunoon Dam (20000 ML storage) with Wilsons River Pumping*

Table G1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

**Table G1: Climate Change Factors**

| Case | Dunoon Dam Storage ML | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2$^{o}$C (~2060) | 20000 | 18300 | 15800 | 11000 | 12300 | D/A | 0.672 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table G2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table G2: Secure Yield Adjusted for Climate Change**

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) Run Du21* | Adjustment factor for Climate Change | With Climate Change |
| 2$^{o}$C (~2060) | New | 23100 | 0.672 | 15500 |

** see Table 4.7*

DRAFT

### *H. Dunoon Dam (50000 ML storage) with Wilsons River Pumping*

Table H1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change. It is noted the 5/10/10 rule has been changed to 5/15/15 to be consistent with the 5/15/15 case being considered for the original historic case.

**Table H1: Climate Change Factors**

| **Case** | **Dunoon Dam Storage ML** | **Secure Yield Estimates ML/a** | | | | **Relevant Case in terms of NOW Draft Policy** | **Adopted Factor to be Applied for Climate Change** |
|---|---|---|---|---|---|---|---|
| | | **Historic from Climate Change data Base** | **Median from GCMs (5/15/15)** | **Lowest from GCMs (5/15/15)** | **Lowest from GCMs rerun with (10/15/25)*** | | |
| | | A | B | C | D | | |
| 2°C (~2060) | 50000 | 27700 | 23500 | 14800 | 16200 | D/A | 0.585 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table H2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

**Table H2: Secure Yield Adjusted for Climate Change**

| **Case** | **Demand Pattern** | **Secure Yield Estimates ML/a** | | |
|---|---|---|---|---|
| | | **Original Historic (5/15/15) Run Dt21*** | **Adjustment factor for Climate Change** | **With Climate Change** |
| 2°C (~2060) | New/2060 | 34300 | 0.585 | 20000 |

* *see Table 4.8*

DRAFT

## *I. Dunoon Dam (20000 ML storage) with Wilsons River Pumping*

Table I1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change. . It is noted the 5/10/10 rule has been changed to 5/15/15 to be consistent with the 5/15/15 case being considered for the original historic case.

### Table I1: Climate Change Factors

| Case | Dunoon Dam Storage ML | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/15/15) | Lowest from GCMs (5/15/15) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| $2^oC$ (~2060) | 20000 | 19400 | 16800 | 11200 | 12300 | D/A | 0.634 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table I2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

### Table I2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/15/15) Run Dy21* | Adjustment factor for Climate Change | With Climate Change |
| $2^oC$ (~2060) | New/2060 | 24300 | 0.634 | 15400 |

***** *see Table 4.8*

## *J. Scenario 3 (Extended Groundwater)*

Table J1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Node 9 to 1.58 ML/d; @ Ballina to 6.93 ML/d; @ Byron to 3.47 ML/d;@Node 2 to 2.47 ML/d;@Node 4 to 2.47 ML/d)*.

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### Table J1: Climate Change Factors

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2$^{o}$C (~2060) | New/2060 | 19200 | 17400 | 13900 | 15900 | D/A | 0.828 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table J2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

### Table J2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) Run K01* | Adjustment factor for Climate Change | With Climate Change |
| 2$^{o}$C (~2060) | New/2060 | 20600 | 0.828 | 17050 |

* *see Table 4.9*

## *K. Scenario 5 (Deferred Desalination)*

Table K1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Node 9 to 1.096 ML/d; @ Ballina to 2.78 ML/d; @ Byron to 1.78 ML/d;@Node 2 to 1.09 ML/d;@Node 4 to 1.09 ML/d)*.

### Table K1: Climate Change Factors

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2°C (~2060) | New/2060 | 19100 | 17500 | 14300 | 16000 | D/A | 0.837 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table K2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach.

### Table K2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) Run K02* | Adjustment factor for Climate Change | With Climate Change |
| 2°C (~2060) | New/2060 | 21200 | 0.837 | 17700 |

* *see Table 4.9*

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## *L. Scenario 4 (Indirect Potable Reuse)*

Table L1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Node 9 to 1.096 ML/d; @ Ballina to 1.78 ML/d; @ Byron to 1.78 ML/d;@Node 2 to 1.09 ML/d;@Node 4 to 1.09 ML/d;@Lismore source to 3 ML/d; and reduced flows to 30 ML storage to ECD)*.

### Table L1: Climate Change Factors

*Program KOUS6CIS*

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| $2^{o}$C (~2060) | New/2060 | 20600 | 19500 | 15900 | 18100 | D/A | 0.879 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table L2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach. Two sets of results are provided in Table L2, one using the traditional best estimate of the historic secure yield as proposed in the methodology. However it is arguable that since the historic estimate is reduced by the additional sources within the model for the 15 GCMs/1-historic then when applying the adjustment factor to prevent a bias or double accounting the original historic should also be based on reduced additional sources. An estimate is also provided without the above potential bias.

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### Table L2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| $2^{o}$C (~2060) | New/2060 | 21000 (1) | 0.879 | 18450 |
| | | *19300 (2)* | *0.879* | *16960* |

*(1) From Run K03 using unreduced additional water sources (see Table 4.10)*
*(2) From Run Kx3 using reduced additional water sources for 2060 climate change conditions*

## M. Revised Scenario 4 (Indirect Potable Reuse)

Table M1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Richmond to 1.096 ML/d; @ Ballina to 1.78 ML/d; @ Byron to 1.78 ML/d; and reduced flows to 30 ML storage to ECD).*

### Table M1: Climate Change Factors

*Program S6CIS*

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2$^{o}$C (~2060) | New/2060 | 18800 | 17500 | 13800 | 15800 | D/A | 0.840 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table M2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach. Two sets of results are provided in Table M2, one using the traditional best estimate of the historic secure yield as proposed in the methodology. However it is arguable that since the historic estimate is reduced by the additional sources within the model for the 15 GCMs/1-historic then when applying the adjustment factor to prevent a bias or double accounting the original historic should also be based on reduced additional sources. An estimate is also provided without the above potential bias.

### Table M2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 2$^{o}$C (~2060) | New/2060 | 18400 (1) | 0.840 | 15450 |
| | | *17400 (2)* | *0.840* | *14600* |

*(1) From Run 4A using unreduced additional water sources (see Table 4.12)*
*(2) From Run 4AX using reduced additional water sources for 2060 climate change conditions*

## *N. Revised Scenario 3 (Extended Groundwater)*

Table N1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Richmond to 1.58 ML/d; @ Ballina to 4.93 ML/d; @ Byron to 2.47 ML/d;@Node 2 to 1.096 ML/d;@Node 4 to 1.096 ML/d)*.

### Table N1: Climate Change Factors

*Program S7AIS*

| Case | Demand Pattern | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| $2^{o}$C (~2060) | New/2060 | 17100 | 15800 | 11900 | 13700 | D/A | 0.80 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table N2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach. Two sets of results are provided in Table N2, one using the traditional best estimate of the historic secure yield as proposed in the methodology. However it is arguable that since the historic estimate is reduced by the additional sources within the model for the 15 GCMs/1-historic then when applying the adjustment factor, to prevent a bias or double accounting, the original historic should also be based on reduced additional sources. An estimate is also provided without the above potential bias.

### Table N2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| $2^{o}$C (~2060) | New/2060 | 18200 (1) | 0.80 | 14550 |
| | | *17700 (2)* | *0.80* | *14150* |

*(1) From Run 3A using unreduced additional water sources (see Table 4.11)*
*(2) From Run 3AX using reduced additional water sources for 2060 climate change conditions*

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## *O. Revised Scenario 2B (Delayed/Staged Dunoon Dam)*

Table O1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Richmond to 1.096 ML/d; @ Ballina to 1.78 ML/d; @ Byron to 1.78 ML/d)*.

### Table O1: Climate Change Factors

*Program SN5IS*

| Case | Dunoon Dam Storage ML | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| 2°C (~2060) | 15000 | 18100 | 16100 | 11300 | 13300 | D/A | 0.735 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table O2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach. Two sets of results are provided in Table O2, one using the traditional best estimate of the historic secure yield as proposed in the methodology. However it is arguable that since the historic estimate is reduced by the additional sources within the model for the 15 GCMs/1-historic then when applying the adjustment factor, to prevent a bias or double accounting, the original historic case should also be based on reduced additional sources. An estimate is also provided without the above potential bias.

### Table O2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| 2°C (~2060) | New/2060 | 22800 (1) | 0.735 | 16750 |
| | | *22700 (2)* | *0.735* | *16650* |

*(1) From Run 3 using unreduced additional water sources (see Table 4.13)*
*(2) From Run 3X using reduced additional water sources for 2060 climate change conditions*

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## *P. Revised Scenario 2B (Delayed/Staged Dunoon Dam)*

Table P1 summarises the key results for determining the factors to apply to the traditional secure yield estimates to allow for Climate Change.

It is noted the water available from the additional water sources reduced by MWH to reflect 2060 climate warming conditions were used *(@Richmond to 1.096 ML/d; @ Ballina to 1.78 ML/d; @ Byron to 1.78 ML/d)*.

### Table P1: Climate Change Factors

*Program SN5IS*

| Case | Dunoon Dam Storage ML | Secure Yield Estimates ML/a | | | | Relevant Case in terms of NOW Draft Policy | Adopted Factor to be Applied for Climate Change |
|---|---|---|---|---|---|---|---|
| | | Historic from Climate Change data Base | Median from GCMs (5/10/10) | Lowest from GCMs (5/10/10) | Lowest from GCMs rerun with (10/15/25)* | | |
| | | A | B | C | D | | |
| $2^oC$ (~2060) | 10000 | 16000 | 14500 | 10400 | 12000 | D/A | 0.75 |

** Subsequent to Samra&Cloke, 2010, the Technical Steering Committee revised 5/10/25 to 10/15/25*

It is noted that the secure yields in column A are slightly different than the original historic secure yields. This was a common finding of the pilot study due to differences in data sets.

Table P2 provides the secure yield estimates adjusted for climate change in accordance with the above proposed approach. Two sets of results are provided in Table P2, one using the traditional best estimate of the historic secure yield as proposed in the methodology. However it is arguable that since the historic estimate is reduced by the additional sources within the model for the 15 GCMs/1-historic then when applying the adjustment factor, to prevent a bias or double accounting, the original historic case should also be based on reduced additional sources. An estimate is also provided without the above potential bias.

### Table P2: Secure Yield Adjusted for Climate Change

| Case | Demand Pattern | Secure Yield Estimates ML/a | | |
|---|---|---|---|---|
| | | Original Historic (5/10/10) | Adjustment factor for Climate Change | With Climate Change |
| $2^oC$ (~2060) | New/2060 | 20400 (1) | 0.75 | 15300 |
| | | *20300 (2)* | *0.75* | *15200* |

*(3) From Run 5 using unreduced additional water sources (see Table 4.13)*
*(4) From Run 5X using reduced additional water sources for 2060 climate change conditions*

# 6. Recommendations

The results presented in this report should be used keeping in mind the assumptions on which the estimates are based.

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# 7. References


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http;//www.rouswater.nsw.gov.au/cp_themes/default/page.asp?p=DOC-NYG-58-41-45.

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# 8. Figures

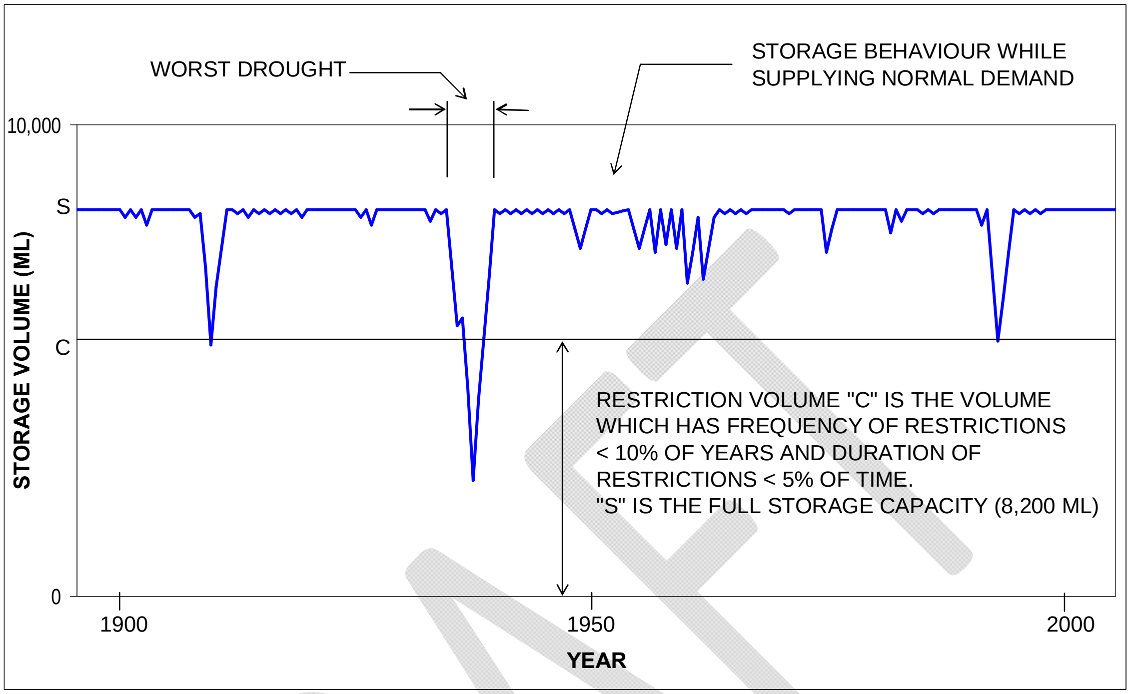


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**Figure 1** shows the results of simulating an example utilityȯs storage behavior for 120 years of daily streamflow, rainfall and evaporation data and shows that:

- Unrestricted water demand can be supplied for over 95% of the time and over 90% of years (ie. whenever the storage volume is above the **restriction volume C**). In order to satisfy the 5/10/10 rule, restrictions must be imposed whenever the volume of water in storage falls below the **restriction volume C**.
- A 10% reduction in demand is applied when the storage falls below **restriction volume C**
- The worst drought shown in Figure 1 is for approximately the 5-year period January 1939 to December 1943
- The minimum simulated storage volume is approximately 30% of the full storage capacity.

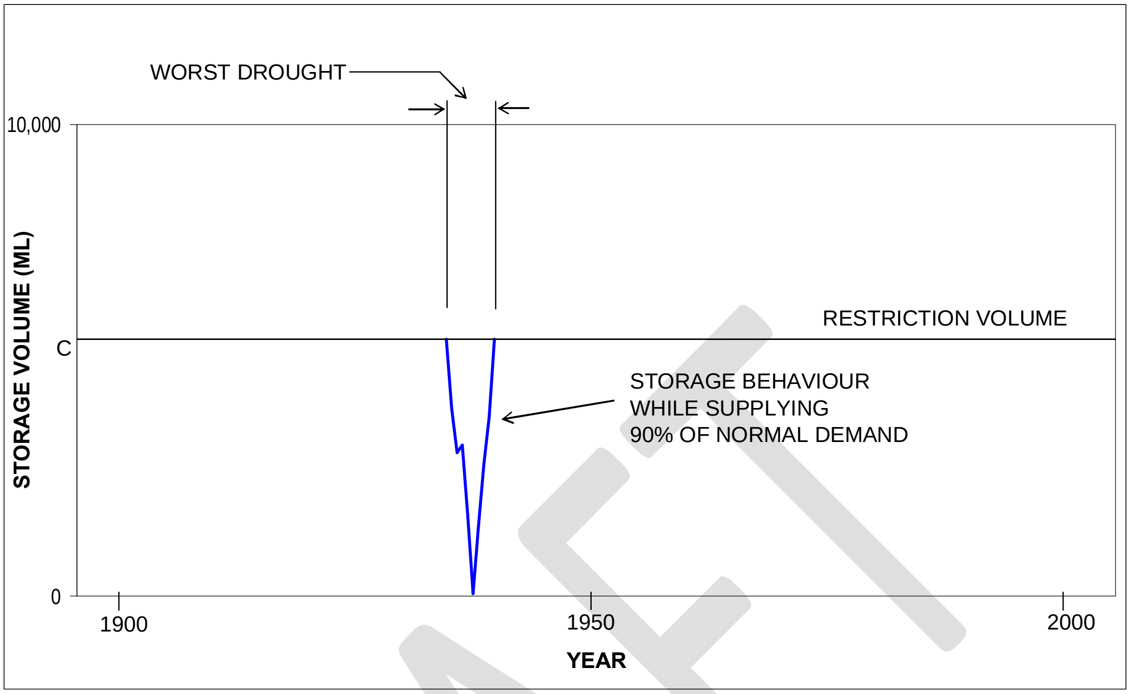


**Figure 2** shows the results of simulating storage behaviour for the worst drought identified in Figure 1 <u>(5-year drought from January 1939 to December 1943)</u> on the following basis:

- A 10% reduction in demand for the full 5-year drought as the storage volume is below the Restriction volume C
- The commencing storage volume for this simulation is the **restriction volume C** and the resulting minimum simulated storage volume is approximately 2% of the full storage capacity.

**Comment**

Imposition of the requirements of the 5/10/10 rule approximates the severity of a ó1 in 1000 yearô drought and is necessary in order to enable a utility to manage its system in a drought more severe than the worst drought in the 120 year historical record, with only moderate drought water restrictions.

As the first year of the worst drought for this example utility is simulated in **<u>both Figure 1 and Figure 2</u>**, the water supply system must be able to cope with effectively a 6-year drought, rather than the 5-year worst drought in Figure 1 as it takes about 1-year to drawdown to **restriction volume C.**

It is important to note that the analytical process for the 5/10/10 rule is iterative and that a solution is identified only when all 3 requirements have been met.

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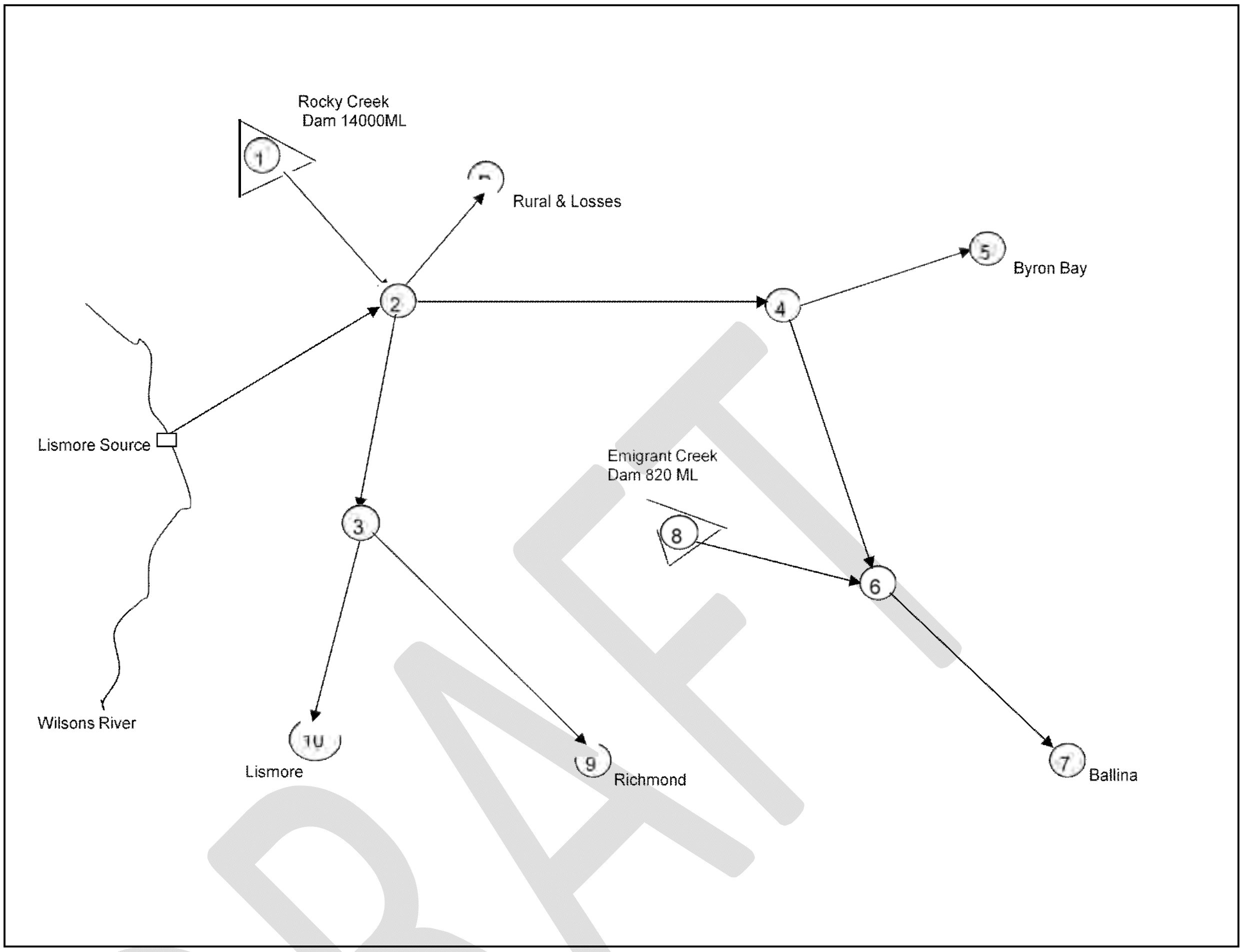


**Figure 3 Rous Regional Water Supply Existing Headworks System Schematic**

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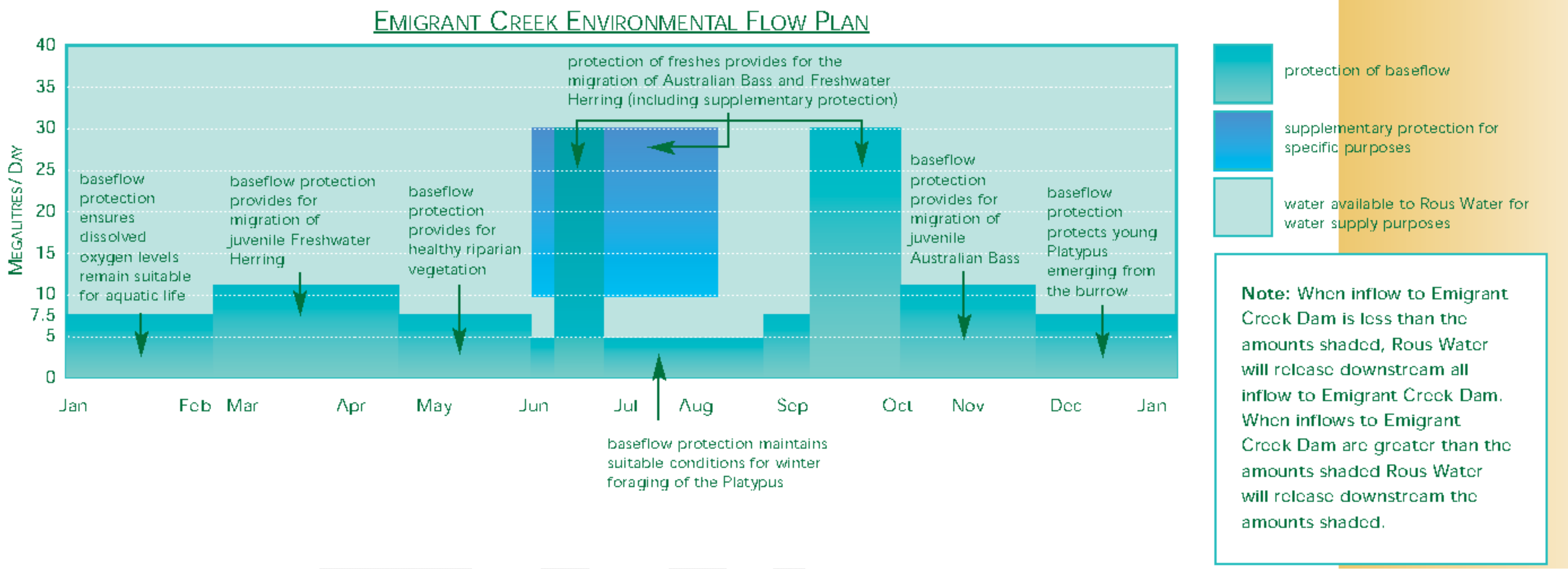


**Figure 4 Emigrant Creek Environmental Flow Plan**
(Taken from Ref 17)

# 9. Appendices

## Appendix A – Modelled Transfers

Summary of Model output of summary of transfers between nodes for selected cases.

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NSW URBAN WATER SERVICES 9/05/2013

MODELLED TRANSFER RATES

Existing Rocky Creek Dam and Emigrant Creek Dam
==============================================

Run No. YX1

Old Existing Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10034 | 1538 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1995 | 222 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5084 | 515 |
| Junction No.3 | Lismore | T30 | 21.3 | 4064 | 407 |
| Junction No.3 | Richmond River | T39 | 22.9 | 1019 | 123 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5689 | 803 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3035 | 357 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 2654 | 446 |
| Junction No.6 | Ballina | T67 | 22.9 | 3674 | 446 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1021 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2734 | 930 |

Run No. YX2

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 9928 | 1314 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1333 | 129 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 4985 | 467 |
| Junction No.3 | Lismore | T30 | 21.3 | 4213 | 393 |
| Junction No.3 | Richmond River | T39 | 22.9 | 772 | 78 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6439 | 732 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2984 | 296 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3455 | 435 |
| Junction No.6 | Ballina | T67 | 22.9 | 4483 | 435 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1028 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2830 | 930 |

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Rocky Creek Dam Raised 8m and Emigrant Creek Dam
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Run No. YR1

Old Existing Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 6725 | 1661 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 2153 | 240 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5486 | 556 |
| Junction No.3 | Lismore | T30 | 21.3 | 4386 | 440 |
| Junction No.3 | Richmond River | T39 | 22.9 | 1100 | 132 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5333 | 867 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3276 | 385 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 2058 | 481 |
| Junction No.6 | Ballina | T67 | 22.9 | 3965 | 481 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1907 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6247 | 930 |

Run No. YR2

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 6812 | 1457 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1476 | 142 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5521 | 518 |
| Junction No.3 | Lismore | T30 | 21.3 | 4665 | 435 |
| Junction No.3 | Richmond River | T39 | 22.9 | 855 | 87 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6332 | 811 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3305 | 329 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3027 | 482 |
| Junction No.6 | Ballina | T67 | 22.9 | 4965 | 482 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1938 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6516 | 930 |

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Dunoon Dam without Wilson Pumping

Run No. Dn11

Old Existing Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 17468 | 2066 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2873 | 320 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 7320 | 743 |
| Junction No.3 | Lismore | T30 | 59.9 | 5852 | 587 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1468 | 177 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 8721 | 1006 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4371 | 515 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 4350 | 491 |
| Junction No.6 | Ballina | T67 | 64.6 | 5291 | 643 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 941 | 248 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1446 | 1898 |

Run No. Dn21

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 17385 | 1842 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1909 | 184 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 7141 | 670 |
| Junction No.3 | Lismore | T30 | 59.9 | 6034 | 563 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1107 | 112 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 9756 | 989 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4275 | 425 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 5481 | 598 |
| Junction No.6 | Ballina | T67 | 64.6 | 6422 | 624 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 941 | 248 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1421 | 1839 |

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# Dunoon Dam with Wilson Pumping

Run No. Dw11

Old Existing Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 19417 | 3745 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 4853 | 541 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 12363 | 1255 |
| Junction No.3 | Lismore | T30 | 59.9 | 9884 | 991 |
| Junction No.3 | Richmond River | T39 | 64.6 | 2479 | 298 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 14356 | 1954 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 7382 | 869 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 6975 | 1086 |
| Junction No.6 | Ballina | T67 | 64.6 | 8936 | 1086 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1961 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6582 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 5572 | 3745 |

Run No. Dw21

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 19317 | 3219 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 3259 | 315 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 12191 | 1144 |
| Junction No.3 | Lismore | T30 | 59.9 | 10302 | 962 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1889 | 191 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 16285 | 1792 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 7297 | 726 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 8987 | 1066 |
| Junction No.6 | Ballina | T67 | 64.6 | 10963 | 1066 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1976 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6638 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 5779 | 3213 |

NSW URBAN WATER SERVICES 27/05/2013

MODELLED TRANSFER RATES

## Existing Rocky Creek Dam and Emigrant Creek Dam

Run No. BX1 - Option B1

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10138 | 1371 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1391 | 134 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5202 | 487 |
| Junction No.3 | Lismore | T30 | 21.3 | 4396 | 410 |
| Junction No.3 | Richmond River | T39 | 22.9 | 806 | 81 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6749 | 763 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3114 | 309 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3635 | 454 |
| Junction No.6 | Ballina | T67 | 22.9 | 4678 | 454 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1043 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2823 | 930 |
| Off-Creek Stor | Junction No.2 | Ttx | 3.60 | 381 | 112 |

Run No. Cx1 - Option B2

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10202 | 1371 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1391 | 134 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5202 | 487 |
| Junction No.3 | Lismore | T30 | 21.3 | 4396 | 410 |
| Junction No.3 | Richmond River | T39 | 22.9 | 806 | 81 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6621 | 763 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3114 | 309 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3507 | 454 |
| Junction No.6 | Ballina | T67 | 22.9 | 4678 | 454 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1171 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3011 | 930 |
| Off-Creek Stor | Emigrany Ck Dam | Ttx | 2.30 | 249 | 71 |

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Run No. Cx2 - Option B3

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10115 | 1352 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1371 | 132 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5129 | 480 |
| Junction No.3 | Lismore | T30 | 21.3 | 4335 | 404 |
| Junction No.3 | Richmond River | T39 | 22.9 | 795 | 80 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6565 | 753 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3071 | 305 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3495 | 448 |
| Junction No.6 | Ballina | T67 | 22.9 | 4613 | 448 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1118 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2951 | 930 |
| Off-Creek Stor | Emigrany Ck Dam | Ttxa | 3.46 | 167 | 73 |

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NSW URBAN WATER SERVICES 29/05/2013

MODELLED TRANSFER RATES FOR WATER AND WASTE WATER OPTION

## Existing Rocky Creek Dam and Emigrant Creek Dam

Run No. B29-1 - Option D1

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10886 | 1571 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1594 | 154 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5961 | 558 |
| Junction No.3 | Lismore | T30 | 21.3 | 5037 | 470 |
| Junction No.3 | Richmond River | T39 | 22.9 | 924 | 93 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 7815 | 875 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3568 | 354 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4247 | 520 |
| Junction No.6 | Ballina | T67 | 22.9 | 5361 | 520 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1114 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3115 | 930 |
| Extra sypply | Junction No.2 | Ttx | 8.30 | 1368 | 257 |

Run No. C29-1 - Option D2

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10243 | 1381 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1400 | 135 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5238 | 491 |
| Junction No.3 | Lismore | T30 | 21.3 | 4426 | 413 |
| Junction No.3 | Richmond River | T39 | 22.9 | 812 | 82 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6647 | 769 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3136 | 312 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3511 | 457 |
| Junction No.6 | Ballina | T67 | 22.9 | 4710 | 457 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1199 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3042 | 930 |

Plus an extra supply of 1.8 ML/d to Emigrant Creek Dam

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Run No. C30-1 - Option D3

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10552 | 1438 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1458 | 141 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5454 | 511 |
| Junction No.3 | Lismore | T30 | 21.3 | 4609 | 430 |
| Junction No.3 | Richmond River | T39 | 22.9 | 845 | 85 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6870 | 800 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3265 | 324 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3605 | 476 |
| Junction No.6 | Ballina | T67 | 22.9 | 4905 | 476 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1300 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3231 | 930 |
| Off-Creek Stor | Emigrany Ck Dam | Ttxa | 2.30 | 247 | 71 |

Plus an extra supply of 1.8 ML/d to Emigrant Creek Dam

Run No. C29-2 - Option D4

New Demand Pattern

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10548 | 1438 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1458 | 141 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5455 | 511 |
| Junction No.3 | Lismore | T30 | 21.3 | 4609 | 430 |
| Junction No.3 | Richmond River | T39 | 22.9 | 845 | 85 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6865 | 800 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3265 | 324 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3600 | 476 |
| Junction No.6 | Ballina | T67 | 22.9 | 4905 | 476 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1305 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3230 | 930 |

Plus an extra supply of 3.5 ML/d to Emigrant Creek Dam

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NSW URBAN WATER SERVICES 17/06/2013

MODELLED TRANSFER RATES

Dunoon Dam with Wilson Pumping
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Run No. Dv21

New Demand Pattern (Dunoon Dam storage = 25000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 16265 | 2400 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2432 | 235 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 9096 | 853 |
| Junction No.3 | Lismore | T30 | 59.9 | 7687 | 717 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1410 | 143 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 11949 | 1336 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 5445 | 541 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 6504 | 794 |
| Junction No.6 | Ballina | T67 | 64.6 | 8180 | 794 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1676 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5499 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1714 | 2394 |

Maximum daily transfer from Dunoon Dam = 77.41 ML/d

Run No. Du21

New Demand Pattern (Dunoon Dam storage = 20000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 15317 | 2200 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2229 | 215 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 8338 | 782 |
| Junction No.3 | Lismore | T30 | 59.9 | 7046 | 657 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1292 | 131 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 10918 | 1224 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4991 | 496 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 5927 | 728 |
| Junction No.6 | Ballina | T67 | 64.6 | 7498 | 728 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1572 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5097 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1071 | 2149 |

Maximum daily transfer from Dunoon Dam = 70.96 ML/d

NSW URBAN WATER SERVICES 25/06/2013

MODELLED TRANSFER RATES

Dunoon Dam with Wilson Pumping

Run No. Dt21 (5/15/15 Rule)

New Demand Pattern (Dunoon Dam storage = 50000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 19452 | 3266 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2791 | 270 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 11429 | 1073 |
| Junction No.3 | Lismore | T30 | 59.9 | 9891 | 925 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1538 | 156 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 17916 | 1953 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 6609 | 659 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 11307 | 1294 |
| Junction No.6 | Ballina | T67 | 64.6 | 13293 | 1294 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1986 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6678 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 6005 | 3260 |

Maximum daily transfer from Dunoon Dam = 105.35 ML/d

Run No. Dy21 (5/15/15 Rule)

New Demand Pattern (Dunoon Dam storage = 20000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 15859 | 2314 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1978 | 191 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 8099 | 760 |
| Junction No.3 | Lismore | T30 | 59.9 | 7009 | 655 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1090 | 110 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 12474 | 1384 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4684 | 467 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 7790 | 917 |
| Junction No.6 | Ballina | T67 | 64.6 | 9420 | 917 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1630 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5323 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1369 | 2288 |

Maximum daily transfer from Dunoon Dam = 74.63 ML/d

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Run No. Dp21 (5/10/10 Rule)

New Demand Pattern (Dunoon Dam storage = 50000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 19337 | 3228 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2763 | 267 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 11314 | 1061 |
| Junction No.3 | Lismore | T30 | 59.9 | 9791 | 914 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1522 | 154 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 17725 | 1930 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 6543 | 651 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 11182 | 1279 |
| Junction No.6 | Ballina | T67 | 64.6 | 13160 | 1279 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1977 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 6645 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 5819 | 3222 |

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Maximum daily transfer from Dunoon Dam = 104.12 ML/d

Run No. Dq21 (5/10/10 Rule)

New Demand Pattern (Dunoon Dam storage = 20000ML)

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 15308 | 2199 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1884 | 182 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 7716 | 723 |
| Junction No.3 | Lismore | T30 | 59.9 | 6678 | 623 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1038 | 105 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 11867 | 1315 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4462 | 444 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 7404 | 872 |
| Junction No.6 | Ballina | T67 | 64.6 | 8975 | 872 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1571 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5093 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1067 | 2149 |

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Maximum daily transfer from Dunoon Dam = 70.95 ML/d

