All communications to be addressed to:
[redacted]

KYOGLE COUNCIL
GATEWAY TO THE RAINFORESTS
UNIQUE & DIVERSE REGION
MEETING THE CHALLENGES OF OUR

[redacted]

CONTACT [redacted]

ENTERED

June 12, 2007

The Honourable Peter Beattie
Premier Queensland
Department of Premier and Cabinet
PO Box 15185
City East QLD 4002

Dear Premier

Re: Integrated Water Supply Options for North Eastern New South Wales and South Eastern Queensland.

A report was presented to Kyogle Council in relation to the recently published report titled "Integrated Water Supply Options for North Eastern New South Wales and South Eastern Queensland", prepared by the Snowy Mountains Engineering Corporation on behalf of the National Water Commission. At its ordinary meeting of May 21, 2007, Council resolved;

> *"That Council writes to the New South Wales and Queensland State Governments, Tenterfield Shire Council and the National Water Commission expressing support for future investigation of the proposed dams at the Clarence River upstream of Tabulam, Duck Creek and on the Richmond River upstream from Grevillia".*

Please also find attached a copy of the brief report presented to Council at their ordinary meeting of May 21, 2007, for your reference and information.

Should you have any further enquiries please do not hesitate to contact [redacted]

Yours faithfully

[redacted]

CC

Premier New South Wales
Mayor Tenterfield Shire Council
General Manager Tenterfield Shire Council
National Water Commission

TITLE **INTEGRATED WATER SUPPLY OPTIONS FOR NE NSW AND SE QLD**

Summary/Purpose

This report is to provide Council with information relating to the implications of the recent report into Integrated Water Supply Options for North East New South Wales and South East Queensland produced by the National Water Commission.

Background Information

The Federal Government recently expressed interest in expanding its role in water management across the country. In line with this, the National Water Commission engaged the Snowy Mountains Engineering Corporation (SMEC) to undertake a desk top study into options to supply water to the south-east of Queensland from the Northern Rivers area. The outcome from this was the document titled "Integrated Water Supply Options for North East New South Wales and South East Queensland" released in April 2007.

This report is presented as an overview of the potential impacts and opportunities associated with the options discussed in the SMEC report.

Report

This report does not attempt to provide a summary or overview of the document titled "Integrated Water Supply Options for North East New South Wales and South East Queensland", but provides an assessment of the likely local impacts and/or opportunities of the matters raised in the document. The level of detail provided in the SMEC report is very coarse, and a considerable amount of further investigation is required to test the feasibility of the options proposed, extensive consultation would also be required with all stakeholders before any of the proposals could proceed.

1. Most Feasible Short Term Options for SE QLD

The option identified as TW7, consisting of a dam on the Tweed River at Rocky Cutting with delivery pipeline to the headwaters of the Nerang Basin, would appear to be the most likely short term solution for getting water to south-east QLD. The potential yield from this option is around 20,000 ML per year. This option is identified for future investigation. This proposal has little or no impact on the Kyogle Local Government Area (LGA).

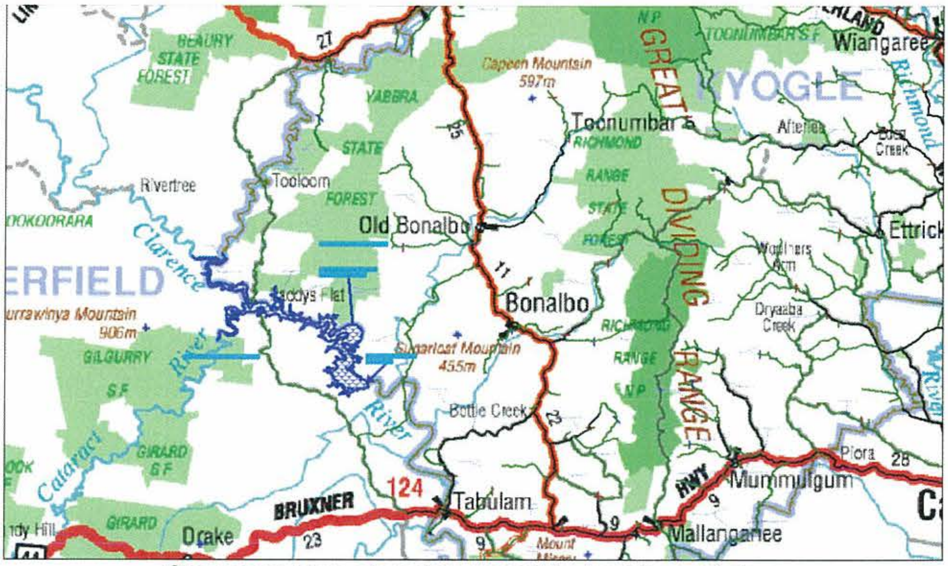
2. Most Feasible Long Term Options for SE QLD

The option identified as CL3b, consisting of a dam on the Clarence River upstream of Tabulam and Duck Creek with delivery pipeline to the headwaters of the Logan Basin, would appear to be the most likely long term solution for getting water to south-east QLD. The potential yield from this option is around

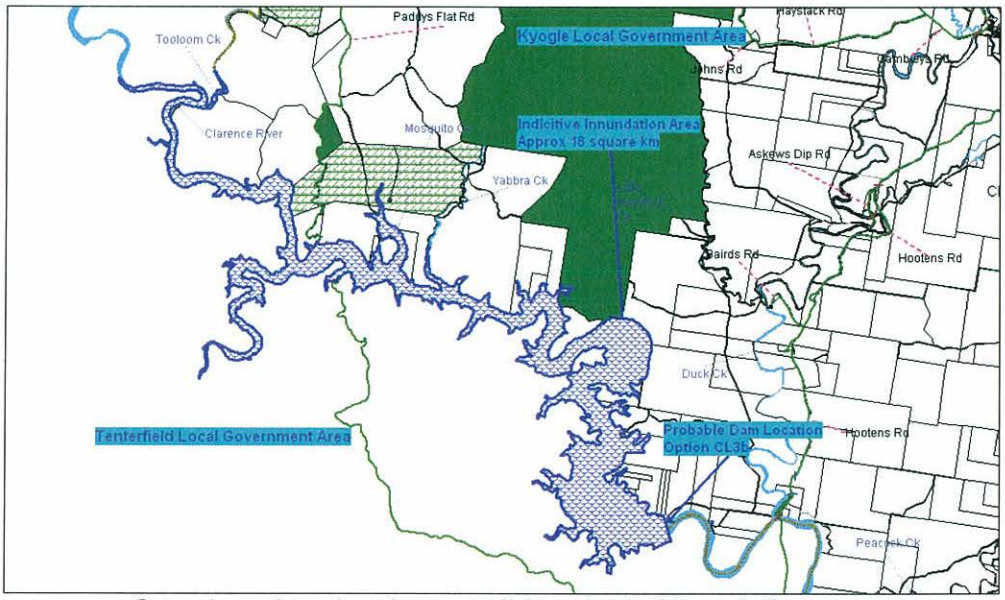
100,000 ML per year. This option is identified for future investigation. This option could potentially have a significant impact on the Kyogle LGA.

3. Possible Opportunities for Kyogle and the Northern Rivers Region

If the option identified as CL3b were to proceed, there would need to be considerable effort by all tiers of Government to resolve the sharing of water from the dam associated with this option. The dam proposed would have a volume of around 250,000ML, and be able to deliver around 100,000 ML per year in a sustainable manner. An indicative inundation map has been prepared by Council staff to show the most likely location and extent of a dam on the Clarence River upstream of Tabulam and Duck Creek. See figures below;



Overview plan showing possible location of dam



Overview plan showing possible extent of inundation area

The pipeline to deliver the water into south-east QLD would pass Old Bonalbo, Urbenville, and Woodenbong on its way to the upper reaches of the Logan River catchment. There exists opportunities for Kyogle Council to secure the long term source for both its water supplies in the Clarence River, and there also exists opportunities for a genuine regional water supply to be developed to service all areas in the North Coast.

The option of a dam on the Richmond River upstream of Grevillia was also included in the SMEC report. This option is quickly discounted due to the high capacity to runoff ratio. In other words it would be very difficult to keep a dam full in this location, particularly during times of low rainfall. This essentially makes this dam non-feasible. It could be possible, however, to supplement such a dam with excess water from a dam such as that proposed in option CL3b. This could change the feasibility of a dam in this location, and could allow the Richmond River to become a regulated stream, with benefits to local irrigators and other primary producers.

There are obviously several other potential impacts not discussed in this report, both positive and negative. It must be recognised that at this point in time these options have only been very coarsely investigated by the SMEC and the National Water Commission, and essentially only from an economic perspective. For any one of the options to proceed, extensive investigation works and assessment of social and environmental impacts would need to be undertaken, in conjunction with comprehensive stakeholder consultation. At this point in time Council has the opportunity to elect to reject the options which may impact on the people of Kyogle LGA, or embrace the opportunity to further investigate the potential impacts, whether they be positive or negative. Given the current climate, both political and natural, it appears as though doing nothing will not be an option for the QLD State Government and/or the Federal Government.

Resolved

1. That the report on Integrated Water Supply Options for North East New South Wales and South East Queensland was received and noted.
2. That Council writes to the NSW and QLD State Governments, Tenterfield Shire Council and the National Water Commission expressing support for further investigation of the proposed dam on the Clarence River upstream of Tabulam, Duck Creek and on the Richmond River upstream from Grevillia.

Referenced Documents

1. "Integrated Water Supply Options for North East New South Wales and South East Queensland", Snowy Mountains Engineering Corporation, April 2007

Birthplace of Our Nation

6 August 2007

KYOGLE COUNCIL RECEIVED - 8 AUG 2007 Doc. No.

[redacted]

[redacted]

By facsimile: [redacted]

Dear [redacted]

Re: Integrated Water Supply Options for Northern New South Wales

I refer to the recent meeting in Kyogle attended by representatives of Kyogle Council, Rous Water and Tenterfield Shire Council on 26 July 2007 with the Assistant Minister for the Environment and Water Resources, the Hon John Cobb, MP, and confirm Council's support for further investigations by the State and Federal Governments, of water storage options that will provide a security of supply for local town water supplies, within the Northern Rivers area of New South Wales.

In the report "Integrated Water Supply Options for North East New South Wales and South East Queensland", two (2) options were identified that impact on areas within the Tenterfield Shire Local Government area, and which could potentially be included in a Water network or grid for the Northern Rivers area, to secure local water supplies, including the villages of Urbenville and Woodenbong within our respective Shires.

Council has previously written to the Minister for the Environment and Water Resources conveying its support for the further studies required to determine a preferred location and feasibility of a project, that would meet the long term needs of the region for water, in view of projected population growth.

.. 2/ ...

[redacted]

On behalf of Council I would convey its support for any submissions or representations from NOROC to the Federal Minister for the Environment and Water Resources, the Hon Malcolm Turnbull, MP or his State counterpart, the Hon Phil Koperberg, MP for funding to allow further more detailed feasibility studies to be undertaken.

Should you require further information or wish to discuss Tenterfield Shire Council's position, please do not hesitate to contact either the [redacted] or myself on [redacted]

Yours faithfully

[redacted]

INTEGRATED WATER SUPPLY OPTIONS FOR NORTH EAST NEW SOUTH WALES AND SOUTH EAST QUEENSLAND

Integrated Water Supply Options for north east NSW and south east Queensland

Foreword

There will clearly be a need to augment water supplies for the south east of Queensland and the north east of NSW. The NSW-Queensland border should not be an artificial barrier to effective regional water planning. An integrated approach that considers the supply and demand in both north east NSW and south east Queensland may provide a better result than could be achieved separately.

The National Water Commission considers that all options should be on the table in order to find the most effective means to secure water supplies. Options should only be taken off the table when objective evidence warrants that. The existence of a border is not sufficient reason to rule out any option. The Australian Government has sought to commence the process for an integrated approach to regional water supply planning for north east NSW and south east Queensland.

The National Water Commission therefore engaged SMEC to undertake a desk top study to identify the potential for additional sustainable extraction in the Tweed, Brunswick, Clarence, Richmond and Wilson River catchments to meet the future needs of communities in north east NSW and south east Queensland.

The objective of the study was to determine if at least 50,000 megalitres of water per year is available for sustainable extraction, with environmental and riverine ecology protected, and water security for consumptive water users of north east NSW maintained or enhanced. As the NSW Government declined to cooperate, the full objective of determining sustainable levels of extraction could not be achieved.

This report details the results of the desk top study. SMEC considered more than 40 options and refined these options down to the most promising five options.

The Commission stresses that all options will require further detailed environmental and social assessment in line with NSW Government laws, regulations and policies, as they can be expected to have significant impact on the environment. This is consistent with the National Water Initiative which requires that such infrastructure investments be ecologically sustainable and economically viable. Some options may be ruled out following detailed engineering and environmental investigations.

The Commission is prepared to invest in further work to determine the environmental impact of options and the more fundamental issues around sustainable levels of extraction.

The Commission recognises this report as an important first step in investigating options to meet the future water needs of northern NSW and south east Queensland. Much more work and effort will be required to determine if any of these options fit within a regional water planning process. The Commission is now seeking the co-operation of the NSW and Queensland Governments to consider these options further.

This report was commissioned by the National Water Commission.

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Executive Summary

The National Water Commission engaged SMEC Australia to undertake a short term "desk-top" review on the identification and definition of issues associated with improving urban water supply security in South East Queensland (SEQ) and North East New South Wales (NE NSW) by accessing water from the Northern Rivers of New South Wales. The review was required to identify options for sourcing water whilst remaining within the sustainable yield and without detrimentally affecting the current and future users in NSW. It must be emphasised that this review looked at longer term planning issues and was not directed towards options for amelioration of the current drought.

The review recommends five options for further investigation. Four of the five options are based on storage and transfer from the Clarence River whilst the fifth (and cheapest) is based on storage and transfer from the Tweed River catchment. A dam on the Clarence River upstream of Duck Creek with a pipeline to the Logan River could provide up to 100,000 Megalitres (ML) per annum at a price of around $1.73 per kL. This proposal stands out as the best value for money with the capacity to effectively serve both SEQ and NE NSW in the medium to longer term. It is dependant however on construction of a large storage and will require detailed environmental scrutiny.

A second option on the Clarence which could provide up to 100,000 ML per annum would require a dam on the Mann River and a pipeline to the Logan River. Water delivered using this option has been estimated to cost around $2.04 per kL due to longer pipeline costs but would require the construction of a significantly smaller storage on the Mann. Both these options could be operated as reserve storages within a wider SEQ/NE NSW water supply system requiring access only during significant drought conditions. Under normal weather conditions, these storages would remain full and all inflows would be passed through the dam, minimising impacts on downstream users and ecology. Operational modelling will be required to offer confirmation on the potential yield increases whilst minimising environmental and social impacts.

A weir on the Mann River whilst delivering around 50,000 ML per annum is likely to have less environmental impact than a dam. Supply security, however, could be an issue in conditions of prolonged drought and its operation may necessitate storage of the water within Queensland dams.

A dam on the Tweed and transfer of water to the Nerang River could provide around 20,000 ML per annum at a cost of around $1.42 per kL. The particular advantage of this option in addition to its lower cost is the rapidity with which it could be brought into service.

It should also be emphasised that all options proposed require further detailed environmental and social assessment in line with the NSW Government laws, regulations and policies, as they can be expected to have significant impact on the environment.

Environmental assessment within the context of this "desk-top" review was conducted at a very broad level.

The study looked at a list of forty possible options for capturing water at different sites, transferring water via alternate routes from three coastal catchments (Tweed, Richmond and Clarence) to three delivery locations in South East Queensland (Logan and Nerang Basins and to Tugun). From this list, twenty five options were selected for further examination based on a range of hydrologic, environmental and engineering factors.

For each of these twenty five options, annual yield was estimated and costs were developed for dams, weirs, pump stations, pipelines, tunnels, engineering, surveying, geotechnical studies, land resumption etc. A financial/economic analysis was conducted of these twenty five options to further refine the list to five preferred options for further investigation. The selected preferred options, which are listed in the Table below, were based on considerations of cost, yield and financial costs. Some options may be ruled out following detailed engineering and environmental investigations.

Option	River	Description	Estimated Yield (ML/year)	Unit Cost of Bulk Water ($/kL)
TW7	Tweed	Dam on Oxley River. Pipeline from Brays Park Weir to Nerang River	20,000	$1.42
CL3b	Clarence	Dam on Clarence Upstream of Duck Creek. Pipeline to Logan River	100,000	$1.73
CL5b	Clarence	Dam on Tooloom Creek. Pipeline/tunnel to Logan River	20,000	$1.65
MA1	Clarence	Weir on Mann River. Pipeline to Logan River	50,000	$2.12
MA2	Clarence	Dam on Mann River. Pipeline to Logan River	100,000	$2.04

A major advantage of these options is the development of a proposal that could simultaneously service the needs of SEQ and the cities of NE NSW, without sacrificing the supply security of either party. Such a proposal would also allow the integration of supply across the North East of NSW and prevent the piecemeal development of options within these areas. As stated earlier these options do not have to supply water at all times. Rather from an environmental and economic perspective it may be preferable to operate them as "reserve" storages, which are activated during major droughts and kept full at all other times.

The supply security associated with these options was estimated approximately using historical data records. To determine these estimates more precisely it would be necessary to develop a mathematical model of the Northern Rivers system and the SEQ urban water supply systems. Such a model would enable optimisation of supply procedures and ensure that supply security to SEQ could be maintained while holding reserves of water in NSW.

In terms of the overall requirements of this investigation, it can be concluded that these options are viable from hydrologic, engineering and economic perspectives. It is recommended that further studies be conducted to refine the options further and develop a phased program of actions for implementation by the governments of the Commonwealth, Queensland and NSW.

It could be repeated that environmental and social assessment of the options was considered in a fairly broad fashion. Limits on levels of regulation and adoption of the NSW's stressed rivers policies of providing minimum flows from dams formed an important consideration of this study in sizing storages. Regulation of rivers was limited to around fifteen percent as a basis for environmental and riverine ecology health. The ratio of storage capacity to annual inflow was also generally kept below unity to ensure the viability of the storages.

The rivers of Northern NSW are subject to a number of legislative and policy requirements that would need to be addressed in a more detailed assessment. These include the National Parks legislation, stressed rivers policies, estuarine management policies, River Flow Objectives, acid sulphate soil issues, endangered species legislation, fisheries and fishway requirements and wild and scenic rivers policies. There are also strong community attitudes in these regions that would need to be accommodated in any future development.

Selection of dam sites was based on previous studies, examination of topographic military maps and recent studies on the Tweed River. Ten possible dam sites were examined in the course of this study and each was assessed in terms of degree of regulation, land resumption, National Park considerations, road and rail location, and previously identified issues.

Financial analyses were undertaken by specialist economic consultants, Hassall and Associates. It was found during this analysis that the largest contributing factor to annual costs is the capital charge, which represents about sixty percent of the annual charge across all options. However for options with high operational and maintenance costs the capital charge was around forty percent of the annual charge. The financial analysis also considered the costs of treatment and transport to the retail consumer, in order to assess comparisons with the Tugun desalination plant.

1 Introduction

1.1 Objectives

The objective of this study, as set out in the brief, is the identification and definition of issues associated with improving urban water supply security in South East Queensland and North East NSW by accessing water from the Northern Rivers region of NSW. This study was structured as a desk top assignment with the focus on identifying options for sourcing and storing water in the Tweed, Brunswick, Clarence, Richmond and Wilson River catchments; whilst remaining within the sustainable yield and without detrimentally affecting the current and future users in New South Wales.

1.2 Background

The rivers of North East NSW have historically been associated with high flows and extreme flood behaviour resulting in large scale damage in the urban and rural areas of the region. These rivers are subject to consistent and heavy rainfall during the summer months averaging 1200 mm. across the catchments. The Tweed River catchment has the highest rainfall of any significant catchment in NSW with an average annual rainfall of 1700 mm.

Historic droughts have generally not exceeded 2 to 3 years maximum. The current drought is seen as being one of the worst experienced to date.

