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Queensland Government
Natural Resources and Water

# Department of Natural Resources & Water

## Direct Connection Pipeline – Burdekin to South East Queensland

October 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

# Contents

## Table Index

# Figure Index



# Appendices

# Executive Summary

## ES.1 Background

Queensland is currently experiencing unprecedented growth in population and industrial and mining development which is greatly increasing the demands on the water supply infrastructure. Concurrent with these trends, one half of Queensland is being subjected to drought which is reportedly the worst in one hundred years being the result of a series of dry years so severe that water storage systems, planned and built for a normal sequence of dry years, are having difficulty in coping with these additional demands.

The Direct Connection Pipeline report considers the specific case of providing a water transfer system that is able to transfer water from the Burdekin Dam to the South East Queensland Water Grid and also to provide consideration for the reverse operation of this water transfer system.

The route selection process using the GIS based condition weighting process, Infrastructure Corridor Analysis (INCA) has been applied to determine the optimal routes for this pipeline.

## ES.2 Supply Requirements

The report considers the ability to provide three levels of supply:

- 60 litres per capita per day (lpcd);
- 100 litres per capital per day; and
- 140 litres per capita per day.

The 140 litres per capita per day represents the current minimum sustainable demand being implemented in South East Queensland.

Note the above demands are purely residential and do not allow for any major industrial demands.

The populations to be considered in this report are as detailed in Table ES-1:

**Table ES-1 SEQ Populations Projections**

| Year | SEQ Population[1] |
|---|---|
| 2012 | 3,127,562 |
| 2026 | 3,959,481 |
| 2056 | 5,192,433 |

Based on the supply requirements and the populations listed in Table ES-1, the required daily demands are summarised in Table ES-2.

[1] Queensland Planning and information Forecasting Unit (PIFU) medium series projections and extrapolations as provided by NRW.

Table ES-2 Projected SEQ Water Demand

| Year | Demand ML/d | | |
|---|---|---|---|
| | Lpcd demand | | |
| | 60 | 100 | 140 |
| 2012 | 188 | 313 | 438 |
| 2026 | 238 | 396 | 554 |
| 2056 | 312 | 519 | 727 |

## ES.3 Pipeline Operational Frequency

For the purposes of this report three operational frequencies for the pipeline have been evaluated as advised by NRW:

- Emergency operation – 1 in 50 years;
- Emergency operation – 1 in 10 years; and
- Continuous operation.

## ES.4 Route Selection Process

In common with other types of linear development, the effect a water pipeline may have on the natural and built environment (including social and cultural heritage) largely depends on the route taken. Consequently, careful selection of the route is of prime importance in minimising environmental impact.

Recognising this, a systematic and transparent approach to identifying potentially suitable corridors for the Burdekin to South East Queensland transfer, was applied.

The Infrastructure Corridor Assessment (INCA) methodology used for this report combines Multi Criteria Assessment (MCA) approaches with desktop-based Geographic Information Systems (GIS) analysis to optimise route selection against a range of study objectives.

Within the INCA framework, MCA techniques are used to identify, rank and weight the performance criteria that drive the INCA corridor modelling process. The adoption of MCA ensures that the route selection process takes a balanced, transparent and traceable approach that considers environmental, socio-economic and engineering evaluation criteria while supporting a range of inputs from project stakeholders.

Based on this analysis the preliminary route selected is detailed in Map ES-1.


1:2,486,129 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Department of Natural Resources and Water

Direct Connection Pipeline
- Burdekin to South East Queensland

Preliminary Pipeline Route

job no. 42-14725
rev no. 0 - 3 Oct 2007

Map ES-1

\42\14725\GIS\Projects\360_Study_Report_Maps\MapES-1_Provisional_Route_Options.mxd

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## ES.5 Direction Connection Pipeline

### ES5.1 Pipeline Characteristics

The proposed pipeline utilises a welded mild steel cement lined (MSCL) pipe with up to 8 pump stations depending on the flow scenario. The initial concept is for the pipeline to operate as a closed system (continuous pipeline with a number of intermediate pump stations operating in series along the route). The pipe material and the closed system concept are commonly used for long pipelines. Detailed design of the pipeline will allow other systems and pipe materials to be investigated that may offer capital and operating cost savings as well as operational improvements.

The pipeline is capable of being operated in both directions.