NSW URBAN WATER SERVICES 26/06/2013

MODELLED TRANSFER RATES

Rocky Creek Dam with Wilson Pumping Plus various Waste Water input

Run No. K01 (5/10/10 Rule) for Scenario 3

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 9850 | 1379 |
| Extra water | Junction No.2 | Tno2 | 2.74 | 1000 | 85 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1683 | 162 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6251 | 590 |
| Junction No.3 | Lismore | T30 | 21.3 | 5963 | 556 |
| Junction No.3 | Richmond River | T39 | 22.9 | 288 | 39 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5744 | 730 |
| Extra water | Junction No.4 | Tno4 | 2.74 | 1000 | 85 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2579 | 276 |
| Extra water | Byron Bay | Tbyb | 3.84 | 1405 | 119 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4164 | 538 |
| Junction No.6 | Ballina | T67 | 22.9 | 5200 | 538 |
| Extra water | Ballina | Tbal | 7.71 | 2814 | 239 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1036 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2828 | 930 |

Run No. K02 (5/10/10 Rule) for Scenario 5

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 9957 | 1401 |
| Extra water | Junction No.2 | Tno2 | 1.37 | 500 | 42 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1731 | 167 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6474 | 611 |
| Junction No.3 | Lismore | T30 | 21.3 | 6136 | 572 |
| Junction No.3 | Richmond River | T39 | 22.9 | 339 | 44 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5155 | 685 |
| Extra water | Junction No.4 | Tno4 | 1.37 | 500 | 42 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3100 | 322 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 2555 | 405 |
| Junction No.6 | Ballina | T67 | 22.9 | 3597 | 405 |
| Extra water | Ballina | Tbal | 12.74 | 4650 | 395 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1041 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2904 | 930 |

NSW URBAN WATER SERVICES 04/07/2013

MODELLED TRANSFER RATES

Rocky Creek Dam with Wilson Pumping Plus various Waste Water input

Run No. K51 (5/15/15 Rule) for Scenario 3

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10544 | 1493 |
| Extra water | Junction No.2 | Tno2 | 2.74 | 1000 | 85 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1778 | 172 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6643 | 628 |
| Junction No.3 | Lismore | T30 | 21.3 | 6302 | 588 |
| Junction No.3 | Richmond River | T39 | 22.9 | 341 | 45 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6346 | 798 |
| Extra water | Junction No.4 | Tno4 | 2.74 | 1000 | 85 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2806 | 299 |
| Extra water | Byron Bay | Tbyb | 3.85 | 1405 | 119 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4541 | 584 |
| Junction No.6 | Ballina | T67 | 22.9 | 5655 | 584 |
| Extra water | Ballina | Tbal | 7.71 | 2814 | 239 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1114 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3224 | 930 |

Run No. K52 (5/15/15 Rule) for Scenario 5

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10706 | 1525 |
| Extra water | Junction No.2 | Tno2 | 1.37 | 500 | 42 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1835 | 177 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6897 | 652 |
| Junction No.3 | Lismore | T30 | 21.3 | 6502 | 607 |
| Junction No.3 | Richmond River | T39 | 22.9 | 396 | 50 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5799 | 759 |
| Extra water | Junction No.4 | Tno4 | 1.37 | 500 | 42 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3344 | 347 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 2955 | 454 |
| Junction No.6 | Ballina | T67 | 22.9 | 4088 | 454 |
| Extra water | Ballina | Tbal | 12.74 | 4650 | 395 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1134 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3325 | 930 |

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Run No. K03 (5/10/10 Rule) for Scenario 4

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 11447 | 1676 |
| Extra water | Junction No.2 | Tno2 | 1.64 | 599 | 51 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1715 | 165 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6406 | 605 |
| Junction No.3 | Lismore | T30 | 21.3 | 6077 | 566 |
| Junction No.3 | Richmond River | T39 | 22.9 | 329 | 43 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 8196 | 975 |
| Extra water | Junction No.4 | Tno4 | 1.64 | 599 | 51 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3061 | 318 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 5734 | 707 |
| Junction No.6 | Ballina | T67 | 28.4 | 7168 | 707 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1434 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3673 | 930 |
| Extra water | Wilson Pumping | Twpa | 3.34 | 599 | 104 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 2.30 | 246 | 71 |
| Extra Water | Emigrant Ck Dam | Tv8n | 3.45 | 526 | 107 |

Run No. K53 (5/15/15 Rule) for Scenario 4

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 12175 | 1799 |
| Extra water | Junction No.2 | Tno2 | 1.64 | 599 | 51 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1817 | 176 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 6826 | 646 |
| Junction No.3 | Lismore | T30 | 21.3 | 6440 | 601 |
| Junction No.3 | Richmond River | T39 | 22.9 | 386 | 49 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 8826 | 1049 |
| Extra water | Junction No.4 | Tno4 | 1.64 | 599 | 51 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 3303 | 343 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 6121 | 757 |
| Junction No.6 | Ballina | T67 | 28.4 | 7655 | 757 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1534 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 4055 | 930 |
| Extra water | Wilson Pumping | Twpa | 3.34 | 641 | 104 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 2.30 | 254 | 71 |
| Extra Water | Emigrant Ck Dam | Tv8n | 3.45 | 541 | 107 |

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MODELLED TRANSFER RATES

Rocky Creek Dam with Wilson Pumping Plus various Water Sources
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Run No. 3a (5/10/10 Rule) for Revised Scenario 3 (2060)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 9752 | 1339 |
| Extra water | Junction No.2 | Tno2 | 1.37 | 500 | 42 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1486 | 143 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5445 | 515 |
| Junction No.3 | Lismore | T30 | 21.3 | 5265 | 491 |
| Junction No.3 | Richmond River | T39 | 22.9 | 180 | 28 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6075 | 739 |
| Extra water | Junction No.4 | Tno4 | 1.37 | 500 | 42 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2518 | 265 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4057 | 517 |
| Junction No.6 | Ballina | T67 | 22.9 | 5077 | 517 |
| Extra water | Ballina | Tbal | 5.48 | 2000 | 170 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1020 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2755 | 930 |

Run No. 3b (5/15/15 Rule) for Revised Scenario 3 (2060)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10376 | 1444 |
| Extra water | Junction No.2 | Tno2 | 1.37 | 500 | 42 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1572 | 152 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5799 | 550 |
| Junction No.3 | Lismore | T30 | 21.3 | 5572 | 521 |
| Junction No.3 | Richmond River | T39 | 22.9 | 228 | 33 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6620 | 802 |
| Extra water | Junction No.4 | Tno4 | 1.37 | 500 | 42 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2723 | 286 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4397 | 558 |
| Junction No.6 | Ballina | T67 | 22.9 | 5488 | 558 |
| Extra water | Ballina | Tbal | 5.48 | 2000 | 170 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1091 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3116 | 930 |

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Run No. 3c (5/10/10 Rule) for Revised Scenario 3 (2030)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 9760 | 1329 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1404 | 135 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5111 | 484 |
| Junction No.3 | Lismore | T30 | 21.3 | 4976 | 464 |
| Junction No.3 | Richmond River | T39 | 22.9 | 135 | 24 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 5995 | 725 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2325 | 245 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 3670 | 479 |
| Junction No.6 | Ballina | T67 | 22.9 | 4688 | 479 |
| Extra water | Ballina | Tbal | 5.48 | 2000 | 170 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1018 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2751 | 930 |

Run No. 3d (5/15/15 Rule) for Revised Scenario 3 (2030)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 97.0 | 10440 | 1443 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1499 | 145 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5499 | 521 |
| Junction No.3 | Lismore | T30 | 21.3 | 5312 | 496 |
| Junction No.3 | Richmond River | T39 | 22.9 | 187 | 29 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 41.3 | 6591 | 793 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2549 | 268 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 22.9 | 4042 | 524 |
| Junction No.6 | Ballina | T67 | 22.9 | 5138 | 524 |
| Extra water | Ballina | Tbal | 5.48 | 2000 | 170 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1096 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3148 | 930 |

NSW URBAN WATER SERVICES 19/07/2013

MODELLED TRANSFER RATES

Rocky Creek Dam with Wilson Pumping Plus various Water Sources

Run No. 4a (5/10/10 Rule ) for Revised Scenario 4 (2060)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 10928 | 1530 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1503 | 145 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5538 | 523 |
| Junction No.3 | Lismore | T30 | 21.3 | 5325 | 496 |
| Junction No.3 | Richmond River | T39 | 22.9 | 213 | 31 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 7342 | 878 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2559 | 268 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 4783 | 609 |
| Junction No.6 | Ballina | T67 | 28.4 | 6157 | 609 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1374 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3455 | 930 |
| Extra water | Wilson Pumping | Twpa | 0.00 | 0 | 0 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 2.30 | 241 | 71 |
| Extra Water | Emigrant Ck Dam | Tv8n | 3.45 | 516 | 107 |

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Run No. 4b (5/15/15 Rule) for Revised Scenario 4 (2060)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 11562 | 1634 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1590 | 154 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5896 | 558 |
| Junction No.3 | Lismore | T30 | 21.3 | 5636 | 526 |
| Junction No.3 | Richmond River | T39 | 22.9 | 261 | 36 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 7875 | 940 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2766 | 290 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 5109 | 651 |
| Junction No.6 | Ballina | T67 | 28.4 | 6574 | 651 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1465 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3800 | 930 |
| Extra water | Wilson Pumping | Twpa | 0.00 | 0 | 0 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 2.30 | 249 | 71 |
| Extra Water | Emigrant Ck Dam | Tv8n | 3.45 | 530 | 107 |

Run No. 4c (5/10/10 Rule) for Revised Scenario 4 (2030)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 9836 | 1330 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1331 | 128 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 4834 | 458 |
| Junction No.3 | Lismore | T30 | 21.3 | 4716 | 440 |
| Junction No.3 | Richmond River | T39 | 22.9 | 118 | 22 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 6464 | 758 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2151 | 228 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 4313 | 530 |
| Junction No.6 | Ballina | T67 | 28.4 | 5338 | 530 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1025 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 2793 | 930 |
| Extra water | Wilson Pumping | Twpa | 0.00 | 0 | 0 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 0.00 | 0 | 0 |
| Extra Water | Emigrant Ck Dam | Tv8n | 0.00 | 0 | 0 |

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Run No. 4d (5/15/15 Rule) for Revised Scenario 4 (2030)

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 102.5 | 10462 | 1435 |
| Extra water | Junction No.2 | Tno2 | 0.00 | 0 | 0 |
| Junction No.2 | Rural & Losses | T2r | 11.4 | 1418 | 137 |
| Junction No.2 | Junction No.3 | T23 | 44.2 | 5189 | 492 |
| Junction No.3 | Lismore | T30 | 21.3 | 5023 | 469 |
| Junction No.3 | Richmond River | T39 | 22.9 | 166 | 27 |
| Extra water | Richmond River | Tric | 1.69 | 615 | 52 |
| Junction No.2 | Junction No.4 | T24 | 46.8 | 7011 | 821 |
| Extra water | Junction No.4 | Tno4 | 0.00 | 0 | 0 |
| Junction No.4 | Byron Bay | T45 | 18.4 | 2356 | 249 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 28.4 | 4655 | 572 |
| Junction No.6 | Ballina | T67 | 28.4 | 5751 | 572 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.00 | 1096 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 3156 | 930 |
| Extra water | Wilson Pumping | Twpa | 0.00 | 0 | 0 |
| Off-Creek Stor | Emigrant Ck Dam | Toea | 0.00 | 0 | 0 |
| Extra Water | Emigrant Ck Dam | Tv8n | 0.00 | 0 | 0 |

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NSW URBAN WATER SERVICES 25/07/2013

MODELLED TRANSFER RATES

Rocky Creek Dam with Wilson Pumping Plus various Water Sources

Run No. 01 (5/10/10 Rule ) for Revised Scenario 2B
DUNOON DAM CAPACITY 20000 ML

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 16205 | 2390 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2048 | 198 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 8373 | 785 |
| Junction No.3 | Lismore | T30 | 59.9 | 7258 | 677 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1115 | 114 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 12891 | 1429 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4827 | 482 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 8064 | 947 |
| Junction No.6 | Ballina | T67 | 64.6 | 9732 | 947 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1668 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5467 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1641 | 2364 |

Run No. 02 (5/15/15 Rule) for Revised Scenario 2B
DUNOON DAM CAPACITY 20000 ML

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 16540 | 2466 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 2112 | 204 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 8640 | 810 |
| Junction No.3 | Lismore | T30 | 59.9 | 7486 | 699 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1154 | 118 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 13324 | 1475 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4985 | 497 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 8339 | 977 |
| Junction No.6 | Ballina | T67 | 64.6 | 10044 | 977 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1705 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5608 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1929 | 2460 |

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Run No. 03 (5/10/10 Rule) for Revised Scenario 2B
DUNOON DAM CAPACITY 15000 ML

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 15163 | 2171 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1860 | 179 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 7605 | 713 |
| Junction No.3 | Lismore | T30 | 59.9 | 6593 | 615 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1012 | 104 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 11669 | 1298 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4383 | 438 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 7286 | 860 |
| Junction No.6 | Ballina | T67 | 64.6 | 8838 | 860 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1553 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5023 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 948 | 2118 |

Run No. 04 (5/15/15 Rule) for Revised Scenario 2B
DUNOON DAM CAPACITY 15000 ML

New Demand Pattern with revised demand ratios

| PIPELINE from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 15764 | 2295 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1962 | 190 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 8018 | 754 |
| Junction No.3 | Lismore | T30 | 59.9 | 6954 | 650 |
| Junction No.3 | Richmond River | T39 | 64.6 | 1064 | 110 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 12314 | 1372 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4617 | 463 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 7696 | 909 |
| Junction No.6 | Ballina | T67 | 64.6 | 9316 | 909 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1620 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 5286 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 1244 | 2264 |

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Run No. 05 (5/10/10 Rule) for Revised Scenario 2B
DUNOON DAM CAPACITY 10000 ML

New Demand Pattern with revised demand ratios

| P I P E L I N E from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 13924 | 1942 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1666 | 161 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 6816 | 638 |
| Junction No.3 | Lismore | T30 | 59.9 | 5905 | 550 |
| Junction No.3 | Richmond River | T39 | 64.6 | 911 | 93 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 10428 | 1162 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 3934 | 392 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 6495 | 770 |
| Junction No.6 | Ballina | T67 | 64.6 | 7924 | 770 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1429 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 4545 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 442 | 1732 |

Run No. 06 (5/15/15 Rule) for Revised Scenario 2B
DUNOON DAM CAPACITY 10000 ML

New Demand Pattern with revised demand ratios

| P I P E L I N E from | to | | CAPACITY (ML/day) | TRANSFER (ML/a) | MAX.TRAN (ML/month) |
|---|---|---|---|---|---|
| Rocky Dam | Junction No.2 | T12 | 273.2 | 14679 | 2076 |
| Junction No.2 | Rural & Losses | T2r | 32.2 | 1775 | 172 |
| Junction No.2 | Junction No.3 | T23 | 124.5 | 7251 | 682 |
| Junction No.3 | Lismore | T30 | 59.9 | 6290 | 588 |
| Junction No.3 | Richmond River | T39 | 64.6 | 961 | 99 |
| Extra water | Richmond River | Tric | 1.75 | 639 | 54 |
| Junction No.2 | Junction No.4 | T24 | 116.5 | 11095 | 1241 |
| Junction No.4 | Byron Bay | T45 | 51.9 | 4174 | 419 |
| Extra water | Byron Bay | Tbyb | 2.74 | 1000 | 85 |
| Junction No.4 | Junction No.6 | T46 | 64.6 | 6922 | 823 |
| Junction No.6 | Ballina | T67 | 64.6 | 8424 | 823 |
| Extra water | Ballina | Tbal | 2.74 | 1000 | 85 |
| Emigrant Dam | Junction No.6 | T86 | 8.0 | 1503 | 248 |
| Wilson Pumping | Junction No.2 | T112 | 30.0 | 4833 | 930 |
| Dunoon Dam | Junction No.2 | T132 | 273.2 | 609 | 1763 |

## Appendix B – Climate Change Paper

Paper from óPractical Responses to Climate Changeö National Conference 2010, Melbourne, Institution of Engineers Australia.

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# NSW RESPONSE FOR ADDRESSING THE IMPACT OF CLIMATE CHANGE ON THE WATER SUPPLY SECURITY OF COUNTRY TOWNS

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## ABSTRACT

Under the NSW Government's *Best-Practice Management of Water Supply and Sewerage Guidelines*, local water utilities in non-metropolitan NSW are required to prepare and implement a comprehensive 30-year integrated water cycle management (IWCM) strategy. The IWCM strategy is prepared for the utility's water supply, sewerage and stormwater businesses, including the water supply headworks, and is effectively a 30-year rolling strategy, which must be reviewed and updated by each utility every 6 years.

For the past 25 years most urban water supply headworks in country NSW have been sized on a robust Security of Supply basis. This security of supply basis has been designed to cost-effectively provide sufficient dam storage capacity to allow the water utility to effectively manage its water supply in future droughts of greater severity than experienced over the past 100 or more years. 'Secure Yield' is the water demand that can be expected to be supplied with only moderate water restrictions during a significantly more severe drought than had been experienced historically. The required water restrictions must not be too severe, not too frequent, nor of excessive duration. Recent analysis for the severe 2001-2007 drought has confirmed the continuing robustness of the NSW Security of Supply basis.

To understand the potential impact of climate change on the security of urban water supplies, results are presented from a pilot study for 11 non-metropolitan NSW water supplies utilising 112 years of downscaled daily hydrometeorological data from 15 global climate models for climate change projections for the year 2030 using the A1B medium warming emissions scenario. This analysis enabled determination of the impact of climate change on the Year 2030 secure yield for each water supply.

Future 30-year IWCM strategies in NSW will need to include assessment of the secure yield of the utility's water supply in accordance with the analysis reported for the pilot study. Implementation of these strategies, together with the required 6-yearly updates, will address future water security.

## INTRODUCTION

The NSW Government is tackling the challenge of the impact of climate change on non-metropolitan urban water utilities in a multi-pronged approach through comprehensive best practice management requirements, as noted below.

The key element of the NSW response to climate change is that the utilities will be required to determine their urban water supply security along the lines of the analysis reported in this paper for the pilot study for 11 NSW water supplies. Reporting of such water supply security analysis will need to be documented in each utility's 30-year IWCM strategy.

### Background

The NSW Government's *Best-Practice Management of Water Supply and Sewerage Guidelines* (Dept Water and Energy, 2007) is the key driver for reform of planning and management and performance improvement in non-metropolitan NSW. 106 NSW local water utilities provide piped water supply and sewerage services to the 1.8 million people in NSW country towns (97.9% water supply coverage). The 19 requirements of the guidelines include:

- Annual performance monitoring by each utility;
- Current 20 year strategic business plan and financial plan;
- Regulation of water supply, sewerage and trade waste (including pay-for-use water pricing, full cost recovery, commercial sewer usage, trade waste and developer charges, trade waste approvals for all dischargers and a sound trade waste regulation policy by each utility);
- Demand management;
- Drought management ; and

- Integrated Water Cycle Management (IWCM) - comprehensive 30 year strategy required for the utility's water supply, including headworks, sewerage, and where cost-effective, stormwater businesses. A full range of scenarios must be evaluated on a rigorous triple bottom line (TBL) basis, with extensive community involvement. The IWCM Strategy is effectively a 30-year rolling strategy, which must be reviewed and updated by each utility every 6 years.

The non-metropolitan NSW utilities have annual revenue of $950 million and an asset base with a current replacement cost of almost $20 billion (NSW Office of Water, 2010 (1) : vii). Overall, the utilities had met 82% of the requirements of the *Best-Practice Management Guidelines* by June 2009. The Best-Practice Management Guidelines, the IWCM Guidelines, the 7 IWCM Information Sheets and the annual NSW Water Supply and Sewerage Performance Monitoring Reports and Benchmarking Reports are available on the NSW Office of Water website (www.water.nsw.gov.au).

**NSW Security of Supply Basis**

45 local water utilities have surface water supplies with storage dams in non-metropolitan NSW. Such utility storages have in the main been sized on the NSW Security of Supply basis since the mid–1980s (NSW Public Works, 1986; Samra & French, 1988 and Cloke, 1995).

The purpose of the NSW Security of Supply basis is to determine the cost-effective storage volume and transfer capacities required to enable each water utility to operate its system with only moderate water restrictions in the event of occurrence of droughts of similar severity to those in the historical record, generally back to at least 1895. The utility would also be able to cope with significantly more severe droughts albeit with more severe water restrictions. Effectively, each water supply system would be able to cope with approximately a '1 in 1000 year drought' (Cloke & Samra, 2009 :13).

Under the NSW Security of Supply basis (commonly referred to as the '5/10/20 rule'), water supply headworks systems are normally sized so that:

a) Duration of restrictions does not exceed 5% of the time; and

b) Frequency of restrictions does not exceed 10% of years (ie. 1 year in 10 on average); and

c) Severity of restrictions does not exceed 20%. Systems must be able to meet 80% of the unrestricted water demand (ie. 20% average reduction in consumption due to water restrictions) through a repetition of the worst recorded drought, commencing with the storage drawn down to the level at which restrictions need to be imposed to satisfy a) and b) above.

This enables the utilities to operate their systems without restrictions until the volume of stored water approaches the trigger level determined by a) and b) above (typically about 50% to 60% of the storage capacity). If at this trigger level, the utility imposes drought water restrictions which reduce demand by 20%, the system would be able to cope with a repeat of the worst recorded drought, commencing at that time, without emptying the storage.

'Secure yield' is defined as the highest annual water demand that can be supplied from a water supply headworks system while meeting the above '5/10/20 rule[1]'.

The robustness of the NSW Security of Supply basis has been demonstrated by Cloke & Samra (2009 :7) who showed that for the 10 NSW urban water supplies studied, the very severe 2001 to 2007 drought resulted in a reduction in the secure yield of up to 7% for 7 of the water supplies and a reduction of about 15% for the other 3 supplies.

The first paragraph in footnote 2 below[2], which is a quote from page 3 of the *2008-09 NSW Water Supply and Sewerage Performance Monitoring Report* shows that for the 15 years from 1986, the frequency of drought water restrictions by the non-metropolitan NSW water utilities was consistent with the implied target of no restrictions in 90% of years in b) above.

The *2008-09 NSW Water Supply and Sewerage Benchmarking Report* shows each utility's drought water restrictions over each of the last 6 years (page 56).

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[1] As noted at the top of page 3, this has been superseded by a '5/10/10 rule' since February 2009.

[2] 'For the 15 years from 1986 to 2000/01, on average, the NSW utilities did not apply any drought water restrictions for 87% of the years, which include the severe 1993 to 1994 drought. This is consistent with the implied target of no restrictions in 90% of years in the NSW Security of Supply basis (commonly referred to as the '5/10/10 rule').

For the 23 years from 1986 to 2008/09, on average, the NSW utilities did not apply any drought water restrictions for 75% of the years. However, this period includes both the above 1993 to 1994 drought and the very severe 2001 to 2008/09 drought.'

The *2008-09 Performance Monitoring Report* (page 8) also shows 'there has been a 47% reduction in the volume of average annual residential water supplied per property in non-metropolitan NSW over the last 18 years (from 330 to 175kL per connected property)'. It is therefore considered that it will now be much more difficult to achieve a 20% reduction in consumption than it was 20 years ago as there has been a large reduction in outdoor water use. Accordingly, in February 2009 the NSW Office of Water agreed to basing future planning in non-metropolitan NSW on being able to achieve an average of only a 10% reduction in consumption through a repetition of the worst drought commencing with the storage already drawn down to satisfy the restriction duration and frequency criteria in a) and b) on page 2. Thus the NSW '5/10/20 rule' has been superseded by a '5/10/10 rule'.

Accordingly, a pilot study has been undertaken to examine the impacts climate changed hydrometeorological data has on water security for 11 surface water supplies and to develop a methodology suitable for application for this purpose by the other NSW water utilities.

## PILOT STUDY

A Climate Change Steering Group has been formed to oversee a climate change pilot study for 11 urban NSW water supplies and development of NSW guidelines for local water utilities on assessing the impact of climate change on the secure yield of their water supplies. The Steering Group members are:

- Peter McLoughlin (National Water Commission)
- Jai Vaze (NSW Office of Water/CSIRO)
- Peter Cloke (NSW Public Works - commissioned to carry out the pilot study)
- Sascha Moege (Local Government and Shires Associations)
- Wayne Franklin (NSW Water Directorate)
- Sam Samra, Mike Partlin, Peter Ledwos (NSW Office of Water)

As indicated above, the purpose of the pilot study was to provide insights on the impacts of climate changed hydrometeorological data on the water security of the 11 water supplies in the pilot study and to then develop a suitable methodology and guidelines for application by the other NSW water utilities.

The pilot study (Samra & Cloke, 2010 :10) involved undertaking hydrological and system modelling to determine the impact of climate change on secure yield. The pilot study incorporates the scientific logic of the CSIRO's Murray Darling Basin Sustainable Yields Project (Chiew et al, 2008), which used daily historical data from 1895 to 2006 and applied the relevant global climate models (GCMs) to provide projected (~2030) climate changed data for each GCM for this period.

The pilot study uses daily values of rainfall and evapotranspiration from the NSW Office of Water's 2008 data sets[3] (Vaze et al, 2008) for 15 GCMs. These future climate change series for ~2030 were obtained by Vaze et al by scaling the historical 1895-2006 daily rainfall and evapotranspiration data using the methods detailed in Chiew et al ,2008.. These data sets involve extension of the CSIRO data for the Murray Darling basin to cover all of NSW and are based on the Year 2030 A1B warming scenario[4]; a mid range emissions scenario.

The study essentially involved two modelling steps:

- Daily rainfall and evapotranspiration data were inputted into existing calibrated rainfall-runoff models to produce climate changed daily streamflows[5]
- The daily climate changed streamflows, rainfall and evapotranspiration were inputted into water supply system simulation models[6] to determine climate changed secure yields.

The climate changed secure yields were compared with the secure yields for a repeat of the historical data set as noted on page 5.

[3] This comprehensive data set provides projections of down scaled daily climate changed data for the Year 2030 for all of NSW. It is the best such data set available at present, and was therefore used for the pilot study. As noted on page 10 this data set now covers all of NSW, Victoria and the Murray Darling Basin, including Adelaide. As noted on page 10 improved and longer term projections of climate changed data are expected to be developed in the future and these should be applied by water utilities when they become available.

[4] It is noted that there is little difference in the impacts of the various warming scenarios considered by the IPCC for the Year 2030. Such impacts diverge in longer term projections such as for the Year 2050 or 2070.

[5] Use of a locally calibrated daily rainfall-runoff model for each water supply is essential. The analysis carried out in the pilot study demonstrated that use of generalised streamflow estimates available from the NSW Office of Water data sets is inappropriate for security of water supply analysis. In NSW, such a local daily rainfall-runoff model is routinely developed for any water supply secure yield study.

[6] Similarly, a suitable system simulation model is routinely developed in NSW for any water supply secure yield study.

Table 1 lists the 15 GCMs that were used to produce the data sets

*Table 1: The 15 Global Climate Models*

| Climate Data Series | GCM | Modelling Group | Country |
|---|---|---|---|
| 1 | CCCMA T47 | Canadian Climate Centre | Canada |
| 2 | CCCMA T63 | Canadian Climate Centre | Canada |
| 3 | CNRM | Meteo-France | France |
| 4 | CSIRO-MK3.0 | CSIRO | Australia |
| 5 | GFDL 2.0 | Geophysical Fluid Dynamics Lab | USA |
| 6 | GISS-AOM | NASA/Goddard Institute for Space Studies | USA |
| 7 | IAP | LASG/Institute of Atmospheric Physics | China |
| 8 | INMCM | Institute of Numerical Mathematics | Russia |
| 9 | IPSL | Institut Pierre Simon Laplace | France |
| 10 | MIROC-M | Centre for Climate Research | Japan |
| 11 | MIUB | Meteorological Institute of the University of Bonn, | Germany |
| | | Meteorological Institute of KMA | Korea |
| 12 | MPI-ECHAMS | Max Planck Institute for Meteorology, DKRZ | Japan |
| 13 | MRI | Meteorological Research Institute | Japan |
| 14 | NCAR-CCSM | National Center for Atmospheric Research | USA |
| 15 | NCAR-PCMI | National Center for Atmospheric Research | USA |

It is noted that to maintain relativity and ensure consistency in the pilot study, modelled streamflow data was used throughout. However in practice in determining 'historical' secure yield, best use is made of the observed data for each utility. Thus the historical estimates in Table 2 differ slightly from the current best estimates of secure yield, which include consideration of the observed data. Thus the Steering Group recommends applying the percentage change in secure yield in column (9) of Table 2 to the utility's current best estimate of secure yield in order to obtain the climate changed secure yield estimate.

*Table 2: Comparison of Secure Yield Estimates#*

| | Estimated Secure Yield (ML) | | | | % Change in Secure Yield From Historical Data Set | | | |
|---|---|---|---|---|---|---|---|---|
| Water Utility<br>(1) | Historical Data Set*<br>(2) | Median of 15 Global Climate Models (GCMs)<br>(3) | Lowest GCM<br>(4) | Lowest GCM with 25% severity<br>(5) | Median of 15 GCMs<br>[(3) – (2)]×100 / (2)<br>(6) | Lowest GCM<br>[(4) – (2)]×100 / (2)<br>(7) | Lowest GCM with severity of 25%<br>[(5) – (2)]x100 / (2)<br>(8) | Adopted % Change in Year 2030 Secure Yield due to Climate Change<br>[lesser of (6) & (8)] (%)<br>(9) |
| 1 | 21,500 | 20,000[14] | 17,500 [9] | 19,500 | -7% | -19% | -9% | **-9%** |
| 2 | 3,400 | 3,500 [1] | 3,200 [9] | 3,600 | +3% | -6% | +6% | **+3%** |
| 3 | 12,400 | 12,200 [1] | 11,400 [6] | 12,600 | -2% | -8% | +2% | **-2%** |
| 4 | 7,700 | 7,200 [13] | 6,700 [3] | 7,200 | -6% | -13% | -6% | **-6%** |
| 5 | 5,200 | 4,900 [4] | 4,500 [9] | 4,800 | -4% | -13% | -8% | **-8%** |
| 6 | 495 | 450 [12] | 400 [3] | 435 | -9% | -19% | -12% | **-12%** |
| 7 | 4,850 | 4,150 [4] | 3,250 [3] | 3,600 | -14% | -33% | -26% | **-26%** |
| 8 | 3,600 | 3,600 [8] | 2,900 [3] | 3,400 | 0% | -19% | -6% | **-6%** |
| 9 | 480 | 360 [8] | 220 [4] | 240 | -25% | -54% | -50% | **-50%** |
| 9+ | 1500 | 1260 [7] | 880 [4] | 1060 | -16% | -41% | -29% | **-29%** |
| 10 | 185 | 175 [4] | 115 [9] | 135 | -5% | -38% | -27% | **-27%** |
| 11 | 16,900 | 15,300 [4] | 14,300 [13] | 15,700 | -9% | -15% | -7% | **-9%** |

# On the basis of '5/10/10 rule' in ML/a, except for columns (5) and (8), which involve a severity of 25% (ie. a '5/10/25 rule').
* 111 years of data (1896 to 2006) from the "Future climate and runoff projections (in 2030) for NSW and ACT" Database.
+ Enlarged storage for proposed augmentation.
In columns (3) and (4), the relevant GCM is shown within square brackets, eg. for Utility 10 the secure yield shown in column (3) is based on GCM 4.

Figure 1 shows the general location of the 11 NSW water supply systems examined which covered a range of attributes: large, small, on-stream storage, off-stream storage, coastal, inland and multi-sources.`

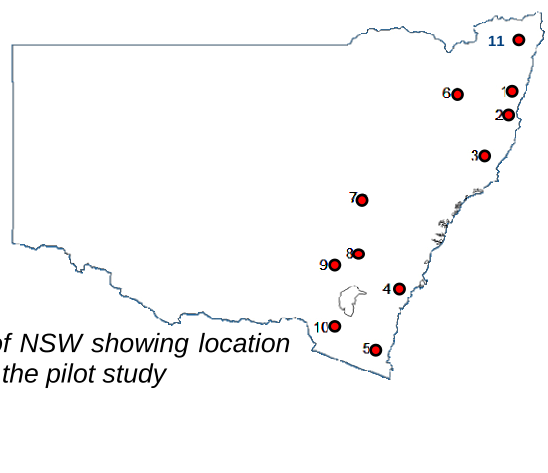


*Figure 1: Map of NSW showing location of the utilities in the pilot study*

## RESULTS OF THE PILOT STUDY
### Climate Change

The projected impacts of climate change in ~2030 on the average annual rainfall, streamflow and evapotranspiration for each utility's water supply, in comparison with the historical data sets are shown in Figures 2, 3 and 4 respectively. Note that there is a tendency towards drying in NSW.

Following determination of the average annual rainfall for each of the 15 GCMs for each utility, the GCM with the highest average annual rainfall is shown as 'Highest' in Figure 2, expressed as a percentage change in comparison with the historical average annual rainfall. Similarly, the GCM with the lowest average annual rainfall for a utility is shown as 'Lowest' and the GCM with the median average annual rainfall from the 15 GCMs is shown as 'Median' in Figure 2.

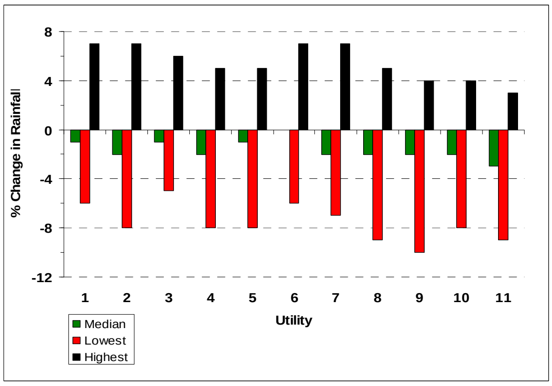


*Figure 2: % Change in the Average Annual Rainfall for the Global Climate Models (GCMs) shown compared with the result for the Historical Data Set*

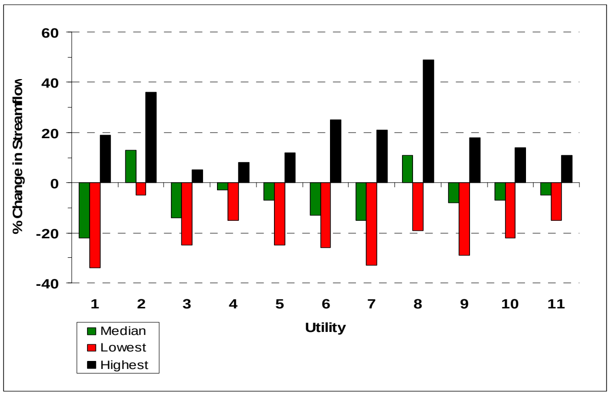


*Figure 3: % Change in the Average Annual Streamflow for the Global Climate Models (GCMs) shown compared with the result for the Historical Data Set*

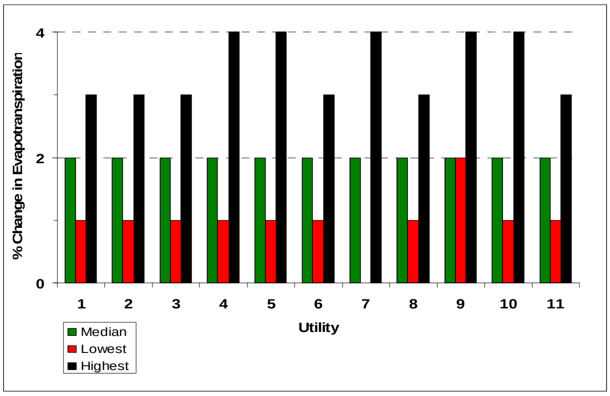


*Figure 4: % Change in the Average Annual Evapotranspiration for the Global Climate Models (GCMs) shown compared with the result for the Historical Data Set*

Figure 2 shows that the changes in the average annual rainfall for the GCM with the median change range from no change (Utility 6) to a reduction of 3% (Utility 11) (median is a 2% reduction). For the GCM with the lowest change, the range is reductions of 5% (Utility 3) to 10% (Utility 9) (median is an 8% reduction). For the GCM with the highest change, the range is increases of 3% (Utility 11) to 7% (Utilities 1, 2, 6 and 7) (median is a 5% increase).

Figure 3 shows that the changes in the average annual streamflow for the GCM with the median change range from an increase of 13% to a reduction of 22% (median is a 7% reduction). For the GCM with the lowest change, the range is reductions of 5% to 34% (median is a 25% reduction). For the GCM with the highest change, the range is increases of 5% to 49% (median is an 18% increase).