The Clarence River catchment with an area of 22 700 square kilometres and a mean annual runoff of around 5,000,000 ML per annum has been the subject of a number of diversion proposals over the last fifty years. The most recent public proposal involved the construction of a 900,000 ML storage on the Mann River (a tributary of the Clarence River) and involved the transfer of 950,000 ML per annum to the Border Rivers basins. There have also been a number of proposals for accessing water from other rivers in the basin including the Tweed, Wilson and Richmond Rivers.

South East Queensland is the fastest growing area of Australia with a current population growth of around 50 000 persons per annum. This rate of growth is predicted to continue for several more decades placing pressure on the regions current water resources.

The major urban water sources in South East Queensland, Wivenhoe Somerset are operated by SEQ Water, the Hinze/Little Nerang dams owned by Gold Coast Water and the Baroon Pocket Dam owned by Aquagen. The current drought has seriously depleted the water resources of this region with current storage levels of around 23 percent in the SEQ Water dams. It has also raised questions about the viability of the existing supply systems and the effectiveness of the methodologies adopted in Queensland to access and ensure water supply security.

1.3 Available Information

As befits the nature of this "desk-top" investigation, the study was heavily reliant on work undertaken and published by others. (There was however significant original work undertaken in the assessment of options for water transfers as described in Chapter 5).

Although detailed technical information on recent investigation in Queensland and prior studies in NSW was not made available to this study, there were substantial quantities of information available in the public domain to arrive at a reasonable understanding of the issues.

The report by the Queensland Government "Water for South East Queensland, August 2006" (Reference 1) was the primary reference for information on supply and demand in SEQ. Information was also extracted from previous reports associated with the SEQ regional water supply strategy (Reference 2). Information on demand studies carried out by the Queensland Water Commission et. al. (Reference 3) and the Mary River Council of Mayors (Reference 4) was also made available to this study. The latter report (Reference 4) is unpublished, has not been peer reviewed and was not made available in full to this study

Some information on specific issues was also provided to this study following a meeting with officers of the Queensland Water Commission and the Department of Natural Resources, Mines and Water. Recent water supply and demand studies (Reference 5) was supplied by the Tweed Shire Council for the Tweed River and by Rous Water for the Wilson River catchment (References 6 & 7). Information was also obtained by discussion with officers of Tweed Shire Council, Rous Water and North Coast Water and perusal of public documents on the Web.

NSW Government Agencies were invited to contribute to this study but did not offer any assistance. Consequently no meetings were held with NSW Government Departmental officers.

Data and information on water transfer options and possible dam sites in NSW accessed using several recent publications, which were in turn based upon previous studies. The most comprehensive of these studies was by Ghassemi and White (Reference 8) which is currently awaiting publication.

Rainfall data were obtained from the Bureau of Meteorology, whilst flow data were extracted from the Pinneena database of the NSW Department of Natural Resources (Reference 9). It should be noted, however, that information from these databases were applied with only minimal quality assessment and it is recommended that detailed quality control checks are undertaken in the next phases of this project.

Within the timeframes of this study, all work was undertaken in the office. No detailed site investigations or theodic surveys were undertaken. It was necessary to confine topographic assessment to utilisation of the 1:250 000 Military maps with 10 metre contours.

2 Water Requirements for SE Queensland & NE NSW

2.1 South East Queensland Water Demands

As previously mentioned SEQ has been experiencing significant population pressure since 1980 with an annual population increase of around 50,000 persons per annum. The region is one of the most productive and dynamic areas of Australia with its Gross Regional Product of $100 billion expected to double by 2020.

The most recent population projections developed by the Population Information Forecasting Unit of the Queensland Government and presented in Reference 1, are shown in Table 2.1 below.

Table 2.1 SE Queensland Population Forecasts

Year	Population (millions)
2006	2.78
2016	3.38
2026	3.96
2050	5.08

These figures were also presented in reviewed by the Institute of Sustainable Futures as a part of their investigations for the Mary River Council of Mayors (Reference 4). That report concurred with the population estimates for 2026.

The population forecasts were then applied to the estimation of future demand based on a number of different scenarios for water savings within the residential sector. Forecasting was based on a highly detailed assessment of demand and the effect of demand management measures (Reference 3), involving considerable complexity of analysis.

The projections indicate that based on a "business as usual" scenario, the total urban water demand would reach 930 000 ML in 2050, while under a "high savings" scenario, the 2050 demand would be around 690 000 ML. A "moderate savings" scenario for the residential sector however was adopted, which forecast a 2050 demand of 750 000 ML. This moderate savings scenario was based on a daily residential consumption of 250 litres per head, which is not too dissimilar to figures being currently used by other Australian urban water authorities. This review was advised that there was information in Reference 4 that did not concur with these projections, but that information was not made available.

Information on demand extracted from Reference 1 is presented in Table 2.2 below.

Table 2.2 SE Queensland Demand Forecasts

Year	Demand (ML)
2006	450 000
2016	475 000
2026	575 000
2050	750 000

It may be noted that the assumed unit residential demand of 250 litres per capita per day equates to a total annual demand in 2050 of only 464 000 ML. It can thus be inferred that there will be a projected demand of 288 000 ML in 2050 associated with non-residential urban demands and leakage.

2.2 North East NSW Water Demands

The coastal towns of NE NSW have also been subject to significant population pressures in the recent past and it is anticipated that these pressures will continue for the foreseeable future. There are three major urban water suppliers in this region viz. Rous Water, North Coast Water and Tweed Shire Council.

Rous Water is the regional water supply authority for the local government areas of Lismore, Richmond Valley and Ballina. Population in the Rous Water service area is anticipated to reach 148,000 in 2050 from a current base of around 85,000 persons.

North Coast Water is the regional water supply authority for the Clarence Valley, Grafton and Coffs Harbour. Current population was estimated at around 113,000 persons and it is anticipated that the 2050 population is likely to be around 235,000.

It has been estimated that the Tweed Shire Council has a current population of around 80,000 and based on extrapolation of currently available information, it is anticipated that this population could reach around 190,000 in 2050. The population forecasts for the three regions are shown in Table 2.3.

Following a process similar to that adopted for SEQ, the demand projections for the three water supply authorities is shown in Table 2.4.

It can be seen that there will be a significant requirement for urban water supplies in the towns of NE NSW over the next forty to fifty years amounting to around 43 000 ML. As an indication of the current status of water availability it could be noted that in the recent past a number of towns in NE NSW have suffered from extended water restrictions.

Table 2.3 NE NSW Population Forecasts**

Year	Rous Water	North Coast Water	Tweed Shire
2005	85 000	113 000	80 000
2050	148 000	235 000	190 000

** It should be noted that these population forecasts were based on a number of different documents, which may have adopted very different methods of forecasting population growth. Furthermore there has been significant extrapolation of the published information. Consequently these figures should be considered as "**indicative**" and developed only for the purposes of this study.

Table 2.4 NE NSW Demand Forecasts (ML) **

Year	Rous Water	North Coast Waters	Tweed Shire	Total
2005	12 600	15 800	10 200	38 600
2050	18 000	35 700	28 000	81 700

** It should be also noted that these demand forecasts were based on a number of different documents, which may have adopted very different methods of forecasting demand and population growth. Furthermore there has been significant extrapolation of the published information. Consequently these figures should be considered as "**indicative**" and developed only for the purposes of this study.

2.3 South East Queensland Supply Availability

There are 19 major urban water surface storages in SEQ, as well as small quantities of groundwater. The yield from these storages was estimated as 630 000 ML in November 2005 (Reference 2) based mostly on the Historic No Failure Yield (HNFY) methodology.

This methodology provides an estimate of the yield that can be derived from a supply system based on the assumption that this supply system can just withstand the worst historic drought within the period of record. Consequently if the period of record were to be extended to encompass droughts worse than the previously recorded drought, the yield of the system would fall. Furthermore there is no contingency for droughts worse than the historic recorded event.

In 2006, the system yield was re-calculated using a Level of Service (LOS) approach, which involved assigning a risk profile to the supply and calculating the yield arising from that profile. Although this approach is not totally constrained by historic droughts, the selection of the necessary standards for supply security is to some extent arguable. Using this methodology however, the yield of the existing supply system was reduced to 450 000 ML per annum, a reduction of almost thirty percent. It is also stated in Reference 1 that the yield was set equal to the present demand.

Details of the changes and the manner in which the LOS methodology was interpreted and applied were not available to this study and consequently it is difficult to meaningfully comment on these changes. Nevertheless the LOS approach has been recommended by the Water Services Association of Australia and has been successfully applied to the Sydney supply system over the last fifteen years. It could be noted however that a recent study (Reference 4) has questioned the conservativeness of the approach adopted.

The main conclusion of this analysis is that supply and demand are just in balance under current conditions and consequently there is no capacity at present within the current system to service additional growth.

2.4 North East NSW Supply Availability

Rous Water has estimated its yield from the current supply system at around 12 500 ML per annum. It is possible that this figure will be reduced further as the NSW Government enforces requirements for environmental flows on urban water supply authorities and the current drought is brought into the analysis. Rous Water is considering a number of possible augmentation options to cater for the additional growth.

One option that is being examined in detail is a 30 ML per day abstraction from Howard's Grass approximately 5 kilometres upstream of Lismore. It is expected that this augmentation would add around 11 000 ML per annum to the yield.

North Coast Water is currently developing a strategy to secure a reliable bulk water supply for the region with augmentation options including the 30 000 ML Shannon Creek storage and a 90 kilometre pipeline. It is anticipated that with this augmentation, North Coast Water will be able to provide a yield of 22 700 ML per annum. It was not possible to obtain an estimate of the current yield of their supply system, within the timeframe of this study and it has been assumed to be roughly equal to the current demand of 15 800 ML per annum.

Tweed Shire Council have recently re-assessed their yield (Reference 5) using a different approach to that adopted by Queensland but maintaining contingencies for droughts worse than the historic drought as well as for environmental flows. Under these conditions their yield was estimated at 10 100 ML per annum. Two options are being considered for augmenting supply; either by raising the existing Clarrie Hall Dam or construction of a new storage on Byrrill Creek. These options were designed to enable Tweed Shire Council to provide a yield of 24 500 ML per annum, but could offer up to around 30 000 ML per annum if extended further.

2.5 Supply Shortfall

Based on the analysis above, the future supply shortfalls in SEQ and NE NSW are shown in Tables 2.5 and 2.6 below.

Table 2.5 Supply Shortfall in SEQ (ML)

Year	Medium Savings	Business as Usual
2026	120 000	220 000
2051	300 000	500 000

Table 2.6 Supply Shortfall in NE NSW (ML)

Year	Rous Water	North Coast Waters	Tweed Shire	Total
2050	5 400	19 900	17 800	43 100

2.6 Supply Options

Reference 1 identifies a number of supply options and provides information on the cost and the anticipated yield of these options. Extracts from that document are presented in Table 2.7 below and are shown schematically in Figures 2.1 and 2.2. It can be seen that a comprehensive staged program of infrastructure development has been developed by the Queensland Government to meet the anticipated demands of 2050.

2.7 Conclusions

Forward planning estimates of population and water demand in SEQ and NE NSW suggest that there will be significant and sustained growth. The figures presented in Reference 1 and Reference 3 are based on a comprehensive analysis of demand within SEQ and are a suitable basis for forward planning.

The calculation of yield for SEQ has moved forward from the traditional Historic No Failure Yield methodology to a more risk based system of assessment using "level of service". The level of conservativeness implanted in the "level of service" could be compared against other urban water suppliers and possibly be reviewed.

Overall though it is clear that there will be soon be a gap between the demand and the available supply in SEQ and a program of infrastructure development has been proposed to address those issues.

A similar comment can be made about the towns of NE NSW, albeit on a smaller scale. A program of infrastructure development has been planned separately by each major water supply authority in the region.

In a hydrological sense, droughts do not always follow the same pattern on both sides of the McPherson Range which forms the border between Queensland and NSW. It has been observed; particularly in the shorter droughts that there could be surplus flows on one side of the Range with drought conditions afflicting the other. Thus a system of storages that could supply both sides of the border with acceptable levels of security could prove to be a hydrologically and economically efficient approach to drought planning in SEQ and NE NSW.

Table 2.7 Proposed infrastructure in SEQ

Description	Completion Year	Yield (ML/a)	Estimated Cost ($ millions)
Cedar Grove Weir	2007	3 000	10
Desalination Plant	2008	45 000	850
Western Corridor Recycling Scheme			
Phase 1	2008	30 000	641.5
Phase 2	2020	30 000	1142.4
Southern Regional Pipeline	2008	0**	600
Raised Mount Crosby Weir	2008	6 000	50.6 – 73.3
Raised Hinze Dam	2010	5 000	110
Traveston Dam Stage 1	2011	70 000	1,400 – 1,700
Wyaralong Dam	2011	18 000	500
Bromelton Off stream storage	2011	5 000	40
Water Harvesting into Hinze dam	2016	10 000	100
Borumba Dam Stage 3	2025	40 000	250
Traveston Dam Stage 2	2042	40 000	600-800
TOTAL		**752 000**	**6,936 -7,458**

** It was suggested at a meeting with QWC that Southern Regional Pipeline would enable the yield of the system to be increased by around five percent.

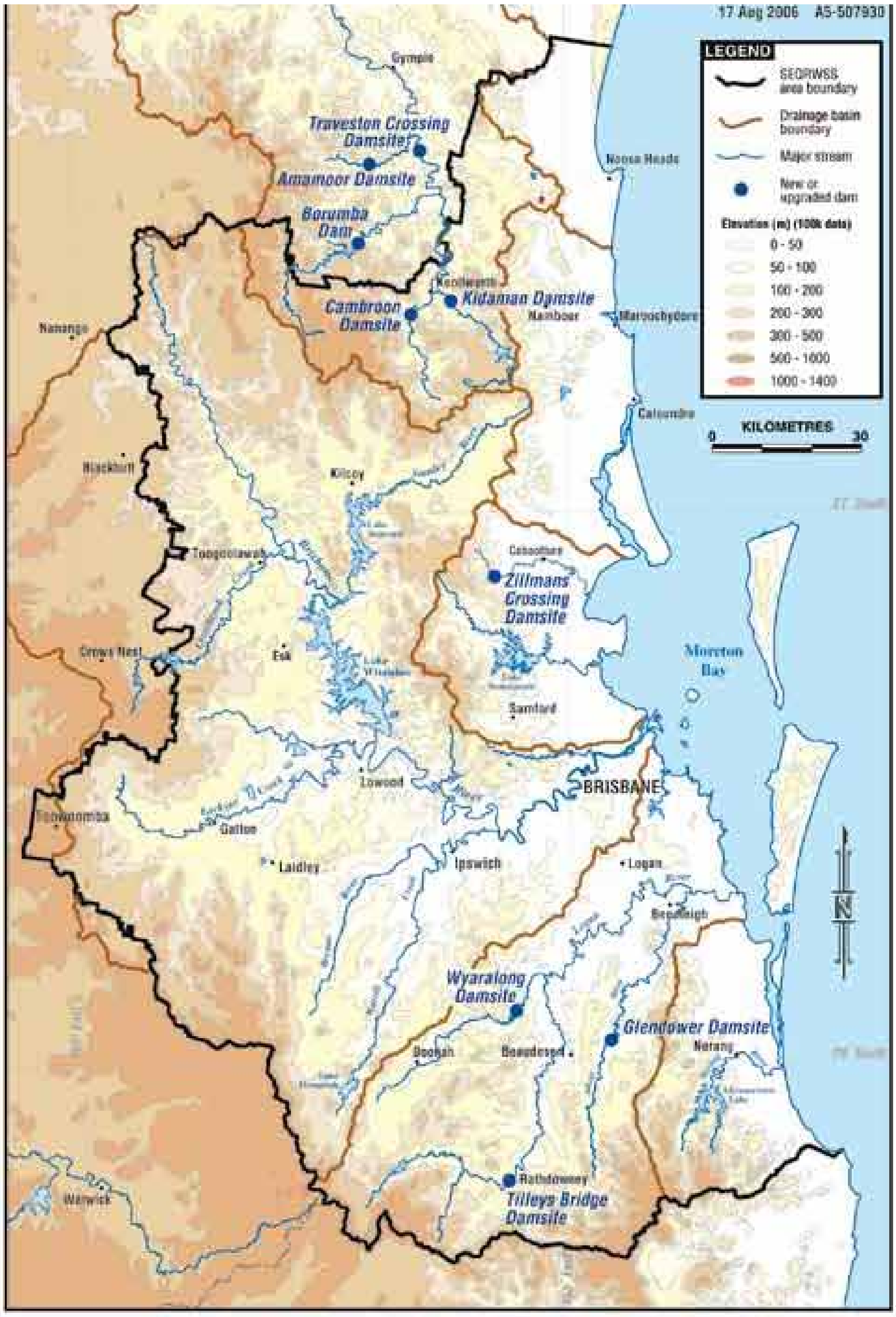


Figure 2.1 Water Supply Options for South East Queensland (Source: Water for South East Queensland, Natural Resources, Mines & Water 2006)

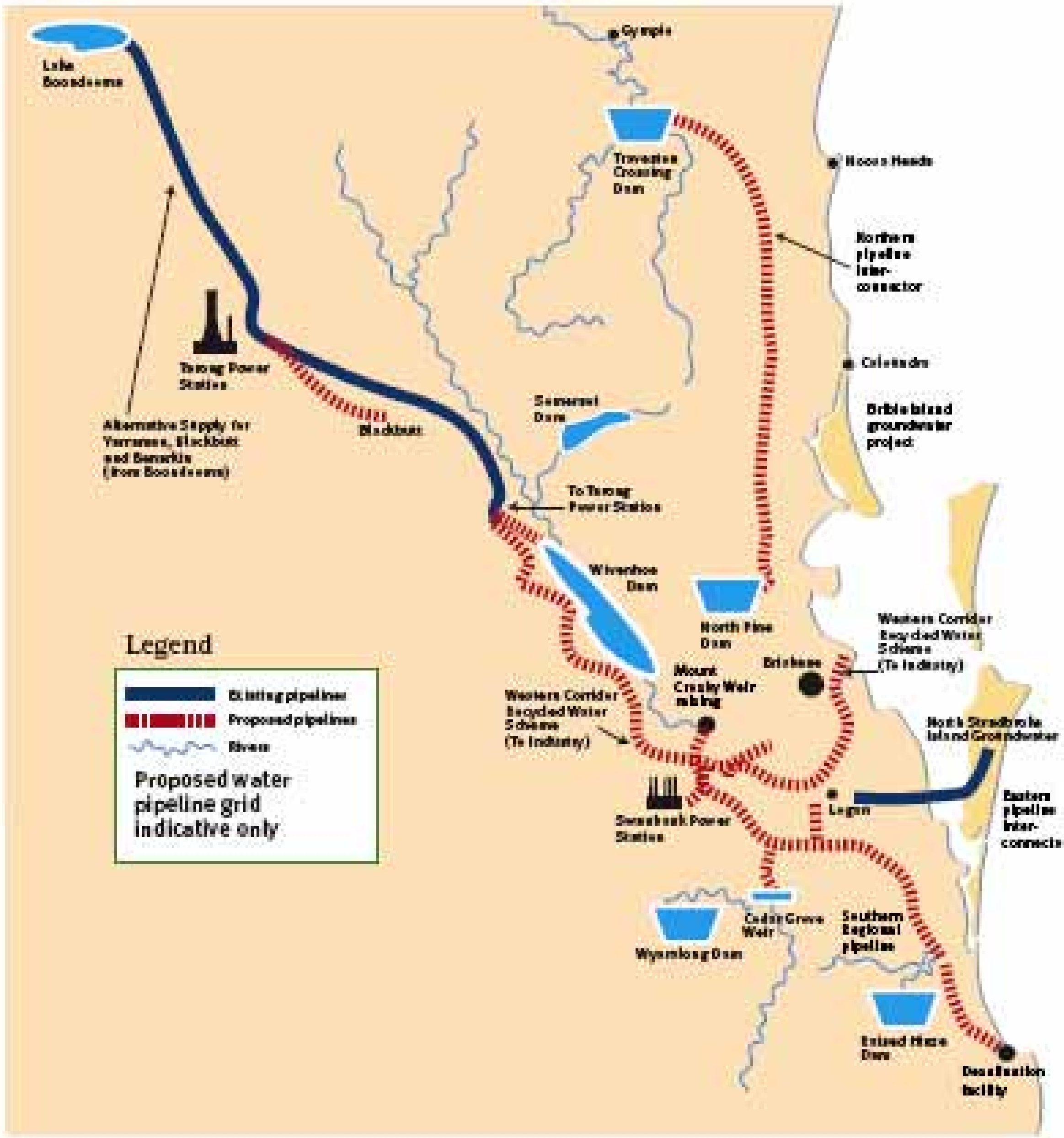


Figure 2.2 Potential Grid for moving water between storage facilities in SEQ (Source: Water for South East Queensland, Natural Resources, Mines & Water 2006)

3 Water Availability in NE NSW Rivers

3.1 Hydrologic Issues

The hydrologic issues relate to: -

- Basic approach;
- Availability of flow records in each of the three Basins;
- Modelled flows;
- Adequacy of flow records;
- Estimation of dam inflows in Richmond and Clarence Basins;
- Tweed River Basin; and
- Risk issues.