Figure 4 shows that for the GCM with the median change, the change in the average annual evapotranspiration is a 2% increase in each case. For the GCM with the lowest change, the range is increases of nil to 2% (median is a 1% increase). For the GCM with the highest change, the range is increases of 3% to 4% (median is a 3% increase).

### Secure Yield

The results of the pilot study with respect to secure yield are shown in Table 2. Columns (2), (3) and (4) show the secure yield for each of the 11 utilities in the pilot study for the historical data, the median of 15 GCMs and the lowest GCM on the basis of the '5/10/10 rule'.

Columns (6) and (7) show the changes in secure yield for the median of 15 GCMs and the lowest GCM in percentage terms. For the median GCM (column (6)) the change in secure yield varies from an increase of 3% (Utility 2) to a reduction of 25% (Utility 9). For the lowest GCM (column (7)) the change in secure yield varies from a 6% reduction (Utility 2) to a reduction of 54% (Utility 9).

As discussed in Samra & Cloke (2010 :5) the Steering Group considers that a balanced approach to determining the secure yield after climate change would be to adopt the lesser of:

a) secure yield for the median of 15 GCMs on the basis of the '5/10/10 rule'
b) secure yield for the GCM with the lowest secure yield on the basis of a '5/10/25 rule'; the 25% severity of restrictions under this rule amounts to being able to 'survive' occurrence of the lowest GCM, albeit with relatively harsh water restrictions to cope with the reduced availability of water.

Thus a utility's core planning under a) above would be on the basis of the '5/10/10 rule'. However, under b) above, the utility would also need to ensure its system would be able to survive the lowest GCM under the severe restrictions involved in a '5/10/25 rule'.

Column (5) of Table 2 shows the secure yield of the lowest GCM on the basis of 25% severity of restrictions (ie. a '5/10/25 rule'). For comparison purposes, the percentage change in secure yield is shown in column (8).

The above approach is considered to provide a reasonable balance between avoiding excessive capital expenditure by the utilities and avoiding very harsh future drought water restrictions. The 25% severity for the GCM with the lowest secure yield is considered to be acceptable in view of the low probability of occurrence of such a GCM and is informed by the outcomes of at least 35% reduction in consumption achieved by several NSW utilities in the current drought, including Goulburn, Orange and the Central Coast (Samra & Cloke, 2010: 5).

The adopted change in the Year 2030 secure yield due to climate change for each utility is shown in column (9) of Table 2 and Figure 5. This is identical with the values shown in column (6), for 4 utilities (2, 3, 4 *and 11). The adopted changes for the other 7 utilities are on the basis of 25% severity of restrictions for the* lowest GCM, and are up to 25 percentage points lower than for the median GCM.

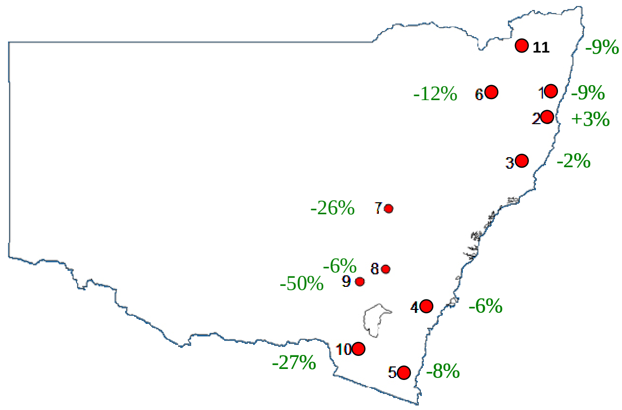


*Figure 5: Map of NSW showing adopted % change in Year 2030 Secure Yield due to climate change for each utility in the pilot study*

**Note:**
For Utility 9, the changes in secure yield for the existing small storage dam and for the proposed enlargement of the dam were -50% and -29% respectively.

The 3 utilities with a reduction in the adopted secure yield of over 25% are inland utilities in mid and southern NSW. This finding is consistent with the Victorian expectation of increasing drought severities.

Storage behaviour diagrams for each utility are shown in Figures A1 to A12 in Appendix A on page 11. These show the storage behaviour (expressed as % of full storage capacity) while delivering an annual demand[7] equivalent to the secure yield determined for the historical data for a repeat of:

- the historical climate conditions and
- for a repeat of the climate changed conditions that produced the
    - highest,
    - median and
    - lowest climate changed secure yield for each utility.

Using the climate changed inflows, Figures A1 to A12 show that except for Utility 10 (Figure A11), the storages did not empty while supplying a demand equivalent to the historic secure yield for each utility. This includes the results in Figures A9 and A10 for Utility 9 which had the largest reduction in secure yield. It is important to note that the existing small storage capacity for Utility 9 results in a 50% reduction in secure yield (column 9 of Table 2). However after the proposed augmentation of the storage dam, there would be only a 29% reduction in the secure yield, which demonstrates that the impact of climate change is system dependent.

[7] Unrestricted demand was supplied until the storage volume fell to the restriction volume for each utility (typically about 50% to 60% of full capacity). Thereafter 90% of the demand was supplied until there was a significant recovery in the storage volume, when the unrestricted demand was resumed. As it was necessary to use the first year of each dataset to initialise the daily rainfall-runoff models, each simulation was generally carried out with the remaining 111 years of daily hydroclimate data.

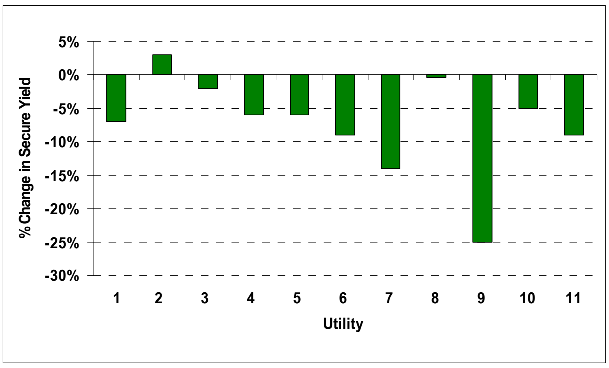


*Figure 6: Median % Change in the Secure Yield from the 15 Global Climate Models compared with the result for the Historical Data Set*

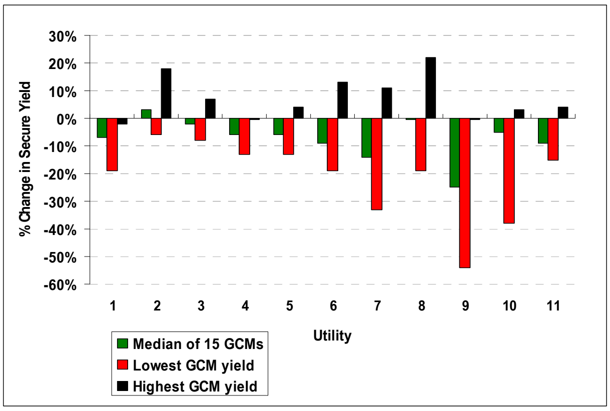


*Figure 7: % Change in the Secure Yield for the Global Climate Models (GCMs) shown compared with the result for the Historical Data Set*

Figure 6 provides a graphical representation of the percentage change in secure yield for the GCM with the median secure yield, in comparison with the historical data set. These results are as shown in column (6) of Table 2 and range from an increase of 3% to a reduction of 25%.

Figure 7 also provides a graphical representation of this percentage change for the GCM with the lowest secure yield (from column (7) of Table 2) and that for the GCM with the highest secure yield, in comparison with the historical data set. As also noted above, the results for the GCM with the lowest secure yield range from a reduction of 6% to a reduction of 54% (column (7) of Table 2). The results for the GCM with the highest secure yield range from an increase of 22% to a reduction of 2%.

The GCMs which provided the median, lowest and highest changes in the average annual rainfall, streamflow and evapotranspiration[8] (refer to Figures 2 to 4) are not necessarily those which resulted in the median, lowest and highest changes in secure yield (refer to Figure 7).

A report on the pilot study will be published on the NSW Office of Water website in 2010 in order to disseminate the results and findings of the study.

Tables 3 and 4 show the key characteristics of the 4 simulations shown for each utility in Figures A1 to A12 on page 12, Table 3 provides a comparison of the resulting minimum storage volume for each simulation and indicates that the minimum storage volume for the historical data set ranges from 31% to 49% of the full storage capacity (column (3)). For the median of GCMs, the minimum storage volume ranges from 23% to 49%, with 3 utilities having a minimum storage volume of 23% to 25% of capacity (column (4)). However, for the lowest GCM, 4 utilities have a minimum storage of under 15% of capacity (Utilities 7, 9, 10 and 11), with the storage volume for the small Utility 10 emptying for a period of 6 months (column (5)). For the highest GCM, the minimum storage volume ranges from 32% to 51% of capacity (column (6)).

*Table 3: Comparison of Minimum Storage Volumes*

| Water Utility | Storage Capacity (ML) | **Minimum Storage Volume (%) while supplying the Historical Secure Yield** | | | |
|---|---|---|---|---|---|
| | | Historical Data Set | Median of 15 Global Climate Models (GCMs) | Lowest GCM | Highest GCM |
| (1) | (2) | (3) | (4) | (5) | (6) |
| 1 | 35,600 | 39 | 30 | 20 | 40 |
| 2 | 5,500 | 31 | 33 | 27 | 41 |
| 3 | 4,500 | 43 | 49 | 31 | 51 |
| 4 | 4,900 | 46 | 44 | 42 | 46 |
| 5 | 3,780 | 49 | 34 | 24 | 37 |
| 6 | 460 | 34 | 31 | 22 | 42 |
| 7 | 22,500 | 37 | 23 | 10 | 43 |
| 8 | 15,500 | 38 | 38 | 23 | 46 |
| 9 | 850 | 37 | 25 | 9 | 37 |
| 9+ | 2,470 | 37 | 30 | 14 | 42 |
| 10 | 100 | 31 | 29 | 0 for 6 months | 32 |
| 11 | 14,800 | 33 | 23 | 14 | 39 |

+ Enlarged storage

[8] Eg. for Utility 1, the median rainfall, streamflow, evapotranspiration and secure yield resulted from GCMs 5, 5 , 9 and 14 respectively.

*Table 4: Comparison of Storage Drawdowns*

| Water Utility (1) | % of the time storage is drawn down below volumes shown while supplying the Historical Secure Yield | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Historical Data Set (2) | | | Median of 15 Global Climate Models (GCMs) (3) | | | Lowest GCM (4) | | | Highest GCM (5) | | |
| | **60%** | **40%** | **20%** | **60%** | **40%** | **20%** | **60%** | **40%** | **20%** | **60%** | **40%** | **20%** |
| 1 | 1.4 | 0.1 | 0.0 | 1.5 | 0.5 | 0.0 | 3.1 | 0.7 | 0.1 | 1.2 | 0.0 | 0.0 |
| 2 | 3.7 | 0.8 | 0.0 | 2.8 | 0.7 | 0.0 | 5.0 | 0.8 | 0.0 | 1.1 | 0.0 | 0.0 |
| 3 | 0.7 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 1.3 | 0.1 | 0.0 | 0.5 | 0.0 | 0.0 |
| 4 | 1.5 | 0.0 | 0.0 | 2.1 | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 |
| 5 | 0.2 | 0.0 | 0.0 | 1.1 | 0.2 | 0.0 | 2.1 | 0.3 | 0.0 | 0.7 | 0.0 | 0.0 |
| 6 | 1.4 | 0.2 | 0.0 | 1.1 | 0.2 | 0.0 | 2.3 | 0.4 | 0.0 | 0.7 | 0.0 | 0.0 |
| 7 | 5.0 | 0.4 | 0.0 | 9.5 | 1.4 | 0.0 | 18 | 5.2 | 0.8 | 2.5 | 0.0 | 0.0 |
| 8 | 7.0 | 0.2 | 0.0 | 6.1 | 0.3 | 0.0 | 16 | 2.9 | 0.0 | 1.0 | 0.0 | 0.0 |
| 9 | 1.4 | 0.2 | 0.0 | 1.7 | 0.6 | 0.0 | 2.5 | 0.8 | 0.2 | 0.8 | 0.1 | 0.0 |
| 9+ | 1.4 | 0.2 | 0.0 | 1.5 | 0.4 | 0.0 | 2.4 | 0.5 | 0.1 | 1.0 | 0.0 | 0.0 |
| 10 | 2.0 | 0.5 | 0.0 | 2.7 | 0.8 | 0.0 | 4.3 | 1.4 | 0.7 | 1.5 | 0.4 | 0.0 |
| 11 | 1.5 | 0.3 | 0.0 | 3.4 | 0.7 | 0.0 | 4.9 | 1.3 | 0.4 | 1.6 | 0.1 | 0.0 |

+ Enlarged storage

In summary, Table 3 shows that for the median GCM, the minimum resulting storage volume for most of the utilities is a little lower than that for the historical data, indicating slightly more severe droughts than had been experienced historically. For the lowest GCM, all the minimum storage volumes are much lower than the historical data set. This indicates the occurrence of much more severe droughts, with 5 of the utilities experiencing a minimum storage volume of under 15% of full capacity, in comparison with the historical data set, where the minimum storage volume was 31% of full capacity.

For the 4 simulations for each utility discussed in Table 3 above, Table 4 provides a comparison of the percentage of time each storage is drawn down below 60%, 40% and 20% of full capacity. These draw downs indicate the relative vulnerability of each water supply to supply failure due to emptying of the storage. For the historical data set (column (2)) of Table 4 shows that the percentage of time the storage volume falls below 60% of full capacity exceeds 5% only for Utility 8, where restrictions are implemented at a storage capacity of 55% under the '5/10/10 rule'. Column (3) of Table 4 shows that for the median of GCMs, 2 utilities (Utilities 7 & 8) have storage volumes under 60% of capacity for more than 5% of the time. Only these 2 utilities have such storage volumes for more than 5% of the time for the lowest GCM, but the duration now extends to 16% to 18% of the time for this GCM (column (4)). For the highest GCM, the duration of such storage volumes does not exceed 2.5% of the time for any utility (column (5)).

Table 4 also shows that for the historical data set (column (2)), the percentage of time the storage volume falls below 40% of full capacity, which could be expected in a severe drought, does not exceed 0.8% for all the utilities. Column (3) of Table 4 shows that for the median of GCMs, only Utility 7 has such storage volumes exceeding 0.8% of the time. However, for the lowest GCM only 7 utilities have such storage volumes not exceeding 0.8% of the time, with the other 4 utilities (Utilities 7, 8, 10 and 11)) experiencing durations of 1.3% to 5.2% of the time (column (4)). For the highest GCM, the duration of such storage volumes does not exceed 0.4% of the time (column (5)).

In addition, Table 4 shows that for the historical data set (column (2)), the median of GCMs (column (3)) and the highest GCM (column (5)), the storage volume never falls below 20% of full capacity, which could be expected to occur only in an extreme drought. However, for the lowest GCM, 5 utilities (Utilities 1, 7, 9, 10 and 11) have a storage volume below 20% of capacity for at least 0.1% of the time (column (4)).

As previously noted, the *Best-Practice Management Guidelines* require each NSW water utility to prepare a comprehensive 30-year IWCM Strategy. The IWCM strategies will need to include assessment of the secure yield of the utility's water supply on the basis of new NSW guidelines proposed for release in late 2010. The utilities will be able to soundly plan for the security of their water supply for climate change by developing and implementing their 30-year IWCM strategy on the basis of the climate changed secure yield determined along the lines of the pilot study for 11 NSW water supplies.

As noted on page 3, the pilot study has focused on climate change projections for the Year 2030 based on predictions for the A1B mid range warming emissions scenario. This is not only due to the availability of the daily database but because there is only a small difference in the climate change projections between different emissions scenarios for the year 2030. These differences will be magnified for longer-term projections, such as year for the year 2050 or 2070.

**DISCUSSION**

**The 1895-1902 Federation Drought**

The severe 2001-2007 drought has been claimed as the worst drought since records began in Australia and has resulted in questioning of the reliability of several major water supplies in Australia. Fortunately NSW country town water supplies that had been planned on the basis of the NSW security of supply basis (ie. 5/10/20 rule) have been able to maintain the expected supply. It is hypothesised that this is because the 5/10/20 rule incorporates the very severe Federation drought of 1895-1902 and allows for maintaining a 20% restricted supply through in effect a '1 in 1000 year' drought (Cloke & Samra, 2009 :13).

It is understood consideration of Perth's and Melbourne's water supply reliability was until recently based on flow records post the Federation drought, as shown in their plots of inflows (*from 1911 for Perth and from 1913 for Melbourne*) (Gill, 2008 and Rhodes et al, 2010). The plot of inflows to Perth's water supply headworks has been repeatedly shown as an example of a shifting climate.

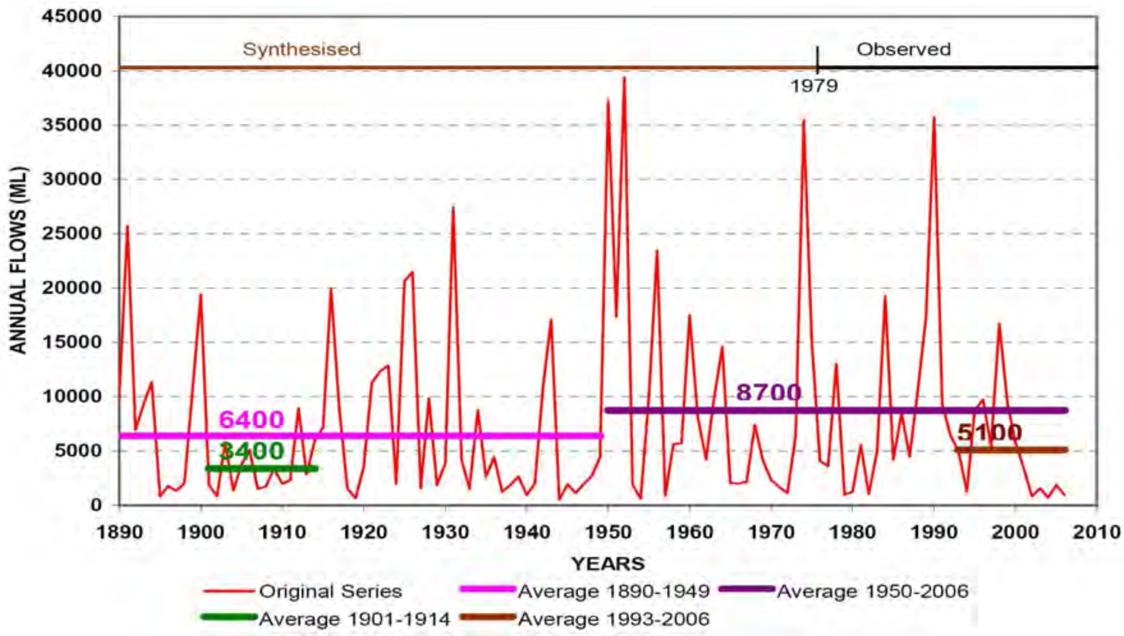


*Figure 8: Annual Historic Flows Periodic Comparison*

An equivalent plot of inflows for a Tablelands water utility in central NSW [catchment area 100 km$^2$] is shown in Figure 8. With the inclusion of the Federation drought it suggests that the 2001-2007 drought was more likely to be due to climate variability rather than climate change and in terms of water supply headworks was not the worst drought on record.

If the Federation drought and pre 1915 droughts had not been incorporated in the water supply planning, secure yields for many NSW water supplies would have been determined to have been much higher and may have then been impacted by the 2001-2007 drought. **For example for Utility 7, post the Federation drought, the secure yield would have been determined as some 25% higher and post 1915, some 50% higher than the historical secure yield.** This highlights the importance of including the Federation Drought in any security of supply simulation studies to avoid such over-estimation of secure yield.

Accordingly, it is considered that the robustness of the NSW security of supply basis, combined with analysis for climate change as developed in the pilot study, will continue to provide reliable and cost-effective water supply security for NSW country towns.

**Reducing uncertainty in climate models**

The overall summary of the **Ozwater '10 Workshop on Climate Change Impacts on the Water Sector** (Claydon, et al., 2010: 3) includes:

> 'Reducing uncertainty in climate models is an active area of research – in particular coupled ocean-atmosphere general circulation models (GCMs). There have already been (published) steps made to provide this more refined (downscaled) output in Bureau of Meteorology and CSIRO climate projections, especially for drought. However, the core aspects of how best to apply these various models using sophisticated integrated modelling procedures remains an ongoing interesting research and operational issue.'

It is acknowledged that reducing uncertainty in climate models and how best to apply them is an area of ongoing research.

However, water supply planning and decision making requires assessment of the impact of climate change on water supply security. At present, the best available downscaled daily hydrometeorological data in Australia is for 15 GCMs along the lines developed by the Murray Darling Basin Sustainable Yields Project. Such data is now available for all of NSW and Victoria, as well as for all of the Murray Darling Basin, including Adelaide. It is therefore considered that the analysis carried out in this pilot study could be used to assess the Year 2030 climate change impacts for urban water utilities in the areas with such downscaled data which have surface water supplies with storage dams.

In addition, there are some major research activities such as the research in SEACI[9] Theme 2 which focus on improving hydroclimate change projections for south-eastern Australia. They are specifically investigating

(i) GCM assessment and selection for hydrological application and

(ii) assessing the relative merits of different downscaling methods and relative uncertainties in various components in estimating climate change impact on runoff (GCM projections, downscaling methods and hydrological modelling) (Vaze J., 2010).

The above research includes consideration of dynamic downscaling, which has the potential to improve the projections of drought persistence for severe droughts.

Accordingly, as such better hydroclimate change data becomes available in the future, it should be applied in future planning. In this regard, where a utility has sufficient supply capacity to enable it to defer a major capital investment decision for additional surface water supplies for 5 or more years, it should do so, as the better hydroclimate change data likely to be available by that time would enable the utility to make a more robust investment decision.

## CONCLUSIONS

1 A sound basis has been developed for non-metropolitan urban water utilities to assess the impact of climate change for the Year 2030 on the secure yield of their urban water supply. This is an adaptive management approach which enables utilities to carry out sound climate change planning and decision making immediately, using the existing 112 years of downscaled daily hydrometeorological data sets for 15 GCMs. As better hydroclimate change projections become available in the future, these will need to be applied in future planning by the utilities.

2 The results for the 11 utilities in the pilot study are shown in Figure 5 on page 6. These indicate that the main impacts on Year 2030 secure yield are:

- no greater than a reduction of 9% for the 7 coastal and tablelands utilities
- reductions of almost 30% for the 3 inland utilities in mid and southern NSW, after allowing for the proposed augmentation of the existing small storage capacity for Utility 9.

3 Future utility 30-year IWCM strategies in NSW will need to include assessment of the secure yield of the utility's water supply in accordance with the analysis reported for the pilot study. Implementation of these strategies, together with the required 6-yearly updates, will address the future water security of these utilities.

## ACKNOWLEDGMENTS

Each member of the Climate Change Steering Group for their valuable strategic advice and inputs. Peter Ledwos, Ian Burton and Richard Cooke of the NSW Office of Water for their significant contributions to the pilot study.

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The many NSW Councils which have engaged NSW Public Works over the years to carry out yield studies, thus enabling use of the study models for the analysis reported in the pilot study.

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## APPENDIX A

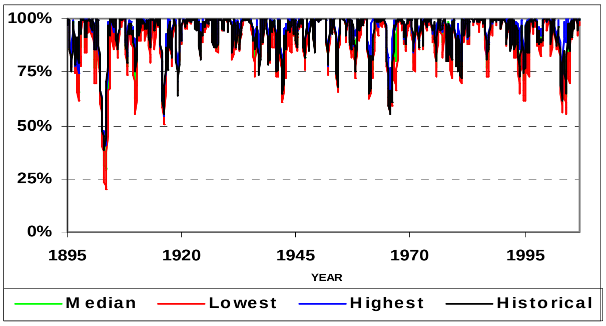


*Figure A1: Storage Behaviour Diagram for repeat of years 1895 to 2006 for different climate conditions for Utility 1*

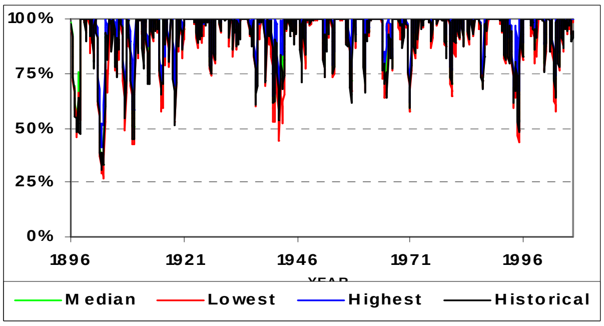


*Figure A2: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 2*

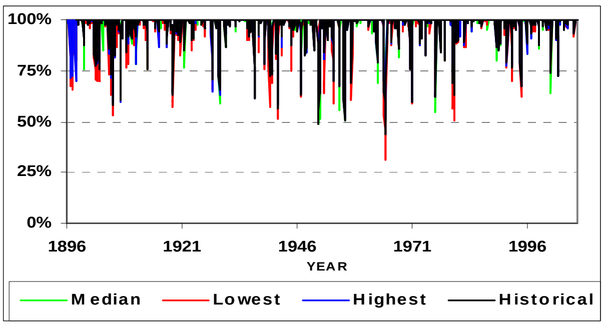


*Figure A3: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 3*

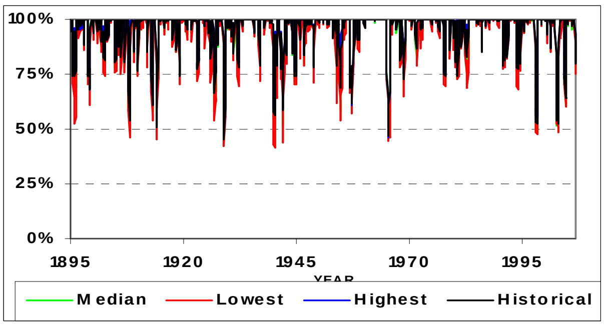


*Figure A4: Storage Behaviour Diagram for repeat of years 1895 to 2006 for different climate conditions for Utility 4*

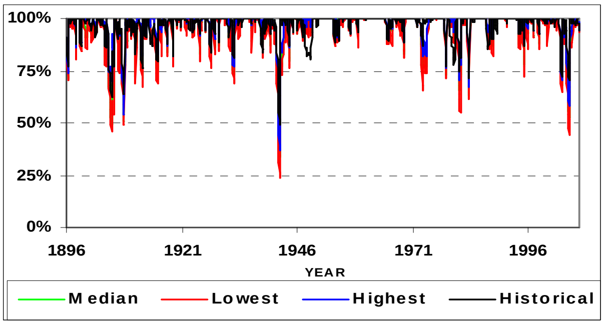


*Figure A5: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 5*

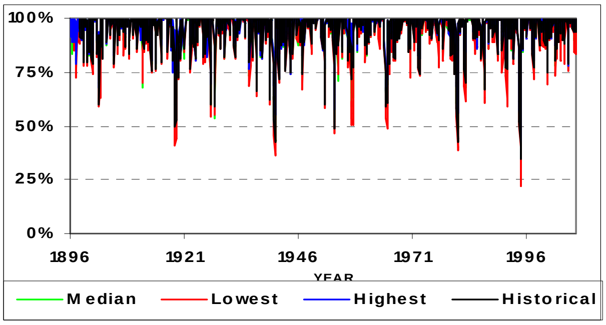


*Figure A6: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 6*

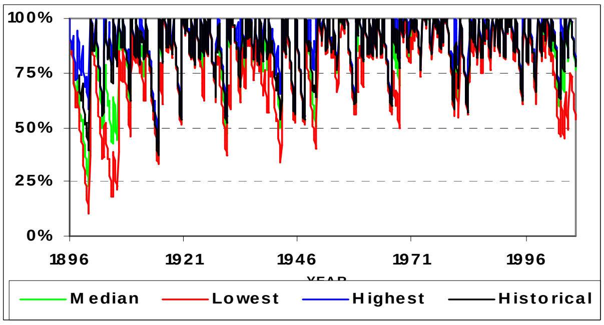


*Figure A7: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 7*

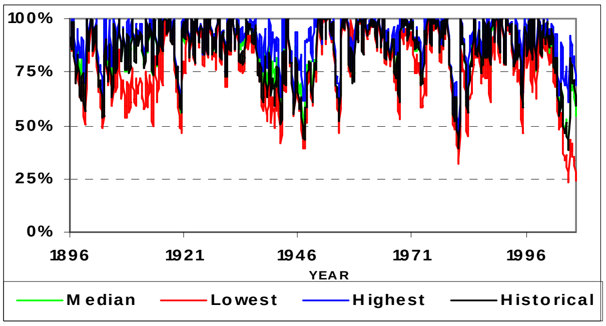


*Figure A8: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 8*

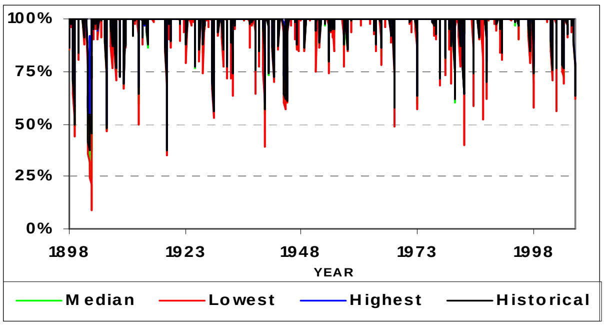


*Figure A9: Storage Behaviour Diagram for repeat of years 1898 to 2006 for different climate conditions for Utility 9 – Existing Storage*

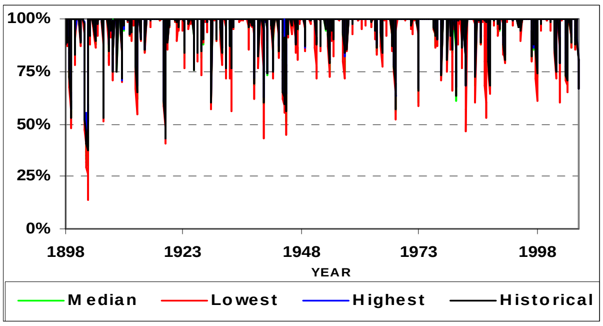


*Figure A10: Storage Behaviour Diagram for repeat of years 1898 to 2006 for different climate conditions for Utility 9 – Enlarged Storage*

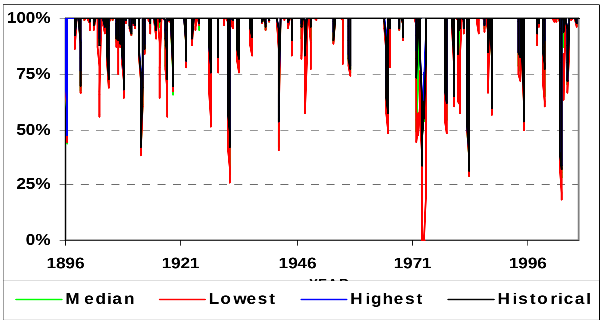


*Figure A11: Storage Behaviour Diagram for repeat of years 1896 to 2006 for different climate conditions for Utility 10*

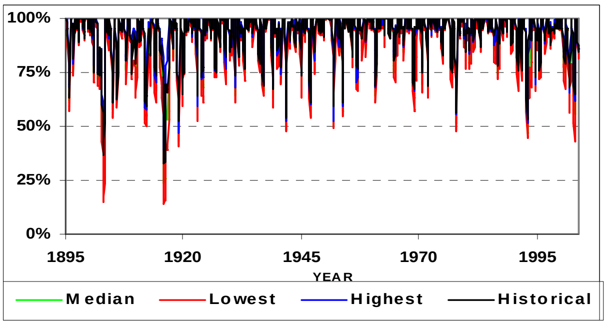


*Figure A12: Storage Behaviour Diagram for repeat of years 1895 to 2003 for different climate conditions for Utility 11*

# D Coarse screening of options

Coarse screening of 12 water supply augmentation options was undertaken prior to this study. The screening of each of the options was undertaken by the PRG over 3 successive meetings (PRG Meeting #9, #10, #11)[7].

The criteria for assessment were:

- Healthy – safe / fit for purpose
- Reliable – availability, measureable benefit
- Sustainable – meet principles of Environmentally Sustainable Design
- Acceptable – community support
- Integrated – resource management, infrastructure
- Achievable – legal, practically viable, built environment timeliness

[7] http://www.rouswater.nsw.gov.au/cp_themes/default/page.asp?p=DOC-DIE-27-72-2. Accessed 9/07/2013.

**Table D-1: Coarse Options Screening**

| No | Option | Description | Conclusion | Pass/Fail |
|---|---|---|---|---|
| 1 | **Potable Reuse** | This would involve treating sewage effluent from an existing or new sewage treatment plant to produce reclaimed water of a quality that would be suitable for drinking purposes. This water would then be provided direct to Rous Water consumers. This option involves a very complex water treatment process. | While this option can provide only limited benefits, it is a strategy that could be adopted in some circumstances and there are examples of this approach being used elsewhere in Australia. | Fail |
| 2 | **Raising Rocky Creek Dam** | This would entail raising the existing dam by up to 8 metres to a height of up to 36 metres and more than doubling the existing 14,000 ML storage capacity to 35,000ML. Because of the need to provide environmental flows, this would only increase the yield of the dam by about 8.5% or 1,200 ML/annum. | Because NPWS is likely to oppose this proposal and because of the environmental impacts associated with extensive removal of endangered ecological communities, this project is not recommended for further consideration. This is particularly so given that while the project is a major undertaking, it can only provide a very low increase in yield. | Fail |
| 3 | **Desalination** | Desalination of sea water or saline groundwater to provide significant amounts of water to one of the region's major urban areas. Could easily be staged in modules with capacities of say 1,000 ML/annum and augmented as required. | This option is considered suitable for further consideration. Energy usage and the sensitivity of the location are significant issues that will need to be addressed. | Pass |
| 4 | **Groundwater** | This could be achieved by developing a number of bore fields within the region each with a capacity of up to 2,000 ML/annum. Each bore field could be staged in modules of say 1,000 ML/annum and augmented as required. | This option is considered to be suitable for further consideration. The rights of other irrigators and groundwater dependent ecosystems are likely to be key issues. | Pass |
| 5 | **Urban Stormwater for Urban Irrigation** | This option entails collection and storage of urban stormwater runoff, followed by treatment and irrigation of the treated water onto open space areas. | While this option can provide only limited benefits, it is a strategy that could be adopted in some circumstances and there are examples of this approach being used elsewhere in Australia. | Pass |
| 6 | **Urban Stormwater for Non-potable urban use** | This option would entail provision of a significant storage dam downstream of a new urban development area, with a dedicated treatment plant and a dedicated | This option passes the coarse screening assessment. It should be noted however that it is unlikely in the foreseeable future that | Pass |

| No | Option | Description | Conclusion | Pass/Fail |
|---|---|---|---|---|
| | | reticulation system to supply treated water for outside use and toilet flushing within the new urban development area. | there will be any greenfield development sites that are suitable especially given that future development sites such as Ballina Heights are already committed to installing a dual water supply system to recycle reclaimed water (a strategy which provides a climate independent source). | |
| 7 | **Potable Use of Urban Stormwater** | This option would entail harvesting urban stormwater runoff by providing a significant storage dam downstream of an urban development area. The collected water would then be pumped via a new dedicated pipeline to an existing water treatment plant (e.g. Nightcap WTP or Emigrant Creek WTP) for subsequent supply to consumers. In this way the stormwater would be used to supplement Rous Water's existing raw water sources (e.g. Rocky Creek Dam, Emigrant Creek Dam and the Wilson River Source). | Subject to finding a site that would provide sufficient catchment and storage capacity and is appropriate in respect of technical and environmental issues, this option is considered suitable for further consideration. | Pass |
| 8 | **Indirect Potable Reuse** | This involves provision of a sophisticated treatment process, pumping station and transfer pipeline to deliver highly treated reclaimed water directly into an existing major storage dam (e.g. Rocky Creek Dam or Emigrant Creek Dam) or possibly a groundwater source, for subsequent extraction, treatment and transfer using existing infrastructure. | While Australian Guidelines for Water Recycling: Managing Health and Environmental Risks provides guidelines for the implementation and management of these types of schemes, it is unclear at this stage whether this option would be supported by the NSW Ministry of Health. While recent experience elsewhere in Australia indicates that this option may not gain community support, in recognition of the trend of increasing community understanding of water treatment technology and water cycle management principles, this option cannot be discounted at this stage. It is therefore recommended that indirect potable reuse be subject to further consideration. | Pass |
| 9 | **Recycling of Reclaimed Water for Non Potable Urban Use** | This involves provision of further treatment of reclaimed water produced by a sewage treatment plant, and provision of a pumping station, transfer pipeline and | The option of developing dual water supply schemes for the recycling of reclaimed water for non-potable use passes all of the | Pass |

| No | Option | Description | Conclusion | Pass/Fail |
|---|---|---|---|---|
| | | dedicated reticulation system to deliver treated reclaimed water for outside use and toilet flushing within new urban development areas. | assessment criteria. There are a number of similar schemes that are approved and operating within NSW and this type of scheme is now being implemented at Ballina Heights. Because there is scope for further application within the Rous Water supply area, this option is worthy of further consideration. | |
| 10 | **Regional connections – Casino / Rous Water** | This option involves the interconnection of the Rous Water supply with the Casino water supply sourced from Jabour Weir. | This option fails to pass the assessment as it does not provide a significant increase in water security for the Rous Water supply. | Fail |
| 11 | **Regional Connections – Purchase existing entitlements for Toonumbar Dam** | This option involves accessing existing water entitlements within the Toonumbar regulated water source. Water would be transferred to the Casino Water Treatment Plant for treatment to potable standards and then pumped into the Rous Water supply. | This option fails to pass the assessment as it does not provide sufficient water security during periods of low water availability. | Fail |
| 12 | **Regional Connections – Establish new Town Water Supply licence for Toonumbar Dam** | This option involves a new Town Water Supply licence within the Toonumbar regulated water source. Water would be transferred to the Casino Water Treatment Plant for treatment to potable standards and then pumped into the Rous Water supply. | This option passes the assessment, provided that the Licence conditions of the NSW Office of Water can be met. | Pass |

# E Environmental constraints

A desktop environmental constraints assessment has been undertaken for the development options. This included reviewing existing environmental reports, interrogating of various Federal, State and local government data bases and search tools plus appraisal of aerial imagery. The results of the assessment are provided in Table E-1.

**Table E-1: Environmental constraints assessment**

| Option | Environmental constraints |
|---|---|
| B1. Goonellabah Catchment | • Alignment follows existing road/infrastructure corridors and does not cross through any mapped protected areas.<br>• 17 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o Pipeline adjacent to Wilson Park<br>o Rotary Park Rainforest Reserve approx. 1km from pipeline<br>o No major risks/constraints identified. |
| B2. Alstonville Catchments | • Pipe alignment follows road and does not cross through any mapped protected areas<br>• 34 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>• Killen Falls Scrub located approx. 3km north of Tintenbar.<br>o Lumley Park Scrub – Alstonville<br>o Maguires Creek Scrub – 1.5km north of Alstonville<br>o No major risks/constraints identified. |
| B3.Cumbalum Ridge Development | • Pipe alignment follows road/existing infrastructure corridors and does not cross through any mapped protected areas<br>• 34 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o Killen Falls Scrub located approx. 3km north of Tintenbar. |

| Option | Environmental constraints |
|---|---|
| | • No major risks/constraints identified. |
| D1. East and South Lismore STPs | • Pipe alignment follows road and does not cross through any mapped protected areas<br>• 18 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o Pipeline adjacent to Wilson Park<br>o Rotary Park Rainforest Reserve approx. 1km from pipeline<br>• No major risks/constraints identified. |
| D2. Alstonville STP | • Pipe alignment follows road and does not cross through any mapped protected areas<br>• 34 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o Killen Falls Scrub located approx. 3km north of Tintenbar.<br>o Lumley Park Scrub – Alstonville<br>o Maguires Creek Scrub – 1.5km north of Alstonville<br>• No major risks/constraints identified. |
| D3. Alstonville STP and stormwater harvesting | • Pipe alignment follows road and does not cross through any mapped protected areas<br>• 34 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Unlikely to be issue in existing infrastructure corridors.<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o Killen Falls Scrub. Located approx. 3km north of Tintenbar.<br>o Lumley Park Scrub – Alstonville<br>o Maguires Creek Scrub – 1.5km north of Alstonville<br>• No major risks/constraints identified. |
| D4. Ballina and Lennox Head STPs | • Pipeline route intercepts SEPP 14 wetlands between Lennox Head STP and Ballina STP, particularly around North Creek. Underbore where practicable to avoid. Follows existing recycled water infrastructure corridor. |

| Option | Environmental constraints |
|---|---|
| | • 62 + Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined.<br>• ASS likely to be encountered through this area<br>• Register of National Estate sites in vicinity<br>  ○ North Creek Midden (potentially impacted if any excavation near North Creek)<br>  ○ Killen Falls Scrub. Located approx. 3km north of Tintenbar (unlikely to be impacted)<br>  ○ Ballina Nature Reserve (unlikely to be impacted) |
| F1. Maximise existing sources (Woodburn) | • Woodburn - no mapped groundwater dependent ecosystems (GDE) in vicinity.<br>• Lumley – potential for GDE around existing bore site |
| F2. New sources (Coastal Sands) | • Ballina/Byron coastal sands – no mapped groundwater dependent ecosystems in vicinity. |
| F3. New sources (Fractured Basalt) | • North of Emigrant Dam – no GDE mapped<br>• South of Rocky Creek Dam - no GDE mapped |
| G1. Tyagarah (ocean feed water) | • Potential to trigger EPBC for listed marine species, listed threatened species and communities<br>• Brine discharge into Cape Byron Marine Park (NSW). Found nothing in *Marine Parks Regulation 2009* that would preclude desalination as an option in a Marine Park.<br>• Potential community resistance from stakeholders (surf riders, scuba, tourism operators, conservationists)<br>• Risks associated with construction of intake/discharge pipeline through coastal area (nature reserve), disturbance to dunes, seafloor<br>• Close to Tyagarah Nature Reserve and SEPP 14 wetlands<br>• 4 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined |
| G2. South Ballina (ocean feed water) | • Potential to trigger EPBC for listed marine species, listed threatened species and communities<br>• Site located close to SEPP 14 wetlands.<br>• Risks associated with construction of intake/discharge pipeline through coastal area, disturbance to dunes, seafloor<br>• Require pipeline crossing of Richmond River to supply water to Pine Ave Reservoir – construction risk |

| Option | Environmental constraints |
| --- | --- |
| | • 14 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined |
| J1. Regional Desalination (ocean feed water) | • Potential to trigger EPBC for listed marine species, listed threatened species and communities<br>• 24 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined |
| I1. Toonumbar Dam – modify water sharing plan | • Pipeline route generally follows roads. Will traverse some farm land and require crossing of Richmond River. Underbore likely required.<br>• Approx 40 Aboriginal heritage sites in vicinity (basic search) – extensive search recommended once location refined. Also 3 declared Aboriginal places.<br>o Casino Bora Ring – located approx. 3.5km north of Casino town centre (unlikely to be impacted)<br>o Parrots Nest (Goorumbil) – located 1.4km north of Bruxner H'way (unlikely to be impacted).<br>o Cubawee – located approx. 8km east of Lismore centre (will not be impacted)<br>• No likely EPBC triggers<br>• Register of National Estate sites in vicinity (unlikely to be impacted)<br>o 13 sites in and around central Casino on register including post office, police station, banks etc (unlikely to be impacted)<br>o Tomki Meat House and Barn, 2135 Bruxner Hwy, Casino (adjacent to alignment but unlikely to be impacted)<br>• Require pipeline crossing of Richmond River at Bundocks Road – construction risks |

## Dunoon Dam Environmental Impacts

A number of environmental investigations have been undertaken looking at impact of the proposed Dunoon Dam.  The findings from each of these studies are shown in Table E-2.

**Table E-2: Key findings from cultrual heritage and enviromental investigations**

| Investigation | Key findings |
|---|---|
| **Cultural Heritage** | • Sixteen Aboriginal sites were located, consisting of scarred trees, grinding grooves, artefacts and a collection of 15 burials. The collection of Aboriginal sites together is generally of regional significance<br>• All identified sites would be inundated should the proposed dam be built.<br>• Aboriginal stakeholders are of the opinion that the Aboriginal sites should remain undisturbed and that no level of disturbance is considered acceptable to them, especially disturbance to the burial site, which they see serving as a direct link to ancestors. |
| **Aquatic Ecology** | • Identified a number of threatened aquatic species as potentially occurring at the site.<br>• Assessments of significance indicate that with appropriate mitigation, the proposed Dunoon Dam is unlikely to have a significant impact on these species. |
| **Terrestrial Ecology** | Likely impacts to the following are unlikely to be mitigated:<br>• Loss of Lowland Rainforest<br>• Loss of threatened fauna species and ROTAP species<br>• Loss of threatened fauna habitats<br>• Severance of local wildlife corridors<br>• Advises that an appropriate offset program would be required to enable the proposal to proceed |
| **Environmental Flows** | Identified regime to improve downstream health and function:<br>• Transparent flows up to 100 ML/day<br>• Protection of very low flows<br>• Up to three additional 3-day, 100 ML/day, dry weather releases for ecosystem function |

# F Groundwater options assessment

*Chris Jewell and Associates were engaged to assess the groundwater options in the Rous Supply Area. This Appendix was prepared by Peter Dupen and reviewed by Chris Jewell.*

## Introduction

The then Department of Land Water Conservation estimated in the Upper North Coast Groundwater Resource Study (McKibbin, 1995) that average recharge into North Coast aquifers is of the order of 1,700,000 ML/y. Whilst much of this recharge is required to support existing users and the environment, it remains at least theoretically possible that a substantial proportion of the projected shortfall in Rous Water's future supplies could be sourced from groundwater.

The Water Sharing Plan (WSP) for the Alstonville Plateau Groundwater Sources 2003 estimated the annual recharge to those sources (the Alstonville Basalt Aquifer) as 44,472 ML, but set a long-term average annual extraction limit (after taking environmental water into account, of only 8,895 ML. The Alstonville Plateau Groundwater Sources are divided into six zones, and sub-limits are set for each zone.

Background information on the hydrology, geology, hydrogeology and groundwater dependence of ecosystems within the Rous Water catchments is summarised in a document entitled The Future Water Strategy; Groundwater Options position paper (Parsons Brinckerhoff, 2011). The following appendix takes that report as a starting point, and provides a more detailed assessment of the potential groundwater sources that are most likely to be able to significantly augment Rous Water's future potable water supplies. These potential groundwater sources may be grouped into three broad subdivisions; enhancement and maximisation of existing groundwater sources, identification and exploitation of new groundwater supplies from suitable aquifers, and the potential use of artificial recharge, for example irrigation or injection of suitably treated water or effluent, for storage and later abstraction.

**Table F-1: Groundwater options overview**

| Option | Description |
|---|---|
| 1a. Maximise existing fractured basalt source | Lumley Park Well is 82 m deep, completed in the Alstonville Basalt, and is licensed to abstract 530 ML/y. Water is of high quality. Test pumping and monitoring by DLWC/NOW indicates that it is a sustainable source when pumping at around 200 ML/y, but testing was limited and the effective yield that could be abstracted without impacting on neighbouring users, including some highly sensitive local GDE, has not been quantified as yet.<br><br>Convery's Lane well is 110 m deep, completed in the Alstonville Basalt and is licensed to abstract 253 ML/y. Test pumping and monitoring by DLWC/NOW indicates that abstraction from this well is unsustainable even when pumping at only 60 ML/y, causing large drawdowns in neighbouring wells. This well should not be relied on except for low volumes during drought periods, and it may be preferable to decommission the well and trade the licence for a new, better performing well in a more robust aquifer where permitted by the Water Sharing Plan (WSP). |
| 1b. Maximise Woodburn sources | The Woodburn bore-field comprises three relatively shallow wells and a treatment plant at a site between Woodburn and Evans Head. Numerous quality and volume issues have been experienced and, coupled with its remoteness from main demand centres and intermittent usage patterns, this bore-field has proved a problematic and under-utilised source. Recent assessment by Rous Water (Woodburn Bore Site Rehabilitation – Usability study including Hazard Identification and Risk Assessment, undated) indicates that it could potentially produce up to 640 ML/y if it were to be suitably assessed and upgraded and that this volume is within demand projections for the "lower river" supply region, but the current licence would allow only 242 |

| Option | Description |
| --- | --- |
| | ML/y to be abstracted. The bore-field would need to be relocated to accommodate Pacific Highway works. The projected costs to move the bore-field and complete the upgrade are not included in the "Usability" document (Rous Water, undated).<br><br>There is currently no Water Sharing Plan in operation for the local coastal sand aquifers, and thus they are regulated under the Water Act (1910). A WSP is being developed by NOW however, and is likely to be completed and take effect within the next few years. |
| 2a. Locate and prove new sources in tertiary fractured aquifers (basalt) | The Alstonville Plateau Basalt aquifer group comprises a set of shallow aquifers which are highly responsive to rainfall and are effectively unavailable for large new town water supplies, and a set of semi-confined aquifers which are in some areas potentially capable of greater exploitation for drinking water supply (Brodie and Green 2002, Green, 2006).<br><br>The aquifer has historically been subject to very large drawdowns in some locations, and the Water Sharing Plan restricts which parts of the aquifer are available for significant new abstractions.<br><br>Aquifers outside the Water Sharing Plan boundaries (and especially outside embargoed Zones 1 and 2) are considered more prospective. Of the basalt areas within the Rous Water region, the two most convenient locations to locate a suitable supply would be either south (and hydraulically down-gradient) of Rocky Creek Dam, due to the proximity of the existing Nightcap Treatment Plant and associated mains, or north of Emigrant Creek Dam due to the proximity of mains pipe network and growing water demand centres.<br><br>The aquifers south of Rocky Creek Dam are outside the WSP, and are thus managed less restrictively within the Water Act. There are relatively few existing wells in this area, and thus potential yields are more difficult to predict – Parsons Brinckerhoff suggest that a range of 15 to 38 L/s should be achievable and that a suitable set of bores might realise yields of up to 600 ML/year;these estimates appear reasonable based on available data.<br><br>The basalt aquifer north of Emigrant Creek Dam is managed within the WSP, but some additional abstractions for public water supply may be permissible subject to demonstration that these abstractions are not unacceptably affecting neighbouring water users (including GDEs) or environmental flows. The Convery's Lane source licence could be transferred to a source in this area if considered appropriate. Parsons Brinckerhoff estimate that a set of suitable wells in this area may be capable of providing up to 600 ML/year. |
| 2b. Locate and prove new sources in other hard-rock fractured aquifers (e.g. Kangaroo Ck Sandstone) | The potential use of bedrock aquifers other than the basalts is briefly considered in the Parsons Brinckerhoff (2011) report, which identifies the Kangaroo Creek Sandstone as the most prospective other hard-rock aquifer in the region. This sandstone unit was noted by Drury (WRC, 1982) to be a reliable source of good quality water due to its combination of intergranular porosity and frequent fracture zones. Proven yields and water quality are generally only moderate however and there is little evidence that this or other local aquifers could sustain the types of volumes that would contribute significantly to Rous Water's Future Water targets. They may however offer some potential for artificial recharge schemes, discussed below. |
| 2c. Locate and prove | The ability to abstract large quantities of groundwater from coastal |

| Option | Description |
|---|---|
| new sources in coastal sand aquifers | sand aquifers is well established, but in the North Coast region there are significant constraints on abstraction due to issues with GDEs, acid-sulfate soils and saline intrusion into the aquifer. Nonetheless, studies (e.g. Punthakey & Woolley, 2012) have demonstrated that it is possible to abstract quantities that would significantly contribute to Rous Water's future targets (500 – 2,000 ML/y) without causing unacceptable impacts, provided that the dynamics of the aquifer are clearly understood and an adaptive monitoring and management regime is adopted.<br><br>Water quality is frequently an issue with coastal sand aquifers. For instance the Woodburn sources suffer from high iron, organic carbon, hydrogen sulfide, carbon dioxide and low alkalinity, all of which need to be treated prior to entering drinking water supply.<br><br>As sand aquifers are widely distributed along the coast, an important advantage of these types of aquifers is that it may be possible to locate bore fields in suitable locations close to the two major demand centres of Ballina and Byron Bay. Conversely, land is more intensively used in these areas, making sustainable abstraction more difficult. |
| 2d. Locate and prove new sources in alluvial aquifers | The alluvial aquifers within the Rous Water region are primarily confined to the Wilson River Valley and these are already quite heavily exploited by agriculturalists. A key constraint of alluvial aquifers is that, as they are closely connected to river water levels, their use is likely to be constrained during drought periods. As identified by Parsons Brinckerhoff (2011), it appears unlikely that it would be feasible to locate a sustainable new source that would significantly contribute to Rous Water's Future Water targets. CMJA agrees with this conclusion in terms of new sources, but notes that one potential source for supplying summer excess water for local hard-rock MAR schemes (see next two dot-points) would be a bank-filtered source adjacent to the river. |
| 3a. MAR schemes in coastal sand aquifers | One way of improving the sustainability of coastal sand aquifers is to inject or irrigate surplus water into them and then to re-abstract the water when it is required, a process referred to as Managed Aquifer Recharge (MAR). This can be undertaken on a seasonal basis, for example injecting the water during the wetter summer months and abstracting during drier months, or it can be used to store water for inter-seasonal drought periods.<br><br>Using MAR in coastal sand aquifers offers particular opportunities – aquifers are often highly permeable for easy injection and those near urban areas may have ready water supplies in the form of treated effluents or stormwater – and disadvantages e.g. groundwater flows may be so high that the water is not available for later retrieval.<br><br>Artificial recharge of treated effluents is already occurring at a number of coastal sand locations, e.g. irrigation of melaleuca wetlands at West Byron treatment works, Byron Bay golf course etc. A new scheme at Iluka will see most of their treated effluent sprayed on the local golf course.<br><br>At this stage there are no MAR schemes in the North Coast region, in that there is no specific recovery of water artificially recharged. While there may be significant environmental benefits in doing so, there are also significant technical and social challenges to be met, especially if the intention is to use treated sewage effluent for eventual human consumption.<br><br>Coastal sand aquifers in the North Coast region are frequently partially |

| Option | Description |
|---|---|
| | separated by layers of indurated sands, known as coffee-rock. Where these haven't been removed by historical sand mining activities, the partial confinement of the coffee-rock layers provides some opportunity for improved management of the aquifers (Punthakey & Woolley, 2012). Coffee-rock has been observed in sand layers around Ballina and Byron Bay, but the specific occurrences are not known to have been mapped. |
| 3b. MAR schemes in bedrock aquifers | In hard-rock aquifers, MAR schemes generally use direct injection of waters (e.g. summer excess from local surface waters or treated stormwater or effluent) via boreholes screened in confined aquifers with sufficiently high permeability. Although this requires significant energy and needs to be closely managed to prevent the injection and recovery bores from becoming clogged by suspended particulates or precipitates, there are some significant advantages to this type of scheme, e.g.:<br>• Process can be managed to allow higher-quality injected waters to be stored as a "bubble" within low-quality groundwater aquifer that wouldn't otherwise be exploitable.<br>• Contingent on many factors, costs are approximately half that of equivalent surface water storages (DWLBC, 2002) and have relatively small footprints. |

Although it holds three active sets of groundwater abstraction licenses (at Woodburn, Convery's Lane and Lumley Park), Rous Water is not currently abstracting groundwater for public water supply except during drought periods. The Future Water Strategy; Groundwater Options position paper (Parsons Brinckerhoff, 2011) identified opportunities to augment current groundwater usage at two of these sites (Lumley Park and Woodburn) in order to realise at least the full licensed capacity at these sites, and notes that there may be opportunities to increase licensed capacities at Woodburn.

## Constraints, benefits and costs

The key constraints, potential benefits and approximate costs of developing and operating the options for increased groundwater abstractions are summarised in the following sections. Only those options considered to be capable of making significant contributions to Rous Water's Future Water targets are considered below. Options referred to above that are not considered below have generally been removed because they are not considered to be capable of making sufficiently large contributions to be considered within this strategy. Some of these options, such as sourcing additional water from alluvial aquifers, may be worth separate consideration if relatively small contributions are needed for specific needs within the water supply network.

**Table F-2: Constraints**

| Option | Technical/physical constraints | Sustainability constraints |
|---|---|---|
| 1a. Maximise existing Lumley Park source | Limited pump testing indicates that the Lumley Park well is a good source, but its sustainable yield has not been quantified. For this reason it is not certain that the well is capable of delivering the full licence capacity of 530 ML/y.<br><br>To reach the full licensed yield, it is likely that some refurbishment of the well and additional pumping and pipework would be necessary. | As the Lumley Park source has not been systematically assessed, it is not known at what point unacceptable drawdown in local water tables may occur.<br><br>As well as local groundwater abstractions for agriculture, the source is spatially but possibly not hydraulically associated with a number of identified GDEs (Brodie et al, 2002). The first of these is Lumley |

| Option | Technical/physical constraints | Sustainability constraints |
|---|---|---|
| | Groundwater at the Lumley Park Bores has been observed to vary from around 5 to 12 metres below ground level (mbgl) for GW081006 and from 23 to 47 mbgl in GW081005 (DNR, 2006). | Park itself, which is a rare rainforest remnant and which contains at least one spring that provides base flow to Maguires Creek, where a small melaleuca swamp community and another rainforest remnant with platypus live. Thus, the maximum capacity of the Lumley Park Bore may well be constrained by its currently unquantified level of interaction with local GDEs. |
| 1b. Maximise existing Woodburn source | The Woodburn Source is currently constrained by numerous technical issues, not least the imminent need to re-site the bores and associated treatment facilities due to re-routing of the Pacific Highway.<br><br>Besides re-siting of the bore-field system, a number of upgrades to treatment would be required in order to enable the facility to meet its licence capacity, briefly discussed in Rous Water (undated).<br><br>It will be essential to undertake groundwater hydrology studies to re-establish the Woodburn bore-field in a suitable location.<br><br>Groundwater is generally found at depths of less than 10 mbgl in coastal sand aquifers. | Coastal aquifers are generally shallow and are therefore often in intimate hydraulic connection with local waterways and ecosystems.<br><br>The sustainability of a coastal aquifer bore field on the north coast will be constrained by the ways that it is connected to GDEs, by the risks of oxidising potential acid sulfate soils and of inducing increased saline intrusion into the aquifer. All of these potential interactions need to be understood in order to confirm the sustainable limits of abstraction. |
| 2a. Locate and prove new sources in tertiary fractured aquifers (basalt) | Key technical issues in finding new hard-rock sources will be locating suitable aquifers. The most suitable aquifers will be at least partially confined, heavily fractured and, in the case of basalt aquifers, are also likely to be vesicular and connected to palaeo-soil surfaces.<br><br>Each new hard-rock source is likely to require a land-take of approximately 40 $m^2$, not including treatment area which may or may not be at the source site, nor access roads. | In order to allow licensing of high-volume supply wells in hard-rock aquifers, and particularly in the Alstonville Plateau Basalt Aquifer, the nature of interactions between the new source and other groundwater users, including the environment will need to be understood. This will necessitate test pumping and monitoring in the potentially impacted receptors, e.g. other wells and surface water levels. If appropriate, and subject to the restrictions within the WSP, entitlements from the Convery's Lane licence could be transferred to a new source in this area. |
| 2c. Locate and prove new sources in coastal sand aquifers | The technical issues involved in finding and developing new coastal sand aquifers are similar to those of relocating the Woodburn bore-field described under point 1b. above.<br><br>An opportunity exists to broaden the Woodburn bore field relocation study | The sustainability issues of new coastal sand aquifers are the same as those described under point 1b. above. |

| Option | Technical/physical constraints | Sustainability constraints |
|---|---|---|
| | to cover the coastline from Byron Bay south to Woodburn to find the most suitable locations and potential yields available at these prospective sites. If appropriate, entitlements from the Woodburn licence could be transferred to a new site.<br><br>Each new bore-field is likely to require an area of approximately 0.5 Ha, which may include treatment facilities if needed to be located on-site. The size of the bore-field will be largely a function of permeability, allowing a number of wells to operate simultaneously without undue interference and causing unacceptable drawdowns in each well. | |
| 3. MAR schemes in coastal sand aquifers | The biggest technical constraint on a coastal sand-hosted MAR scheme is likely to be locating a suitable source of water, either from summer surface flows or treated stormwater/sewage effluent.<br><br>Another key technical constraint on designing and operating a MAR scheme in coastal sand aquifers is that natural groundwater flows need to be low enough that the injected / irrigated water will remain within the aquifer to be recovered at a later date.<br><br>A MAR scheme in coastal sands is likely to require a similar land-take as a primary bore-field in Point 2b above. | In order to run a MAR scheme sustainably, particularly where the injected or irrigated water is sourced from treated effluent, it is necessary to understand the dynamics of the aquifer closely, necessitating significant testing and modelling of groundwater behaviour and implementation of an adaptive management regime (Punthakey and Woolley, 2012). |
| 3b. MAR schemes in bedrock aquifers | The biggest technical constraint on operating a MAR scheme in local bedrock aquifers is finding a sufficiently permeable aquifer to make injection cost-effective.<br><br>Water harvested from surface-water streams or bank-infiltrated sources would be the most suitable source of water.<br><br>A MAR scheme in hard-rock aquifers is likely to require a similar land-take as a primary bore in Point 2a above. | The key sustainability constraint for bedrock aquifers is that the interactions between the aquifer and local groundwater users, including environmental receptors, are well understood. Drawdown in the production well(s) can then be restricted to the point where unacceptable impacts on other users won’t occur. |

**Table F-3: Benefits**

| Option | Potential Volumes | Other Benefits |
|---|---|---|
| 1a. Maximise existing Lumley Park source | If all infrastructure and sustainability constraints were resolved, it would be legally possible to harvest the full licensed capacity of the Lumley Park bore, which is 530 ML/y.<br><br>In reality, it is likely that the well would maintain less than this, but should be at least 250 ML/y and may be up to 500 ML/y based on currently available indications. | As Lumley Park bore is already established, infrastructure costs to re-commission and maximise abstraction would be relatively low (see Table below).<br><br>Further, the basalt aquifer has significant storage capacity and thus maximisation of this source would make Rous Water's supplies more drought-resilient than at present. |
| 1b. Maximise existing Woodburn source | In its internal report on the options of rehabilitating the Woodburn, Rous Water (undated) estimates that each of the three licensed bores could deliver around 1 ML/d, which equates to a maximum technical yield of around 1,000 ML/y if there were sufficient demand for the water. However, it is unrealistic to run the bore field so continually and a more appropriate maximum yield is estimated at around 640 ML/y. This is substantially higher than the 242 ML/y for which the bore-field is currently licensed.<br><br>Based on the current regulatory regime, it appears reasonable to estimate that NOW would accept a well-researched application to increase the licence capacity of this source to at least 500 ML/y. | Although it has lain idle for some time and is in need of upgrade if the source is to be brought back into service, the existing pipework and treatment plant at Woodburn is of value and would thus lessen the cost of implementation relative to establishing a new bore-field and treatment system. |
| 2a. Locate and prove new sources in tertiary fractured aquifers (basalt) | The basalt aquifers of the North Coast are highly productive. For the same reason however, they are already heavily exploited particularly within Zones 1 and 2 of the Alstonville Water Source.<br><br>With sufficient exploration drilling and proving of aquifer sustainability characteristics, it appears reasonable to estimate that at least two and up to five new basalt-aquifer bores could be developed at locations accessible to existing pipework, each contributing up to 500 ML/y to Rous Water's target supplies. | As there is substantial storage in these aquifers, the basalt aquifer supplies are relatively robust during drought periods, and thus these new sources would potentially make Rous Water's supplies significantly more drought-resilient than at present. |
| 2c. Locate and prove new sources in coastal sand aquifers | Experience at Hat Head (Punthakey and Woolley, 2012) and Woodburn (Rous Water, undated) confirms that plentiful groundwater supplies are available within the regional coastal aquifers. However, there are substantial water quality and | A key benefit of coastal-sand aquifers is that they are found close to both Ballina and Byron Bay. It may well be possible to locate suitable bore-fields that, with sufficient treatment on-site, could greatly reduce current energy costs of supplying these two centres. |

| Option | Potential Volumes | Other Benefits |
|---|---|---|
| | sustainability issues associated with these aquifers<br><br>With sufficient exploration drilling and proving of aquifer sustainability characteristics, it appears reasonable to estimate that at least two and up to three new coastal aquifer bores could be developed at locations close to major demand centres, each contributing up to 1,000 ML/y to Rous Water's target supplies. | |
| 3a. ASR schemes in coastal sand aquifers | The key volume constraint on establishing a large-scale ASR scheme in the north-coast is finding a suitable water supply near a suitable coastal aquifer.<br><br>The Alstonville Reclaimed Water Scheme provides a useful benchmark of the type of water volumes which might be available for a MAR scheme. In this scheme, where treated effluent is irrigated on farmland above basalt soils, approximately 450 ML/y is being applied.<br><br>On this basis, it is tentatively estimated, contingent on being able to find a suitable water source and aquifer and meeting the many technical, social and institutional challenges that may arise, that a single ASR scheme might be developed in coastal aquifers with a harvestable yield of 200 to 500 ML/y. | There are significant environmental benefits in irrigating or injecting treated effluents into a coastal aquifer rather than disposing of them into a local waterway. The types of ecosystems found on coastal aquifers include melaleuca and other types of wetlands, and have large natural capacities for assimilating nutrients and attenuating pathogens, as demonstrated at West Byron STP treatment |
| 3b. ASR schemes in bedrock aquifers | Again, the key constraint for a MAR scheme in a bedrock aquifer will be locating a sustainable source of water not otherwise already exploited, for example excess wet-season flows in rivers.<br><br>If a suitable source of water could be found and licensed, it is estimated that implementation of a hard-rock MAR scheme in the region could potentially result in an additional 100-500 ML/y.<br><br>MAR schemes in bedrock aquifers are more expensive to implement due mainly to the energy and infrastructure involved in injecting the water into the aquifer. | A key benefit of a hard-rock MAR scheme is that it can be run to provide additional drought-resilience to Rous Water's overall supplies. |

## Next steps

The steps required to bring the identified options through to implementation vary depending on the option, and are summarised in Table F-4.

**Table F-4: Groundwater options development next steps**

| Option | Steps Required to Implement Option |
|---|---|
| 1a. Maximise existing Lumley Park source | CCTV survey to establish condition of well<br>Cleaning / redevelopment of well by suitable method<br>Pump-testing to enable assessment of sustainable yield<br>Upgrade of pump and other infrastructure that may be constraining yield |
| 1b. Replace existing Woodburn source | Investigate suitable sites around Woodburn Source<br>Relocate wellfield to avoid interference with highway upgrade works<br>Install new wells, salvage existing pumps and headworks and replace where necessary<br>Pump-test new wellfield and assess sustainable output. Apply for adjusted licence if required.<br>Upgrade treatment systems if required |
| 2a. Locate and prove new sources in tertiary fractured aquifers (basalt) | Undertake detailed desk study to locate most prospective and convenient well locations.<br>Drill 2-5 new sources plus monitoring wells, with pumps & headworks<br>Pump testing to confirm sustainable yield, likely to require multi-day testing programmes at each location, may need to drill new monitoring wells if no existing ones suitable.<br>Apply for licence for each source, based on interpretation of pump testing results. Depending on site sensitivities, e.g. proximity to GDEs, may need to undertake numerical modelling (MODFLOW or similar).<br>May need to install site pre-treatment, along with new headworks and site infrastructure. |
| 2c. Locate and prove new sources in coastal sand aquifers | Undertake detailed desk study to locate most prospective and convenient well locations.<br>Drill 2-3 new well-fields plus monitoring wells.<br>Investigate relationship of each well-field with GDEs, saline waters and acid-sulphate soils.<br>Pump testing to confirm sustainable yield, likely to require multi-day testing programmes at each location.<br>Apply for licence for each source, based on interpretation of pump testing results. Interpretation will need to include numerical modelling to determine interactions with GDEs, coastal salinity and acid-sulphate soil deposits.<br>May need to install site pre-treatment, along with new headworks and site infrastructure.<br>Some site pre-treatment |

| Option | Steps Required to Implement Option |
|---|---|
| | Modelling, reporting and application for licences |
| 3a. MAR schemes in coastal sand aquifers | Undertake detailed desk study to locate most prospective and convenient MAR locations.<br>Drill single new recharge well-field plus monitoring wells, with pumps & headworks.<br>Undertake detailed pump testing to confirm sustainable yields and relationship between MAR well and aquifer.<br>Undertake extensive flow and water quality modelling, reporting and application for licences |
| 3b. MAR schemes in bedrock aquifers | Undertake detailed desk study to locate most prospective and convenient MAR locations.<br>Drill single new recharge well-field plus monitoring wells, with pumps & headworks.<br>Undertake detailed pump testing to confirm sustainable yields and relationship between MAR well and aquifer.<br>Undertake extensive flow and water quality modelling, reporting and application for licences |

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# G Financial modelling (FINMOD)

# Rous Water

## Financial Assessment of Future Water Strategy Scenarios

12-043

July 2013

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**PROJECT 12-043– ROUS WATER FWS FINMOD ASSESSMENT**

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## CONTENTS

1. INTRODUCTION 1

2. METHODOLOGY 1

3. FWS SCENARIOS 3

4. EXPENDITURE 3

5. FUNDING 5

6. SCENARIO OUTPUTS 6

7. COMPARISON OF SCENARIOS 11

APPENDIX 1: SCENARIO OUTPUTS 17

## FIGURES

Figure 1: Comparison of capital works expenditure for 2013 Base Case and FWS Control Case 2

Figure 2: Required Income (Dollar Yield), Cash & Investments and Borrowings (FWS Control Case) 2

Figure 3: Comparison of Capital Works Expenditure – 5/10/10 scenarios 3

Figure 4: Comparison of Capital Works Expenditure – 5/15/15 scenarios 4

Figure 5: Comparison of OMA Expenditure – 5/10/10 scenarios 4

Figure 6: Comparison of OMA Expenditure – 5/15/15 scenarios 5

Figure 7: Business as Usual Scenario 7

Figure 8: Scenario 2-A: Staged Dunoon Dam (5/10/10) 7

Figure 9: Scenario 3-A: Extended Groundwater (5/10/10) 8

Figure 10: Scenario 4-A: Indirect Potable Reuse (5/10/10) 8

Figure 11: Scenario 5-A: Deferred Desalination (5/10/10) 9

Figure 12: Scenario 2-B: Staged Dunoon Dam (5/15/15) 9

Figure 13: Scenario 3-B: Extended Groundwater (5/15/15) 10

Figure 14: Scenario 4-B: Indirect Potable Reuse (5/15/15) 10

Figure 15: Scenario 5-B: Deferred Desalination (5/15/15) 11

Figure 16: Comparison of Dollar Yield Required – 5/10/10 scenarios 11

Figure 17: Comparison of Cash and Investments – 5/10/10 scenarios 12

Figure 18: Comparison of New Loans Required – 5/10/10 scenarios 12

Figure 19: Comparison of Borrowings – 5/10/10 scenarios 13

Figure 20: Comparison of Dollar Yield Required – 5/15/15 scenarios 13

Figure 21: Comparison of Cash and Investments – 5/15/15 scenarios 14

Figure 22: Comparison of New Loans Required – 5/15/15 scenarios 14

Figure 23: Comparison of Borrowings – 5/15/15 scenarios 15

# 1. INTRODUCTION

This report provides the results of the financial analysis of the Rous Water Future Water Strategy (FWS) scenarios.

The aim of this report is to provide information to Rous Water on the impact of the proposed expenditure program for each scenario on the required revenue to be recovered through bulk supply charges.

# 2. METHODOLOGY

A financial model was developed for the Rous Water bulk water supply fund in 2009 using FINMOD, the financial planning software developed by the NSW Office of Water for use by non-metropolitan water utilities. This model is updated by Rous Water annually.

The model prepared for the 2013/14 financial planning review (2013 Base Case) has been used to develop the FINMOD cases for the FWS scenarios. The 2013 Base Case has been modified to provide a FWS "Control Case" as follows:

- Removed FWS Capex allowance of $500k p.a. 2014-2023 ($5m);
- 30 year CWP modifications (delay in expenditure in years 4-6) to result in nil new loans;
- Extended to 50 year model (2013-2063) – results up to 2060 will be reported here;
- CWP for years 31-50 set as average of years 1-30;
- OMA expenditure for years 31-50 set as equivalent to year 30; and
- Minimum cash and investments = $2m.