The Northern Rivers Basins experience high rainfall and have the highest runoff characteristics of all streams in NSW. Their headwaters are in precipitous mountains with high stream network density. Rainfalls generally decrease southwards, although headwaters of the southern catchments also experience high rainfalls.

Rainfall exhibits seasonality. Highest rainfalls occur in the summer months, with considerably lower averages in spring and autumn.

Stream flows exhibit rapid rises and falls and high flows generally do not persist over extended durations.

3.1.1 Basic approach

The brief for the consultancy for Phase 1, required SMEC to undertake a "desk-top" analysis of the potential to deliver water into the South East Queensland water supply systems.

Computer Modelling

No detailed computer modelling of the three river systems was undertaken.

To undertake such analyses in the Tweed, Richmond and Clarence Basins, having regard to the characteristics of basins and the relative scales of the proposals, it would have been necessary to develop daily rainfall-runoff data to estimate daily runoff from each sub-catchment under consideration and then an operational model to test variations in options.

The timeframe of the "desk top study" precluded such actions. An alternative approach was required.

Drought Analyses

The approach applied was to base the hydrologic analyses on droughts within the NSW Basins and compare those with the key droughts within the Queensland Basins, which might receive water from NSW under the diversion options under consideration.

Queensland critical drought for augmentation of SEQ's water supply

As the yields being examined for the diversion proposals are less than those associated with the Queensland storages in the Logan and Nerang Basins, it could be expected the drought events and drought durations would vary. Queensland's critical droughts extend over 10 years, whereas the critical drought for the diversion schemes are about 2 to 3 years and are associated with the current drought and not the early 20th century one

The secure "yields"[1] used in the Queensland studies to test the feasibility of schemes are based on drought analyses, using computer modelling over a period of record, which covers over 100 years from the 1890s to date. The flow record is based on a combination of recorded flows and rainfall-runoff models.

The critical droughts within the period of record used in Queensland were identified from available Queensland documents. The critical design droughts occurred in the extended droughts early in that period from the late 1890s to mid 1910 to 1920 for the Hinze Dam (Nerang Basin) and proposed Wyaralong Dam (Logan Basin).

NSW critical droughts in servicing diversions to Queensland

It would not have been possible to develop inflow estimates, over the same period of record used by Queensland, without developing rainfall runoff models for all the sub-catchments in all three basins, at which works of storage or diversion were proposed. That output could not have been achieved in the consultancy duration.

The approach adopted was to focus on the historic drought sequences within the bounds of streamflow records availability.

Details of the drought analyses are presented in the Section on "Water Availability Issues."

3.1.2 Availability of Flow Records

The initial task was to examine existing flow records and enquire on the availability of any modelled flows, which could be used.

[1] A secure or "safe yield" represents the volume of water available from a river system, under specified operation rules, over the most critical design drought.

The use of the available flow records depends on their coverage and their quality. The following Sections outline record availability and comment on the actions undertaken to test adequacy.

Historical records of flows in the Tweed, Richmond and Clarence Basins are available from the NSW Department of Natural Resources Pinneena, a digitised database containing all DNR's streamflow records.

The salient details of the key streamflow stations and hydrologic statistics in Table 3.1.

Table 3.1 Details of Streamflow Records for Key Sites in the Three NSW Basins

Basin	Stream	Station Name and No		Catchment (sq. kms)	Period of Record		Average Annual Flow[2] (megalitres)
					From	To	
Tweed	Oxley River	Eungella	201001	213	1947	To date	149 000
	Rous River	Boat Harbour No 1	201002	124	1947	1957	134 000
	Tweed River	Kunghur	201004	49	1954	1982	34 000
	Rous River	Boat Harbour No 2	201005	111	1957	1985	94 000
	Oxley River	Tyalgum	201006	153	1969	1982	112 000
	Hopping Dick Ck	Limpinwood	201007	26	1969	1982	28 000
	Rous River	Chillingham	201008	57	1969	1982	55 000
	Roland Creek	Uki	201009	36	1969	1982	26 000
	Byrrill Creek	Glen Warning	201010	74	1969	1982	41 000
Richmond	Richmond River	Wiangaree	203005	702	1943	To date	252 000
	Lynchs Creek	Wiangaree	203006	117	1943	1984	109 000
Richmond	Byron Creek	Binna Burra	203012	39	1951	To date	40 000
	Wilson River	Eltham	203014	223	1957	To date	177 000

[2] The Annual Flow are those published in DNR data sets for the period of record

Basin	Stream	Station Name and No		Catchment (sq. kms)	Period of Record		Average Annual Flow[2] (megalitres)
					From	To	
	Richmond River	Grevillia	203026	140	1969	1985	28 000
	Findon Creek	Terrace Creek	203027	137	1969	1985	39 000
Clarence	Clarence River	Tabulam	204002	4550	1909	To date	756 000
	Mann River	Jackadgery	204004	7800	1919	To date	1 830 000
	Kooreelah Creek	Hewetsons Mill	204040	231	1954	1985	61 000
	Tooloom Creek	Tooloom Falls	204042	308	1955	1986	73 000
	Duck Creek	Capeen	204049	270	1970	1985	74 000
	Tooloom Creek	Upper Tooloom	204050	596	1970	1986	119 000
	Clarence River	Paddys Flat	204051	2230	1970	To date	386 000
	Clarence River	Baryulgil	204900	7490	1971	To date	1 220 000

Note: In the Tweed and Richmond Basins flow records are not available before 1947 and 1943 respectively. In the Clarence Basin there are records for the station on the Clarence River at Tabulam commencing in 1909.

3.1.3 Modelled Flows

In the Tweed and Richmond Basins flow records are not available before 1947 and 1943 respectively. In the Clarence there are records for the station on the Clarence River at Tabulam commencing in 1909.

Modelled Toonumbar Dam Inflows

The NSW DNR had prepared a rainfall runoff model for inflows to Toonumbar Dam in the upper Richmond Basin. The modelled hydrologic details for the dam are: -

Catchment Area of Ironpot Creek – (sq kms)	98
Average Annual Inflow – (megalitres per annum)	38,000
Average Annual Inflow – (megalitres per annum per sq. km)	380

It is understood that the modelled flows, which covers the period 1890 to 2005, have not been verified with recorded flow data. Nevertheless, in keeping with the "desk-top" nature of the study, these flow estimates have been adopted. Flow records at the site are available from 1967. For most of the period, the flow records are outflows from the dam.

The catchment of Toonumbar Dam is in close proximity to catchments above Grevillia in the upper Richmond Basin and to Tooloom Creek in the upper Clarence Basin.

Modelled Inflows within the Tweed Basin

Tweed Shire Council developed rainfall-runoff flows for key stations in the Tweed Basin in its investigations of *"Tweed River System Water Supply Security Review - November 2006"* (Reference 5). The National Water Commission made these flows available to SMEC.

3.1.4 Adequacy of Flow Records

Coverage of drought periods

1900's Drought

The periods of measured streamflow records in each of the NSW Basins do not cover the full extent of drought period early in the 20th century.

There are no measured flow data for the early 1900's drought. Availability of modelled flows became important, especially for the period late 1890s to 1920.

2000's Drought

There are flow records for a number of stations in each basin in key locations for the current drought.

The adequacy of the records in each Basin was tested for reliability but only on a limited basis.

Records Reliability

Experience indicates it is good practice to undertake a full test of the adequacy of the record for all stations used. In this instance as Phase 1 is a "desk-top" study only, the quality assessment was based on simply examining the relative runoff per square kilometre for selected stations covering contemporaneous timeframes.

For each Basin it would be expected that variations would not be significant for catchments of similar area and some reduction in runoff would occur as the catchment area increased. No attempt was made to test adequacy of rating tables nor were discussions held with officers in DNR with expertise in the flow data.

The NSW DNR's Pinneena database contains indications of the quality of individual data in the record and a general comment on overall adequacy. The brief checks suggest some of the records require further examination. Those stations were not used.

The variations would indicate that if the investigations were to proceed to a further Phase, a QA test should be made for key stations.

No attempt was made to test adequacy of rating tables nor were discussions held with officers in DNR with expertise in the flow data. The Pinneena database contains indications of individual data in the record and a general comment on adequacy. The brief checks suggest some of the records require further examination. Those stations were not used.

In future work, detailed QA of the modelled flows will be required.

3.1.5 Estimation of dam inflows in Richmond & Clarence Basins

The requirement to have coverage of droughts early in the 20th century has led to the use of the Toonumbar modelled flows, which cover the period 1890 to 2005 as the benchmark data. Examination of the Toonumbar flows indicated that, for the yields being sought, the current drought appeared the most critical.

Factors for conversion of Toonumbar flows to inflows to potential storages on the upper Richmond River (Grevillia site) and on Tooloom Creek (Downstream Urbenville site) are: -

Richmond	Grevillia	130% Toonumbar
Tooloom Creek	(Downstream Urbenville site)	38% Wiangaree with comparisons to the modelled Toonumbar Dam flows

For the Wilson River the diversion point flows near Binna Burra were based on 40% of the Wilson River at Eltham.

For the Clarence River and Mann River proposals, recorded flows are available at Jackadgery and Tabulam for the current drought periods. For the Clarence River dam sites Upstream of Tabulam (Downstream and Upstream of Duck Creek), Paddys Flat and Tabulam flows were adjusted using a ratio of catchment areas for these stream flow stations.

For the lower Clarence River systems, the Jackadgery flows were used for proposals on the Mann River.

Confidence in estimates of dam inflows

The level of confidence in flow estimates made by SMEC could be round plus or minus 20%. (Normal flow records generally have a confidence level of about 10%).

Over the critical drought periods, low flows prevail. Variations of storage capacity at the sites involved might add or reduce the dam height by several metres. The dam costs are a low proportion of the total cost of the schemes, with the transport systems being the predominant share. Accordingly, for a study of this type, a more detailed study is not warranted.

If the decision is taken to further examine options, it would be advisable to prepare more reliable dam inflows (using rainfall-runoff models) and a computer based operational model.

3.1.6 Estimation of dam inflows in Tweed River Basin

Tweed Shire Council (Reference 5), has undertaken a comprehensive investigation into potential works to meet the future urban water supply needs under Tweed Council's management.

These studies involved development of rainfall-runoff models and a computerised operational model to evaluate options. The main hydrologic outputs from the modelling were estimates of "yields" for a range of proposals. These yield estimates represent "system yields", which integrate management of storage releases with flows for the unregulated streams. The implication of this approach is that in droughts most of the uncontrolled flows are taken up in servicing demands.

Tweed Shire Council considered three options to provide storage in the Tweed.

- Raise Clarrie Hall dam;
- A new dam on Byrrill Creek near Glen Warning; and

- A new dam on the Oxley River at Rocky Gully.

Storage capacities were determined to meet specific yields for the first two options and these have been adopted by SMEC.

For the Rocky Gully option on the Oxley River, it has been assumed that the Tweed Shire Council storage capacity-yield relationship for the Byrrill Creek option, with the existing Clarrie Hall Dam, would apply for the Rocky Gully option. A check on inflows to the Rocky Gully Dam confirmed this assumption as being reasonable.

3.2 Water Availability

The water availability issues relate to: -

- Basic approach;
- In-valley demands;
- Water availability outcomes;
- Limits on levels of water extraction;
- Outcomes.

3.2.1 Basic Approach

Diversion Range

The volumes examined were 10,000 to 20,000 megalitres per year from each Basin. A 5,000 ML per year option was examined in the Tweed Basin. In the Clarence Basin diversions of up to 100 000 megalitres per year were also examined.

No attempt has been made to estimate the impacts of the additional NSW inflows on Queensland “yields”.

Losses of about 10% were allowed for transport of the water from the delivery at the headwaters of the Logan Basin to the proposed Cedar Grove Weir site and of the Nerang Basin to Hinze Dam, to cover the situation of possible termination of the pipelines in upper reaches. If the pipelines extend to the Queensland regulatory works in both basins the losses would not occur. Because of the length of the NSW droughts removal of the losses provision would only marginally affect sizing of the dams in the Northern River catchments.

Types of Schemes

Assessments of the potential to divert water from the NSW Basins to South East Queensland focussed on two options, defined as:

- Run-of river; and

- Secure supplies.

Run-of river

The durations of the Queensland design droughts in the Logan and Nerang Basins have some relevance in the analyses. In Queensland the critical droughts occur in the early 20th century. Because of the size of the Queensland storages, the duration of these droughts is over 10 years.

The durations of the design droughts for the NSW Basins are shorter (2 to 3 years) and relate to the current drought. Therefore, during the longer Queensland drought periods there is an opportunity to access NSW flows. Examination of the critical droughts in NSW and Queensland for the particular scales of developments involved, suggested the potential for run-of-river options should be considered. The supplies from NSW would be limited to periods of high flow and there is no guarantee of secure flows.

Future occurrence of contemporaneous droughts of the same length in both States is a risk. This is not evident in the historical drought sequences for the projects under consideration.

Options in all three Basins were examined for this management option.

Secure supplies

Secure supplies require provision of storages. Historical critical droughts were examined to estimate the capacities of storages at various selected sites to deliver either 10,000, 20,0000, 50,000 or 100 000 megalitres per year from selected sites.

The capacities were based on a historic yield. No additional storage provision was made to improve security beyond the historic yield.

Assessments were made of the storage capacities required to service either critical drought using a monthly timeframe.

The Queensland diversions were based on 12 equal monthly volumes.

No attempt has been made to estimate the impacts of the additional NSW inflows on Queensland “yields”.

Desired output of the “desk-top” study

The desired output of the “desk-top” study is to be able to compare the costs of any diversion proposal with the cost of options in Queensland. In such circumstances, the sizing of storages needs to be based on delivery of: -

- Queensland diversion volumes; and

- current NSW water supply, agricultural and environmental demands without adding to their security.

There would be opportunities to integrate NSW water supply, agricultural and environmental requirements into any of the "secure supply" options but that should be in a later Phase.

3.2.2 In-Valley Demands

Consumptive demands

The consumptive demand estimates were extracted from a number of documents. These demands varied in some instances.

Richmond Basin

Irrigation In the Richmond system, there is a reasonable level of irrigation. However, under drought situations, as the upper Richmond River is unregulated, there is limited access to the flows. Minimal release allowances were adopted.

Water supply The town of Kyogle is reliant on water from the upper River. The NSW DEUS has prepared an *"Kyogle Integrated Water Cycle Management Plan –2003"* (Reference 10). Allowance was made for releases from the dam to provide flow from the upper catchment but not to improve current security levels.

Clarence Basin

For the four options in the upper Clarence Basin no provisions for water supply or irrigation demands Downstream of the dam sites were made. Releases to meet the 80% were applied.

Tweed Basin

As outcomes from the Tweed Shire Council studies were used to assist in sizing the storages in the Tweed, it was not necessary to consider the in-valley demands. These are incorporated in the outcomes of those studies.

Environmental demands

Policies in NSW provide for environmental flows below dams. A minimum flow of 95% (dry) is practiced for very low flows and 80% in low flow periods. Releases to meet the 80% and 95% limits were applied.

Department of Natural Resources flow records at nearby gauging stations were used for fixing environmental flows for each of the dam sites under consideration in the Richmond and Clarence Basins. These are shown in Table 3.2.

In the Tweed Basin, the Tweed Shire Council studies provisions have been made for the rivers' environmental requirements. The Tweed system yields are net of environmental requirements.

Table 3.2 Minimum environmental flows

Dam Site Identification		Streamflow Station used	Flow Estimate (ML/day)	
			95%	80%
Richmond				
Wilson R	Nr Binna Burra	Eltham	30	70
Richmond R	Upstream Kyogle	Wiangaree	30	60
Richmond R	Upstream Grevillia	Toonumbar	4	15
Clarence				
Tooloom Ck	Downstream Urbenville	Upper Tooloom	0.1	17
Clarence R	Upstream Tabulam	Tabulam	10	60
Mann R	Near Jackadgery	Jackadgery	70	250

3.2.3 Water Availability Outcomes

Run-of river

For the upper Richmond River option, it was possible to use the modelled daily records for Toonumbar flow related to the 80% (dry) flow at Wiangaree to provide preliminary estimates of the diversion potential to the Logan Basin. Diversions during high flow times of 10,000 megalitres per year could be achieved in about 60%-70% of the time over the period 1890 to 2005. A similar outcome from Tooloom Creek and the Wilson River during periods of high flows might be expected.

During the critical drought for the proposed Wyaralong Dam, additional NSW flows of up to 10,000 megalitres per year could be added to dam inflows or reduce releases, with the effect of potentially increasing the yield of the dam by 6 000 to 7 000 megalitres per year.

For the Tweed or Wilson River options, no attempt was made to assess actual water availability for run-of river options but because of the differences in duration of critical drought sequences, increases in secure yield based on the historic record could be likely.

For diversion of 20 000 megalitres, the impacts were not estimated, and again the similar ration was applied in the water pricing.

Detailed modelling would be essential to confirm such outcomes and to test all options for water availability benefits and to coordinate operation of flow conditions in the NSW and

Queensland systems. Daily flow estimates would be essential for all locations in NSW and the Queensland models applied.

Secure supplies

The storage capacities required to service the Queensland diversions are presented in Table 3.3 for the Richmond and Clarence Basins. All were based on the current drought. In 2006, higher than normal flows occurred early in 2006, which would have replenished the smaller storages, for diversion to Queensland of 10,000 to 50,000 megalitres per year. For the lower Clarence, the storage option for the Mann River near Jackadgery to deliver 100,000 megalitres per year would be replenished by 2006.

Table 3.3 Storage Yields Relationship

Dam Site Identification		Historic Yield (ML per year)	Storage Capacity (megalitres)	Levels of Regulation	
				Average Inflow (ML/Year)	Percentage Regulation at dam site
Richmond					
Wilson R	Nr Binna Burra	10,000	20,000	70,000	14%
		20,000	60,000		28%
Richmond R	Upstream Grevillia	10,000	30,000	40,000	25%
		15,000	50,000		37%
		20,000	80,000		50%[3]
Clarence					
Tooloom Ck	Downstream Urbenville	10,000	15,000	100,000	15%
		20,000	35,000		20%
Clarence R	Upstream Tabulam; Downstream Duck Creek	10,000	20,000	650,000	8%
	Upstream Tabulam Upstream Duck Creek	100,000	250,000[4]	650,000	15%[5]
		50,000	90,000		
Mann R	Nr Jackadgery	50,000	River weir	1,800,000	3%
		100,000	100 000		8%

[3] At Wiangaree the level of regulation for 20,000 megalitres per year diversion would be less than 10%.

[4] For the upper Clarence option, diverting 50,000 megalitres per year from the site Upstream of Tabulam and Upstream of Duck Creek, the storage of 90,000 megalitres would not have refilled at December 2006. With continuation of the drought into 2007 the storage requirement could be higher

[5] 15% represents the level Downstream of Duck Creek. At the dam site the level is 25%.

A relationship between the average annual inflow to a dam and its storage capacity is a good index for sizing storages. The ratios give an indication of the hydrologic limits. High ratios point towards difficulties in filling the storage. The ratios for all Basins' options are indicated in Table 3.4.