The FWS Control Case represents the adopted financial position (i.e. excluding any future expenditure on the FWS). The resulting capital works program is shown in Figure 1 compared to the 2013 Base Case. The required dollar yield, cash and investments and borrowing for the FWS Control Case are shown in Figure 2.

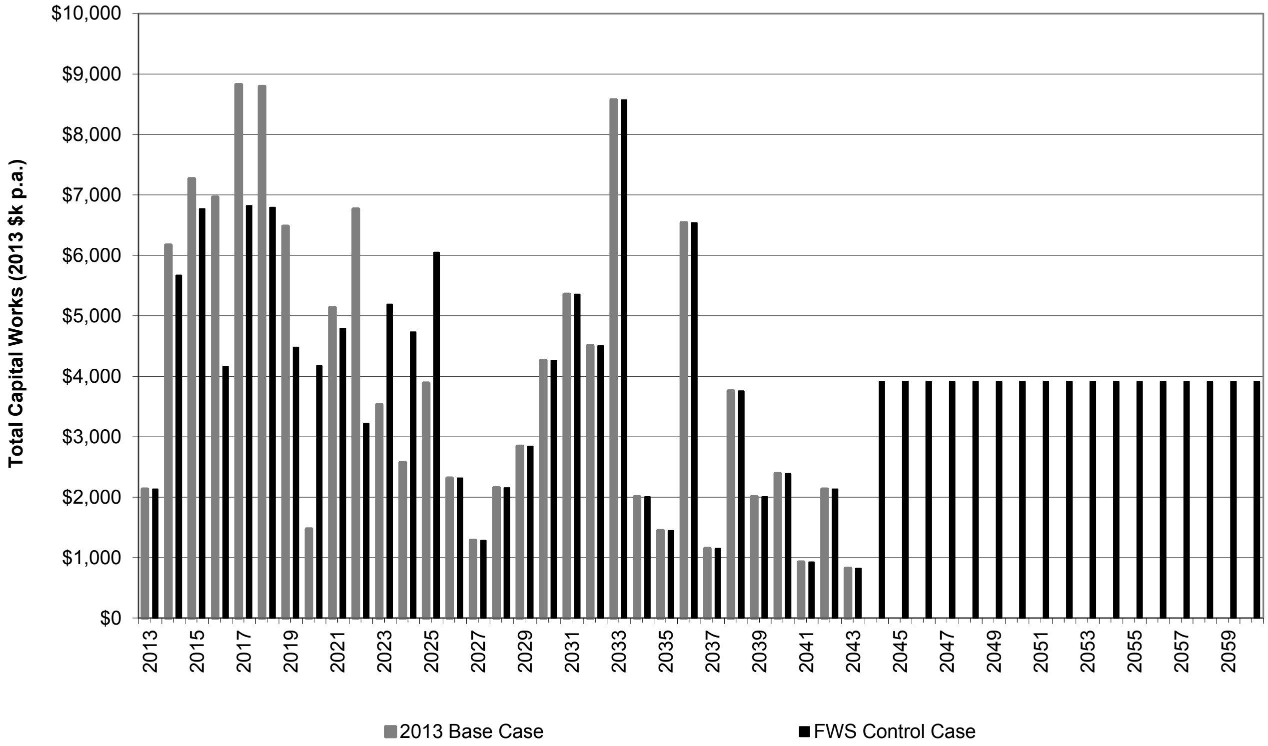


**Figure 1: Comparison of capital works expenditure for 2013 Base Case and FWS Control Case**

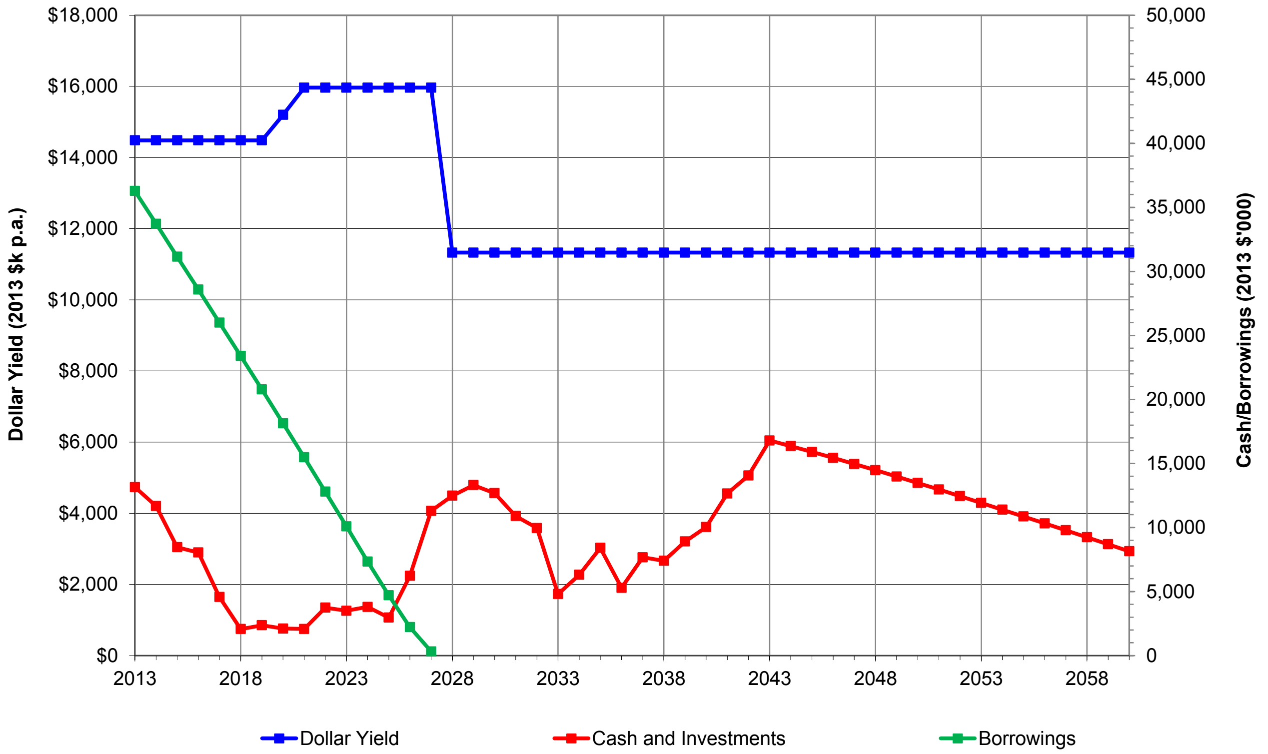


**Figure 2: Required Income (Dollar Yield), Cash & Investments and Borrowings (FWS Control Case)**

# 3. FWS SCENARIOS

The FWS scenarios are:

- Scenario 1: Business as Usual (50,000ML Dunoon Dam by 2024);
- Scenario 2: Staged Dunoon Dam;
- Scenario 3: Extended groundwater;
- Scenario 4: Indirect potable reuse; and
- Scenario 5: Deferred desalination.

Supply scenarios 2 to 5 have been assessed with two different drought restriction protocols based on the 5/10/10 rule ("A" scenarios) and 5/15/15 rule ("B" scenarios).

# 4. EXPENDITURE

Rous Water's FWS consultant, MWH, has provided data on the net change in capital expenditure and operating expenditure for the FWS scenarios as well as the timing of the expenditure. No financial optimisation has been undertaken as part of the FINMOD assessment. For each scenario, the net change in capital expenditure and operating expenditure has been added to the FWS Control Case to create the FWS scenario cases.

A comparison of the total capital works and OMA expenditure for each FWS scenario case is given in the following figures.

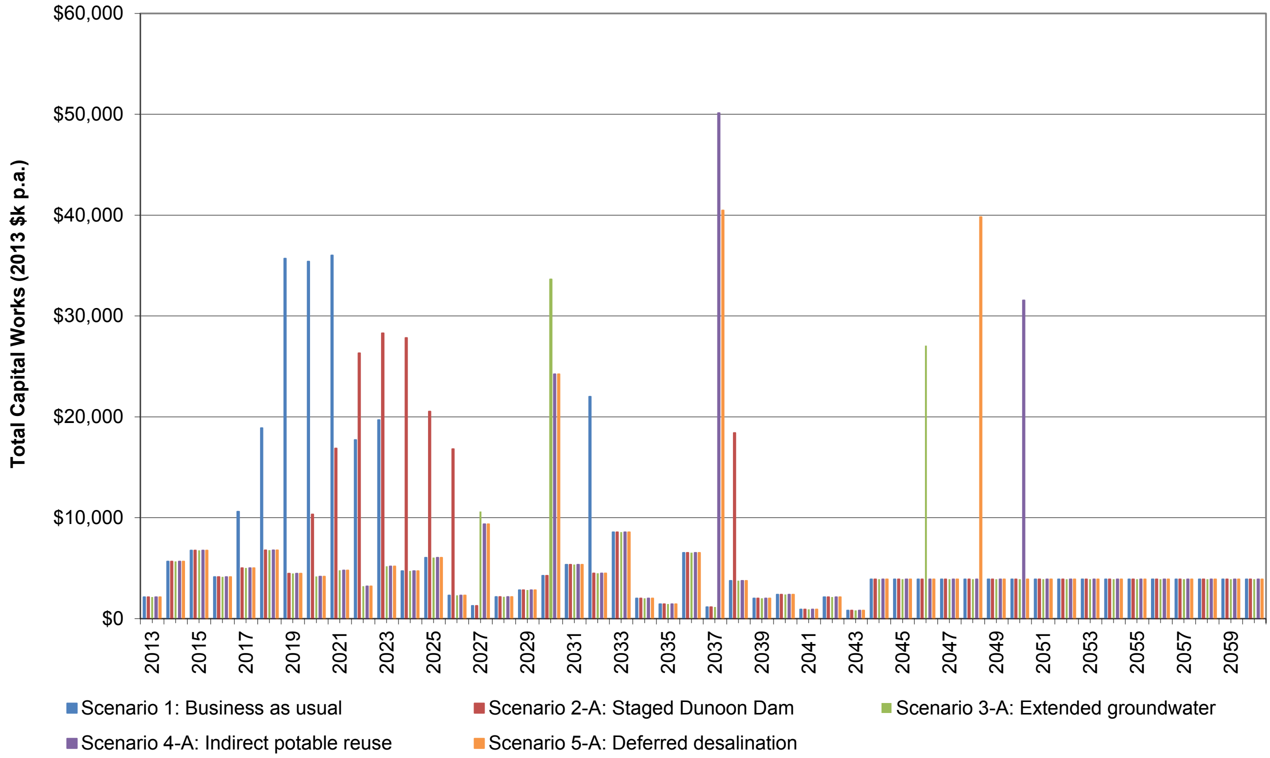


**Figure 3: Comparison of Capital Works Expenditure – 5/10/10 scenarios**

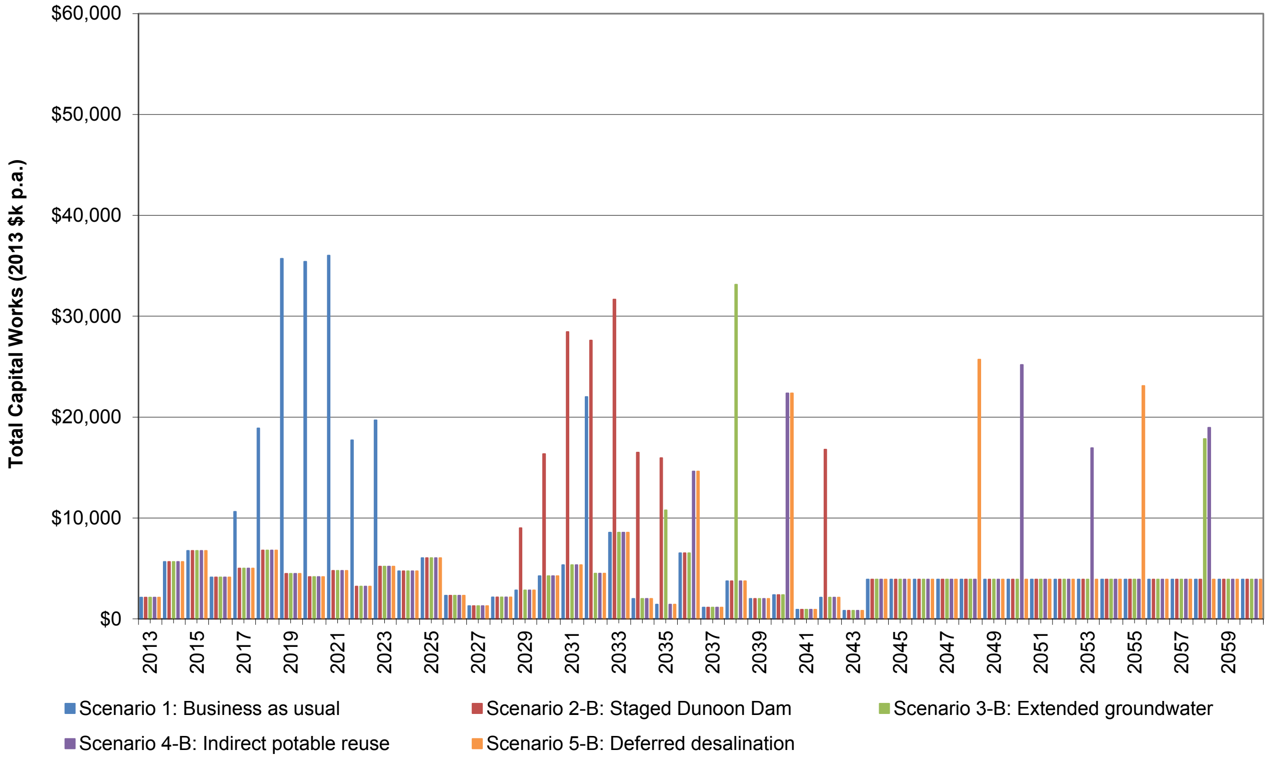


**Figure 4: Comparison of Capital Works Expenditure – 5/15/15 scenarios**

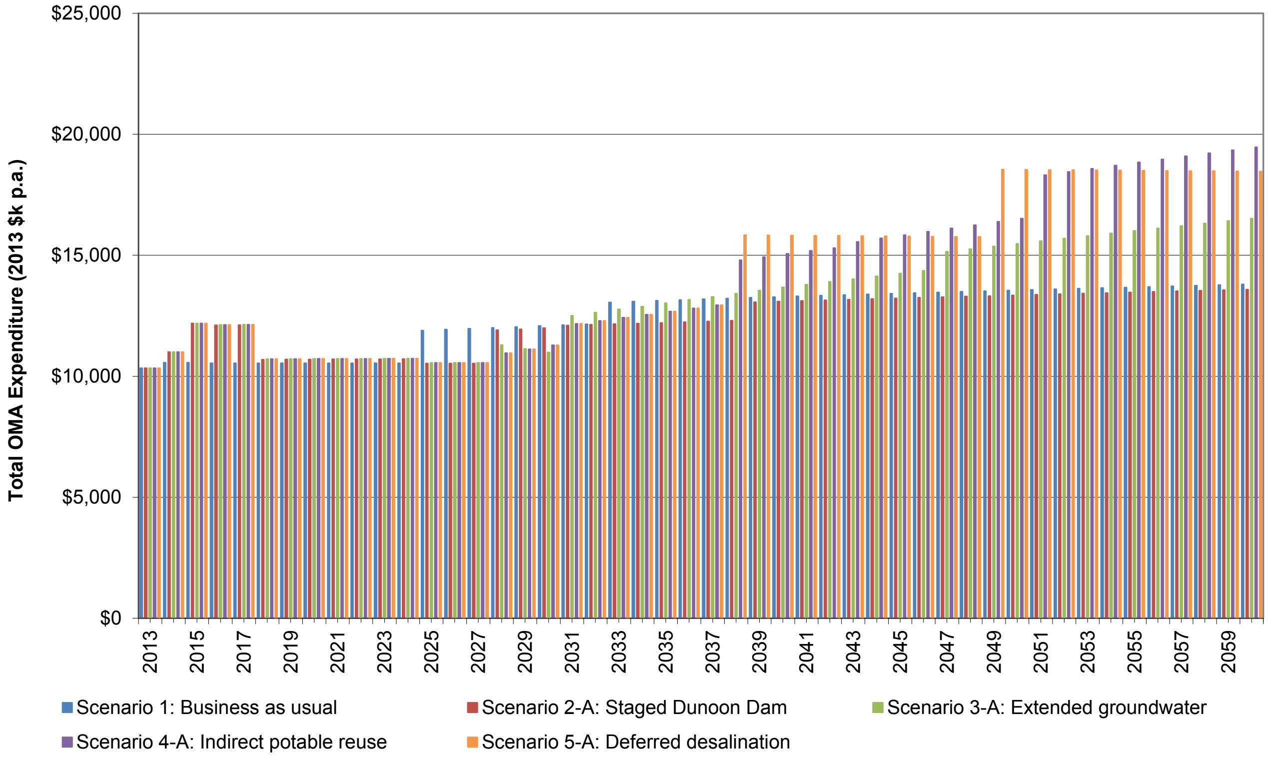


**Figure 5: Comparison of OMA Expenditure – 5/10/10 scenarios**

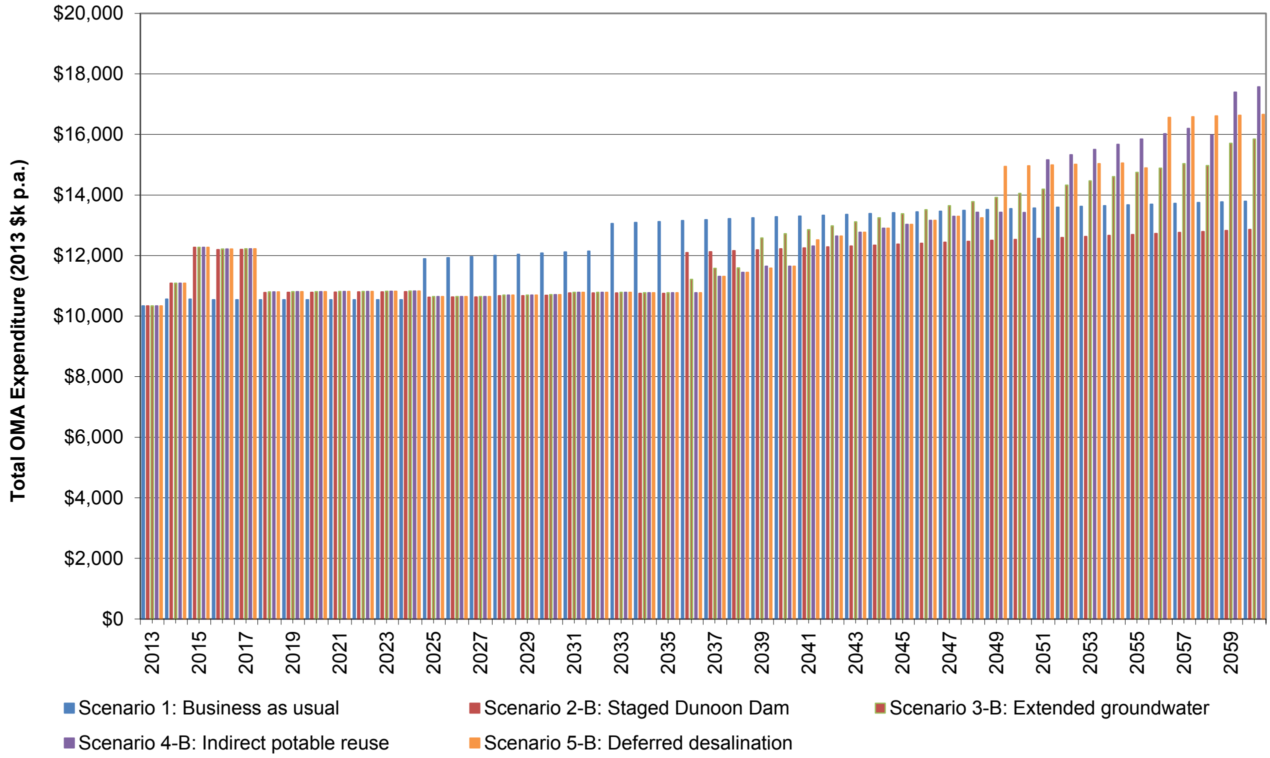


**Figure 6: Comparison of OMA Expenditure – 5/15/15 scenarios**

## 5. FUNDING

Where possible, the capital works programs and recurrent expenditure is funded through existing cash levels which is determined by the amount of revenue received from the Constituent Councils (dollar yield) and retail customers. Where planned expenditure exceeds the available cash levels, loans are required. A minimum cash level of $2.0m has been maintained for the fund in each case.

Different loan structures can be modelled in FINMOD. All cases presented in this report assume conventional loans (principal amortised over life of loan with regular principal and interest repayments at 8% p.a.). The term of the loan has been set according to the size of the loan (or group of loans) required to fund each major project as shown in Table 1. Loans greater than $40m are assumed to require a 50 year term and loans less than $40m are assumed to require a 20 year term. Modifications to the loan structure can be made to optimise the borrowings if required.

**Table 1: Loan Assumptions**

| Scenario | Major Project | Year | Total Loan Required (2013 $'000) | Term of Loan (years) [1] |
|---|---|---|---|---|
| 1: Business as Usual | Dunoon Dam and transfer system | 2019 – 2023 | 123,000 | 50 |
| | NC WTP Upgrade | 2032 | 14,000 | |
| 2-A: Staged Dunoon Dam | Dunoon Dam and transfer system | 2022 – 2026 | 86,500 | 50 |
| | NC WTP Upgrade | 2038 | - | |
| 3-A: Extended groundwater | Woodburn groundwater | 2027 | - | 20 |
| | Coastal sands groundwater | 2030 | 18,000 | |
| | Fractured basalt groundwater | 2046 | 10,000 | |

| Scenario | Major Project | Year | Total Loan Required (2013 $'000) | Term of Loan (years) [1] |
|---|---|---|---|---|
| 4-A: Indirect potable reuse | Woodburn groundwater | 2027 | - | 20 |
| | Coastal sands groundwater | 2030 | 10,000 | |
| | Lennox/Ballina STPs | 2037 | 34,000 | |
| | Alstonville STP | 2050 | 12,000 | |
| 5-A: Deferred desalination | Woodburn groundwater | 2027 | - | 20 |
| | Coastal sands groundwater | 2030 | 10,000 | |
| | Desalination | 2037 | 31,000 | |
| | Desalination | 2048 | 30,000 | |
| 2-B: Staged Dunoon Dam (5/15/15) | Dunoon Dam and transfer system | 2031 – 2035 | 75,000 | 50 |
| | NC WTP Upgrade | 2042 | - | |
| 3-B: Extended groundwater (5/15/15) | Woodburn groundwater | 2035 | - | - |
| | Coastal sands groundwater | 2038 | - | |
| | Fractured basalt groundwater | 2058 | - | |
| 4-B: Indirect potable reuse (5/15/15) | Woodburn groundwater | 2036 | - | - |
| | Coastal sands groundwater | 2040 | - | |
| | Lennox/Ballina STPs | 2050 | - | |
| | Alstonville STP | 2058 | - | |
| 5-B: Deferred desalination (5/15/15) | Woodburn groundwater | 2036 | - | - |
| | Coastal sands groundwater | 2040 | - | |
| | Desalination | 2048 | - | |
| | Desalination | 2055 | - | |

1. The default option is the same term for each loan in each scenario. Modifications to the loan structure can be made to optimise the borrowings if required.

# 6. SCENARIO OUTPUTS

Each scenario has been modelled with the results shown in the following figures (capital works, new loans required and dollar yield required).

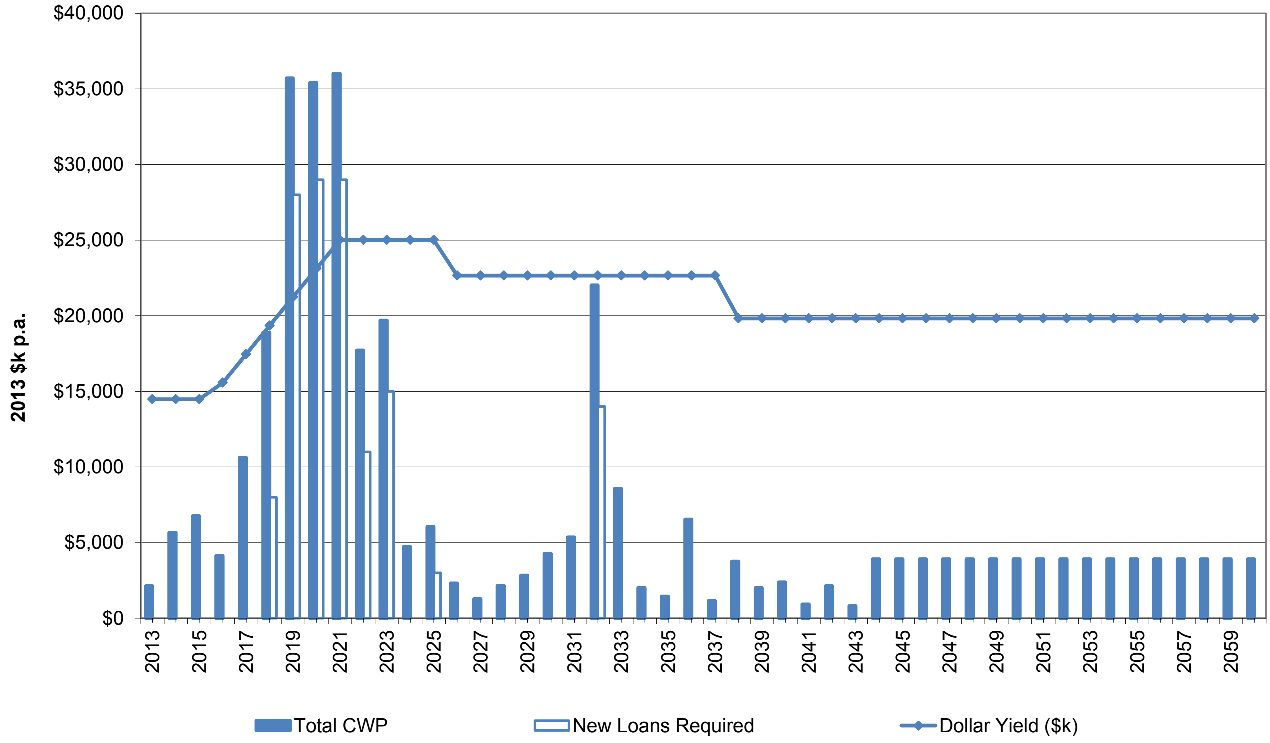


**Figure 7: Business as Usual Scenario**

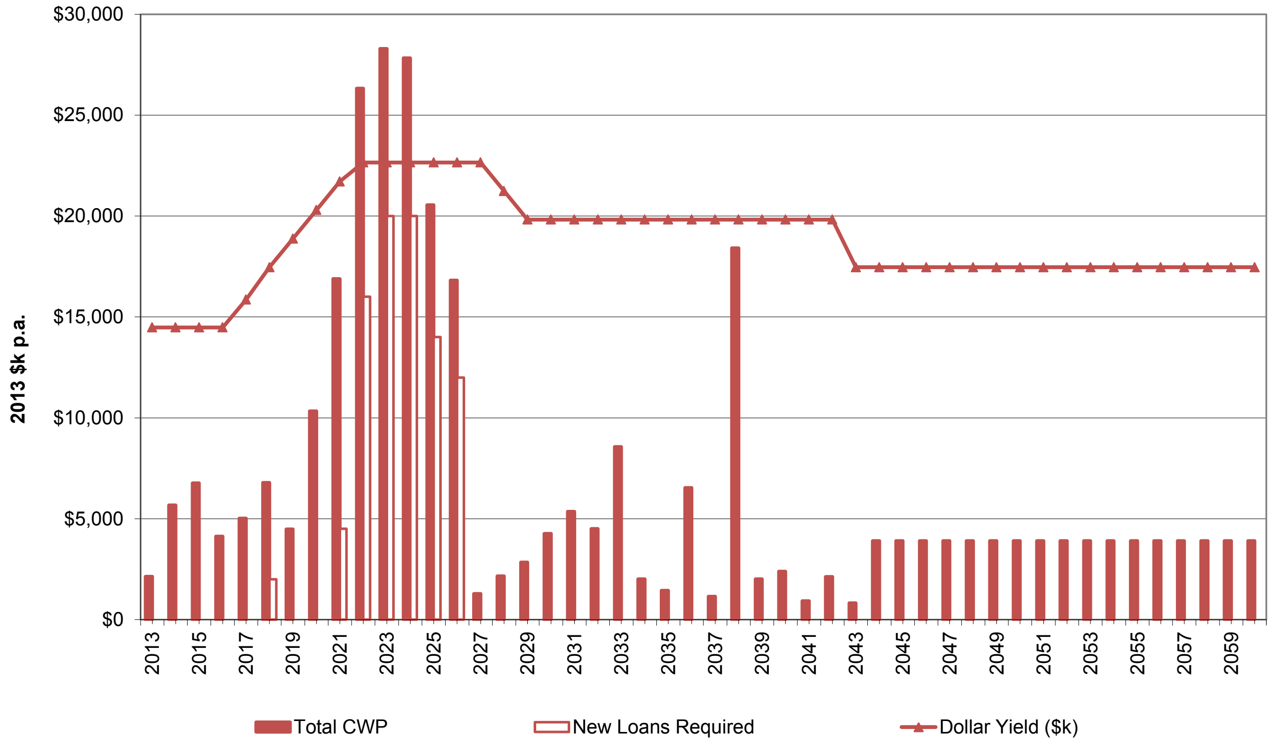


**Figure 8: Scenario 2-A: Staged Dunoon Dam (5/10/10)**

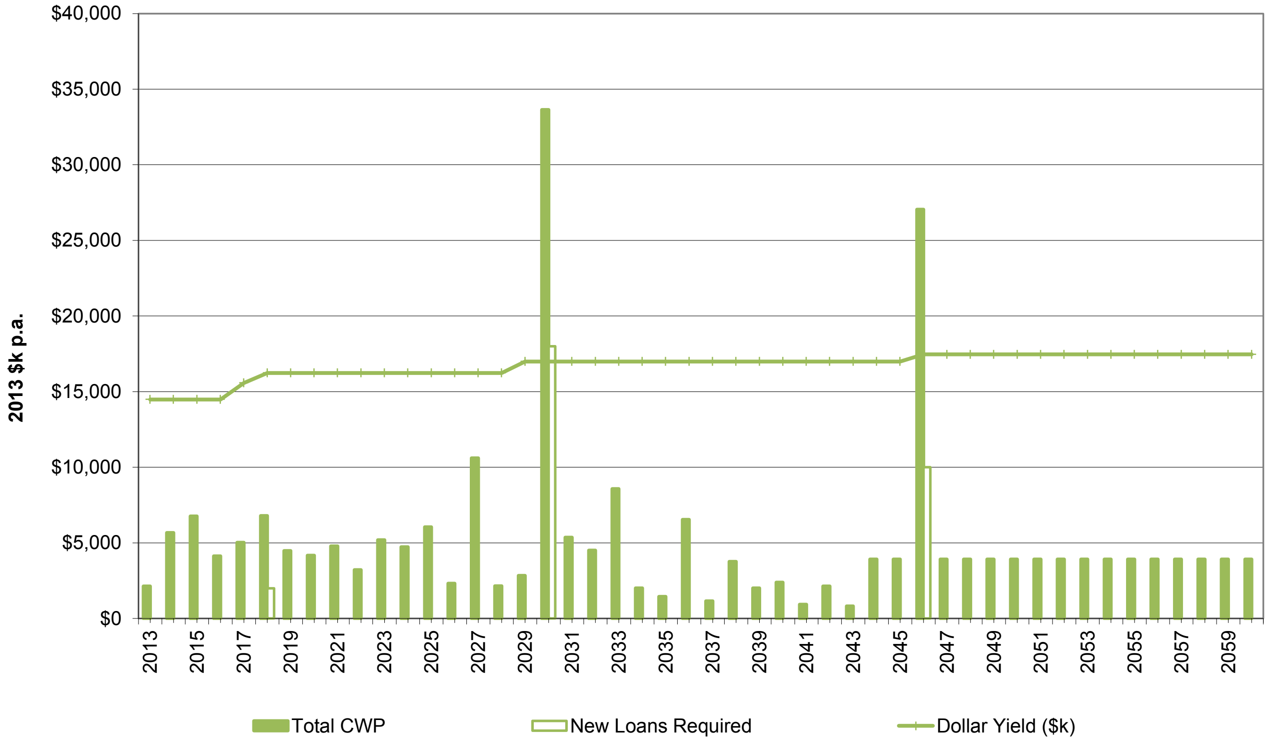


**Figure 9: Scenario 3-A: Extended Groundwater (5/10/10)**

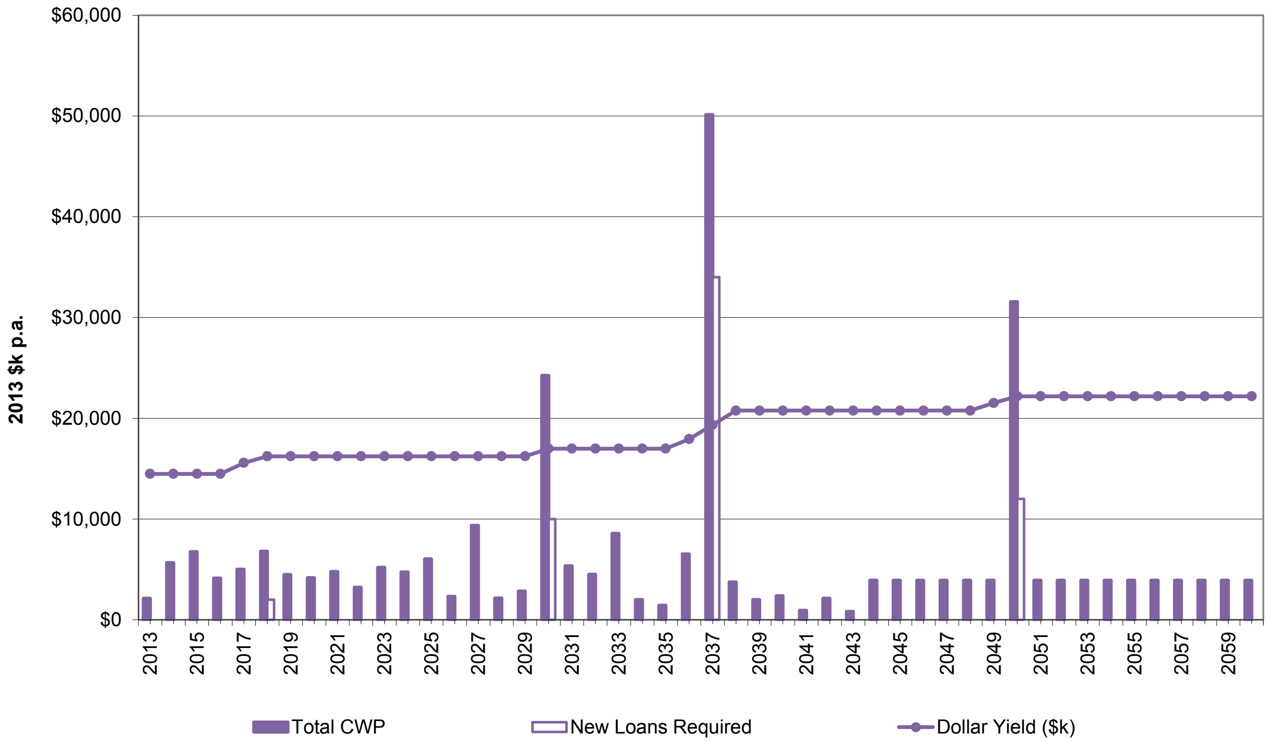


**Figure 10: Scenario 4-A: Indirect Potable Reuse (5/10/10)**

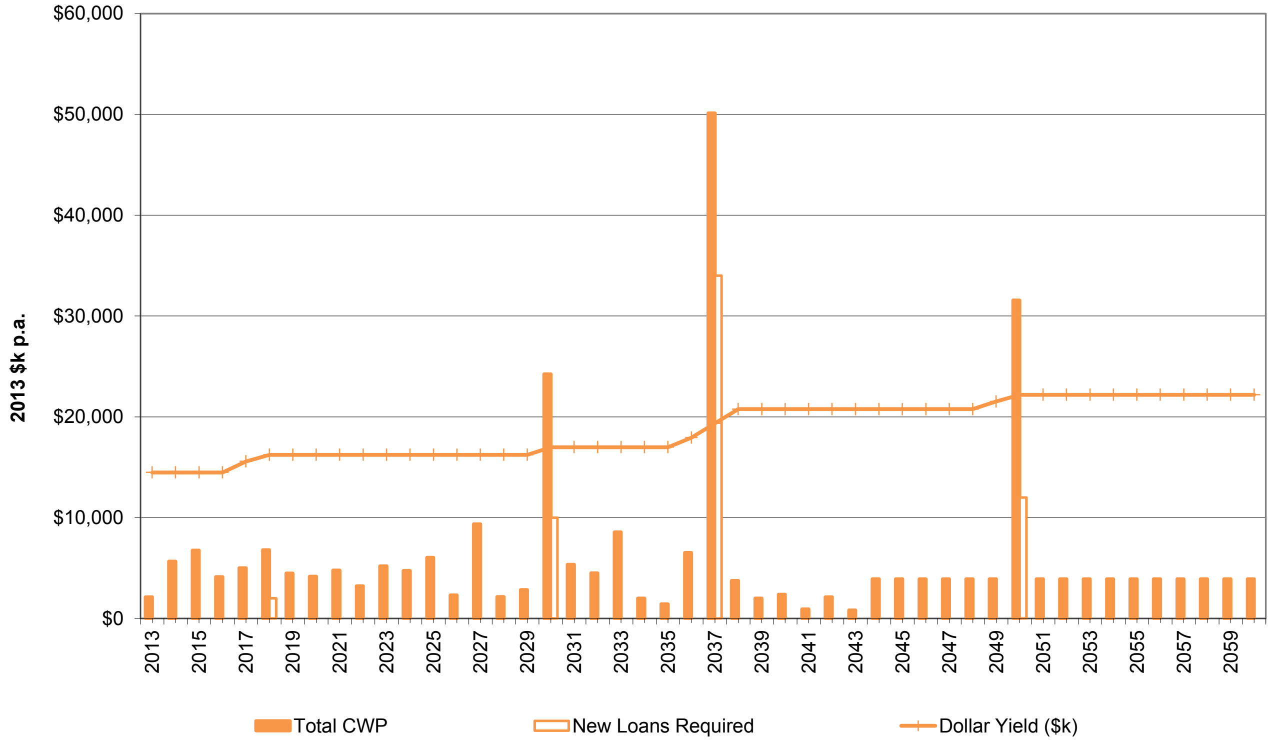


**Figure 11: Scenario 5-A: Deferred Desalination (5/10/10)**

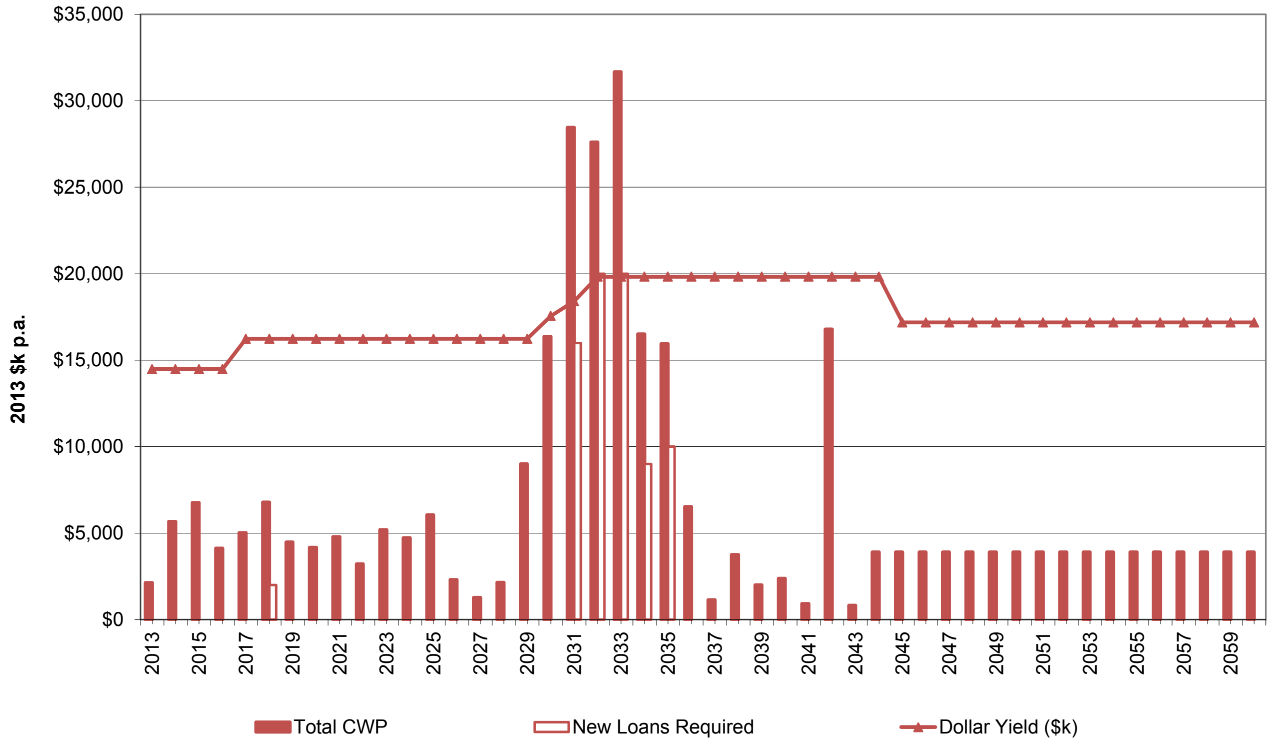


**Figure 12: Scenario 2-B: Staged Dunoon Dam (5/15/15)**

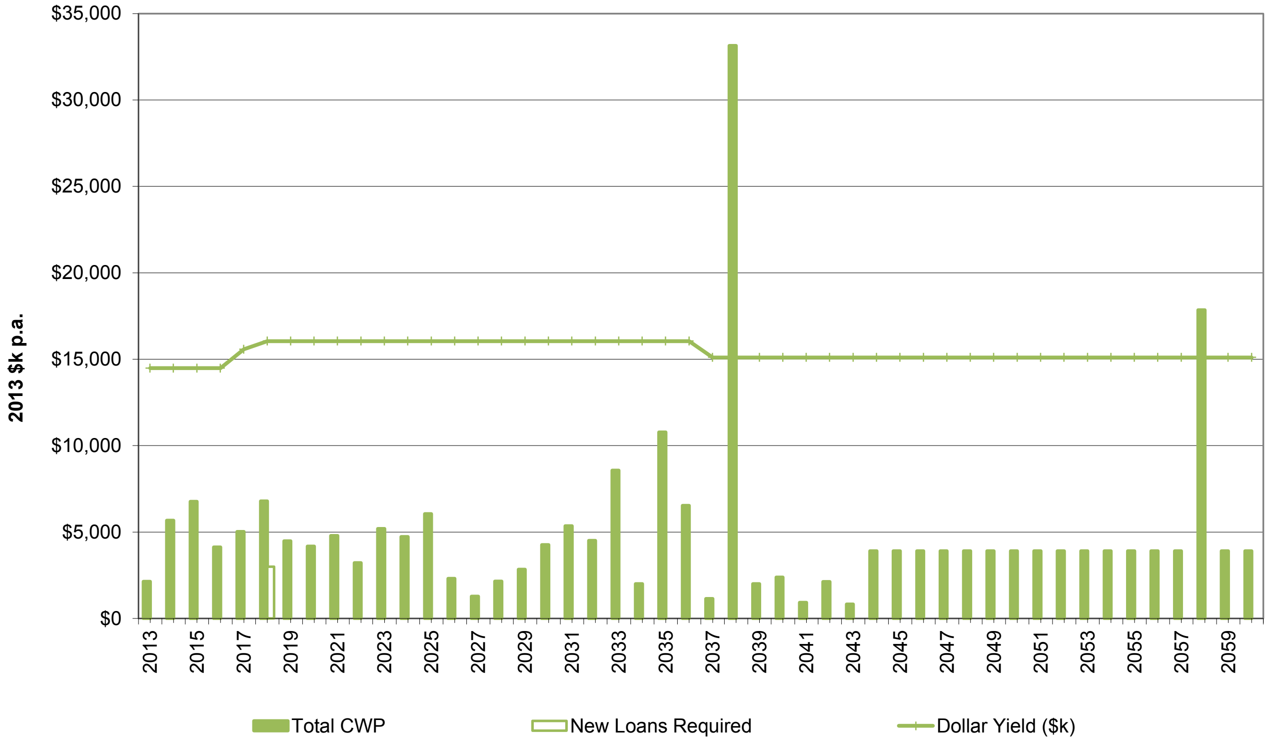


**Figure 13: Scenario 3-B: Extended Groundwater (5/15/15)**

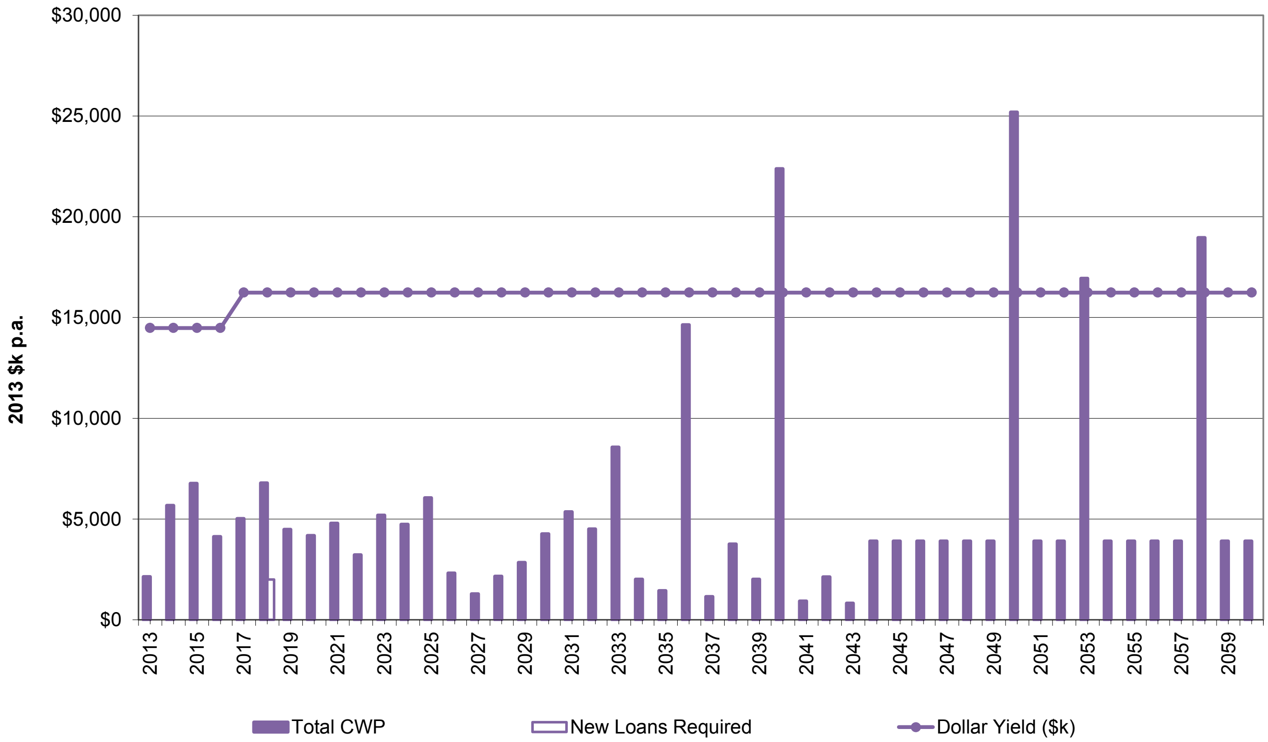


**Figure 14: Scenario 4-B: Indirect Potable Reuse (5/15/15)**

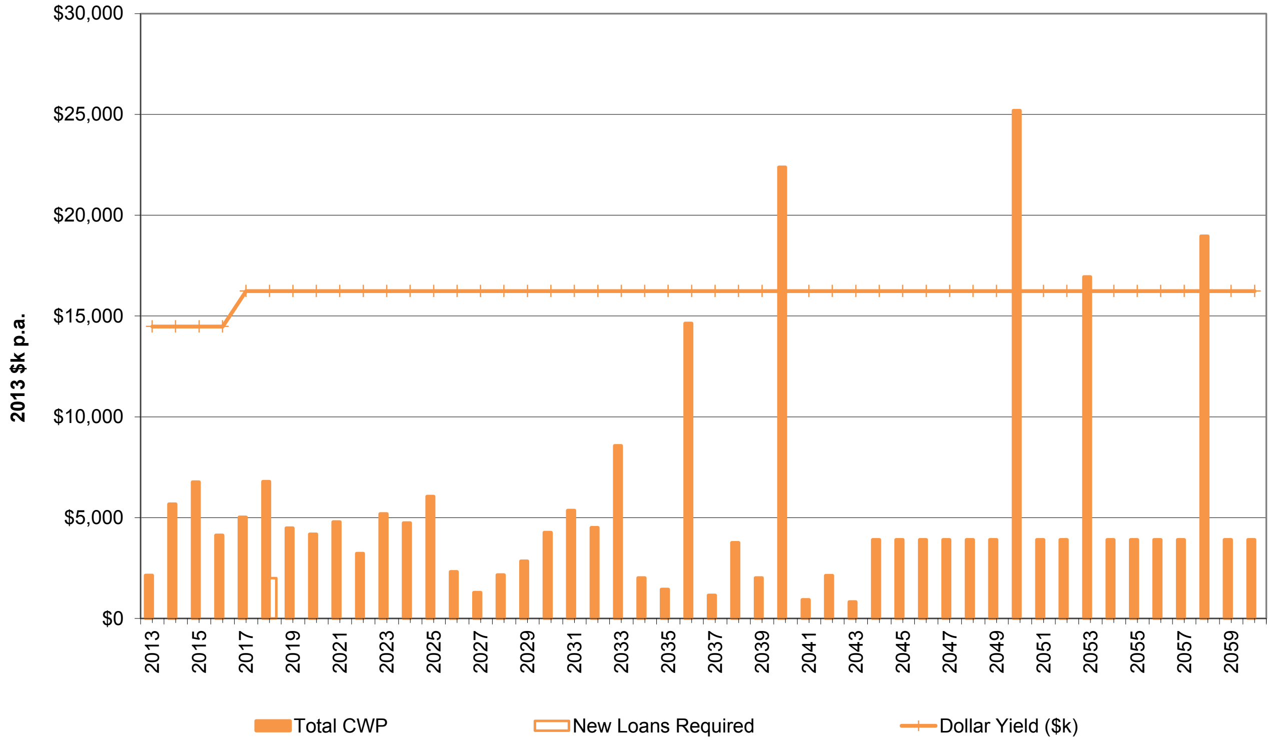


**Figure 15: Scenario 5-B: Deferred Desalination (5/15/15)**

# 7. COMPARISON OF SCENARIOS

Each scenario is compared in the following figures (new loans required, dollar yield required, cash and investments and borrowings outstanding).