Table 3.4 Ratios of Average Annual Inflows to Storage Capacities

Dam Site Identification		Storage Capacity (megalitres)	Average Inflow (ML/Year)	Ratio of Storage size to Average Inflow at dam site
Tweed				
Byrrill Ck	Glen Warning	45 000	70,000	64%
Doon Doon Ck	Clarrie Hall Dam	15,000 – now	43 000	35%
		35 000 - future		81%
Oxley R.	Rocky Cutting	35,000	140,000	25%
Richmond				
Wilson R	Nr Binna Burra	20,000	70,000	29%
		60,000		86%
Richmond River	Upstream Grevillia	30,000	40,000	75%
		50,000		125%
		80,000		200%
Clarence				
Tooloom Ck	Downstream Urbenville	15,000	100,000	15%
		25,000		25%
		50,000		50%
Clarence R	Upstream Tabulam Downstream Duck Creek Upstream Tabulam Upstream Duck Creek	20,000	650,000	3%
		250,000		38%
Mann R	Nr Jackadgery	River weir	1,830,000	Not relevant
		70,000		5%

Richmond Basin

The inflow storage ratio and percentage regulation levels indicate the Upstream Grevillia site would have hydrologic limit issue to consider. The storage capacity should probably not exceed 50,000 megalitres thus limiting secure diversion supplies from this site to 10,000 to 15,000 megalitres per year. Options to 20,000 megalitres per year have been tested for cost comparisons.

For the Wilson River site, for the capacity range considered, hydrologic limit issues would not be an issue. However, there are considerable resumption issues as the storage basin is occupied by a relatively dense occupancy level.

Clarence Basin

For the Tooloom Creek option there will be limits due to the proximity of village developments in the upper limits of the storage and potential wild and scenic river issues.

For diversions of 100,000 megalitres to Queensland from the upper Clarence River, the issue is availability of dam sites to secure Queensland supplies. Upstream of Tabulam and Upstream of Duck Creek, there is a potential site to meet a secure supply of 100,000 megalitres per year. Availability of sites Downstream is limited and any storage proposal would raise issues related to potential inundation of high conservation areas and significant road relocations.

Tweed Basin

As indicated earlier in this report, the Tweed Shire Council outputs were used to indicate the storage capacities of potential dams in the Tweed Basin.

SMEC has adopted the storage yield relationships for those dams.

The storage yield relationships for the Tweed dams are shown in Table 3.5:

Table 3.5 Storage yield relationships for Tweed Dams

Dam	System Yield (ML per year)	Storage Capacity (Megalitres)
Byrrill Creek	20 000	45 000
Clarrie Hall Dam	12 000	35 000
Rocky Cutting	20 000	35 000

In the Tweed valley there is currently a level of regulation in the southern catchments of the Tweed River, Upstream of the streamflow station at Uki. Clarrie Hall Dam has modified Downstream flows at Uki in recent years but for illustrative purposes, flow data for that station is used to indicate regulation levels.

- Current water supply and other uses are about 10,000 megalitres per year; and
- Future water supply estimates for the Tweed suggest an additional demand of 18,000 megalitres per year.

3.2.4 Limits on Levels of Water Extraction

There is a level of community opinion that the percentage regulation limit in coastal systems should not exceed about 10% to 15%.

In Coastal Basins, the topography within the river systems can materially affect the regulation percentage. The catchments have a high density of tributary streams, which feed the main rivers stems. Flows increase significantly as the main collector river passes Downstream. Consideration of regulation levels need to have regard to this situation.

Richmond and Clarence Basins

It is apparent from the data in Table 3.3 that:

- Only the Clarence Valley could provide 50,000 megalitres per year or greater. It would be possible to extract greater than from 50,000 megalitres per year from sites on the upper Clarence River or the Mann River, based on the volumes of water flowing in the rivers. For the options in the Clarence Basin, the levels of regulation are listed below. Diversions beyond 15% will be regarded as significant and environmental and community considerations will dictate outcomes for such options.

<u>Upper Clarence River</u>		
Upstream Tabulam Downstream Duck Creek	10,000 ML per year diversion	8%
Upstream Tabulam Upstream Duck Creek	100,000 ML per year diversion	15%
<u>Mann River</u>		
Near Jackadgery	50,000 ML per year diversion	3%
	100,000 ML per year diversion	5%

- For the Wilson River, the diversion limits should not exceed 10,000 megalitres per year at the Binna Burra site, (14% regulation). If the diversion site were to move Downstream towards Eltham, the diversion limit could approach 20 000 megalitres per year;
- For the upper Richmond River, a diversion limit of 10,000 to 15,000 megalitres per year appears to be the limit at the Upstream Grevillia dam site. The length of river before entry of significant tributary flows is relatively short. At the Wiangaree stream flow station, about 10-15 kms Downstream (average annual flow of 252,000 ML/year), the regulation percentage for 20,000 megalitres per year is 8%. A secure supply diversion from 20,000 megalitres per year option has been included but the Grevillia Dam sizing and storage inundation issues may preclude its further consideration.
- For the Tooloom Creek option, 10,000 megalitres per year would be about the limit below the dam based on 10% regulation. The location of the diversion works is within the lower reaches of Tooloom Creek and the demands below the site before the stream enters the upper Clarence River would be low. 20,000 megalitres per year diversion might be posible and has been included as an option. Environmental considerations would dictate increasing diversion limits.
- For the options in the Clarence Basin, the levels of regulation are at Upstream Tabulam Downstream Duck Creek for 10,000 megalitres diversion 8%; at Upstream Tabulam Upstream Duck Creek for 100,000 megalitres diversion 15%; and near Jackadgery for 50,000 and 100,000 megalitres 3% and 5% respectively. Beyond 15% regulation these are significant diversion levels and environmental considerations will indictate outcomes of these options

Tweed Basin

For the Tweed Basin the Southern arm of the Tweed River is regulated. The levels of regulation under varying scenarios are: -

- Under current Tweed demands of about 10,000 megalitres per year, the regualtion level is 5% at Uki;
- Under future Tweed demands of about 28,000 megalitres per year, the regulation is 14% at Uki.
- With Queensland diversions added to Tweed's future demands levels, the regulation levels would be 19% for diversions of 10,000 megalitres per year and 24% for diversions of 20,000 megalitres per year.

The level of regulation on the southern system above Uki will be high even under Tweed future demands. At present all the other streams are unregulated.

For the Rocky Cutting option on the Oxley River, the levels of regulation below the dam site would be: -

- For a Queensland diversion limit of 10,000 megalitres per year, 13%
- For a Queensland diversion limit of 20,000 megalitres per year, 26%

If the measurement location were to be Brays Park Weir (356,000 megalitres per year), with Tweed's future demand of 28,0000 megalitres per year, the levels of regulation from the Rocky Cutting option would be about 11% and 13.5% for diversion limits of 10,000 and 20,000 megalitres per year respectively. The levels of regulation for the Tweed basin with diversions to Queensland are significant issues.

3.3 Other Issues

Water availability will be dependent not only on hydrologic outcomes but consideration of a number of other issues. In this section issues addressed include:

- Opportunities
- Environmental
- Social
- Institutional

3.3.1 Opportunities

Integration of actions

If a decision were to be made to investigate proposals in more detail, the opportunity should be taken to consider joint storage proposals, possible developed in a staged manner. Capacity and cost sharing arrangements would be required.

If augmentation of works to accommodate Tweed council's future needs up to 2030 were to be introduced over the next few years it might be possible to enable access to Queensland over that period progressively reducing supplies as Tweed demands grew. If that were to be an acceptable situation the minimum design criteria would need to embrace a minimum diversion capacity of 20 000 megalitres per year.

Hydro-electricity generation

Delivery of water across the McPherson Range provides an opportunity to generate hydro-electric generation. Static heads involved are about 500 metres.

Irrigation supply security

In the upper Richmond Basin there are a number of licenses for irrigation and industry. At present irrigation is opportunistic when accessing river water. If this option were to progress, a capacity sharing proposal might be achievable to better secure town water, irrigation and industry but because of the hydrologic situation; this may be limited.

In the Tweed Basin the levels of irrigation are less but some arrangements would be possible for the Oxley River option.

Flood mitigation

Dams provide some level of flood mitigation for the minor to moderate floods. Their impacts are far less for major floods. 1940-50s studies showed little benefits. It is unlikely those conclusions would change.

3.3.2 Environmental

Legislative requirements

The politics of the legislation requirements in each state would need attention, especially EIA actions and NSW National Parks legislation..

Application of NSW's "Stressed Rivers" policies;

In 1998, the NSW government introduced "Stressed Rivers Policy" (Reference 11). The policy is primarily a classification-based approach based on division of the Basins into smaller sub-catchments. The classifications cover both hydrologic and environmental stress and also provides for consideration of high conservation aspects. Each classification has a high medium and low index. The policies provides for restricting further extractions for streams with high classification levels. The stressed classifications are indicated below in the three matrices. (Source: NSW DLWC 1998 Stressed Rivers Policy Reports).

For the northern NSW Basins, in the late 1990s, the NSW Department prepared reports on classifications in the Tweed, Richmond and Clarence Basins. The community based Northern River Catchment Management Authority now has responsibility for overview of the stressed classifications. The 1998 classifications are shown in Table 3.6.

The Tweed River system currently under Clarrie Hall's regulation was seen to have a high degree of regulation with some environmental health issues. The Oxley and Rous River were less stressed.

The Upper Richmond River (Kyogle sub-catchment) from which the Queensland diversions would be extracted is seen to be in high stress from hydrologic and environmental viewpoints and has high conservation value areas.

	Low ENVIRONMENTAL STRESS	Medium ENVIRONMENTAL STRESS	High ENVIRONMENTAL STRESS
High PROPORTION OF WATER EXTRACTED	CATEGORY U1 Immediate indications are that water extraction is causing a problem. However, more detailed evaluation should be undertaken to confirm. It is also likely that conflict between users may be occurring during critical periods.	CATEGORY S3 Water extraction is likely to be contributing to environmental stress.	CATEGORY S1 Water extraction is likely to be contributing to environmental stress.
Medium PROPORTION OF WATER EXTRACTED	CATEGORY U2 There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	CATEGORY S4 Water extraction may be contributing to environmental stress.	CATEGORY S2 Water extraction may be contributing to environmental stress.
Low PROPORTION OF WATER EXTRACTED	CATEGORY U4 There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	CATEGORY U3 Environmental stress is likely to be due to factors other than water extraction and, as stress is not high, these rivers would be a lower priority for management action	CATEGORY S5 While environmental stress is likely to be due to factors other than water extraction, the high level of environmental stress means it is important to ensure extraction is not exacerbating the problem.

Notes:
1. Dark shading indicates categories with high combined stress rating
2. Lighter shading indicates categories with medium combined stress rating
3. Absence of shading indicates categories with low combined stress rating

Figure 1: Matrix of Stress Classifications and Management Categories

	Low ENVIRONMENTAL STRESS	Medium ENVIRONMENTAL STRESS	High ENVIRONMENTAL STRESS
High PROPORTION OF WATER EXTRACTED	CATEGORY U1 Medium Priority for River Management Plans excepting high conservation streams	CATEGORY S3 Highest priority for River Management Plan	CATEGORY S1 Highest priority for River Management Plan
Medium PROPORTION OF WATER EXTRACTED	CATEGORY U2 Low priority for River Management Plan excepting High Conservation Streams	CATEGORY S4 Medium Priority for River Management Plans excepting high conservation streams or where full development may put subcatchment into a high stress category	CATEGORY S2 Highest Priority for River Management Plan
Low PROPORTION OF WATER EXTRACTED	CATEGORY U4 Low priority for River Management Plan excepting High Conservation Streams	CATEGORY U3 Low priority for River Management Plan excepting High Conservation Streams	CATEGORY S5 Medium Priority for River Management Plans excepting high conservation streams or where full development may put subcatchment into a high stress category

Figure 2: Matrix for Management Planning Priorities

	Low ENVIRONMENTAL STRESS	Medium ENVIRONMENTAL STRESS	High ENVIRONMENTAL STRESS
High PROPORTION OF WATER EXTRACTED	CATEGORY U1 Embargo may be lifted subject to Type 2 conditions	CATEGORY S3 Embargo maintained	CATEGORY S1 Embargo maintained
Medium PROPORTION OF WATER EXTRACTED	CATEGORY U2 Embargo may be lifted subject to Type 2 conditions	CATEGORY S4 Embargo may be lifted subject to Type 2 conditions	CATEGORY S2 Embargo maintained
Low PROPORTION OF WATER EXTRACTED	CATEGORY U4 Embargo may be lifted subject to Type 1 conditions	CATEGORY U3 Embargo may be lifted subject to Type 1 conditions	CATEGORY S5 Embargo may be lifted subject to Type 2 conditions

Figure 3: Matrix for licence embargo decisions

	Low ENVIRONMENTAL STRESS	Medium ENVIRONMENTAL STRESS	High ENVIRONMENTAL STRESS
High PROPORTION OF WATER EXTRACTED	CATEGORY U1 Limited transfer provisions only	CATEGORY S3 Limited transfer provisions only	CATEGORY S1 Limited transfer provisions only
Medium PROPORTION OF WATER EXTRACTED	CATEGORY U2 Unlimited transfer provisions	CATEGORY S4 Limited transfer provisions only	CATEGORY S2 Limited transfer provisions only
Low PROPORTION OF WATER EXTRACTED	CATEGORY U4 Unlimited transfer provisions	CATEGORY U3 Unlimited transfer provisions	CATEGORY S5 Limited transfer provisions only

Figure 4: Matrix for water licence transfer arrangements

Table 3.6 1998 Classifications

Sub-Catchment	1998	Hyd	Env	HCV
Tweed				
Upper Rous	U4	Low	Low	(1)
Mid Rous	S5	Low	High	(1)
Lower Oxley	U3	Low	Med	(1)
Mid Tweed	S3	High	Med	Yes
Estuary	S5	Low	High	(1)
Richmond				
Gradys Creek	S4	Med	Med	(1)
Kyogle	S1	High	High	Yes
Clarence				
Paddys Flat	S5	Low	High	Yes
Gorges	S5	Low	High	Yes
Tooloom	S5	Low	Med	Yes

The Hydrologic Index is based on:

High flow – 70 to 80% of the 80% (dry) flow

Medium – 40 to 60% of the 80% (dry) flow

Low – 0 to 30% of the 80% (dry) flow

Impacts on Estuaries;

All three Basins have high value estuaries. Their attributes vary but all involve commercial fishing; mangroves; aquatic birdlife; recreational use.

Flood incidences are important for estuary health. The levels of regulation influence flow regimes and thus estuaries.

Sedimentation in the Tweed estuary is an issue. It also experiences depositions from littoral sand drift, south to north. This impacts on navigation.

A "Sand Bypass Scheme" was commissioned in 2001. It is a joint work of NSW and Queensland governments with contributions for management from the Gold Coast Council.

"River Flow Objectives" policies in NSW;

The NSW government has a state-wide policy on River Flow Objectives (RFO). The policy requires development of Management Plans for Basins. The diversion options will need to cover the management plans requirements, which relate primarily to environmental aspects.

If any diversion proposal advances to the next stage, it will be critical to have the environmental flow regimes well defined and that will require coordination with the NRCMA.

Acid sulphate soils;

Acid sulphate soils are found in every coastal estuary in NSW. The largest of these areas are on the coastal floodplains of northern NSW, including the Tweed, Richmond and Clarence. Common activities that trigger oxidation and generation of acid from acid sulphate soils include works to reduce flooding.

Endangered species in the dam catchments;

NSW Government Department reports have identified threatened species in each Basin.

Fisheries

Within the report on Tweed water supply augmentation, there is provision to meet flows to accommodate fish management requirements.

Native Forests.

The location of the Potential works in the Tweed and Richmond Basins would not affect any forests.

The Clarence proposals involve transport through NSW forests in region where old growth forests have focus.

Wild and Scenic Rivers

Clarence proposals especially those in the upper catchment are within areas, which may have wild and scenic classifications.

3.3.3 Social

Community attitudes;

The experiences of the NSW Healthy Rivers Commission in its work on potential diversion of Clarence Basin water for Coffs Harbour water supply should be examined. The Clarence community opposed the inter-basin transfer and this involved only intra-state diversions.

Community involvement

The NSW government in recent times have established Community Management Authorities, (CMA). The Northern Rivers CMA has a defined role in management of the water resources within its area of responsibility. The CMA released a Catchment Action Plan in September 2006.

Any actions to advance any diversion proposal would require CMA involvement.

3.3.4 Institutional

Inter-state water trading;

Policies and agreements will be necessary to identify water rights to give effect to inter-state transfers. These policies will need to address water access and use rights (there are variations in the states' policies).

Water Pricing

Each State has different regulatory processes and their pricing policies vary. This is not seen as a major issue.

Asset Ownership

Construction of works in NSW to service Queensland will require determinations of asset ownership if progressed as a government work. It is not envisaged a major issue.

Water Sharing Plans

Under NSW Water Management Act 2000, a Water Sharing Plan has to be prepared for each river system. The Northern Rivers water Sharing Plans are not completed.

A macro planning process has been developed for water sources where there is less intensive water use.

The Northern Rivers Catchment Management Authority released a Northern Rivers Catchment Action Plan (CAP) in September 2006. The CAP is a Ministerial approved statutory but not regulatory mechanism. It takes into account the macro planning actions. Its objective is to enable prioritisation of natural resources investment to deliver the prioritised outcomes. The CAP covers the full spectrum of Natural Resources Management.

The Integrated Water Cycle Management Plans, (IWCMP), are the focus for urban water with Local government having responsibility. In the upper Richmond and Tweed Basins the IWCMPs are well progressed

Purchase of Water Rights

An alternative option could be for Queensland to buy NSW irrigation licenses below Toonumbar Dam (11,000 megalitres) on Ironpot Creek. It would be a secure supply. Delivery would be via a pipeline across the McPherson Range as for the upper Richmond option.

The diversion volume directly from the dam, based on percentage regulation limits would be 10,000 megalitres per year. The average annual inflow to the dam is 38,000 megalitres per year and that represents about a high 25% regulation. The diversion site further down the system near Ettrick would reduce pipe lengths and improve the percentage regulation index.

This proposal was not costed.

4 Supply Options

4.1 Transportation Issues

The transportation issues deal with:-

- Principles adopted in selection of transportation routes;
- Delivery sites in Queensland;
- Supply locations in NSW;
- Route options using existing “rights-of-way”; and
- The delivery works.

4.1.1 Principles

The principles to be applied in examining potential diversion schemes adopted were: -

- To deliver water from NSW Basins’ sites capable of servicing specified quantities of water to sites in Queensland, in which existing or proposed water supply works are located and can regulate NSW diverted water;
- To site the transport routes on existing ”rights-of-way”, either roads or rail to minimise the length of the delivery works or minimise the energy needed to carry the water to Queensland’s water supply service network.

4.1.2 Delivery Sites in Queensland

Three delivery sites in Queensland were considered appropriate.

- The Logan River Basin, in which there are proposals for a 135,000 megalitre storage at the Wyaralong dam site and for a weir at Cedar Grove on the Logan River;
- The Nerang River Basin, in which the existing Hinze Dam, storing when full 282,000 megalitres and regulating flows to primarily service the Gold Coast; and
- The Queensland pipe network near the site of the desalination plant and associated pipe network at Tugun (near Coolangatta).

Figures A, B, C, and D in Appendix A indicate the locations of these sites.

4.1.3 Supply Locations in NSW

The three NSW river basins examined are the Tweed, Richmond and Clarence.

For the Tweed Basin, only one supply site was examined.

- Brays Park Weir, close to Murwillumbah.

For the Richmond Basin, two sites were examined.

- on the upper Richmond Basin Upstream of Kyogle; and
- on the Wilson River near Binna Burra.

For the Clarence Valley, four sites were examined.

- on the lower Toolom Creek catchment Downstream of Urbenville;
- on the upper Clarence River Upstream of Tabulam and Upstream Duck Creek;
- on the upper Clarence River Upstream of Tabulam and Downstream Duck Creek;
- on the lower Clarence River near Jackadgery.

Figures A, B, C, and D in Appendix A indicate the locations of these sites. For the sites Upstream and Downstream of Duck Creek, the diversion sites are within several kilometres of each other.

Selection of the sites was based on:

- indications from the Military Maps of reasonable storage potential;
- examinations of flow records; and
- principles proposed for assessment of potential diversion limits from the referenced streams having regard to existing use and firm forecasts of future use for consumptive and environmental purposes as documented in available reports.

If any option is to proceed to a next phase of more detailed examination, these outcomes will need to be re-examined.

Runoff at Selected Diversion Points

The estimated annual natural runoff at the selected diversion points is shown in Table 4.1

Table 4.1 Estimated annual natural runoff at selected diversion points

Basin	Diversion Location	Average Annual Flow (megalitres per year)
Tweed	Tweed River at Brays Creek Weir[6]	365 000
Richmond	Richmond River at Wiangaree	252 000
	Wilson River near Binna Burra	70 000
Clarence River	Clarence River Upstream of Tabulam; Downstream Duck Creek	650 000
	Clarence River Upstream of Tabulam; Upstream Duck Creek	400 000
	Mann River near Jackadgery	1 800 000

[6] There is no gauging station at this point, recognised in the Tweed Council Report. The average flow is based on assessments of total basin runoffs

4.1.4 Delivery Routes

Route Options

For each NSW Basin there were several routes examined. Geomorphic criteria of the Queensland receiving streams will dictate the end delivery point of the delivery works, which transport water over the McPherson Range. If the pipelines have to extend to Cedar Grove Weir or Hinze Dam, about 60 and 30 kilometres respectively of additional pipelines might be required.

To the Logan Basin

Delivery to the Logan Basin from the Richmond and Clarence Basins would involve routes across or through the McPherson Range. Diversion from the Tweed Basin to the Logan Basin is not proposed.

To the Nerang Basin

Delivery to the Nerang Basin across the McPherson Range from the Tweed Basin could be achieved using pipelines. Diversion from the Richmond and Clarence Basins to the Nerang Basin and then into Hinze Dam is not proposed.

To Tugun

Delivery of water to the Queensland pipe network near Tugun from the Tweed and Richmond Basins (Wilson River) could be achieved using pipelines. It does not involve crossing the McPherson Range. Diversion from the Clarence Basin to Tugun site not proposed.

DELIVERY ROUTES

One of the principles used to select options was to route the delivery works (pipelines) along existing road and rail "rights-of-way".

An examination of a longitudinal profile of the McPherson Range from virtually the coast to the headwaters of the junction of the Richmond, Clarence and Logan Basins was undertaken. As expected, the section indicates the desirable crossing locations from the Tweed and Richmond Basins corresponded to the major road and rail crossing points.

The Tweed and the Richmond Basin each have reasonable internal road networks and roads crossings the McPherson Range. There is also a rail crossing of the McPherson Range and rail "right-of-way" exists from the Wilson River to the Pacific Highway. For this "desk-top" study, no attempt has been made to discuss potential access/fees with the relevant NSW agencies for use of their assets. In the upper Clarence the roads are mainly secondary roads until the Mount Lindsay Highway is reached near Woodenbong.

For this "desk-top" study, no attempt has been made to discuss potential access/fees with the relevant NSW agencies for use of their assets.

No inspections were made of the routes. Cost estimates of the delivery systems have been based on standard costings for works of this type.

Delivery routes across the McPherson Range and along the Coastal routes are detailed in Table 4.2 and shown on Figures A, B, C, and D in Appendix A.

Table 4.2 Details of Delivery Routes

Basins			Transport Route
Across the McPherson Range			
Tweed	to	Nerang	From Brays Park Weir following the Numinbah Road traversing the McPherson Range at about 500 metres to the headwaters of the Logan Basin. The pipeline will need to continue along the road route to a location where the geomorphic characteristics of the Logan River are adequate to accommodate the additional flows.
Richmond	to	Logan	From a site Upstream of Kyogle heading along the Summerland Way about Grevillia and then traversing the McPherson Range at about 550 metres using the Grady Creek Road or rail right-of-way to the headwaters of the Logan Basin. The pipeline will need to continue along the road or rail route in Queensland to a location where the geomorphic characteristics of the Logan River are adequate to accommodate the additional flows.
Upper Clarence	to	Logan	<u>Tooloom Creek Option</u> Secondary roads from the site to Eight Day Creek Road then to Tooloom then north to Urbenville. Continuing north to Woodenbong then via the Mount Lindsay Highway crossing the McPherson Range at about 550 metres to the headwaters of the Logan Basin. The pipeline will need to continue along the road in Queensland to a location where the geomorphic characteristics of the Logan River are adequate to accommodate the additional flows. <u>Upstream Tabulam Option</u> Following Lower Duck Creek Road to Old Bonalbo then north to Urbenville. Continuing north to Woodenbong then via the Mount Lindsay Highway crossing the McPherson Range at about 550 metres to the headwaters of the Logan Basin. The pipeline will need to continue along the road in Queensland to a location where the geomorphic characteristics of the Logan River are adequate to accommodate the additional flows.
Lower Clarence	to	Logan	From Jackadgery east to Copmanhurst then to the Summerland Way north via Casino to Kyogle and continuing to near Grevillia and then traversing the McPherson Range crossing the McPherson Range at about 550 metres using the Grady Creek Road or rail right-of-way to the headwaters of the Logan Basin. The pipeline will need to continue along the road or rail route in Queensland to a location where the geomorphic characteristics of the Logan River are adequate to accommodate the additional flows.
Coastal Route to Tugun			
Tweed	to	Tugun	From Brays Park Weir east of Murwillumbah following the Tweed Valley Highway to the Pacific Highway and then to Tugun in Queensland.
Richmond	to	Tugun	From the Wilson River near Binna Burra following the Casino to Murwillumbah Railway right-of-way to the Pacific Highway and then into Queensland to Tugun. A variation of this route was to take water into the Tweed at Murwillumbah connecting into the Brays Park Weir to offer flexibility in future management for supplementing either Tweed Basin needs or Queensland diversions.

4.1.5 Delivery Works

Capacity of Delivery Systems

The sizing of the pipelines was based on:

- sizing pipes for annual flows to Queensland of up to 100,000 ML/year; and
- supply of the flows over either a 4 month or a 12 month period.

Advisable Flow Limits

The range of delivery capacities examined were selected as a result of principles applied in determining limits to diversion quantities from each system from hydrologic and level of development viewpoints. Comments on these limits are presented in the Section dealing with assessments of potential water available to Queensland from NSW.

For the Tweed options having regard to current and firm projections of future needs, transport of 10,000 megalitres per year would be seen as the limit over the longer term. A proposal to integrate Tweed and Queensland demands should be considered and this could lead to a 20,000 megalitres per year pipeline capacity being preferable in early years.

For the Richmond options a range of 10,000 to 20,000 megalitres per year was considered to be the appropriate limit for this stage of the studies. A dam to secure 20,000 megalitres per year may create inundation and hydrologic limit issues regarding filling over the longer term.

The Clarence Basin is the only Basin from which 50,000 megalitres per year could be potentially obtained. There is adequate runoff for both sites on the Clarence River itself from a hydrologic viewpoint.

For the Tooloom Creek catchment, a 10,0000 megalitres per year limit is seen as appropriate but, because of the location of the extraction point, an increase to 20,000 megalitres per year might be acceptable from a hydrologic viewpoint.

Diversion Security

Two options were considered.

- **Run-of-river scheme option** limiting Queensland access to NSW water to only high flow periods. The flow characteristics of the three Northern NSW Basins exhibit a high variability, with seasonality present. These characteristics led to adoption of sizing the delivery works to accommodate the annual diversion volumes over 4 month period.

  If high flows occur in any month, consideration of having access would need to be discussed. Prospects of Queensland diversions not being required in high flows times is a reality. Diversion profiles can only be assessed with long term records of daily flows.

- **Secure supply option** involves provision of storages in NSW basins to ensure a secure supply over the worst drought, with delivery in each month of the year.

Table 4.3 indicates some salient engineering details of the Potential delivery systems.

Table 4.3 Pipeline capacities used in costing the options.

Option	Design Period	Diversion Volume (ML per year)	Pipeline Capacity (ML per day)
Run-of river	4 months	10 000	83
		15 000	125
		20 000	166
Secure supply	12 months	10 000	27
		20 000	54
		50 000	135
		100 000	135

Table 4.4 indicates some salient engineering details of the Potential delivery systems.

Table 4.4 Delivery Works

Basins	Maximum Elevation (metres)	Delivery Works Major Details				
		No of Pump Stations	Pipeline Diameter Range (metres)	Length of Delivery works (kms)		
				Pipelines[7]	Tunnel	Delivery site
Across the McPherson Range						
Tweed River to Nerang Basin						
Existing Brays Park Weir in Murwillumbah to Nerang Basin headwaters then run-of-river to Hinze Dam						
	500	5	500 to 959	28	-	Nerang Basin Headwaters
Richmond Basin to Logan Basin						
Richmond River Upstream Kyogle at the Wiangaree weir site to Running Creek in Logan Basin headwaters then run-of-river to proposed Cedar Grove Weir site-Possible extension of pipeline to proposed Wyaralong Dam.						
	550	2	1124	25	-	Logan Basin headwaters
	550	1	1124	30	-	Extend to proposed Wyaralong Dam
Upper Clarence Basin to Logan Basin						
Clarence River at the Upstream Tabulam site to Logan Basin headwaters then run-of-river to proposed Cedar Grove Weir site-Possible extension of pipeline to proposed Wyaralong Dam.						
	550	4	1290	69	-	Logan Basin headwaters
	550	1	1290	30	-	Extended to proposed Wyaralong Dam
Upper Clarence Basin to Logan Basin						
Tooloom Creek site to Logan Basin headwaters then run-of-river to proposed Cedar Grove Weir site-Possible extension of pipeline to proposed Wyaralong Dam						
	550	2	750	41	-	Logan Basin headwaters
	550	1	1290	30	-	Extended to proposed Wyaralong Dam

7 The length of pipelines and tunnels varies with options relating to diversion capacities. The overall route is the same

Basins	Maximum Elevation (metres)	Delivery Works Major Details				
		No of Pump Stations	Pipeline Diameter Range (millimetres)	Length of Delivery works (kms)		
				Pipelines (km)	Tunnel	Delivery site
Lower Clarence Basin (Mann River) to Logan Basin						
Near Jackadgery to the Logan Basin headwaters then run-of-river to proposed Cedar Grove Weir site.						
	550	7	1290	210	**-**	Logan Basin headwaters
Coastal Route to Tugun						
Tweed River to Tugun						
Existing Brays Park Weir in Murwillumbah to Tugun						
	45	1	600 to 1124	40	-	Tugun
Richmond Basin to Tugun						
Potential weir on Wilson River near Binna Burra to Tugun						
	45	1	1124	84	-	Tugun
Wilson River to Murwillumbah						
Potential weir on Wilson River near Binna Burra to existing Brays Park Weir in Murwillumbah						
	55	1	1124	58	-	Brays Park Weir

4.2 Dam Sites

The dam sites issues relate to: -

- Basic approach;
- Selected sites;
- Preliminary engineering details; and
- Specific sites comments

4.2.1 Basic Approach

As this consultancy is limited to a "desk-top" study, potential sites were based on either :

- Sites identified in NSW DNR's reports prepared in the 1970[8];
- Examination of Topographic Military Maps (1 to 25,000) covering each basin;
- Sites identified by Tweed Shire Council in its recent investigations of potential augmentation schemes for Tweed Council's water supply.

4.2.2 Selected Sites

Sites examined in each Basin are indicated in Table 4.5 and on the maps in Appendix A.

Table 4.5 Potential Dam Sites Details

Dam Site Identification		Catchment (sq. km)	Average Annual Flow (megalitres/year)
Tweed			
Oxley R	Rocky Cutting	205	140 000
Rous R	Upstream Chillingham	22	35 000
Byrrill Ck	Glen Warning	56	35 000
Roland Ck	Near Uki	40	20 000
Richmond			
Wilson R	Nr Binna Burra	87	70 000
Richmond R	Upstream Grevillia	130	40 000
Clarence			
Tooloom Ck	Downstream Urbenville	523	100 000
Clarence R	Upstream Tabulam Downstream Duck Creek	3 550	650 000
	Upstream Tabulam Upstream Duck Creek	2 360	400 000
Mann R	Near Jackadgery	7 800	1 830 000

[8] DNR River Valley Reports for the Tweed, Richmond and Clarence Valleys

4.2.3 Preliminary Engineering Details

For each site: -

- SMEC did not inspect pipeline routes or any dam sites in keeping with the ”desk-top” nature of the study.
- Geological assessments have not been made.
- No theodic surveys were undertaken. Storage capacity and physical dimensions of Potential storages for costing were based on the 1 to 25,000 Military Maps. Storage capacities relationships were based on 10 metre contours intervals.

Table 4.6 contains the ”desk-top” study outcomes of the dams' details.

Table 4.6 Very Preliminary Engineering Details

Dam Site Identification		Capacity Range (Megalitres)	Surface Area-(sq. km)
Tweed			
Oxley R	Rocky Cutting	25 000 to 45 000	5
Rous R	Upstream Chillingham	35 000	2
Byrrill Ck	Nr Glen Warning	45 000	3
Roland Ck	Near Uki	20 000	2+
Richmond			
Wilson R	Nr Binna Burra	Pumping weir	Within river
Richmond R	Upstream Kyogle	Pumping weir	Within river
Richmond R	Upstream Grevillia	80 000	6 sq. kms
Clarence			
Tooloom Ck	Downstream Urbenville	Pumping weir	Within river
		30 000	4
Clarence R	Upstream Tabulam Downstream Duck Creek	20 000	Below 1
	Upstream Tabulam Upstream Duck Creek	250 000	15
Mann R	Nr Jackadgery	Pumping weir	Within river
	Upstream Jackadgery	70 000	8

4.2.4 Specific Site Comments

As there have been no engineering investigations by SMEC, other than the “desk-top” work, the following comments on each site are very preliminary and based on assessments from any earlier documentation and from the 1 to 25,000 Military Maps detail.

Table 4.7 Preliminary site specific comments

Dam Site Identification		Site Specific Comment
Tweed		
Oxley R	Rocky Cutting	Proximity to Tyalgum for larger storages. Resumptions of farmlands.
Rous R	Upstream Chillingham	Limited runoff with high capacity to runoff ratio. Percentage regulation issues. Not seen as option.
Byrrill Ck	Glen Warning	Potential National Park consideration. High capacity to runoff ratio. Percentage regulation issues in the Tweed River above Brays Park Weir. Resumptions of farmlands.
Roland Ck	Near Uki	Resumptions would involve high-density farmlands and significant road relocations. Limited runoff with high capacity to runoff ratio. Percentage regulation issues in the Tweed River above Brays Park Weir. Not seen as option.
Tweed R	Brays Park Weir	Use of existing work. Adequacy will require detailed assessment. Prospective consideration of a weir on the Rous river to supplement flows for run-of-river option.
Richmond		
Wilson R	Nr Binna Burra	Road relocations and within high-density population area. Potential scale of resumptions costs suggests avoid dam and limit to run-of-river support system.
Richmond R	Upstream Kyogle	Prospect of consideration of use of Downstream existing Kyogle Weir if weir site proposed were not possible.
Richmond R	Upstream Grevillia	Relocation of Summerland Highway up to 10 kms. Resumptions of farmlands. Limited runoff with high capacity to runoff ratio Percentage regulation issues immediately below dam.
Clarence		
Tooloom Ck	Downstream Urbenville	Power lines in proximity (Military Map interpretation). Resumptions of farmlands.
Clarence R	Upstream Tabulam both sites	Difficult access. Larger storage inundation of significant areas in National Parks Power lines in proximity. Significant intrusion into National Park areas for access and construction. Biodiversity issues
Mann R	Nr Jackadgery	Pumping pool within River. No major storage in this option.
	Upstream Jackadgery	Significant storage for 100,000 megalitres per year diversions causes inundation of 40 kilometres of Mann and Nymbodia Rivers regarded as likely ‘wild and scenic’.

5 Water Transfer Options

5.1 Phase 1 Options

In undertaking Phase 1 of the study, 40 possible options for capturing water from the three major coastal catchments (the Tweed, Richmond and Clarence valleys) of the Northern Rivers of NSW. These options were identified using the following approach.

- Review of existing options from the sources listed below
  - Rankine & Hill – Inland Diversions Report (Reference 12)
  - Ghassemi & White - Inter-Basin Water Transfer Report
  - NSW Water Conservation & Irrigation Commission – Investigations into dam sites
  - Tweed Shire Council – Tweed River System Water Supply Security Review (Reference 5)
  - Tweed Shire Council – Integrated Water Cycle Management report (Reference 13)
  - Healthy Rivers Commission - Clarence River System Inquiry (Ref 14)
  - Rous County Council
  - Gowrie Oakey Creek Irrigators Association
- Identification of new options by
  - Review of Military Maps
  - Analysis of existing streamflow records

The initial 40 options were reduced to 26 options for reasons of engineering feasibility and hydrologic issues. The locations of the 26 options considered in Phase 1 were:

- Tweed River Basin – 14 options
- Richmond River Basin – 5 options
- Clarence River Basin – 7 options

The 26 options are listed in Table 5.1 with the adopted identification coding and shown schematically on Figures A, B, C and D in Appendix A. Further details of each of the options are provided in Sections 3 and 4.

Table 5.1 Identification Coding of Options

1 RUN-OF RIVER

Supply Location in NSW Basin	Queensland Delivery Locations		Diversion Limit ML/year	Option Code
	From NSW Basin	Within Qld's System		
TWEED BASIN				
Tweed River near Murwillumbah across McPherson Range to Nerang Basin				
Existing Brays Park Weir	Nerang Basin headwaters	Existing Hinze Dam	10,000	TW1a
			15,000	TW1b
Tweed River near Murwillumbah via coastal route to Tugun				
Existing Brays Park Weir	Tugun	Qld's supply pipelines near desalination plant site	5,000	TW5c
			10,000	TW5b
			15,000	TW5a
RICHMOND BASIN				
Richmond River Upstream Kyogle (Wiangaree) across McPherson Range to Logan Basin				
Richmond River Upstream Kyogle at the Wiangaree weir site	Running Creek in Logan Basin	Proposed Cedar Grove Weir Pipeline to Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	10,000	RI1a
		Proposed Cedar Grove Weir Pipeline to Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	20,000	RI1b)
Richmond Basin from Wilson R near Binna Burra via coastal route to Murwillumbah and to Tugun				
Weir site on Wilson River near Binna Burra	Integrate with A5-b		10,000	RI3
Richmond Basin from Wilson River near Binna Burra via coastal route to Tugun				
Weir site on Wilson River near Binna Burra	Tugun	Qld's supply pipelines near desalination plant site	10,000	RI4
CLARENCE BASIN				
Upper Clarence Basin across the McPherson Range to Logan Basin				
Tooloom Creek Downstream of Urbenville	Logan Basin headwaters	Proposed Cedar Grove Weir Pipeline to Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	10,000	CL5a

Table 5.1 Identification Coding of Options continued

2 SECURE SUPPLY

Supply Location in NSW Basin	Queensland Delivery Locations		Diversion Limit	Option Code
	From NSW Basin	Within Qld's System	ML/year	
TWEED BASIN				
Tweed River near Murwillumbah across the McPherson Range to Nerang Basin				
Existing Brays Park Weir	Nerang Basin headwaters	Existing Hinze Dam	10,000	TW1d
			20,000	TW1c
Proposed Raising Clarrie Hall Dam with Delivery Option TW1d			12,000	TW3
Proposed Byrrill Creek Dam with Delivery Option TW1d			10,000	TW4b
Proposed Byrrill Creek Dam with Delivery Option TW1c			20 000	TW4a
Potential Rolands Creek Dam with Delivery Option TW1d			10 000	TW6
Potential Rocky Cutting Dam with Delivery Option TW1c			20 000	TW7
Tweed River near Murwillumbah via the coastal route to Tugun				
Existing Brays Park Weir	Tugun	Qld's supply pipelines near desalination plant site	10,000	TW5d
			20,000	TW5e
Proposed Raising Clarrie Hall Dam with Delivery Option TW5d			12,000	TW8
Proposed Byrrill Creek Dam with Delivery Option TW5d			10,000	TW9b
Proposed Byrrill Creek Dam with Delivery Option TW5e			20 000	TW9a
Potential Rolands Creek Dam with Delivery Option TW5d			10 000	TW10
Potential Rocky Cutting Dam with Delivery Option TW5e			20 000	TW11
RICHMOND BASIN				
Richmond Basin across the McPherson Range to Logan Basin				
Richmond River Upstream Kyogle at the Wiangaree weir site	Running Creek in Logan Basin	Potential Grevillia Dam Pipeline to cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site Proposed Cedar Grove Weir or Wyaralong Dam	10,000	RI1d

Table 5.1 Identification Coding of Options continued

Supply Location in NSW Basin	Delivery Locations From NSW Basin	Delivery Locations Within Qld's System	Diversion Limit ML/year	Option Code
CLARENCE BASIN				
Upper Clarence Basin across the McPherson Range to Logan Basin				
Tooloom Creek Downstream of Urbenville	Logan Basin headwaters	Potential dam Downstream Urbenville Proposed Wyaralong Dam Pipeline to Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	20,000	CL5b
Upper Clarence Basin across the McPherson Range to Logan Basin				
Clarence River Upstream of Tabulam-Downstream of Duck Creek	Logan Basin headwaters	Potential Dam Downstream Duck Creek Pipeline to Cedar Grove Weir Proposed Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	10,000	CL3a
Clarence River Upstream of Tabulam-Upstream of Duck Creek	Logan Basin headwaters	Potential Dam Upstream Duck Creek Pipeline to Cedar Grove Weir Proposed Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	100,000 50,000	CL3b CL3c
Lower Clarence Basin (Mann River) across the McPherson Range to Logan Basin				
Weir site on Mann River near Jackadgery	Logan Basin headwaters	Proposed Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	50,000	MA1
Dam site on Mann River Upstream Jackadgery	Logan Basin headwaters	Proposed Cedar Grove Weir Extension of Pipeline from Cedar Grove Weir to Wyaralong Dam site	100,000	MA2

Preliminary cost estimates of the structural components of each option were determined for incorporation into the cost analyses. These preliminary cost estimates were based on:

- Long sections of each pipeline
- Indicative costs of dams, weirs, and pumping stations
- Costs of pipelines and fittings supply and construction
- Unlined tunnel construction costs
- Cost estimates for survey, geotechnical studies, design, & construction supervision
- Cost estimates for operation and maintenance
- Contingencies

It could be noted that the operation costs did not take account of the possibility of energy recovery during transfer of water across the McPherson ranges. An approximate "energy balance" undertaken for this study estimated that approximately forty percent of the energy used to transfer the water across the McPherson range may be recovered through mini-hydro plants.