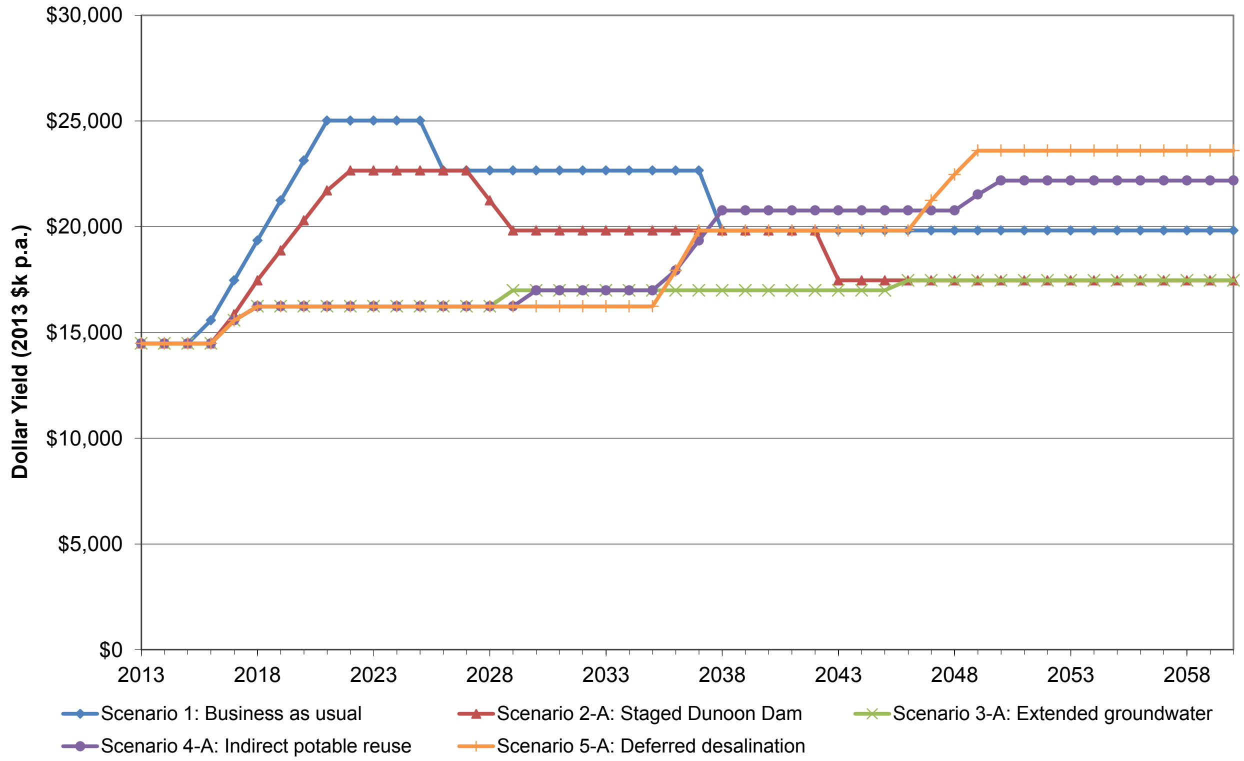


**Figure 16: Comparison of Dollar Yield Required – 5/10/10 scenarios**

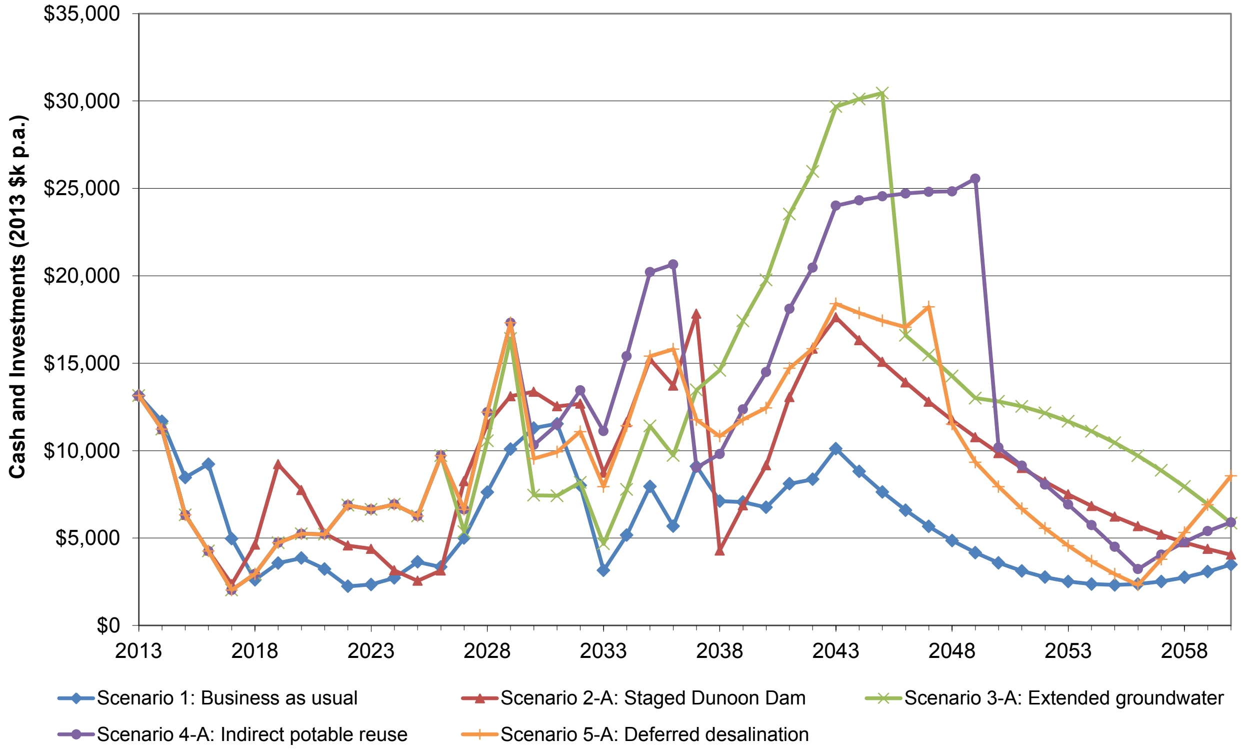


**Figure 17: Comparison of Cash and Investments – 5/10/10 scenarios**

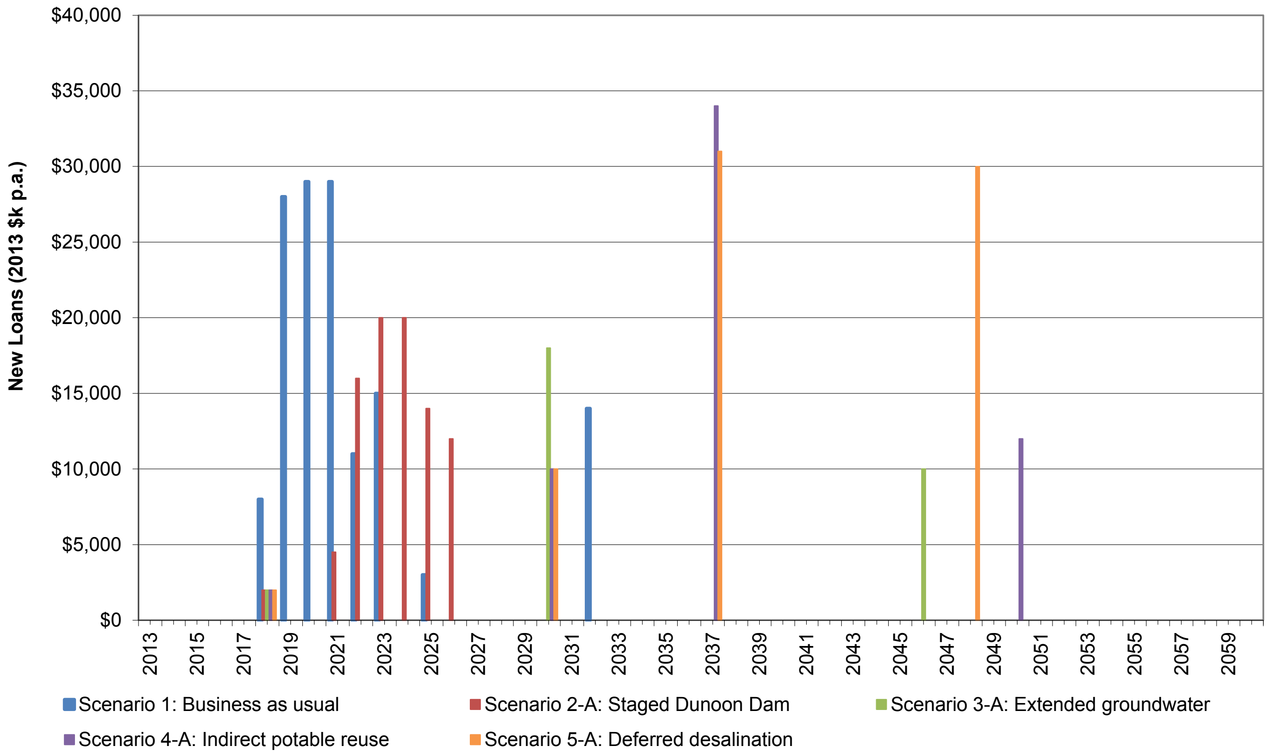


**Figure 18: Comparison of New Loans Required – 5/10/10 scenarios**

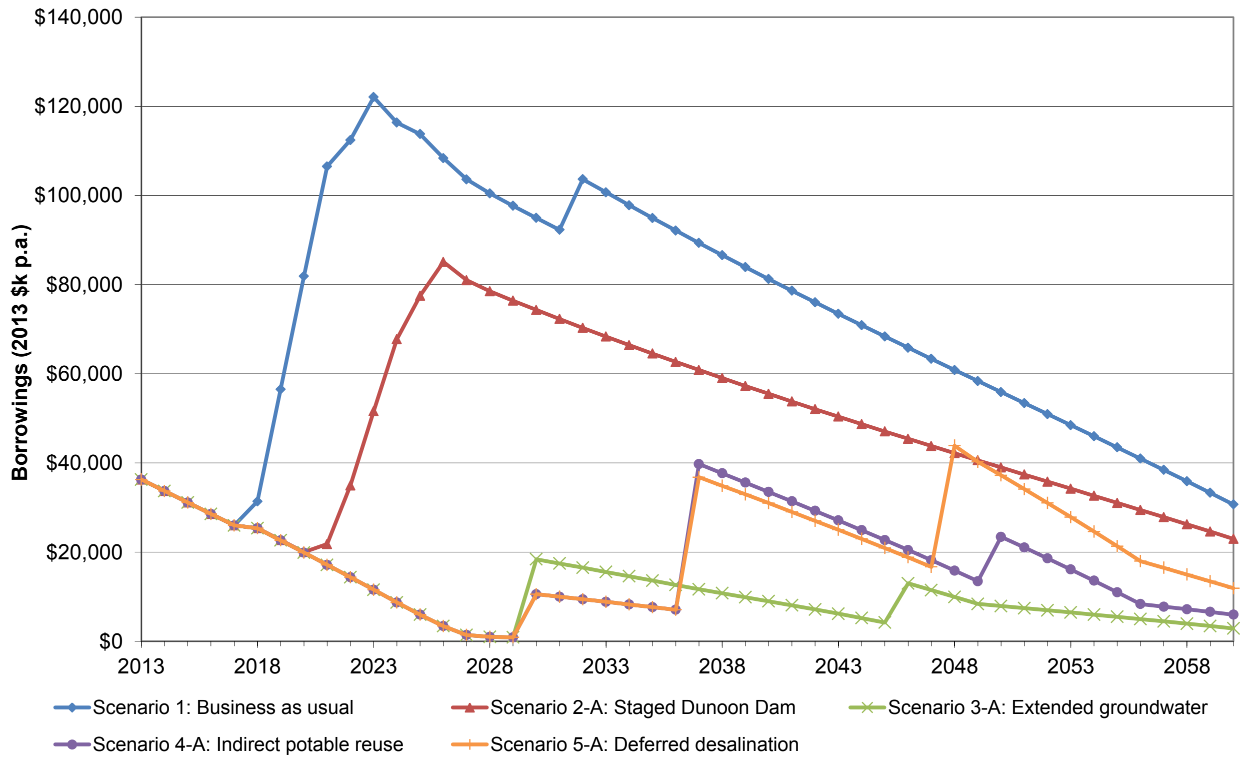


**Figure 19: Comparison of Borrowings – 5/10/10 scenarios**

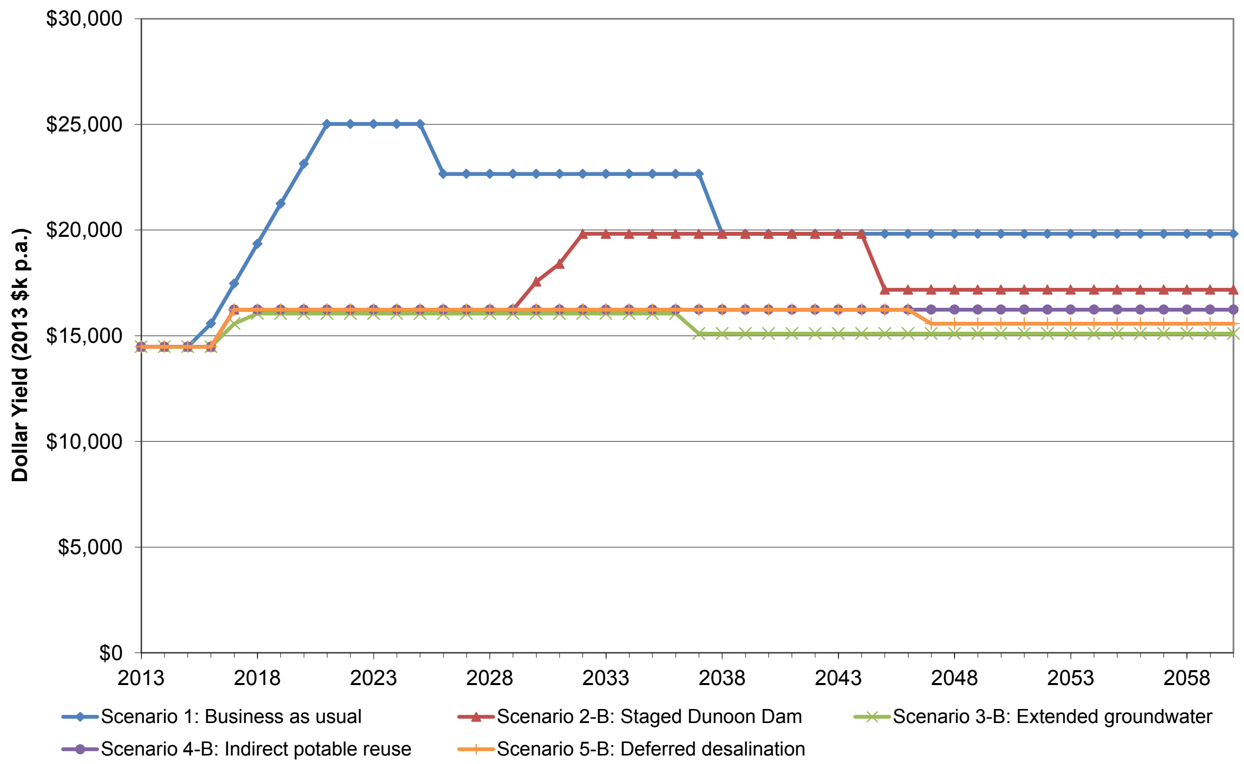


**Figure 20: Comparison of Dollar Yield Required – 5/15/15 scenarios**

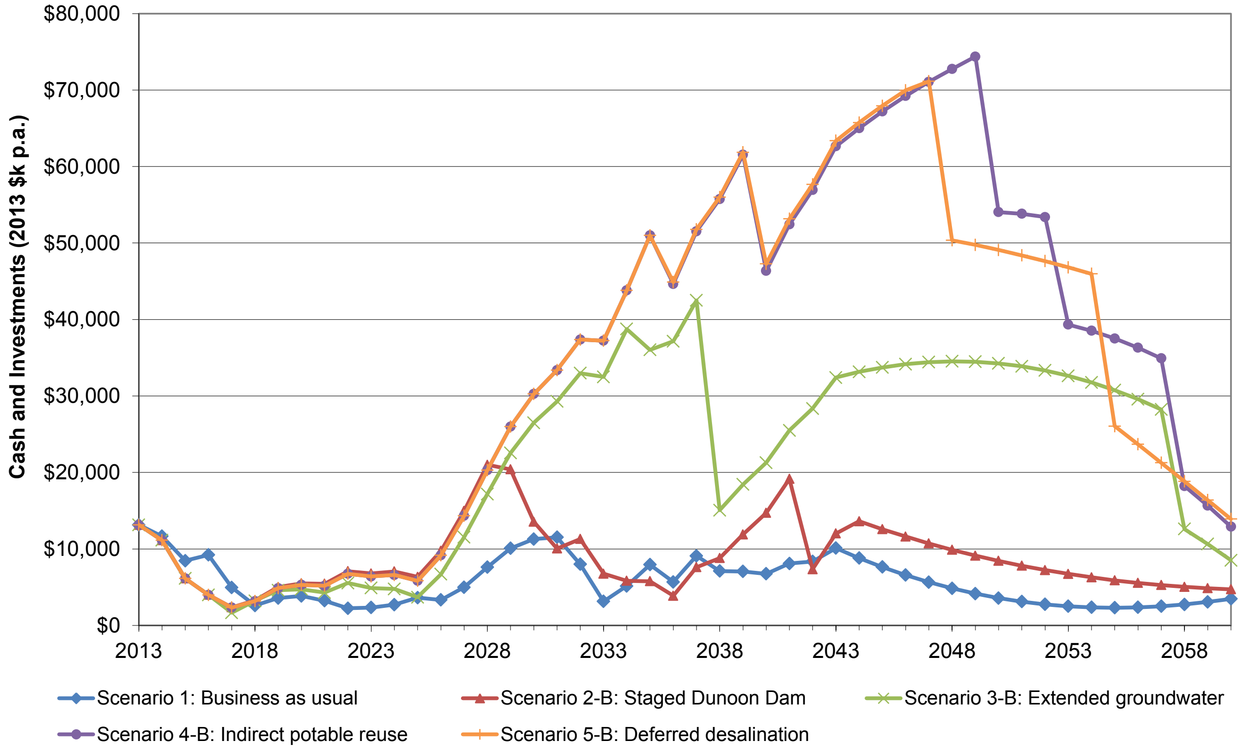


**Figure 21: Comparison of Cash and Investments – 5/15/15 scenarios**

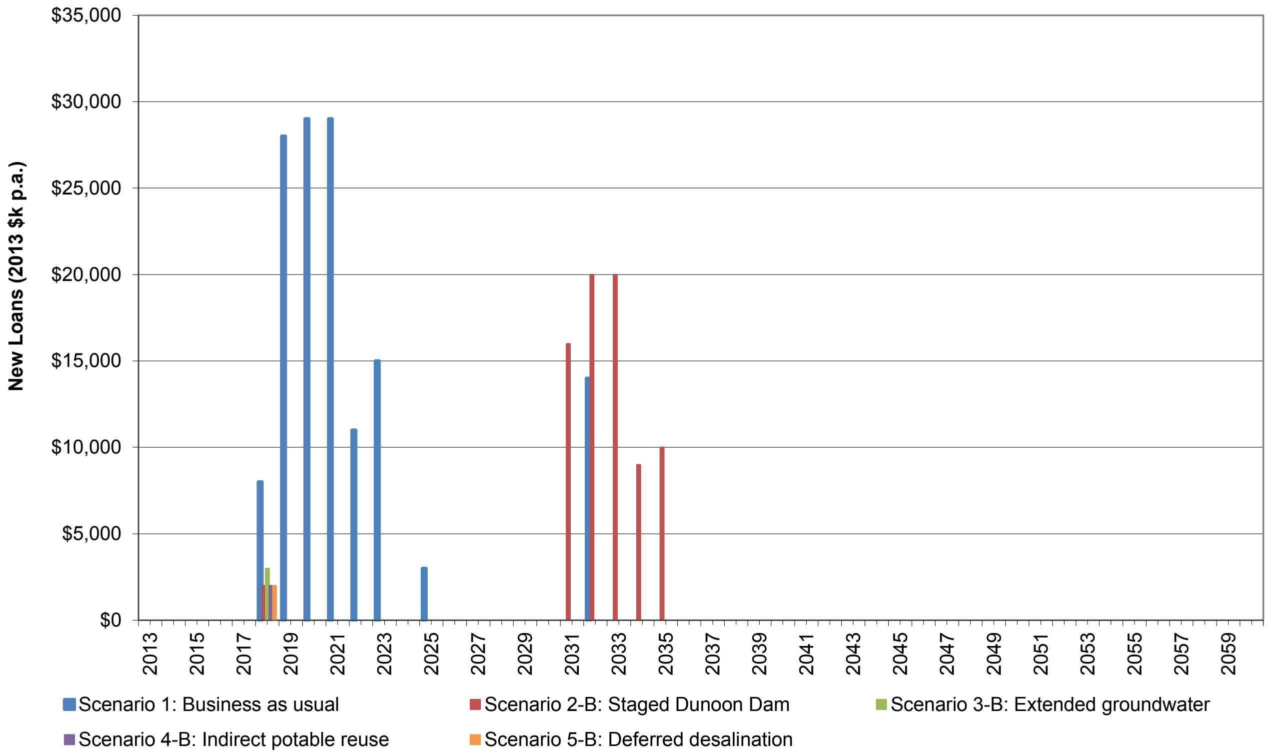


**Figure 22: Comparison of New Loans Required – 5/15/15 scenarios**

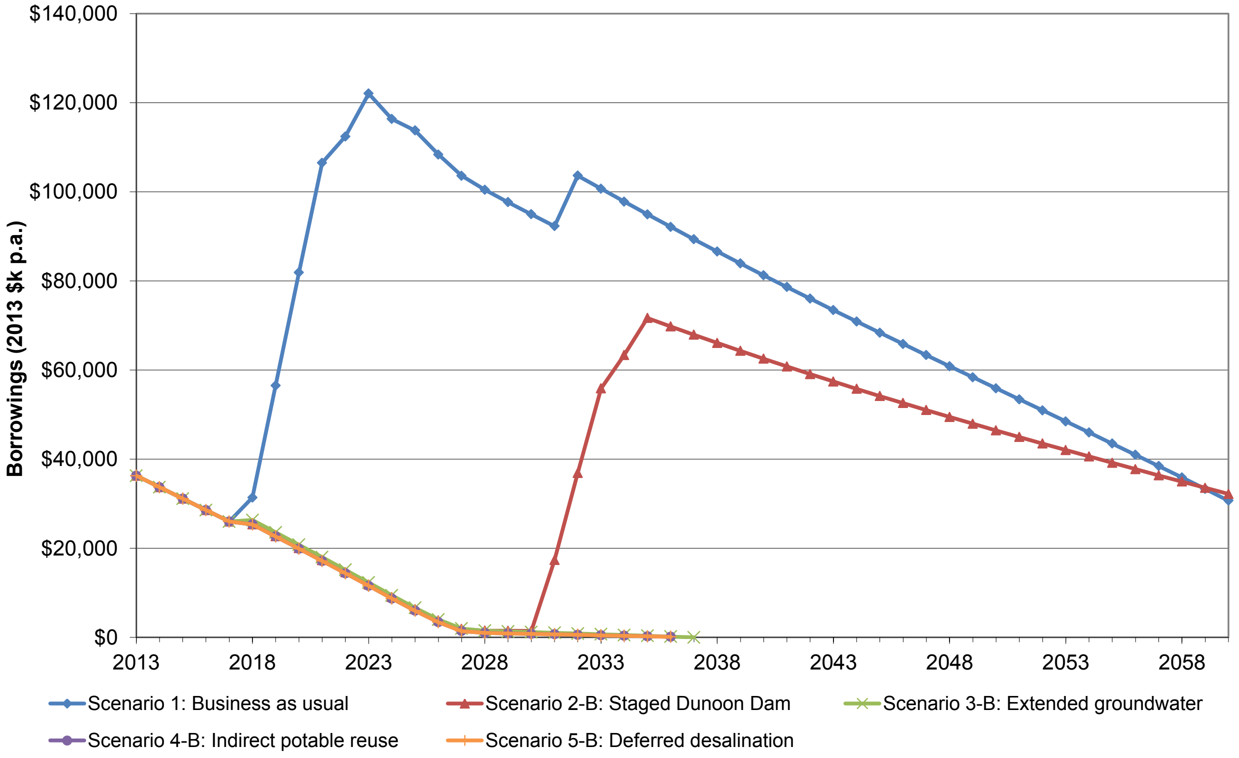


**Figure 23: Comparison of Borrowings – 5/15/15 scenarios**

# APPENDIX 1: SCENARIO OUTPUTS

| | Year | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051 | 2052 | 2053 | 2054 | 2055 | 2056 | 2057 | 2058 | 2059 | 2060 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ML sold previous year | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 | 9440 |
| **FINMOD** | **Case Name** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Notional $/ML = TRB** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 1534 | 1534 | 1534 | 1534 | 1534 | 1610 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 1534 | 1534 | 1534 | 1534 | 1534 | 1534 | 1610 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1691 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 | 1200 |
| 7 | Scenario 1: Business as usual | 1534 | 1534 | 1534 | 1650 | 1850 | 2050 | 2250 | 2450 | 2650 | 2650 | 2650 | 2650 | 2650 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 1534 | 1534 | 1534 | 1680 | 1850 | 2000 | 2150 | 2300 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 2250 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 |
| 9 | Scenario 3-A: Extended groundwater | 1534 | 1534 | 1534 | 1534 | 1650 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 | 1850 |
| 10 | Scenario 4-A: Indirect potable reuse | 1534 | 1534 | 1534 | 1534 | 1650 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 1900 | 2050 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 | 2280 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 | 2350 |
| 11 | Scenario 5-A: Deferred desalination | 1534 | 1534 | 1534 | 1534 | 1650 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1900 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2250 | 2380 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 1534 | 1534 | 1534 | 1534 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1860 | 1950 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 | 1820 |
| 13 | Scenario 3-B: Extended groundwater | 1534 | 1534 | 1534 | 1534 | 1650 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1700 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 |
| 14 | Scenario 4-B: Indirect potable reuse | 1534 | 1534 | 1534 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 |
| 15 | Scenario 5-B: Deferred desalination | 1534 | 1534 | 1534 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1720 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 | 1650 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Dollar Yield ($k)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 14481 | 14481 | 14481 | 14481 | 14481 | 15199 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | 13216 | | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 14481 | 14481 | 14481 | 14481 | 14481 | 14481 | 15199 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 15963 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 | 11328 |
| 7 | Scenario 1: Business as usual | 14481 | 14481 | 14481 | 15576 | 17464 | 19352 | 21240 | 23128 | 25016 | 25016 | 25016 | 25016 | 25016 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 14481 | 14481 | 14481 | 15859 | 17464 | 18880 | 20296 | 21712 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 22656 | 21240 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 |
| 9 | Scenario 3-A: Extended groundwater | 14481 | 14481 | 14481 | 14481 | 15576 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 | 17464 |
| 10 | Scenario 4-A: Indirect potable reuse | 14481 | 14481 | 14481 | 14481 | 15576 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 16992 | 17936 | 19352 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 20768 | 21524 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 | 22184 |
| 11 | Scenario 5-A: Deferred desalination | 14481 | 14481 | 14481 | 14481 | 15576 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 17936 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 21240 | 22468 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 | 23600 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 14481 | 14481 | 14481 | 14481 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 17559 | 18408 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 19824 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 | 17181 |
| 13 | Scenario 3-B: Extended groundwater | 14481 | 14481 | 14481 | 14481 | 15576 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 16048 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 | 15104 |
| 14 | Scenario 4-B: Indirect potable reuse | 14481 | 14481 | 14481 | 14481 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 |
| 15 | Scenario 5-B: Deferred desalination | 14481 | 14481 | 14481 | 14481 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 16237 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 | 15576 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Cash and Investments ($k)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 13150 | 11673 | 8464 | 9229 | 4965 | 2612 | 3571 | 3851 | 3228 | 2238 | 2346 | 2719 | 3632 | 3342 | 4994 | 7620 | 10090 | 11288 | 11532 | 8007 | 3147 | 5160 | 7949 | 5681 | 9103 | 7108 | 7053 | 6749 | 8099 | 8356 | 10102 | 8805 | 7633 | 6585 | 5656 | 4850 | 4156 | 3578 | 3112 | 2756 | 2508 | 2360 | 2313 | 2363 | 2507 | 2744 | 3069 | 3477 |
| 2 | FWS Control Case | 13150 | 11673 | 8464 | 8048 | 4568 | 2068 | 2372 | 2113 | 2078 | 3745 | 3503 | 3802 | 2962 | 6222 | 11300 | 12487 | 13313 | 12678 | 10897 | 9955 | 4800 | 6310 | 8415 | 5292 | 7677 | 7397 | 8907 | 10030 | 12659 | 14055 | 16796 | 16354 | 15902 | 15440 | 14962 | 14478 | 13982 | 13479 | 12968 | 12448 | 11923 | 11394 | 10859 | 10322 | 9781 | 9235 | 8691 | 8144 |
| 7 | Scenario 1: Business as usual | 13150 | 11673 | 8464 | 9229 | 4965 | 2612 | 3571 | 3851 | 3228 | 2238 | 2344 | 2718 | 3632 | 3342 | 4994 | 7621 | 10091 | 11289 | 11534 | 8010 | 3149 | 5163 | 7951 | 5683 | 9105 | 7111 | 7056 | 6753 | 8103 | 8359 | 10106 | 8809 | 7637 | 6589 | 5661 | 4855 | 4161 | 3583 | 3117 | 2761 | 2513 | 2366 | 2319 | 2369 | 2513 | 2750 | 3075 | 3483 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 13150 | 11221 | 6322 | 4280 | 2358 | 4620 | 9220 | 7744 | 5263 | 4567 | 4383 | 3148 | 2555 | 3143 | 8252 | 11510 | 13111 | 13369 | 12536 | 12679 | 8739 | 11631 | 15232 | 13721 | 17831 | 4282 | 6865 | 9161 | 13065 | 15831 | 17624 | 16314 | 15071 | 13898 | 12788 | 11745 | 10768 | 9858 | 9009 | 8223 | 7497 | 6834 | 6229 | 5682 | 5190 | 4753 | 4373 | 4045 |
| 9 | Scenario 3-A: Extended groundwater | 13150 | 11221 | 6322 | 4259 | 2025 | 2952 | 4729 | 5244 | 5215 | 6879 | 6632 | 6924 | 6263 | 9706 | 5365 | 10557 | 16412 | 7449 | 7420 | 8181 | 4667 | 7782 | 11411 | 9723 | 13470 | 14591 | 17416 | 19759 | 23524 | 25971 | 29677 | 30108 | 30452 | 16589 | 15464 | 14268 | 13002 | 12815 | 12530 | 12149 | 11672 | 11107 | 10451 | 9703 | 8866 | 7944 | 6939 | 5851 |
| 10 | Scenario 4-A: Indirect potable reuse | 13150 | 11221 | 6322 | 4259 | 2025 | 2952 | 4729 | 5244 | 5215 | 6879 | 6632 | 6924 | 6263 | 9706 | 6635 | 12194 | 17314 | 10323 | 11490 | 13444 | 11115 | 15407 | 20207 | 20653 | 9027 | 9810 | 12361 | 14492 | 18106 | 20467 | 24008 | 24310 | 24542 | 24705 | 24803 | 24828 | 25556 | 10177 | 9140 | 8052 | 6916 | 5733 | 4499 | 3221 | 4053 | 4776 | 5394 | 5898 |
| 11 | Scenario 5-A: Deferred desalination | 13150 | 11221 | 6322 | 4259 | 2025 | 2952 | 4729 | 5244 | 5215 | 6879 | 6632 | 6924 | 6263 | 9706 | 6635 | 12194 | 17314 | 9543 | 9927 | 11081 | 7940 | 11421 | 15399 | 15800 | 11761 | 10823 | 11781 | 12444 | 14708 | 15833 | 18399 | 17873 | 17427 | 17060 | 18222 | 11513 | 9334 | 7942 | 6682 | 5554 | 4556 | 3685 | 2938 | 2316 | 3787 | 5318 | 6908 | 8550 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 13150 | 11136 | 6146 | 4008 | 2363 | 3269 | 5023 | 5511 | 5453 | 7084 | 6801 | 7056 | 6354 | 9755 | 14976 | 21006 | 20410 | 13551 | 10054 | 11309 | 6773 | 5837 | 5784 | 3884 | 7619 | 8807 | 11905 | 14723 | 19155 | 7355 | 12033 | 13630 | 12589 | 11622 | 10724 | 9895 | 9134 | 8442 | 7810 | 7244 | 6739 | 6291 | 5900 | 5567 | 5283 | 5050 | 4863 | 4724 |
| 13 | Scenario 3-B: Extended groundwater | 13150 | 11136 | 6146 | 3989 | 1658 | 3214 | 4604 | 4726 | 4296 | 5554 | 4892 | 4770 | 3684 | 6697 | 11535 | 17179 | 22546 | 26501 | 29288 | 32975 | 32493 | 38754 | 36030 | 37158 | 42499 | 15066 | 18437 | 21284 | 25503 | 28356 | 32418 | 33155 | 33736 | 34161 | 34428 | 34534 | 34477 | 34258 | 33879 | 33338 | 32635 | 31776 | 30755 | 29575 | 28238 | 12605 | 10634 | 8520 |
| 14 | Scenario 4-B: Indirect potable reuse | 13150 | 11136 | 6146 | 3989 | 2345 | 3191 | 4881 | 5308 | 5187 | 6756 | 6411 | 6602 | 5838 | 9174 | 14333 | 20301 | 25986 | 30263 | 33377 | 37385 | 37220 | 43800 | 50998 | 44647 | 51533 | 55747 | 61543 | 46356 | 52441 | 56945 | 62647 | 65011 | 67205 | 69229 | 71076 | 72746 | 74373 | 54048 | 53824 | 53392 | 39333 | 38525 | 37518 | 36315 | 34918 | 18236 | 15663 | 12911 |
| 15 | Scenario 5-B: Deferred desalination | 13150 | 11136 | 6146 | 3989 | 2345 | 3191 | 4881 | 5308 | 5187 | 6756 | 6411 | 6602 | 5838 | 9174 | 14333 | 20301 | 25986 | 30263 | 33377 | 37385 | 37220 | 43800 | 50998 | 44890 | 51778 | 55995 | 61862 | 47276 | 53159 | 57666 | 63371 | 65738 | 67934 | 69958 | 71146 | 50356 | 49752 | 49095 | 48387 | 47628 | 46820 | 45964 | 26059 | 23680 | 21272 | 18842 | 16390 | 13916 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **New Loans Required** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 0 | 0 | 0 | 0 | 3500 | 6000 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Scenario 1: Business as usual | 0 | 0 | 0 | 0 | 0 | 8001 | 28001 | 29000 | 28999 | 11000 | 15000 | 0 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 13999 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 4500 | 16000 | 19999 | 20000 | 14000 | 12000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Scenario 3-A: Extended groundwater | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17999 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | Scenario 4-A: Indirect potable reuse | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10001 | 0 | 0 | 0 | 0 | 0 | 0 | 34000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11999 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Scenario 5-A: Deferred desalination | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10001 | 0 | 0 | 0 | 0 | 0 | 0 | 31000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29998 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16000 | 20001 | 20000 | 9000 | 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Scenario 3-B: Extended groundwater | 0 | 0 | 0 | 0 | 0 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Scenario 4-B: Indirect potable reuse | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | Scenario 5-B: Deferred desalination | 0 | 0 | 0 | 0 | 0 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Borrowings** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 36275 | 33715 | 31143 | 28573 | 29417 | 32524 | 29465 | 26386 | 23281 | 22107 | 18850 | 15556 | 12362 | 9321 | 6864 | 5963 | 5380 | 4786 | 4182 | 3564 | 2934 | 2289 | 1627 | 949 | 472 | 359 | 243 | 124 | 0 | 0 | | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 36275 | 33716 | 31144 | 28574 | 25994 | 23392 | 20774 | 18139 | 15479 | 12796 | 10084 | 7339 | 4699 | 2218 | 327 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Scenario 1: Business as usual | 36275 | 33715 | 31143 | 28573 | 25993 | 31379 | 56506 | 81888 | 106507 | 112411 | 122042 | 116325 | 113769 | 108355 | 103589 | 100442 | 97672 | 94952 | 92280 | 103629 | 100680 | 97779 | 94924 | 92112 | 89342 | 86612 | 83917 | 81255 | 78626 | 76024 | 73449 | 70897 | 68364 | 65848 | 63347 | 60858 | 58377 | 55902 | 53429 | 50955 | 48477 | 45990 | 43491 | 40978 | 38446 | 35892 | 33310 | 30697 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 36275 | 33716 | 31144 | 28574 | 25994 | 25389 | 22718 | 20032 | 21816 | 34939 | 51613 | 67745 | 77494 | 85070 | 80982 | 78502 | 76391 | 74322 | 72290 | 70297 | 68340 | 66417 | 64527 | 62668 | 60837 | 59035 | 57259 | 55508 | 53780 | 52074 | 50387 | 48718 | 47066 | 45429 | 43805 | 42192 | 40588 | 38991 | 37401 | 35813 | 34226 | 32639 | 31049 | 29454 | 27852 | 26239 | 24616 | 22977 |
| 9 | Scenario 3-A: Extended groundwater | 36275 | 33716 | 31144 | 28574 | 25994 | 25349 | 22637 | 19909 | 17156 | 14378 | 11571 | 8730 | 5995 | 3415 | 1426 | 1000 | 898 | 18407 | 17464 | 16517 | 15564 | 14604 | 13635 | 12656 | 11665 | 10787 | 9897 | 8994 | 8077 | 7143 | 6192 | 5221 | 4228 | 12996 | 11489 | 9953 | 8385 | 7914 | 7440 | 6962 | 6480 | 5992 | 5497 | 4996 | 4486 | 3968 | 3439 | 2900 |
| 10 | Scenario 4-A: Indirect potable reuse | 36275 | 33716 | 31144 | 28574 | 25994 | 25349 | 22637 | 19909 | 17156 | 14378 | 11571 | 8730 | 5995 | 3415 | 1426 | 1000 | 898 | 10580 | 10009 | 9435 | 8857 | 8273 | 7683 | 7086 | 39751 | 37681 | 35602 | 33508 | 31398 | 29268 | 27114 | 24934 | 22723 | 20478 | 18194 | 15867 | 13493 | 23437 | 21044 | 18610 | 16128 | 13595 | 11006 | 8355 | 7776 | 7191 | 6598 | 5996 |
| 11 | Scenario 5-A: Deferred desalination | 36275 | 33716 | 31144 | 28574 | 25994 | 25349 | 22637 | 19909 | 17156 | 14378 | 11571 | 8730 | 5995 | 3415 | 1426 | 1000 | 898 | 10580 | 10009 | 9435 | 8857 | 8273 | 7683 | 7086 | 36815 | 34885 | 32945 | 30992 | 29023 | 27036 | 25026 | 22990 | 20926 | 18829 | 16695 | 43876 | 40262 | 37225 | 34148 | 31026 | 27854 | 24627 | 21337 | 17979 | 16496 | 14991 | 13462 | 11907 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 36275 | 33716 | 31144 | 28574 | 25994 | 25389 | 22718 | 20032 | 17323 | 14590 | 11830 | 9038 | 6352 | 3825 | 1890 | 1520 | 1477 | 1435 | 17367 | 36875 | 55871 | 63382 | 71688 | 69782 | 67915 | 66085 | 64289 | 62526 | 60797 | 59097 | 57427 | 55785 | 54170 | 52582 | 51016 | 49472 | 47950 | 46448 | 44965 | 43498 | 42046 | 40608 | 39183 | 37768 | 36363 | 34964 | 33572 | 32184 |
| 13 | Scenario 3-B: Extended groundwater | 36275 | 33716 | 31144 | 28574 | 25994 | 26327 | 23569 | 20794 | 17995 | 15170 | 12316 | 9428 | 6644 | 4015 | 1977 | 1500 | 1347 | 1191 | 1033 | 871 | 706 | 537 | 363 | 185 | 0 | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Scenario 4-B: Indirect potable reuse | 36275 | 33716 | 31144 | 28574 | 25994 | 25349 | 22637 | 19909 | 17156 | 14378 | 11571 | 8730 | 5995 | 3415 | 1426 | 1000 | 898 | 795 | 689 | 581 | 471 | 358 | 242 | 123 | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | Scenario 5-B: Deferred desalination | 36275 | 33716 | 31144 | 28574 | 25994 | 25349 | 22637 | 19909 | 17156 | 14378 | 11571 | 8730 | 5995 | 3415 | 1426 | 1000 | 898 | 795 | 689 | 581 | 471 | 358 | 242 | 123 | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Total CWP** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | 2134 | 6171 | 7268 | 6960 | 8823 | 8792 | 6480 | 1474 | 5134 | 6764 | 3530 | 2571 | 3888 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 1150 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 2134 | 5671 | 6768 | 4160 | 6823 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 1150 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 7 | Scenario 1: Business as usual | 2134 | 5671 | 6768 | 4128 | 10623 | 18892 | 35713 | 35407 | 36024 | 17721 | 19692 | 4733 | 6050 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 22021 | 8571 | 2008 | 1445 | 6537 | 1150 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 10334 | 16891 | 26321 | 28292 | 27833 | 20550 | 16814 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 1150 | 18414 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 9 | Scenario 3-A: Extended groundwater | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 10612 | 2155 | 2840 | 33639 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 1150 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 27051 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 10 | Scenario 4-A: Indirect potable reuse | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 9378 | 2155 | 2840 | 24246 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 50122 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 31569 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 11 | Scenario 5-A: Deferred desalination | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 9378 | 2155 | 2840 | 24246 | 5357 | 4502 | 8571 | 2008 | 1445 | 6537 | 40482 | 3757 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 39824 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 1283 | 2155 | 9000 | 16361 | 28457 | 27602 | 31671 | 16508 | 15945 | 6537 | 1150 | 3757 | 2007 | 2389 | 928 | 16789 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 |
| 13 | Scenario 3-B: Extended groundwater | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 10774 | 6537 | 1150 | 33135 | 2007 | 2389 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 17843 | 3910 | 3910 |
| 14 | Scenario 4-B: Indirect potable reuse | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 1445 | 14631 | 1150 | 3757 | 2007 | 22374 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 25188 | 3910 | 3910 | 16938 | 3910 | 3910 | 3910 | 3910 | 18954 | 3910 | 3910 |
| 15 | Scenario 5-B: Deferred desalination | 2134 | 5671 | 6768 | 4128 | 5023 | 6792 | 4480 | 4174 | 4791 | 3221 | 5192 | 4733 | 6050 | 2314 | 1283 | 2155 | 2840 | 4261 | 5357 | 4502 | 8571 | 2008 | 1445 | 14631 | 1150 | 3757 | 2007 | 22374 | 928 | 2132 | 820 | 3910 | 3910 | 3910 | 3910 | 25722 | 3910 | 3910 | 3910 | 3910 | 3910 | 3910 | 23106 | 3910 | 3910 | 3910 | 3910 | 3910 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Case** | **Total OMA** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2013 Base Case | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | FWS Control Case | 10339 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 | 10562 |
| 7 | Scenario 1: Business as usual | 10339 | 10562 | 10562 | 10542 | 10542 | 10542 | 10542 | 10542 | 10542 | 10542 | 10542 | 10542 | 11893 | 11931 | 11967 | 12005 | 12042 | 12080 | 12116 | 12149 | 13057 | 13090 | 13123 | 13156 | 13187 | 13218 | 13248 | 13279 | 13306 | 13333 | 13360 | 13387 | 13414 | 13441 | 13467 | 13494 | 13520 | 13546 | 13572 | 13597 | 13623 | 13648 | 13673 | 13698 | 13723 | 13748 | 13772 | 13797 |
| 8 | Scenario 2-A: Staged Dunoon Dam | 10339 | 11001 | 12188 | 12108 | 12117 | 10693 | 10696 | 10700 | 10703 | 10706 | 10710 | 10713 | 10534 | 10534 | 10533 | 11909 | 11943 | 11994 | 12101 | 12131 | 12161 | 12177 | 12208 | 12240 | 12269 | 12299 | 13061 | 13090 | 13117 | 13143 | 13170 | 13196 | 13221 | 13247 | 13272 | 13297 | 13322 | 13347 | 13372 | 13396 | 13421 | 13445 | 13469 | 13492 | 13516 | 13539 | 13562 | 13585 |
| 9 | Scenario 3-A: Extended groundwater | 10339 | 11001 | 12188 | 12128 | 12137 | 10713 | 10716 | 10719 | 10723 | 10726 | 10730 | 10733 | 10554 | 10554 | 10553 | 11298 | 11133 | 10983 | 12500 | 12631 | 12762 | 12884 | 13021 | 13158 | 13288 | 13417 | 13546 | 13675 | 13791 | 13907 | 14021 | 14136 | 14248 | 14359 | 15148 | 15259 | 15369 | 15478 | 15586 | 15693 | 15800 | 15905 | 16009 | 16113 | 16216 | 16318 | 16419 | 16519 |
| 10 | Scenario 4-A: Indirect potable reuse | 10339 | 11001 | 12188 | 12128 | 12137 | 10713 | 10716 | 10719 | 10723 | 10726 | 10730 | 10733 | 10554 | 10554 | 10553 | 10963 | 11115 | 11283 | 12166 | 12295 | 12424 | 12543 | 12677 | 12812 | 12939 | 14800 | 14933 | 15065 | 15185 | 15303 | 15558 | 15700 | 15839 | 15977 | 16113 | 16249 | 16385 | 16519 | 18318 | 18450 | 18581 | 18710 | 18838 | 18966 | 19092 | 19218 | 19342 | 19466 |
| 11 | Scenario 5-A: Deferred desalination | 10339 | 11001 | 12188 | 12128 | 12137 | 10713 | 10716 | 10719 | 10723 | 10726 | 10730 | 10733 | 10554 | 10554 | 10553 | 10963 | 11115 | 11283 | 12166 | 12295 | 12424 | 12543 | 12677 | 12812 | 12939 | 15834 | 15826 | 15819 | 15812 | 15804 | 15797 | 15790 | 15782 | 15775 | 15768 | 15761 | 18543 | 18536 | 18529 | 18522 | 18515 | 18507 | 18500 | 18493 | 18486 | 18479 | 18471 | 18464 |
| 12 | Scenario 2-B: Staged Dunoon Dam | 10339 | 11085 | 12273 | 12195 | 12205 | 10782 | 10786 | 10790 | 10794 | 10798 | 10802 | 10807 | 10628 | 10629 | 10629 | 10673 | 10673 | 10689 | 10764 | 10765 | 10766 | 10752 | 10753 | 12095 | 12127 | 12158 | 12191 | 12223 | 12253 | 12283 | 12314 | 12345 | 12375 | 12406 | 12437 | 12469 | 12500 | 12532 | 12564 | 12597 | 12629 | 12662 | 12694 | 12727 | 12761 | 12794 | 12828 | 12862 |
| 13 | Scenario 3-B: Extended groundwater | 10339 | 11085 | 12273 | 12214 | 12224 | 10801 | 10805 | 10809 | 10814 | 10818 | 10822 | 10826 | 10648 | 10649 | 10649 | 10693 | 10693 | 10709 | 10784 | 10785 | 10786 | 10772 | 10773 | 11217 | 11579 | 11589 | 12583 | 12723 | 12853 | 12983 | 13114 | 13247 | 13379 | 13512 | 13646 | 13781 | 13917 | 14054 | 14191 | 14329 | 14469 | 14608 | 14749 | 14890 | 15032 | 14973 | 15704 | 15850 |
| 14 | Scenario 4-B: Indirect potable reuse | 10339 | 11085 | 12273 | 12214 | 12224 | 10801 | 10805 | 10809 | 10814 | 10818 | 10822 | 10826 | 10648 | 10649 | 10649 | 10693 | 10693 | 10709 | 10784 | 10785 | 10786 | 10772 | 10773 | 10774 | 11312 | 11447 | 11651 | 11649 | 12315 | 12644 | 12773 | 12903 | 13032 | 13163 | 13294 | 13427 | 13426 | 13420 | 15157 | 15329 | 15501 | 15673 | 15847 | 16021 | 16197 | 15981 | 17395 | 17574 |
| 15 | Scenario 5-B: Deferred desalination | 10339 | 11085 | 12273 | 12214 | 12224 | 10801 | 10805 | 10809 | 10814 | 10818 | 10822 | 10826 | 10648 | 10649 | 10649 | 10693 | 10693 | 10709 | 10784 | 10785 | 10786 | 10772 | 10773 | 10774 | 11312 | 11447 | 11584 | 11649 | 12516 | 12644 | 12773 | 12903 | 13032 | 13163 | 13294 | 13243 | 14945 | 14967 | 14989 | 15011 | 15034 | 15057 | 14896 | 16563 | 16586 | 16610 | 16633 | 16657 |

# H GHG assessment

The embodied carbon (carbon from materials used and transportation) for each of the scenarios (x5 scenarios) has been estimated. The embodied carbon estimates were combined with operational greenhouse gas emissions (GHG) for the scenario comparison (including workshop).

## General assumptions

- No staging or discount rate has been applied to embodied carbon used in future construction. Embodied carbon shown is for the ultimate scenario only
- 2 methods used to calculate CO2 emissions
  1) carbon modelling from individual components for each scenario using the Sydney Water Energy and Carbon Estimator
  2) Benchmarking was used for the desalination plant and dam calculations using reference embodied energy data from similar projects. Benchmarking was used because the Energy and Carbon Estimator did not have inputs for these asset types (see assumptions below)
- The spread sheet input values were predefined, as such during data input values had to be rounded up or down to the nearest value e.g. 2800 ADWF $m^3$ entered as 3,000 ADWF $m^3$

## Scenario specific assumptions

### Nightcap WTP

- Scenario 1: 20 ML/day
- Scenario 2: 15 ML/day

### Roads

- Scenarios 1 and 2 used 12 km of roads as stated in data input spread sheet
- 7m wide dual carriage way
- Road Asphalt $m^2$ given road length (e.g. 9 km) multiplied by the road width (7 m)
- All other scenarios no road asphalt measurements was included

### Dunoon Dam upgrade

- Calculations for Dam (50,000 ML) was benchmarked against average tonnes of $CO_2$ per ML from Wyaralong and Tennant Dam embodied energy data
- Scenario 2 scales this dam for a 20,000 ML dam

### Desalination Plant

- Calculations for Desalination Plant (5 ML/d) was benchmarked against average tonnes of CO2 per ML/day from Wonthaggi Desalination Plant embodied energy data

## Results

Table H-1 shows the embodied GHG emissions for each scenario.

**Table H-1: Embodied GHG**

| Scenario | Embodied Carbon (tonnes CO2e) |
|---|---|
| 1 | 132,518 |
| 2 | 58,705 |
| 3 | 10,824 |
| 4 | 25,868 |
| 5 | 19,930 |

# I Risk assessment

A qualitative risk assessment was undertaken by the project team to identify risks associated with the implementation of the plan and to identify the required management actions to be included in the implementation plan.

Green – low risk; yellow – moderate risk; red – high risk.

| Risk area | Description | Likelihood | Description | Consequence | Mitigation Description | Mitigation | Risk |
|---|---|---|---|---|---|---|---|
| **All scenarios** | | | | | | | |
| Supply deficit | Forecast supply deficit is too high or low (changed growth, consumer behaviour, climate impact/yield forecast) | Will probably happen | Change to supply/demand approaches required. Could incur significant cost and service implications. Investment timing changes | Significant effect | Adopt monitoring plan. Include triggers for change in the strategy. Regularly review demand management plans (every 2 years). Regularly review strategy (every 6 years). | Effective | H |
| Regional influence | NOROC regional approach becomes favoured | Could happen | Would need overarching political influence from higher level of government | Minimal effect | Both NOROC and FWS are mutually compatible. Both the groundwater and IPR strategies are staged investment and hence flexible. Develop a watching brief in the Rous FWS monitoring plan | Effective | L |
| Infrastructure sizing | Changed infrastructure sizing and locations as the strategy develops | Will happen | Change to timing and size of infrastructure. Changes in peak day demand forecasting approach impacts on design factors. Cost and revenue implications. | Moderate effect | Regularly review the strategy and demand management plans including definition of peak day design requirements. Update financial planning as infrastructure requirements are developed. | Effective | hH |
| Climate change/drought | Climate change impacts/drought fast-track implementation program | Could happen | Change in water source required or change in staging is required | Minimal effect | Groundwater and IPR are not as significantly impacted by climate change compared to surface water sources | Effective | L |
| Cost estimates | Cost estimates too high or low | Could happen | Need more or less funding | Moderate effect | Groundwater and IPR are staged incremental investment. Regularly update financial estimates and budgets. | Effective | M |
| Funding | Inadequate funding | Unlikely to happen | Investment deferred or ask for grant funding. Tolerate lower level of service for a period | Minimal effect | Assuming the strategy is groundwater, this is a low cost, staged investment. | Effective | L |

| Risk area | Description | Likelihood | Description | Consequence | Mitigation Description | Mitigation | Risk |
|---|---|---|---|---|---|---|---|
| **Scenario 3 - Extended groundwater** | | | | | | | |
| Resource | Inadequate available supply (poor quality/quantity/reliability) | Will probably happen | Need additional supplies earlier than anticipated and perhaps at additional cost | Minimal effect | MAR is the backup | Effective | M |
| Approvals | Insufficient licence approvals to extract groundwater | Unlikely to happen | Need additional supplies earlier than anticipated and perhaps at additional cost | Minimal effect | Early investigation studies, exploratory work in more than one site, stay involved in the water sharing plan process. Scenario 4 is a backup | Moderate | L |
| Approval delays | Extended period for licence approvals | Will happen | Delayed investment, lower levels of service for a period | Minimal effect | Early investigation studies, exploratory work in more than one site, stay involved in the water sharing plan process. Scenario 4 is a backup | Moderate | H |
| Community acceptance | Low acceptance (perceived issues, aesthetics, costs) | Will probably happen | Unable to implement as much groundwater as intended. May need to progress IPR | Minimal effect | Community engagement, capacity building around the option and the overall strategic choices, trials for proving | Effective | M |
| Environmental issues | Groundwater extraction significantly impacts local ecology/heritage | Could happen | Cannot develop the particular site, additional supplies required earlier | Minimal effect | Multiple sites with appropriate environmental investigations, investigations for exploratory work | Effective | L |
| Political support | Absence of political support, continued commitment to council resolved approach | Could happen | Revert to the dam as preferred strategy against the project objectives | Significant effect | Political engagement, community engagement, capacity building. Retain the option of the Dunoon Dam. | Moderate | H |
| Constituent council acceptance | Councils do not support groundwater use | Unlikely to happen | Council does not have approval obligations for this option. | No effect | Not required | Effective | L |
| Ongoing operation | Managing chlorine residual and multiple source management for water quality | Could happen | Out of spec water, boil water alert | Significant effect | Design chlorine management into system operation plans | Effective | M |
| **Scenario 4 - Indirect potable reuse** | | | | | | | |
| Resource | Inadequate available supply (poor quality/quantity/reliability) | Unlikely to happen | Groundwater and IPR not enough supply, therefore need alternative | Significant effect | Backup options for both groundwater (MAR) and IPR (East Lismore/South Lismore) | Effective | M |

| Risk area | Description | Likelihood | Description | Consequence | Mitigation Description | Mitigation | Risk |
|---|---|---|---|---|---|---|---|
| Approvals | Insufficient licence approvals | Unlikely to happen | Insufficient water source, need alternative water source | Significant effect | Early conversations with state regulators, develop management plans | Effective | M |
| Approval delays | Extended period for licence approvals | Will happen | Delayed investment, lower levels of service for a period | Minimal effect | Early investigation studies, exploratory work in more than one site | Moderate | H |
| Community acceptance | Low acceptance (perceived issues, costs) | Will happen | More groundwater or another supply | Significant effect | Recycled water management plan, community engagement and capacity building, pilots, media management | Moderate | H |
| Environmental issues | Local ecology/heritage issues at IPR or groundwater sites | Unlikely to happen | Increase nutrient loads to receiving source | Moderate effect | Alter design | Excellent | L |
| Political support | Absence of political support | Could happen | Revert to the dam as preferred strategy against the project objectives | Significant effect | Political engagement, community engagement, capacity building. Maintain current investments in dunoon site (not further) | Moderate | H |
| Constituent council acceptance | Councils not wanting to progress this option | Unlikely to happen | Insufficient water source, need alternative water source | Significant effect | Ongoing discussion and involvement in developing option | Effective | M |
| Ongoing operation | Multiple sources to manage water quality | Could happen | Out of spec water, alternate water source | Significant effect | Management systems, not directly into reticulation network | Effective | M |
| **Scenario 2 - Deferred Dunoon Dam** | | | | | | | |
| Resource | Inadequate available supply (poor quality/quantity/reliability) | Unlikely to happen | Level of service reduced | Moderate effect | Raise the dam, or alternate supplies groundwater or IPR | Excellent | L |
| Approvals | Unable to achieve approval requirements, existing requirements led to this strategy which does not support dam | Will probably happen | Another supply would be required | Significant effect | Engage with the regulators | Low effectiveness | H |
| Approval delays | Extended period for licence approvals | Will happen | Delayed investment, lower levels of service for a period | Minimal effect | Early investigation studies, exploratory work in more than one site | Moderate | H |
| Community acceptance | Low acceptance (perceived issues, costs) | Unlikely to happen | Another supply would be required | Moderate effect | Groundwater or IPR | Excellent | L |
| Constituent council acceptance | Councils do not support the dam | Will probably happen | Councils have limited ability to prevent | No effect | Not required | Effective | L |
| Environmental issues | Inundation of Aboriginal grave sites, threatened flora and fauna habitat and transport routes inundated | Will happen | Loss of those environmental and heritage values | Significant effect | First stage does not have the cultural heritage impacts, compensation, offsets | Moderate | H |
| Political support | Unable to achieve political support for dam | Unlikely to | Alternative strategy | Significant | Groundwater or IPR | Excellent | L |

| Risk area | Description | Likelihood | Description | Consequence | Mitigation Description | Mitigation | Risk |
|---|---|---|---|---|---|---|---|
| | | happen | | effect | | | |
| Ongoing operation | Risks associated with operational water quality | Highly unlikely | Out of spec water | Significant effect | Management systems, treatment | Effective | L |