5.2 Phase 2 Options

From the 40 Phase 1 options, five options were as being appropriate to be assessed in more detail in Phase 2. The rationale for selecting the five options listed below was the option that provides 50 000 ML/year; the two options that provide 100 000 ML/year and the two options that resulted in the lowest cost in Phase 1.

It should be noted that, as the Phase 2 options were selected on the basis of the Phase 1 costings which have since been revised the relative ranking of the previously lowest cost options may differ in the Phase 2 costings.

Option TW7

- Construction of dam on Oxley River at Rocky Cutting
- Construction of pipeline from Brays Park Weir to head waters of the Nerang River
- Construction of pipeline to Hinze Dam
- Supply of 20 000 ML/yr over 12 months

Option CL3b

- Construction of dam on Clarence River Upstream of Duck Creek
- Construction of pipeline to headwaters of Logan River
- Construction of pipeline to proposed Cedar Grove Weir
- Construction of pipeline to proposed Wyaralong Dam
- Supply of 100 000 ML/yr over 12 months

Option CL5b

- Construction of dam on Tooloom Creek
- Construction of pipeline to headwaters of Logan River
- Construction of pipeline to proposed Cedar Grove Weir
- Construction of pipeline to proposed Wyaralong Dam
- Supply of 20 000 ML/yr over 12 months

Option MA1

- Construction of weir on Mann River near Jackadgery
- Construction of pipeline to headwaters of Richmond River
- Construction of pipeline to headwaters of Running Creek (in Logan system)
- Supply of 50 000 ML/yr over 12 months

Option MA2

- Construction of dam on Mann River Upstream of Jackadgery
- Construction of pipeline to headwaters of Richmond River
- Construction of pipeline to headwaters of Running Creek (in Logan system)
- Supply of 100 000 ML/yr over 12 months

For each of the five Phase 2 options a more detailed desk top review was undertaken of the:

- potential delivery route
- length of pipeline
- most cost efficient delivery works
- amount of rock excavation required
- indicative costs of the construction of dams, weirs, and pumping stations
- cost of resumption of land at the dam and weir sites
- cost of the relocation of road infrastructure

The revised cost estimates were based on recent experience of SMEC's Geotechnical, Roads, Water Infrastructure, Dams, and Civil Infrastructure Groups in undertaking design and construction projects containing similar works. Examples of the generic cost estimates adopted for a range of pipe sizes are provided in Appendix B.

The revised cost estimates for the five Phase 2 options were incorporated into the Cost Analyses described in the following Section. Costs for augmentation of the delivery infrastructure within the existing Queensland system were not included at this stage.

6 Cost Analyses

6.1 Methodology

As discussed in the previous section, 40 possible options for capturing between 7 500 ML and 100 000 ML of water per annum from the three major coastal catchments (the Tweed, Richmond and Clarence valleys) of Northern NSW, and transferring that water via pipelines to supplement urban water supplies in southern Queensland were scoped. Of those possible options, 26 were considered to be feasible on hydrological and engineering grounds and assessed in Phase I and II.

For each of those 26 options annual yield (ML) and cost estimates were developed for:

- Dams / weirs / pumping stations;
- Pipeline Supply;
- Pipeline Construction;
- Structures;
- Preliminaries;
- Survey/geotechnical/design/supervision;
- Contingencies;
- Operating costs (annual); and
- Maintenance costs (annual)

Details on the methods and assumptions used in deriving those estimates are provided in earlier sections of the report. Of the 26 options, 5 were selected for more detailed (Phase II) consideration.

A preliminary cost analysis was undertaken for use in considering the relative feasibility of individual options, and to support decisions on whether to proceed with investment in more detailed option design, costing and impact assessment for a limited set of options or integrated schemes. It should be noted that this is a financial rather than economic assessment. A broader economic assessment (or benefit cost analysis) may be required for any short listed options that are subject to detailed consideration in Phase III.

Supply schemes can be costed to at different points in the supply chain. For instance:

- Bulk untreated water into storage or a bulk water grid;
- Treated and transported bulk water delivered to a retailer; and
- Treated, pressurised and delivered water to retail customers / consumers.

This preliminary cost analysis is focused on the unit cost per kilolitre per annum for bulk untreated supply to south east Queensland. Notional unit costs are then estimated for bulk treated (including transport and losses) water delivered to retailers and water delivered to retail customers, by adding a fixed unit cost for treatment, transport, losses and retail delivery.

The Queensland Government uses 'lower bound' and 'upper bound' principles when setting water prices. Lower bound prices only include costs associated with operation, maintenance, administration, refurbishment, tax, debt funding costs and notional externalities. Upper bound pricing includes those costs and a commercial return on assets. In the absence of information on the precise methodology being used to estimate unit costs for equivalent projects in Queensland, the objective of the methodology adopted in this study is to estimate the $ per kilolitre per annum cost at the 'upper bound' price for bulk untreated water (or higher). The adopted methodology therefore incorporates a number of conservative assumptions and may over estimate the unit costs of each option.

The bulk untreated unit cost is assumed to represent a depreciation charge (for dams, weirs, pumps, pipelines, and other structures), plus operations and maintenance costs, and a return on all capital employed, divided by the estimated annual yield for the option. It is noted that natural resource management charges by the NSW Department of Natural Resources would add around 0.5c per KL.

The following assumptions have been made:

- The cost of works have not been discounted to take into account the period of construction;
- Dam, weirs, pumps and structures are fully depreciated on a straight line basis over 50 years;
- Pipelines are fully depreciated on a straight line basis over 30 years;
- A land resumption and easements cost of $10 million is included for all options;
- A return of 6.5% per annum is charged on all invested capital;
- A 10% increase (equivalent to GST) has been included for all SMEC cost estimates;
- NSW Natural Resource Management bulk water charges are ignored as they are less than 0.5c/kl;
- Supply yields for run-of-river capture options are assumed to be 70% of base yields;
- Supply yields are fully utilised in all years.

These assumptions will generally result in an over estimation of ‘upper bound’ costs. Sensitivity of results to yield assumptions and the required rate of return are considered in later sections.

6.2 Option Costs

Annual costs = annual capital depreciation + capital charge + operations and maintenance costs.

Total annual costs range from $9 million to $204 million depending on the option considered.

Pipeline costs are generally lower for the Tweed Options due to their immediate proximity with southern Queensland. Other capital costs are also generally lower for the Tweed options.

The highest pipeline and structure costs are associated with Clarence options due to scale and transport distances.

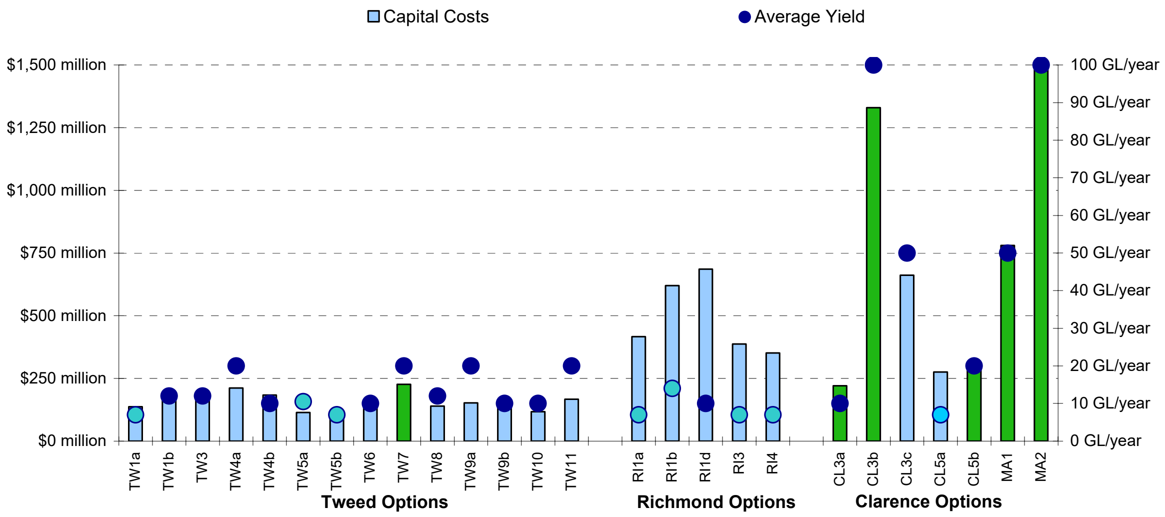
The largest contributing factor to the annual costs is the capital charge. It represents at least 50% of the annual cost of all options, an average of 61%, and a maximum of 73%.

Total annual option costs are not directly comparable as they relate to a range of supply yields that vary from 6 300 ML per annum to 50 000 ML per annum

Table 6.1: Values, Annual Costs and Total Annual Costs ($ million)

Option	Land, Plan & Contingency	Structures (excl. Pipeline)		Pipeline		Capital Charge	O&M	Total Annual Costs
	Value	Value	Annual	Value	Annual	Annual	Annual	Annual
TWEED OPTIONS								
TW1a	$50.9	$45.8	**$0.9**	$40.0	**$1.33**	**$9.2**	**5.0**	**$16.5**
TW1b	$67.4	$92.4	**$1.9**	$26.3	**$0.88**	**$12.6**	**7.7**	**$23.0**
TW3	$67.4	$92.4	**$1.9**	$26.3	**$0.88**	**$12.6**	**7.7**	**$23.0**
TW4a	$84.0	$87.1	**$1.7**	$40.2	**$1.34**	**$14.5**	**11.9**	**$29.4**
TW4b	$76.2	$81.4	**$1.6**	$26.3	**$0.88**	**$12.4**	**7.1**	**$22.1**
TW5a	$42.1	$22.9	**$0.5**	$49.1	**$1.64**	**$7.5**	**1.5**	**$11.1**
TW5b	$37.4	$19.7	**$0.4**	$40.6	**$1.35**	**$6.4**	**1.1**	**$9.2**
TW6	$70.3	$67.1	**$1.3**	$26.3	**$0.88**	**$11.1**	**6.4**	**$19.7**
TW7	$127.4	$58.5	**$1.2**	$40.2	**$1.34**	**$15.4**	**10.4**	**$28.3**
TW8	$51.8	$67.5	**$1.4**	$20.4	**$0.68**	**$9.3**	**3.6**	**$15.0**
TW9a	$64.7	$59.8	**$1.2**	$27.5	**$0.92**	**$10.1**	**4.0**	**$16.2**
TW9a	$60.6	$56.5	**$1.1**	$20.4	**$0.68**	**$9.1**	**3.1**	**$14.0**
TW10	$54.8	$42.2	**$0.8**	$20.4	**$0.68**	**$7.8**	**2.3**	**$11.7**
TW11	$108.1	$31.2	**$0.6**	$27.5	**$0.92**	**$11.0**	**2.5**	**$15.1**
RICHMOND OPTIONS								
RI1a	$135.7	$137.5	**$2.8**	$143.8	**$4.79**	**$27.4**	**5.0**	**$40.0**
RI1b	$193.7	$167.0	**$3.3**	$259.3	**$8.64**	**$40.9**	**8.3**	**$61.1**
RI1d	$226.7	$200.0	**$4.0**	$259.3	**$8.64**	**$45.2**	**10.0**	**$67.9**
RI3	$124.8	$136.0	**$2.7**	$126.3	**$4.21**	**$25.5**	**4.9**	**$37.3**
RI4	$112.1	$114.7	**$2.3**	$124.2	**$4.14**	**$23.1**	**3.9**	**$33.4**
CLARENCE OPTIONS								
CL3a	$82.2	$55.2	$1.1	$82.7	$2.8	**$14.7**	$6.1	**$24.7**
CL3b	$428.3	$399.9	$8.0	$501.5	$16.7	**$90.2**	$58.2	**$173.2**
CL3c	$216.7	$194.5	**$3.9**	$250.7	**$8.4**	**$44.9**	**$28.8**	**$86.0**
CL5a	$95.2	$84.6	**$1.7**	$95.4	**$3.2**	**$18.3**	**$5.9**	**$29.1**
CL5b	$106.5	$101.2	$2.0	$85.9	$2.9	**$19.6**	$8.6	**$33.1**
MA1	$234.8	$190.6	$3.8	$354.9	$11.8	**$53.1**	$37.3	**$106.1**
MA2	$466.2	$320.7	$6.4	$709.9	$23.7	**$101.9**	$71.6	**$203.6**

Note: Red text denotes Phase II options.



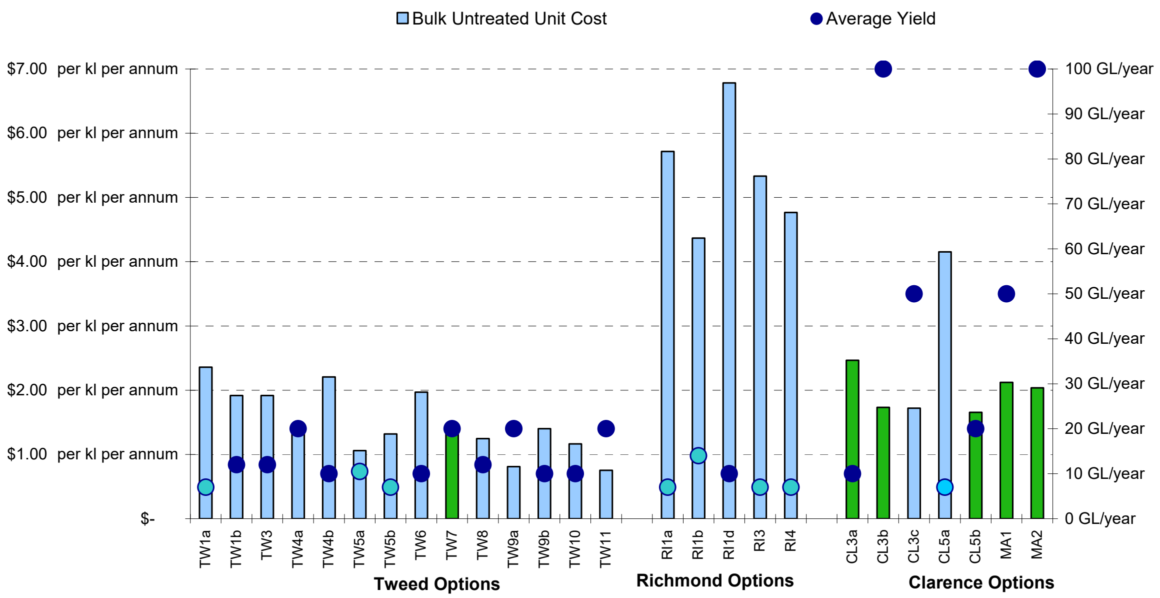
Note: Green columns denote Phase II options; Pale blue dots denote run-of-river capture yields

Figure 6.1: Capital Costs and Average Yields

6.3 Bulk Untreated Unit Costs ($/KL)

The unit cost of bulk untreated water delivered to a Queensland storage or bulk water grid in southern Queensland is estimated by dividing the total annual costs by the average annual yield.

The supply yields for options that capture water from the source river on a run-of-river basis have been reduced to 70% of the base average yield to reflect probably variability in supply over time.



Note: Green columns denote Phase II options; Pale green dots denote run-of-river supply yields

Figure 6.2: Bulk Untreated Water Unit Costs ($ per KL per Annum)

Figure 6.2 shows the range of bulk untreated water unit costs ($0.81 per KL per annum to $6.78 per KL per annum). There are 2 options with bulk untreated unit costs of below $1.00 per KL per annum, both of which could provide a yield of 20 000 ML per annum. There are a further 7 options with bulk untreated unit costs of $1.00 to $1.50 per KL per annum with yields of 7 000 to 20 000 ML. All but one of the Phase II options have bulk untreated unit costs of less than $2.00 per KL per annum. Phase II option TW7 has the lowest bulk untreated unit cost at $1.42 and supplies 20 000 ML. Phase II option CL3b has a bulk untreated unit cost of $1.73 and supplies 100 000 ML, showing an increase in unit costs with volume supplied. The two Phase II options MA1 and MA2, supplying 50 000 ML and 100 000 ML respectively, both have bulk untreated unit costs above $2.00.

Unit costs will vary depending on the point in the supply chain at which the water is delivered. The costed options involve untreated bulk water delivered to storage or a bulk water grid. Unit costs of water delivered to a retailer will included the costs of treatment, transport and bulk losses. In southern Queensland these are assumed to be (on average) in the order of 45c per KL per annum. Unit costs of water delivered by a retailer to a consumer will include additional costs for transport, metering, billing and other factors. In southern Queensland these are assumed to be (on average) in the order of $1.00 per KL per annum.

These notional cost estimates have been added to the bulk untreated unit cost estimates for each scheme to provide a basis on which to compare the considered options with alternative schemes currently under investigation in southern Queensland.

Clearly all unit costs will vary between input locations, off-take locations and differences between years (such as consumption levels and other variable factors). Nevertheless, for the purposes of testing the possible relatively feasibility of the considered options it appears reasonable to use the standard unit costs to lift the bulk untreated water unit cost estimates to treated unit costs to the retailer and the retail unit cost to consumers.

Access was not obtained to the costing information for new supply projects being considered in southern Queensland. However, it is understood that many of the bulk untreated water options may have upper bound unit prices in the order of $0.50 to $2.00 or higher.