# J Options and scenario details

## Stormwater Options

### Yield Assessment Assumptions

| | B1. Goonellabah | B2. Alstonville |
|---|---|---|
| **Pre-development** | | |
| % impervious | 0 | 0 |
| % pervious | 100 | 100 |
| impervious runoff coefficient | 0.7 | 0.7 |
| pervious runoff coefficient | 0.1 | 0.1 |
| factored contributing area | 138,700 | 978,900 |
| **Post-development** | | |
| Storage Area ($m^2$) | 7,341 | 15,000 |
| Storage normal min depth (m) | 1 | 0 |
| Useable maximum depth (m) | 1 | 1.5 |
| Storage volume ($m^3$) | 14,682 | 22,500 |
| Estimated Total catchment | 1,387,000 | 9,789,000 |
| % impervious | 15 | 15 |
| % pervious | 85 | 85 |
| Impervious runoff coefficient | 0.7 | 0.7 |
| Pervious runoff coefficient | 0.1 | 0.1 |
| Factored contributing area ($m^2$) | 263,530 | 1,859,910 |
| **Other factors** | | |
| Pan-evaporation factor | 0.7 | 0.7 |
| Factored contributing area considering environmental flows ($m^2$) | 124,830 | 881,010 |

## Option Details

| Option | Source | Use | Description | Infrastructure Requirements |
|---|---|---|---|---|
| B1. Goonellabah Catchment | Harvesting of existing urban SW catchments surrounding Southern Cross University | Supplement potable supply via transfer to Wilson's River source and Nightcap WTP | Yield from **two** urban stormwater catchments surrounding Southern Cross University pumped up to existing open storage dam and transferred to Wilson's River Source tank | 1. Transfer main and Pump Stations required.<br>2. Additional pump capacity to transfer flows from Wilson's River source to Rocky Creek Dam.<br>3. Pre-treatment- filtration and disinfection<br>4. **Two** storage tanks to receive separate catchments yields and **two** pump to transfer to the existing Southern Cross University storage. |
| B2. Alstonville catchment A, B &C (Ballina) | Harvesting of existing urban SW catchment areas in Alstonville | Supplement potable supply via transfer to Emigrant Creek Dam | Alstonville catchment A, B & C yield diverted from new open storage dam and transferred to Emigrant Creek Dam | 1. Transfer main and Pump Station required.<br>2. Storage pond<br>3. Pre-treatment- filtration and disinfection |
| B3. Ballina Cumbalum Ridge Developments A, B & C | Harvesting of roof areas from new developments | Supplement potable supply via transfer to Emigrant Creek Dam | Roofwater system harvesting of 3 future Cumbalum Ridge residential areas:<br>Precinct A (900 lots, 175.8 ha, 2006-2020);<br>Precinct B (900 lots, 65ha, 2020+); and<br>Precinct C (2100 lots, 160ha, 2015+). | 1. Dedicated roof water collection system feeding into 1 balancing tank per development area<br>2. Transfer main and two pump stations required<br>3. Pre-treatment facilities to be determined |

## Wastewater Options

| Option | Source | Use | Description | Infrastructure Requirements |
|---|---|---|---|---|
| D1. East and South Lismore STP wastewater for indirect potable reuse- Staged | East and South Lismore STP wastewater- currently discharged to Monaltrie Creek and Hollingsworth Creek | Supplement potable supply via transfer to Wilsons River Source | Recycle East & South Lismore STP wastewater for indirect potable reuse via Wilson's River Source | 1. Additional treatment facilities- filtration and disinfection at both East & South Lismore STP<br>2. Two clear water tanks<br>3. Upgraded power and other ancillaries<br>4. Two pumps and two delivery mains |
| D2. Alstonville STP wastewater for indirect potable reuse | Alstonville STP wastewater- currently discharged to Maguire's Creek | Supplement potable supply via transfer to Emigrant Creek Dam | Recycle Alstonville STP wastewater for indirect potable reuse via Emigrant Creek Dam | 1. Additional treatment facilities- filtration and disinfection<br>2. Clear water tank<br>3. Upgraded power and other ancillaries<br>4. Pump and delivery main |

| | | | | |
|---|---|---|---|---|
| D3. Alstonville STP wastewater for indirect potable reuse and stormwater harvesting | Alstonville STP wastewater- currently discharged to Maquires Creek | Supplement potable supply via transfer to Emigrant Creek Dam | Recycle Alstonvillle STP wastewater for indirect potable reuse via Emigrant Creek Dam | 1. Raw water pumps to collect stormwater from creeks.<br>2. Additional treatment facilities- separate filtration and disinfection systems for stormwater and wastewater<br>3. Clear water tank for wastewater.<br>4. Storage dam for stormwater<br>5. Upgraded power and other ancillaries<br>6. Pump and delivery main |
| D4. Ballina and Lennox STP wastewater indirect potable reuse | Ballina and Lennox STP STP wastewater- currently discharged to North Canal Creek and Ocean at Skennars Head | Supplement potable supply via transfer to Emigrant Creek Dam | Recycle Ballina and Lennox STP wastewater for indirect potable reuse via Wilson's River Source | 1. Additional treatment facilities to be determined<br>2. Two clear water tanks<br>3. Upgraded power and other ancillaries<br>4. Pump and delivery main |

## Groundwater Options

| Option | Source/location | Use | Description | Infrastructure Required |
|---|---|---|---|---|
| F1. Maximise existing sources (Woodburn) | Coastal sands (existing licence) | Transferred to nearby pipeline for delivery to reservoirs (either Langs Hill or Evans Head) | Relocate Woodburn bores and treatment facilities to allow for highway upgrade. | • CCTV Inspection<br>• Borehole refurbishment<br>• New well<br>• New pump<br>• Headwork infrastructure<br>• Pump testing<br>• Treatment housing<br>• Land purchase<br>• Road access<br>• Booster pump and transfer main<br>• Treatment facilities<br>• Telemetry |
| F2. New sources (coastal sands) - Extended | Groundwater (coastal sands) - close to Ballina | Ballina connection point: Pine Av Reservoir (5km max) | New shallow bore fields would be developed in the Coastal Sands aquifer. Water treatment facilities and transfer system to nearby reservoirs to be provided. Requires exploratory drilling and testing (quality and quantity), consideration of groundwater dependent ecosystems. Opportunity for staging and increased yields. Extraction licences required. It is understood that submission has been made for 5,000 ML/a for town supply as part of the new sharing plan. | • CCTV Inspection<br>• Borehole refurbishment<br>• New well<br>• New pump<br>• Headwork infrastructure<br>• Pump testing<br>• Treatment housing<br>• Land purchase<br>• Road access<br>• Booster pump and transfer main<br>• Treatment facilities<br>• Telemetry |
| | Groundwater (coastal | Close to main pipe | | • CCTV Inspection |

| | | | | |
|---|---|---|---|---|
| | sands) - close to Byron | network and growth areas. Byron connection point: St Helena Reservoir (7km max) | | • Borehole refurbishment<br>• New well<br>• New pump<br>• Headwork infrastructure<br>• Pump testing<br>• Treatment housing<br>• Land purchase<br>• Road access<br>• Booster pump and transfer main<br>• Treatment facilities<br>• Telemetry |
| F3. New sources (fractured basalt) - Extended | Groundwater (fractured basalt) - north of Emigrant Creek Dam | Close to main pipe network. Connection to adjacent pipeline. | New deep bore fields would be developed in the Fractured Basalt aquifers. Water treatment facilities and transfer system to nearby reservoirs to be provided. Requires exploratory drilling and testing (quality and quantity), consideration of groundwater dependent ecosystems. Opportunity for staging and increased yields. Extraction licences required. | • CCTV Inspection<br>• Borehole refurbishment<br>• New well<br>• New pump<br>• Headwork infrastructure<br>• Pump testing<br>• Treatment housing<br>• Land purchase<br>• Road access<br>• Booster pump and transfer main<br>• Treatment facilities<br>• Telemetry |
| | Groundwater (fractured basalt) - South of Rocky Creek Dam | Close to main pipe network. Connection to adjacent pipeline. | | • CCTV Inspection<br>• Borehole refurbishment<br>• New well<br>• New pump<br>• Headwork infrastructure<br>• Pump testing<br>• Treatment housing<br>• Land purchase<br>• Road access<br>• Booster pump and transfer main<br>• Treatment facilities<br>• Telemetry |

## Desalination Options

| Option | Source | Description | Infrastructure required | Close to energy source | Connection point to existing infrastructure | Discharge Opportunities |
|---|---|---|---|---|---|---|
| G1. Tyagarrah | Ocean Feed | Option 1 involves the extraction of ocean water via a beach well system located beneath Tyagarah Beach, the treatment of | 1. Intake<br>2. Treatment facilities and clear | Ewingsdale zone substation is approx 3-4 km away. The substation has current | Approximately 2 km to existing Rous Water bulk supply pipelines or | Transfer to Brunswick Heads STP (ADWF: 375 ML/year) for treatment and discharge to Brunswick River. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | the extracted ocean water in a desalination plant and the discharge of brine via an ocean outfall pipeline. | water tank<br>3. Brine disposal 2km main and pump<br>4. Other waste-streams<br>5. Delivery pump and main<br>6. Upgraded power and other ancillaries<br>7. Green power (optional)<br>8. Licence approvals. | capacity issues, but is scheduled for upgrade in 2012/13. | Brunswick Head reservoirs | Or West Byron STP (2km) for discharge to Belongil Creek |
| G2. South Ballina | Ocean Feed | Option 2 involves the extraction of ocean water via a beach well system located beneath South Ballina Beach, the treatment of the extracted ocean water in a desalination plant and the discharge of brine via an ocean outfall pipeline. | 1. Intake<br>2. Treatment facilities and clear water tank<br>3. Brine disposal main and pump<br>4. Other waste-streams<br>5. Delivery pump andmain<br>6. Upgraded power and other ancillaries?<br>7. Green power (optional)<br>8. Licence approvals. | Ballina zone substation is approx 5km away and would require crossing of the Richmond River | Approx. 5km away from Pine Av Reservoir and would require crossing of the Richmond River | Ocean Outfall- 1 km |

# Options H-L

| Option | Source | Use | Description | Infrastructure Requirements |
|---|---|---|---|---|
| H. Dunoon Dam | Catchment runoff and direct rainfall<br><br>Increased use of Wilson's River Source | Transferred to Nightcap WTP for treatment (Nightcap requires upgrade from 70 ML/day to 100 ML/day) | Rous Water has resolved to build Dunoon Dam if and when it is needed to secure supply. The new dam would located downstream of Rocky Ck dam and provide 50,000 ML storage. Water would be transferred to Nightcap WTP for treatment.<br><br>Studies indicate Dunoon Dam is technically viable, but with significant environmental and social constraints. State significant infrastructure with State Minister approval required. | A 50,000 ML roller compacted concrete (RCC) type dam is proposed which incorporates a central 30m wide spillway overflow section. Flow over the spillway would be collected in a plunge pool at the downstream toe of the dam. A diversion tunnel would be located at creek bed level just left of the spillway which would be converted to an outlet tunnel once construction of the RCC wall has been completed. An intake structure would be attached to the back of the wall of the dam while an outlet/ valve house arrangement would be located at the downstream end. Normal access to the valve house |

| Option | Source | Use | Description | Infrastructure Requirements |
|---|---|---|---|---|
| | | | | would be via an inclinator attached down the face of the dam, this avoids need for a new road through very difficult terrain. An opening in the roof of the valve house would allow for possible crane access if required.<br><br>A new raw water pumping station is proposed next to the outlet valve house at Dunoon Dam. Water is to be pumped from Dunoon Dam to the reservoirs at Dorroughby, a distance of some 8 kilometres. Rous Water has advised that the pumps will be required to transfer 60 ML/day and, for this, it is assessed that 3 pumps will be required plus a standby pump. Each pump will have the capacity to pump against a head of 120 metres (allowing for losses in the rising main) and have a motor power rating of about 300 kW. To house these pumps and all of associated equipment, a building of 15 metres wide and 30 metres long is envisaged. Access to the pumping station will be via the valve house. As with the valve house, an opening in the roof of the building is to be provided to allow for possible future crane access.<br><br>A 900mm diameter steel cement lined rising main is proposed to transfer water from Dunoon Dam to Dorroughby. (This provides a flow velocity of about 1 metre/sec). A feasible pipeline route is indicated on the attached Figures. Including all fittings and associated work, the total cost estimate of 8 km long rising main.<br><br>Treated at existing Nightcap WTP (Upgrade to Nightcap WTP required (70 - 100 ML/day) in 2023. |
| I. Toonumbar Dam | Toonumbar Dam | Raw water would be piped to the augmented Casino WTP. Treated supply would then be pumped to the Rous Water system at South Lismore. | This option involves the gradual purchase of general security licences from Toonumbar Dam supply area within the Richmond River Regulated Source. Rous Water would then seek conversion to town supply licence with review of the WSP when permitted (post Dec 2020). | 1. Land acquisition<br>2. Purchase of licences<br>3. Upgrade of Casino WTP<br>4. Transfer mains and pumping station |
| J. Regional desalination | Ocean feed | | NOROC has investigated a number of regional supply approaches to meet future supply needs for Rous Water and Tweed Shire. Initial technical investigations identify regional desalination as approach with merit. The strategy is yet to be accepted by NOROC.<br><br>A 70M L/d desalination plant (ocean feed) is potentially located between Pottsville and Ocean Shores. This option relies on joint management and financing arrangements. Potential to trigger | 1. Intake<br>2. Treatment facilities and clear water tank<br>3. Brine disposal 2km main and pump<br>4. Other waste-streams<br>5. Delivery pump and 2km main<br>6. Upgraded power and other ancillaries<br>8. Licence approvals. |

| Option | Source | Use | Description | Infrastructure Requirements |
|---|---|---|---|---|
| | | | Commonwealth EIS requirements (EPBC) and complicated approvals. | |
| K. Increased restrictions | - | - | Continue with the existing water supply sources and accept a reduced security of supply level of service. This will result in increased frequency, duration and severity of enforced water supply restrictions.<br><br>There will be increased adverse impact to the local economy, user amenity and water utility costs. Many costs are difficult to estimate (estimate includes Rous Water enforcement, loss of revenue and social costs). Decreased sales/employment for pool/spa, nurseries, irrigation, turf industry and car washers which supply water restricted products. | - |
| L. Raise Rocky Creek Dam | Rocky Creek Dam | Continue current system operation | Raise the existing Rocky Creek Dam wall by 8m to 36m height to provide an additional 19,500ML storage (total 33.5 GL). Continue current system operation.<br><br>Dam augmentation would trigger the need to provide environmental flow releases.<br><br>Inundated areas likely to include high conservation value ecological communities and parts of the existing WTP. Clearing required in national park (world heritage) and conservation areas. | |

## Option Summary

| Option | Capital Cost ($M) | Operating Cost ($M/annum) | Annualised Cost ($/kL) | Power (kWh/kL) | Footprint (ha) | Lead time | Supply yield |
|---|---|---|---|---|---|---|---|
| B1. Goonellabah Catchments | 9.3 | 0.7 | 2.60 | 1.7 | 15 | Medium (2-5 yrs) | Current: 600<br>Future: 400 |
| B2. Alstonville catchment A, B &C (Ballina) | 7.6 | 0.5 | 2.00 | 1 | 8 | Medium (2-5 yrs) | Current: 600<br>Future: 400 |

| Option | Capital Cost ($M) | Operating Cost ($M/annum) | Annualised Cost ($/kL) | Power (kWh/kL) | Footprint (ha) | Lead time | Supply yield |
|---|---|---|---|---|---|---|---|
| B3. Ballina Cumbalum Ridge Developments A, B & C | 27 | 0.6 | 6.70 | 0.9 | 5 | Long (>5yrs) | Current: 400<br>Future: 300 |
| D1. East and South Lismore STP wastewater for indirect potable reuse- Staged | 20 | 2.5 | 1.70 | 2.0 | 13 | Long (>5yrs) | Current: 2,700<br>Future: 1,900 |
| D2. Alstonville STP wastewater for indirect potable reuse | 9 | 0.5 | 1.90 | 1 | 6 | Long (>5yrs) | Current: 700<br>Future: 600 |
| D3. Alstonville STP wastewater for indirect potable reuse and Stormwater harvesting | 12 | 1.1 | 1.80 | 1 | 8 | Long (>5yrs) | Current: 1,300<br>Future: 1,000 |
| D4. Ballina and Lennox STP wastewater indirect potable reuse | 14 | 0.9 | 1.80 | 1.1 | 8 | Long (>5yrs) | Current: 1,300<br>Future: 1,000 |
| F1. Maximise existing sources (Woodburn) | 3.5 | 0.2 | 2.20 | 0.3 | 1.5 | Short (<2yr) | Current: 240<br>Future: 200 |
| F2. New sources (Coastal sands) | 18 | 1.4 | 1.5 | 0.4 | 7 | Medium (3-5 yrs) | Current: 2,000<br>Future: 1,300 |
| F3. New sources (fractured basalt) | 13 | 0.9 | 1.70 | 0.7 | 7 | Medium (3-5 yrs) | Current: 1,200<br>Future: 800 |
| G1. Tyagarah Desalination | 103 | 9.2 | 3.20 | 4.2 | 5 | Long (>5yrs) | Current: 6,000<br>Future: 6,000 |
| G2. South Ballina Desalination | 107 | 9.2 | 3.30 | 4.2 | 5 | Long (>5yrs) | Current: 6,000<br>Future: 6,000 |
| H1. Dunoon Dam | 110 | 4.0 | 1.80 | 1.6 | 300 | Long (>5yrs) | Current: 20,000<br>Future: 11,300 |
| I1. Toonumbar Dam | 34 | 2.0 | 2.90 | 0.6 | 10 | Long (>5yrs) post 2020 | Current: 2,000<br>Future: 1,000 |
| J1. Regional desalination | 100 | 8 | 3.00 | 4.2 | 10 | Long (>5yrs) | Current: 5,900<br>Future: 5,900<br>(based on Rous contribution) |

| Option | Capital Cost ($M) | Operating Cost ($M/annum) | Annualised Cost ($/kL) | Power (kWh/kL) | Footprint (ha) | Lead time | Supply yield |
|---|---|---|---|---|---|---|---|
| K1. Increased restrictions | - | - | - | - | - | - | 5/15/15: 1,100<br>10/20/40: 3,300 |
| L1. Raise Rocky Creek Dam | 75 | 1.6 | 5.00 | 1.3 | 100 | Long (>5yrs) | Current: 1,500<br>Future: Negligible |

# Scenarios

## Scenario 1: BAU

| Ref | Option | Roads | Dam | Pump Station | Treatment Type | Rising Main | Available supply (ML/a) Current | 2060 |
|---|---|---|---|---|---|---|---|---|
| A1 | Existing Demand Management | | | | | | | |
| H1 | Dunoon Dam | 3.3 kilometres of new roadwork is required which includes two creek crossings (bridges) and 9.0 kilometres of upgraded road. | A 50,000 ML roller compacted concrete (RCC) type dam is proposed which incorporates a central 30m wide spillway overflow section. Flow over the spillway would be collected in a plunge pool at the downstream toe of the dam. A diversion tunnel would be located at creek bed level just left of the spillway which would be converted to an outlet tunnel once construction of the RCC wall has been completed. An intake structure would be attached to the back of the wall of the dam while an outlet/ valve house arrangement would be located at the downstream end. Normal access to the valve house would be via an inclinator attached down the face of the dam, this avoids need for a new road through very difficult terrain. An opening in the roof of the valve house would allow for possible crane access if required.<br><br>Quantity estimates prepared for RCC type dam (dated 3/6/13) | A new raw water pumping station is proposed next to the outlet valve house at Dunoon Dam. Water is to be pumped from Dunoon Dam to the reservoirs at Dorroughby, a distance of some 8 kilometres. Rous Water has advised that the pumps will be required to transfer 60 ML/day and, for this, it is assessed that 3 pumps will be required plus a standby pump. Each pump will have the capacity to pump against a head of 120 metres (allowing for losses in the rising main) and have a motor power rating of about 300 kW. To house these pumps and all of associated equipment, a building of 15 metres wide and 30 metres long is envisaged. Access to the pumping station will be via the valve house. As with the valve house, an opening in the roof of the building is to be provided to allow for possible future crane access. | Treated at existing Nightcap WTP (Upgrade to Nightcap WTP required (70 - 100 ML/day) in 2023 | A 900mm diameter steel cement lined rising main is proposed to transfer water from Dunoon Dam to Dorroughby. (This provides a flow velocity of about 1 metre/sec). A feasible pipeline route is indicated on the attached Figures. Including all fittings and associated work, the total cost estimate of 8 km long rising main | 20,000 | 11,300 |

## Costing assumptions

| | |
|---|---|
| **Staging** | |
| Dunoon Dam | 2024 |
| NC WTP Upgrade | 2032 |
| Dam constructed over 3 years | |
| Allow a year before dam is used to provide time for dam to fill up | |
| Timing and Sizing of NC WTP upgrade based on peak day demand assessment undertaken by MWH | |
| Cost of upgrade of NC WTP based on Conventional Treatment Plant costs | |
| Dunoon Costs Capital Costs as per email advice from George Samios (5 June, 2013) | |
| Land Acquisition | $6,160 |
| Roads | $12,100 |
| Dam | $93,700 |
| Pumping Station | $15,000 |
| Rising Main | $14,000 |
| Cost of upgrade of NC WTP (70 ML-90 ML/day) | $17,519 |
| **Dunoon dam operating cost** | |
| Fixed cost of operation | $424 |
| Transfer mains R&D (fixed) | $140 |
| Pumping station R&D (fixed) | $750 |
| Pumping station energy costs ($'000/ML) | $0.091 |
| Additional pumping from WRS ($'000/ML) | $0.19 |
| Additional Nightcap treatment ($'000/ML) | $ 0.10 |
| Operating cost of Woodburn Bores ($'000/ML) | $0.69 |
| Average current use of Woodburn | $28.49 |
| NC WTP ($'000/ML) | $ 0.14 |
| NC WTP R&D fixed | $876 |

## Scenario 2: Staged Dunoon Dam

| | | | | | | | Rising Main | Available Supply (ML/a) | |
|---|---|---|---|---|---|---|---|---|---|
| **Ref** | **Option** | **Roads** | **Dam** | **Pump Station** | **Treatment** | | | **Current** | **2060** |
| A2 | Enhanced Demand Management | | | | | | | - | 972 |
| H2 | Staged Dunoon Dam | 3.3 kilometres of new roadwork is required which includes two creek crossings (bridges) and 9.0 kilometres of upgraded road. | As for the 50,000 ML arrangement, the 20,000 ML RCC dam option would incorporate a concrete gravity structure with a 30 metre wide spillway at the centre of the dam and plunge pool at the downstream toe. A diversion tunnel would be located at creek bed level, just left of the spillway through the dam wall. This would be converted to an outlet tunnel once construction of the RCC dam has been completed. An intake structure would be attached to the back of the wall while an outlet/ valve house would be located at the downstream end together with an associated pumping station Design features are incorporated in the 20,000ML arrangement to facilitate future raising of the dam. These design features include:<br>-The positions of the valve house and pumping station are located downstream of the dam to suit a larger dam<br>-Sizing of the pumping station, valve house, pipework and associated equipment has been determined to suit a larger dam<br>-The section dimensions for the intake tower allow for possible future raising of the storage to 50,000 ML. | As per 50,000 ML dam | Existing Nightcap WTP Requires upgrade from 70 ML/day to 100 ML/day in 2028 | n/a | As per 50,000 ML dam | 9,300 | 6,400 |

## Costing assumptions

| | |
|---|---|
| Staging | |
| Dunoon Dam | 2028 |
| NC WTP Upgrade | 2038 |
| Dam constructed over 3 years | |
| Allow a year before dam is used to provide time for dam to fill up | |
| Timing of NC WTP upgrade based on peak day demand assessment undertaken by MWH | |
| Cost of upgrade of NC WTP based on Conventional Water Treatment | |
| Dunoon Costs Capital Costs provided by PWD 20GL Options Report, 26/6/13 | |
| Land Acquisition | $6,160 |
| Roads | $12,100 |
| Dam | $69,300 |
| Pumping Station | $15,000 |
| Rising Main | $14,000 |
| Cost of upgrade of NC WTP (70 ML/day to 85 ML/day) | $14,657 |
| **Dunoon dam operating cost** | |
| Fixed cost of operation | $424 |
| Transfer mains R&D (fixed) | $140 |
| Pumping station R&D (fixed) | $750 |
| Pumping station energy costs ($'000/ML) | $0.091 |
| Additional pumping from WRS ($'000/ML) | $0.190 |
| Additional Nightcap treatment ($'000/ML) | $0.100 |
| NC WTP ($'000/ML) | $0.140 |
| NC WTP (R&D) fixed | $733 |

# Scenario 3: Extended groundwater

| | | Treatment | | Pumping Requirements | | | Reservoir | | Transfer Mains | | | Available Supply (ML/a) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref | Option | Type | Capacity (ML/day) | Total head | Flow (L/s) | Hours of Operation | Material | Volume (ML) | Type | Length (km) | Diameter (mm) | Current | 2060 |
| A2 | Enhanced Demand Management | - | | | | | | | | | | - | 972 |
| F1-2 | Maximise existing sources (Woodburn) | Conventional Water Treatment UV Chlorination Fluoridation | 3.5 | 62 | 40.6 | 24 | Steel | 3.5 | DICL | 0.5 | 200 | 640 | 576 |
| F2-2 | New sources (coastal sands) - Extended | Conventional Water Treatment UV Chlorination Fluoridation | 5.5 | 60 | 63.4 | 24 | Steel | 5.5 | DICL | 5 | 250 | 1000 | 900 |
| | | Conventional Water Treatment UV Chlorination Fluoridation | 5.5 | 116 | 63.4 | 24 | Steel | 5.5 | DICL | 7 | 250 | 1000 | 900 |
| F3-2 | New sources (fractured basalt) - Extended | Conventional Water Treatment UV Chlorination Fluoridation | 4.1 | 104 | 47.6 | 24 | Steel | 4.1 | DICL | 8 | 200 | 750 | 675 |
| | | Conventional Water Treatment UV Chlorination Fluoridation | 4.1 | 92 | 47.6 | 24 | Steel | 4.1 | DICL | 4 | 200 | 750 | 675 |

## Costing assumptions

Timing of NC WTP upgrade based on peak day demand assessment undertaken by MWH

Staging

| | |
|---|---|
| Woodburn | 2027 |
| Coastal Sands-Ballina | 2030 |
| Coastal Sands-Byron | 2030 |
| Fractured Basalt | 2046 |
| | |
| NCWTP Upgrade | Not required |

Costs

| | Capital Fixed | Operating ($/ML) | M & D Fixed |
|---|---|---|---|
| Woodburn | $ 9,329 | $ 0.692 | $ 326 |
| Coastal Sands-Ballina | $ 13,278 | $ 0.691 | $ 459 |
| Coastal Sands-Byron | $ 16,100 | $ 0.720 | $ 501 |
| Fractured Basalt | $ 23,141 | $ 0.711 | $ 679 |

| | | Treatment | | Pumping Requirements | | | Additional Pumping Requirements | | | Reservoir | | Transfer Mains | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ref** | **Option** | **Type** | **Capacity (ML/day)** | **Total head** | **Flow (L/s)** | **Hours of Operation** | **Total head** | **Flow (L/s)** | **Hours of Operation** | **Material** | **Volume (ML)** | **Type** | **Length (km)** | **Diameter (mm)** | **Current** | **2060** |
| A2 | Enhanced Demand Management | - | | | | | | | | | | | | | - | 972 |
| F1-1 | Maximise existing sources (Woodburn) | Conventional Water Treatment UV Chlorination Fluoridation | 3.5 | 62 | 40.6 | 24 | | | | Steel | 3.5 | DICL | 0.5 | 150 | 500 | 325 |
| F2-1 | New sources (coastal sands) | Conventional Water Treatment UV Chlorination Fluoridation | 5.5 | 60 | 63.4 | 24 | | | | Steel | 5.5 | DICL | 5 | 150 | 500 | 325 |
| | | Conventional Water Treatment UV Chlorination Fluoridation | 5.5 | 116 | 63.4 | 24 | | | | Steel | 5.5 | DICL | 7 | 150 | 500 | 325 |
| D4 | Ballina and Lennox Heads STPs | Advanced treatment (membrane filtration) followed by UV and disinfection | 6.9 | 121 | 79.9 | 24 | | | | Steel | 0.0 | DICL | 8 | 100 | 1260 | 1260 |
| D3 | Alstonville STP + Stormwater harvesting | Advanced treatment (membrane filtration) followed by UV and disinfection | 5.7 | 88 | 66.5 | 24 | 7 | 88 | 24 | Earthen Clay/PE Lined | 30 | DICL | 13 | 250 | 1049 | 920 |

## Costing assumptions

Timing of NC WTP upgrade based on peak day demand assessment undertaken by MWH.

Staging

| | | Capacity (ML/year) |
|---|---|---|
| Woodburn | 2027 | 500 |
| Coastal Sands-Ballina | 2030 | 500 |
| Coastal Sands-Byron | 2030 | 500 |
| | | |
| Ballina and Lennox Head STPs | 2037 | 1260 |
| Alstonville STP plus stormwater harvesting | 2050 | 1050 |
| | | |
| NC WTP Upgrade | Not required | |
| EC WTP Upgrade (8 ML/day to 20 ML/day) | 2037 | 12 |

Costs

| - | Capital Fixed | Operating ($'000/ML) | M & D (fixed) |
|---|---|---|---|
| Woodburn | $ 8,095 | $0.692 | $ 287 |
| Coastal Sands-Ballina | $ 9,021 | $0.691 | $ 334 |
| Coastal Sands-Byron | $10,965 | $0.720 | $363 |
| | | | |
| Ballina and Lennox Head STPs | $ 35,944 | $0.722 | $1,081 |
| Alstonville STP plus stormwater harvesting | $ 27,659 | $0.721 | $1,665 |
| | | | |
| | | | |
| Emigrant Ck WTP Upgrade (8 ML -20 ML) | $13,028 | $0.140 | $ 651 |

## Scenario 5: Desalination

| Treatment | Pumping Requirements | Additional Pumping Requirements | Reservoir | Transfer Mains | Additional Transfer Mains | Available Supply (ML/a) |
|---|---|---|---|---|---|---|

| Ref | Option | Type | Capacity (ML/day) | Total head | Flow (L/s) | Hours of Operation | Total head | Flow (L/s) | Hours of Operation | Material | Volume (ML) | Type | Length (km) | Diameter (mm) | Type | Length (km) | Diameter (mm) | Current | 2060 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A2 | Enhanced Demand Management | | | | | | | | | | | | | | | | | - | 972 |
| F1-1 | Maximise existing sources (Woodburn) | Conventional Water Treatment<br>UV<br>Chlorination<br>Fluoridation | 3.5 | 62 | 40.6 | 24 | | | | Steel | 3.5 | DICL | 1 | 150 | | | | 500 | 325 |
| F2-1 | New sources (coastal sands) | Conventional Water Treatment<br>UV<br>Chlorination<br>Fluoridation | 5.5 | 60 | 63.4 | 24 | | | | Steel | 5.5 | DICL | 5 | 150 | | | | 500 | 325 |
| | | Conventional Water Treatment<br>UV<br>Chlorination<br>Fluoridation | 5.5 | 116 | 63.4 | 24 | | | | Steel | 5.5 | DICL | 7 | 150 | | | | 500 | 325 |
| G2 | South Ballina (marine feed water) | Desalination | Stage 1 - 1,100 ML/year<br>Stage 2 - 1,100 ML/year | 110 | 80.2 | 24 | 26 | 80 | 24 | | | DICL | 5 | 250 | DICL | 1 | 300 | 2200 | 2200 |

## Costing Assumptions

**Staging**

| | |
|---|---|
| Woodburn | 2027 |
| Coastal Sands-Ballina | 2030 |
| Coastal Sands-Byron | 2030 |
| | |
| South Ballina Desalination- Stage 1 | 2037 |
| South Ballina Desalination- Stage 2 | 2048 |
| NC WTP Upgrade | Not required |

**Costs**

| | Capital Fixed | Operating ($'000/ML) | M & D (fixed) |
|---|---|---|---|
| Woodburn | $ 8,095 | $ 0.69 | $ 287 |
| Coastal Sands-Ballina | $ 9,021 | $ 0.69 | $ 334 |
| Coastal Sands-Byron | $ 10,965 | $ 0.72 | $ 363 |
| | | | |
| South Ballina Desalination- Stage 1 | $ 39,332 | $ 0.77 | $ 1,331 |
| South Ballina Desalination- Stage 2 | $ 35,914 | $ 0.77 | $ 1,286 |

## Scenario Cost Summary

| | Costs | | | | | | |
|---|---|---|---|---|---|---|---|
| **Scenario** | **NPV (7%)** | | **Additional CAPEX** | **Annualised cost ($/kL)** | | **Levelised cost ($/kL)** | |
| | **Rous** | **Community** | **Rous** | **Rous** | **Community** | **Rous** | **Community** |
| Scenario 1 | $289,000,000 | $315,000,000 | $158,000,000 | 1.57 | 1.71 | 1.70 | 1.85 |
| Scenario 2 | $263,000,000 | $282,000,000 | $131,000,000 | 1.43 | 1.53 | 1.54 | 1.65 |
| Scenario 3 | $222,000,000 | $239,600,000 | $62,000,000 | 1.21 | 1.30 | 1.30 | 1.41 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Scenario 4 | $231,000,000 | $249,000,000 | $105,000,000 | 1.26 | 1.35 | 1.36 | 1.46 |
| Scenario 5 | $230,900,000 | $249,000,000 | $103,000,000 | 1.26 | 1.35 | 1.35 | 1.46 |

## Scenario Energy and GHG Emissions

| | Energy | | | GHG Emissions | | | |
|---|---|---|---|---|---|---|---|
| Scenario | Energy (MWh) | MWh/ML | Average energy use (MWh/a) | Total Operational GHG (tonnes CO2e) | Embodied Carbon (tonnes $CO_2$e) | Total GHG Emissions (tonnes CO2e) | Average GHG Emissions (tonnes CO2e/a) |
| Scenario 1 | 287,647 | 0.46 | 6,120 | 307,783 | 132,518 | 440,301 | 9,173 |
| Scenario 2 | 268,501 | 0.50 | 5,713 | 287,296 | 58,705 | 346,000 | 7,208 |
| Scenario 3 | 267,387 | 0.45 | 5,689 | 286,104 | 10,824 | 296,928 | 6,186 |
| Scenario 4 | 332,839 | 0.56 | 7,082 | 356,138 | 25,868 | 382,006 | 7,958 |
| Scenario 5 | 534,796 | 0.90 | 11,379 | 572,232 | 19,930 | 592,162 | 12,337 |
| Scenario 5 (Greenpower) | “ | “ | “ | 241,685 | 19,930 | 261,614 | 5,450 |