Table 6.2: Ranked Unit Costs At Different Points In The Supply Chain

Basis	Rank	Bulk Untreated As Costed	Treated To Retailer + $0.45	Retail To Consumer + $1.00
TW11	1	$0.75	$1.20	$2.20
TW9a	2	$0.81	$1.26	$2.26
TW5a	3	$1.06	$1.51	$2.51
TW10	4	$1.17	$1.62	$2.62
TW8	5	$1.25	$1.70	$2.70
TW5b	6	$1.32	$1.77	$2.77
TW9b	7	$1.40	$1.85	$2.85
TW7	8	$1.42	$1.87	$2.87
TW4a	9	$1.47	$1.92	$2.92
CL5b	10	$1.65	$2.10	$3.10
CL3c	11	$1.72	$2.17	$3.17
CL3b	12	$1.73	$2.18	$3.18
TW1b	13	$1.92	$2.37	$3.37
TW3	14	$1.92	$2.37	$3.37
TW6	15	$1.97	$2.42	$3.42
MA2	16	$2.04	$2.49	$3.49
MA1	17	$2.12	$2.57	$3.57
TW4b	18	$2.21	$2.66	$3.66
TW1a	19	$2.36	$2.81	$3.81
CL3a	20	$2.47	$2.92	$3.92
CL5a	21	$4.15	$4.60	$5.60
RI1b	22	$4.37	$4.82	$5.82
RI4	23	$4.77	$5.22	$6.22
RI3	24	$5.33	$5.78	$6.78
RI1a	25	$5.72	$6.17	$7.17
RI1d	26	$6.78	$7.23	$8.23

Note: Red text delineates Phase II options.

6.4 Sensitivity Analysis

The results of the preliminary costs analysis are significantly affected by a number of core underlying assumptions including the:

- annual supply yield;
- cost estimates provided by SMEC; and
- Weighted Average Cost of Capital (WACC) as applied through the capital charge.

If the annual yield assumptions are decreased, or cost estimates increased, then the bulk untreated unit costs will increase proportionally.

The effect of +15% in assumed costs or -15% in assumed yield, and +25% in assumed costs or -25% in assumed yield, on the estimated unit costs for each option are illustrated in the following table.

Table 6.3: Bulk Untreated Water Unit Costs – Sensitivity to Costs

	Rank	As Estimated	+15% Costs OR -15% Yield	+25% Costs OR -25% Yield
TW11	1	$0.75	$0.87	$0.94
TW9a	2	$0.81	$0.93	$1.01
TW5a	3	$1.06	$1.22	$1.32
TW10	4	$1.17	$1.34	$1.46
TW8	5	$1.25	$1.43	$1.56
TW5b	6	$1.32	$1.52	$1.65
TW9b	7	$1.40	$1.61	$1.75
TW7	8	$1.42	$1.63	$1.77
TW4a	9	$1.47	$1.69	$1.84
CL5b	10	$1.65	$1.90	$2.07
CL3c	11	$1.72	$1.98	$2.15
CL3b	12	$1.73	$1.99	$2.16
TW1b	13	$1.92	$2.20	$2.40
TW3	14	$1.92	$2.20	$2.40
TW6	15	$1.97	$2.27	$2.46
MA2	16	$2.04	$2.34	$2.54
MA1	17	$2.12	$2.44	$2.65
TW4b	18	$2.21	$2.54	$2.76
TW1a	19	$2.36	$2.71	$2.95
CL3a	20	$2.47	$2.84	$3.08
CL5a	21	$4.15	$4.78	$5.19
RI1b	22	$4.37	$5.02	$5.46
RI4	23	$4.77	$5.48	$5.96
RI3	24	$5.33	$6.13	$6.66
RI1a	25	$5.72	$6.57	$7.14
RI1d	26	$6.78	$7.80	$8.48

Note: Red text delineates Phase II options.

The capital charge is a significant determinant of annual costs, representing around 60% for most options, using a 6.5% real pre-tax WACC.

The effects of changes in the WACC +/- 3.5% are shown in the following table.

Table 6.4: Bulk Untreated Water Unit Costs – Sensitivity to WACC (real, pre-tax)

	Rank	3%	6.5%	10%
TW11	1	$0.46	$0.75	$1.05
TW9a	2	$0.54	$0.81	$1.08
TW5a	3	$0.67	$1.06	$1.44
TW10	4	$0.75	$1.17	$1.58
TW8	5	$0.83	$1.25	$1.66
TW5b	6	$0.83	$1.32	$1.81
TW9b	7	$0.91	$1.40	$1.83
TW7	8	$1.00	$1.42	$1.86
TW4a	9	$1.08	$1.47	$1.89
CL3a	10	$1.12	$1.54	$1.97
CL5b	11	$1.13	$1.65	$2.18
CL3c	12	$124	$1.72	$2.20
CL3b	13	$1.25	$1.73	$2.22
TW1b	14	$1.35	$1.92	$2.48
TW3	15	$1.35	$1.92	$2.48
TW6	16	$1.37	$1.97	$2.57
MA2	17	$1.49	$2.04	$2.58
MA1	18	$1.54	$2.12	$2.69
TW4b	19	$1.55	$2.21	$2.87
TW1a	20	$1.65	$2.36	$3.07
CL5a	21	$2.75	$4.15	$5.56
RI1b	22	$2.80	$4.37	$5.94
RI4	23	$2.99	$4.77	$6.54
RI3	24	$3.37	$5.33	$7.29
RI1a	25	$3.61	$5.72	$7.82
RI1d	26	$4.35	$6.78	$9.22

Note: Red text delineates Phase II options.

6.5 Cost Analysis Conclusions

The preliminary cost analysis suggests that there are a number of options that warrant further investigation, on the basis that they appear to be relatively cost effective when using relatively high cost and/or methodological assumptions.

Any further analysis of those options will require:

- The consideration of potential economic impacts on the supply catchments including impacts on in-stream river health, other extractive users, and Downstream impacts on the estuarine environment, sand dredging, and flood plains;
- Scope for additional benefit streams through, for instance, hydro-electricity schemes for pipelines crossing the mountains;
- Hydrological assessment of supply probabilities, the integration of the options into schemes and the assessment of their interaction with supply infrastructure in southern Queensland;
- Assessment of the potential for the options to provide short term peak demand or drought relief for either southern Queensland or growth in demand within the NSW supply catchments;
- A closer comparison of alternative supply options currently being developed within Queensland either by applying the methodology used in this assessment to costs provided by Queensland or by applying the costs assessed for this project using the Queensland methodology;
- The consideration of legislative and policy issues with respect to licensing of works, diversions and their use outside NSW; and
- The scheduling of capital works and other time factors, particularly for integrated schemes.

7 Conclusions

A number of economically and hydrologically feasible options have been identified at "desk top level" for the extraction of significant quantities of water from the rivers of Northern NSW and delivery to SEQ and NE NSW urban water supply systems. The abstraction potential was developed after assessment of broad environmental impacts but it was found that a more detailed environmental analysis will be required before these options are further progressed.

The Clarence River Basin offers the best potential for abstraction of large quantities of water with up to 100,000 ML per annum possible from each of two sites. A dam site upstream of Duck Creek on the Clarence River with a pipeline to Cedar Grove Weir would enable the supply of the above quantity at a unit cost of $1.73 per kilolitre for bulk untreated water. This site would, however, require the construction of a 250,000 ML dam. A dam site on the Mann River (a tributary of the Clarence) with a capacity of around 100,000 ML would also have the potential to supply 100,000 ML per annum to SEQ and NE NSW, at a cost of around $2.04 per kilolitre.

The cheapest options for abstraction exist in the Tweed River with unit costs of around $1.42 per kilolitre. A further advantage of this site is that it would assist both SEQ and the Tweed Shire in the short to medium term, while the longer term options were being progressed. At this stage a limit of 20,000 ML was imposed on abstractions from the Tweed River pending further environmental and engineering assessment.

Although at this stage of the investigation, the Clarence and Tweed options stand out in meeting the short to long term water supply requirements, a combination of a number of different options could also be utilised in the phased development of water supply infrastructure to meet the growing demands of SEQ and NE NSW. Consequently it is important that the other options discussed in the body of the report be re-examined during more detailed investigations.

The options presented in this report were developed after a comprehensive review of available information on population, demand, hydrology, environmental factors and social issues.

- The available population and demand projections for South East Queensland were reviewed and it was concluded that these projections appeared to be reasonable and within the current framework of demand estimation;
- A similar process was applied to the cities of North East NSW and it was found that they also face significant growth pressures and are separately examining supply augmentation options;
- Demand and available supply in both SEQ and NE NSW are currently just in balance and significant shortfalls will develop in the short to medium term;

- It was found that there could be significant benefits in supplying the growing needs of both SEQ and NE NSW from phased development of options in the Northern rivers of NSW;
- The most economic option involved the transfer of water from the Tweed River to the headwaters of the Nerang River;
- The largest quantities of water available for transfer are located in the lower reaches of the Clarence River where quantities of up to 100,000 ML per annum are possibly available for extraction and transfer at each of two different sites;
- The Clarence River valley options however would generally involve higher capital and higher operating costs due to the longer pipelines and associated pumping;
- The highest security of supply is obtained from the construction of large storages but this may entail significant land acquisition costs;
- Development of 'run of river" schemes to transfer water during the wet season would require lower land acquisition costs but would offer less supply security and may require significantly greater operation and maintenance costs;
- It is recognised in this study that there would be a large number of environmental issues and constraints that require further detailed assessment although the options offered were subject to scrutiny for environmental impacts;
- It is also recognised that there will be a number of social/ community issues that will need to addressed in a comprehensive manner if these proposals are to be progressed;
- The results of the financial analysis demonstrate the viability of the options developed although they were based on a number of sweeping assumptions due to the restricted time frame, the nature of the study and the lack of access to recent financial data.

8 Recommendations

8.1 General

This “desk-top” review has demonstrated at a feasibility level that there are economically and environmentally viable options for the supply of large quantities of water from the rivers of Northern NSW to South East Queensland. Five options out of an initial forty were shown to be suitable for further investigation on hydrologic, economic and environmental grounds.

It is recommended that these five identified options be further assessed in order to demonstrate their viability with more detailed investigations. In order to develop a more comprehensive understanding of the benefits and costs it will be important to seek the assistance of the Queensland and NSW Governments and access their recent information on hydrology, costs, supply options, social and environmental considerations.

It is also recommended that the other options developed in this study be re-considered if some of the preferred options are later found less satisfactory or the requirements for water from the Northern Rivers are increased.

It is also recommended that further assessment should be structured towards the generation of a phased program of infrastructure development that could then be compared with the options currently available to Queensland and NSW for augmentation of urban water supply. The critical issues that require further information and examination are covered in further detail in the following sections.

8.2 Supply and Demand

The following actions are recommended to progress the analysis of supply and demand balance in SEQ and NE NSW.

- A review of the demand projections in the SEQ strategy reports and the various studies undertaken in NE NSW to maintain a consistent basis for forecasting;
- A detailed Quality Assurance review of the hydrological information available in Pinneena and the Queensland databases including updating of data to include recent information, checks on rating curves extrapolation, water balance analyses across basins, to ensure that the data being used accurately reflects the hydrological conditions within the catchments;
- Development of a system model covering both SEQ and North Eastern NSW in order to simulate the effect of long term observed and synthesized drought conditions and thereby develop operational rules to ensure supply security for both regions.

8.3 Engineering

- Detailed assessment of the identified dam and weir sites to enable a more comprehensive assessment of their viability and associated cost issues;
- Detailed review of the pipeline routes including geology, topography, soils, vegetation, existing infrastructure, pumping requirements etc to enable more accurate cost estimation;
- Re-examination of pump station locations, construction costs, access to electrical power and possibilities of hydro-generation from water in the pipelines.

8.4 Environmental and Social Issues

- Detailed assessment of the impact of the potential options within the context of the NSW and Queensland environmental legislation;
- Examination of the social and community attitudes within Northern NSW towards the potential options in order to address any perceived community concerns regarding the proposals;

8.5 Cost Analysis

- The consideration of potential economic impacts on the supply catchments including Downstream impacts such as effects on the estuarine environment, water quality issues, sand dredging impacts, flooding impacts and in-stream river health;
- Scope for additional benefit streams through, for instance, hydrol-electric schemes for pipelines crossing the mountains;
- Integration of the options into schemes and their interaction with supply infrastructure in southern Queensland;
- Assessment of the potential for the options to provide short term peak demand or drought relief for either southern Queensland or growth in demand within the NSW supply catchments;
- A closer comparison of alternative supply options currently being developed within Queensland either by applying the methodology used in this assessment to costs provided by Queensland or by applying the costs assessed for this project using the Queensland methodology; and
- The consideration of legislative and policy issues with respect to licensing of works, diversions and their use outside NSW.

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APPENDIX A : Maps of Options

APPENDIX B :Pipeline Costings

Table B.1

Pipe Diameter: 500 mm
Pipe Type: NS DICL Class K9

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$250
Supply of pipe fittings	per metre	$35
Laying of pipeline	per metre	$150
Construction of fittings	per metre	$8
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$5,600,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.2

Pipe Diameter: 600 mm
Pipe Type: NS DICL Class K9

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$280
Supply of pipe fittings	per metre	$15
Laying of pipeline	per metre	$170
Construction of fittings	per metre	$9
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$5,600,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.3

Pipe Diameter: 750 mm
Pipe Type: NS DICL Class K9

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$400
Supply of pipe fittings	per metre	$20
Laying of pipeline	per metre	$220
Construction of fittings	per metre	$11
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$6,500,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.4

Pipe Diameter: 959 mm
Pipe Type: OD MSCL

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$600
Supply of pipe fittings	per metre	$30
Laying of pipeline	per metre	$300
Construction of fittings	per metre	$15
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$6,800,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.5

Pipe Diameter: 1124 mm
Pipe Type: OD MSCL

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$700
Supply of pipe fittings	per metre	$35
Laying of pipeline	per metre	$375
Construction of fittings	per metre	$20
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$7,000,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.6

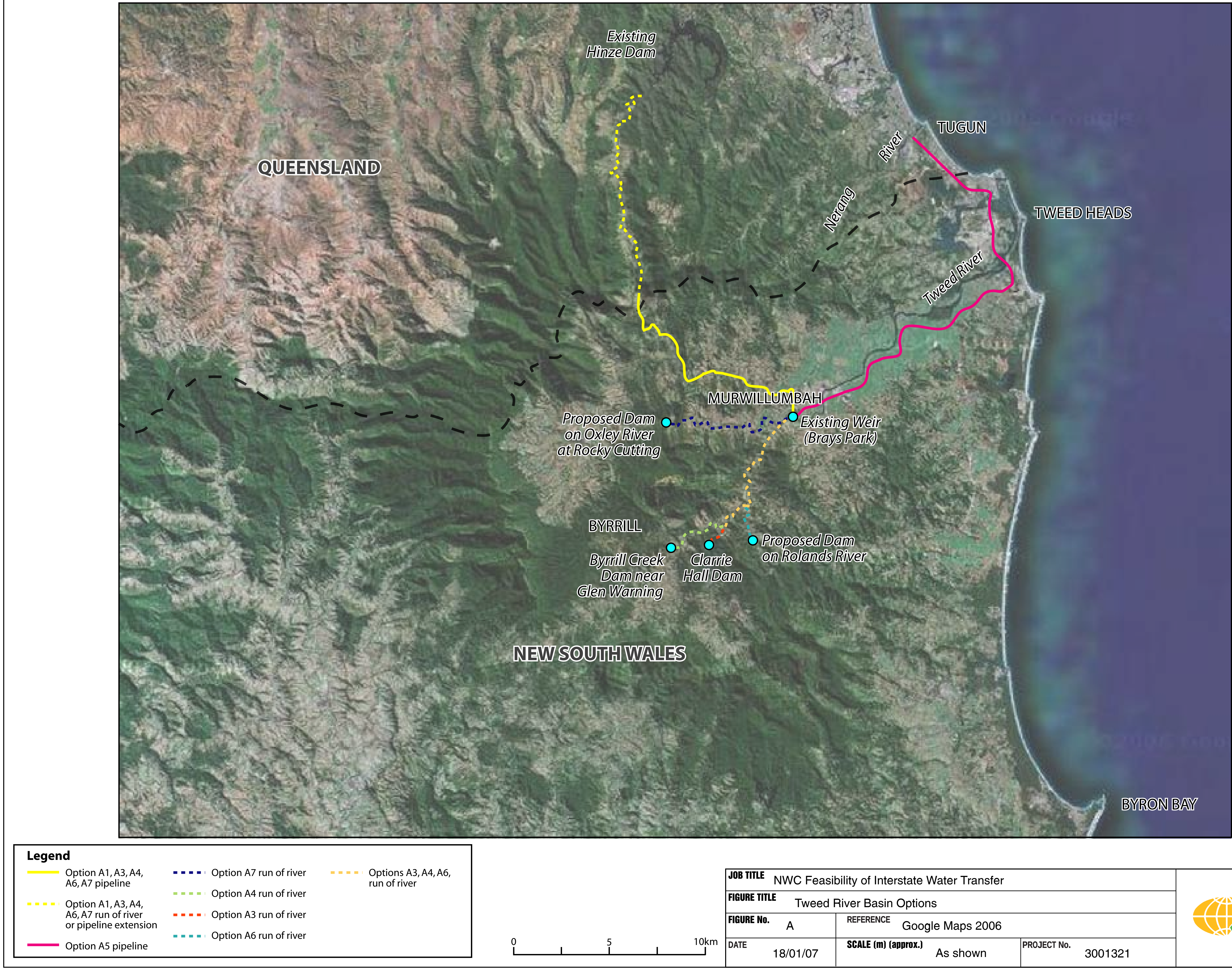
Pipe Diameter: 1290 mm
Pipe Type: OD MSCL

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$800
Supply of pipe fittings	per metre	$40
Laying of pipeline	per metre	$475
Construction of fittings	per metre	$25
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$7,000,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost

Table B.7

Pipe Diameter: 1600 mm
Pipe Type: OD MSCL

Line Item	Unit	Unit Cost ($)
Supply & delivery of pipeline	per metre	$1,330
Supply of pipe fittings	per metre	$67
Laying of pipeline	per metre	$635
Construction of fittings	per metre	$32
Rock excavation	per m^3	$100
Pumping stations (with power to site)	per item	$7,300,000
Tunnels	per metre	$10,000
Main road crossings	per item	$100,000
Minor road crossings	per item	$60,000
River crossings	per item	$500,000
Creek crossings	per item	$100,000
Terminal structures	per item	$300,000
Survey, design, geotechnical & supervision		10% of total pipeline cost
Contingencies		30% of total pipeline cost



JOB TITLE NWC Feasibility of Interstate Water Transfer			
FIGURE TITLE Tweed River Basin Options			
FIGURE No. A	REFERENCE Google Maps 2006		
DATE 18/01/07	SCALE (m) (approx.) As shown	PROJECT No. 3001321	

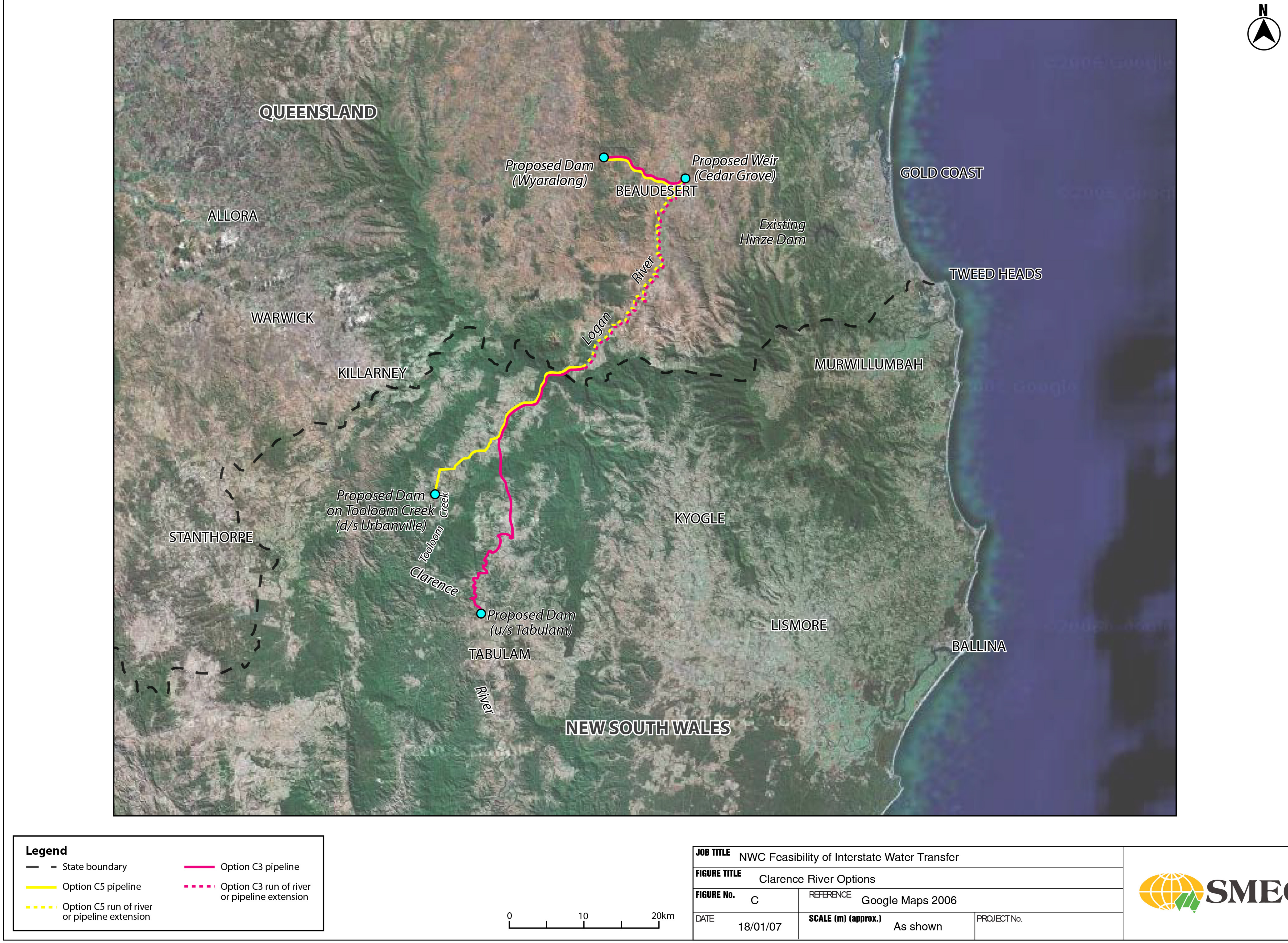
SMEC

Legend

- State boundary
- Option B1a pipeline
- Option B1a run of river or pipeline extension
- Option B1c pipeline
- Option B1c run of river or pipeline extension
- Option B3 pipeline
- Option B4 pipeline

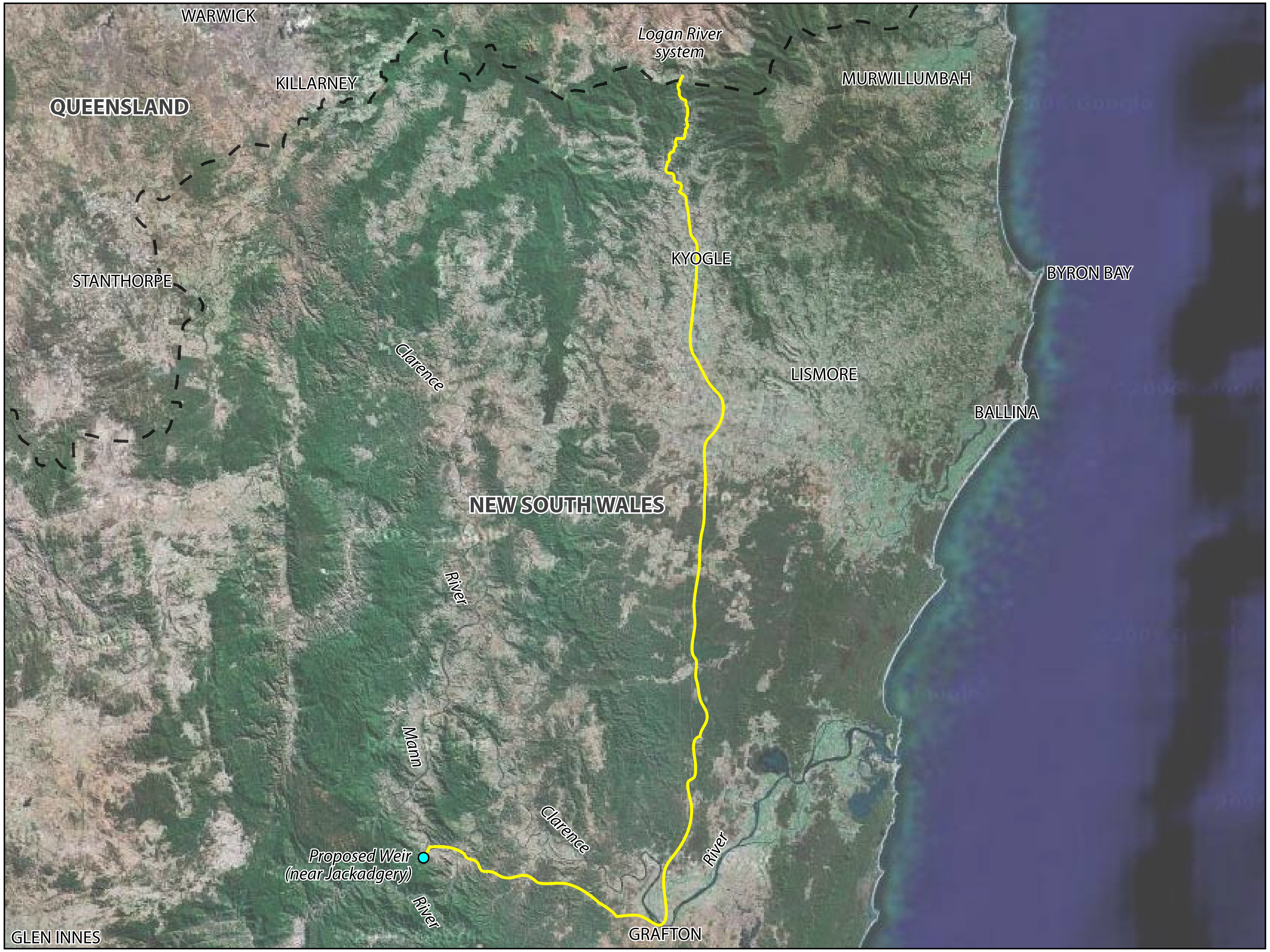
JOB TITLE	NWC Feasibility of Interstate Water Transfer		
FIGURE TITLE	Richmond River Options		
FIGURE No. B	REFERENCE Google Maps 2006		
DATE 18/01/07	SCALE (m) (approx.) As shown	PROJECT No. 3001321	

SMEC



JOB TITLE	NWC Feasibility of Interstate Water Transfer		
FIGURE TITLE	Clarence River Options		
FIGURE No.	C	REFERENCE	Google Maps 2006
DATE	18/01/07	SCALE (m) (approx.)	As shown
PROJECT No.			

SMEC

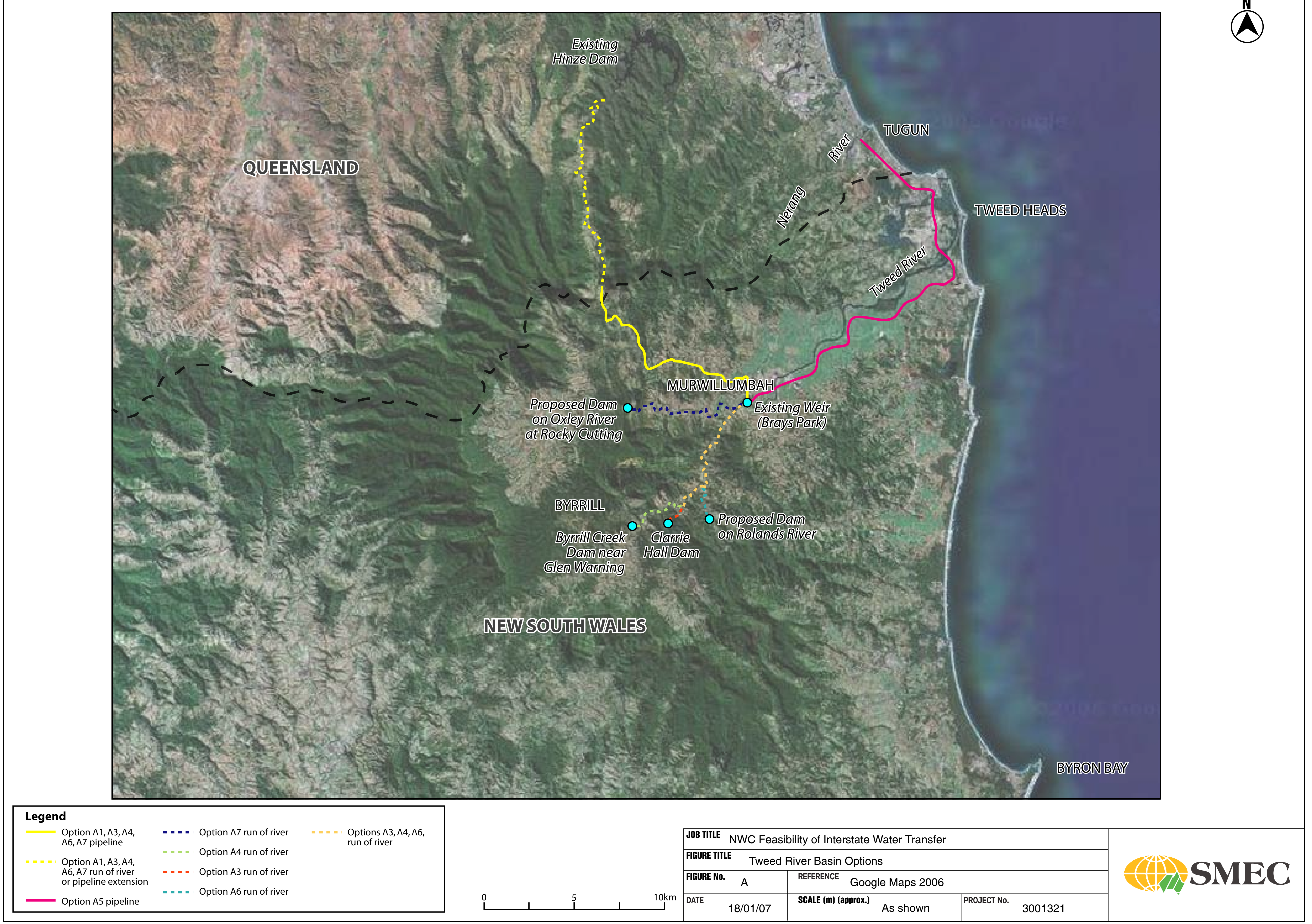


Legend

- State boundary
- Option D1 pipeline

JOB TITLE	NWC Feasibility of Interstate Water Transfer
FIGURE TITLE	Clarence River Basin - Mann River Option
FIGURE No.	D
REFERENCE	Google Maps 2006
DATE	18/01/07
SCALE (m) (approx.)	As shown
PROJECT No.	

SMEC



JOB TITLE NWC Feasibility of Interstate Water Transfer			
FIGURE TITLE Tweed River Basin Options			
FIGURE No. A	REFERENCE Google Maps 2006		
DATE 18/01/07	SCALE (m) (approx.) As shown	PROJECT No. 3001321	

SMEC

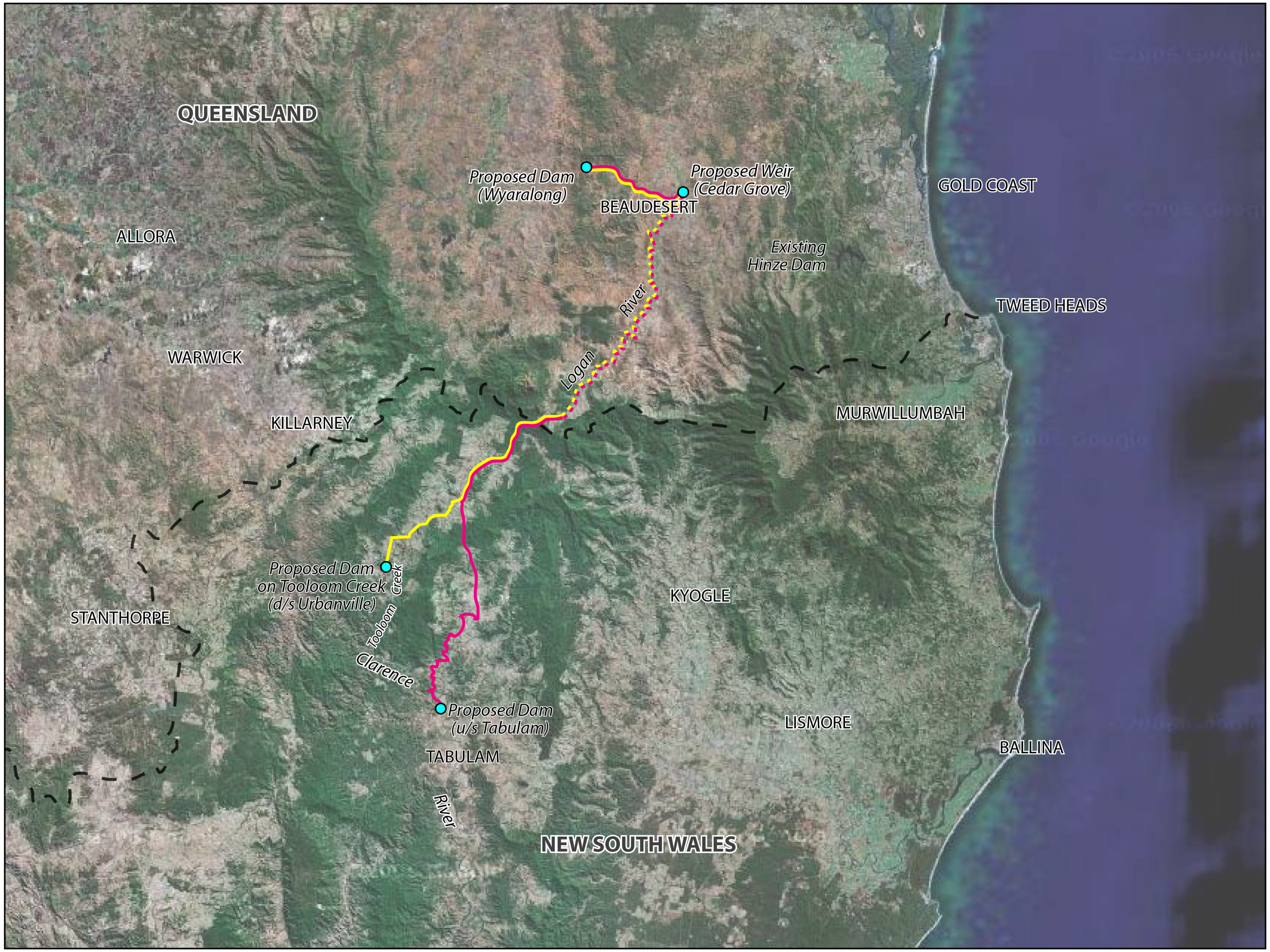
Legend

- State boundary
- Option B1a pipeline
- Option B1a run of river or pipeline extension
- Option B1c pipeline
- Option B1c run of river or pipeline extension
- Option B3 pipeline
- Option B4 pipeline

0 5 10km

JOB TITLE	NWC Feasibility of Interstate Water Transfer		
FIGURE TITLE	Richmond River Options		
FIGURE No.	B	REFERENCE	Google Maps 2006
DATE	18/01/07	SCALE (m) (approx.)	As shown
PROJECT No.	3001321		

SMEC



Legend

- State boundary
- Option C5 pipeline
- Option C5 run of river or pipeline extension
- Option C3 pipeline
- Option C3 run of river or pipeline extension

0 10 20km

JOB TITLE	NWC Feasibility of Interstate Water Transfer		
FIGURE TITLE	Clarence River Options		
FIGURE No.	C	REFERENCE	Google Maps 2006
DATE	18/01/07	SCALE (m) (approx.) As shown	PROJECT No.

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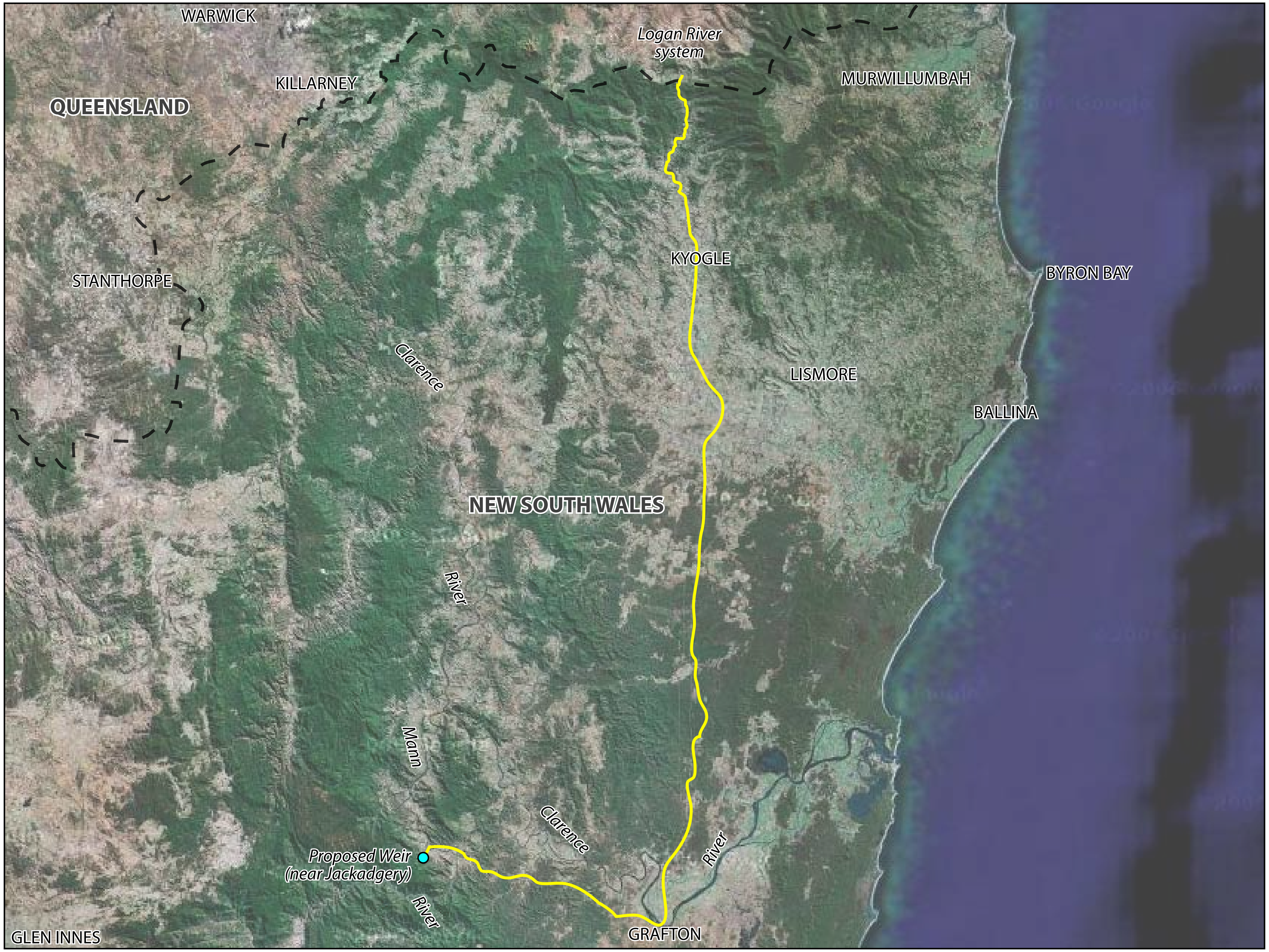

N

Legend

- State boundary
- Option D1 pipeline

0 10 20km

JOB TITLE	NWC Feasibility of Interstate Water Transfer
FIGURE TITLE	Clarence River Basin - Mann River Option
FIGURE No.	D
REFERENCE	Google Maps 2006
DATE	18/01/07
SCALE (m) (approx.)	As shown
PROJECT No.	

SMEC