### ES5.2 Preferred Pipe and Pump Station Options

For the three flow cases a series of pipe sizes and pump stations were analysed for each flow and operational frequency case to determine the options with the lowest NPV. The NPV analysis considered both the capital and operations and maintenance costs. Given that the major cost of the pipeline system is the pipe component, the NPV analysis attempted to minimise the size of the pipe, particularly for low frequency use cases. The reduction in size of the pipe in the analysis was limited so as to ensure the resultant pipe flow velocities stayed within good practice limits.

The optimum pipe diameters for the various demand and frequency of operation scenarios are given in Table ES-3.

**Table ES-3 Optimum Pipe Diameters (Internal Dia in mm)**

| Planning Year | One Year in 50 | One Year in 10 | Continuous Operation |
|---|---|---|---|
| 2012 | 1100 | 1200 | 1380 |
| 2026 | 1450 | 1500 | 1950 |
| 2056 | 1850 | 2050 | 2132 |

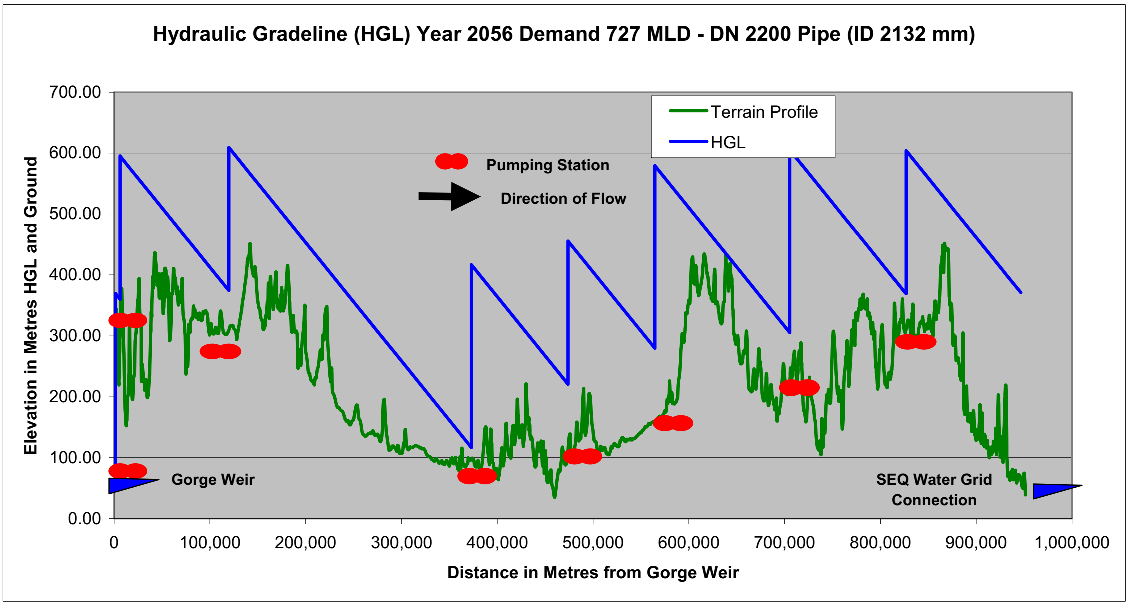
The optimal pipeline sizes for 1 in 10 and 1 in 50 year operational frequencies, are not suitable for the continuous operation case due to the high operational costs and high pipe velocities. Thus the continuous operation case pipe systems have been analysed in more detail.

For the continuous operation scenarios the optimised transfer system comprises:

- 188ML/d - DN1450 (1380mm) ID pipeline and 2 pump stations at 7.99MW and 5 pump stations at 5.3MW capacity
- 396ML/d - DN2000 (1950mm) ID pipeline and 4 pump stations at 15.7MW and 1 pump station at 1 at 8.4 MW capacity
- 727ML/d - DN2200 (2132mm) ID pipeline and 4 pump stations at 30.9MW and 4 pump station at 23.7MW capacity

The hydraulic profile for the 727 ML/day case is shown in Figure ES-2.

**Figure ES- 1 Hydraulic Grade Line (HGL) year 2056 demand (727 ML per day) – DN 2200 pipe (ID2132)**




## ES.6 Estimates

Preliminary estimates for the three (3) optimised continuous operation transfer system scenarios (188, 396 and 727 ML/d) have been determined. All costs detailed "exclude GST".

The cost estimates have been developed based on:

- Recent construction projects;
- Recent cost estimates for similar style projects being developed throughout Australia; and
- Supplier provided estimates.

This provides a sound basis for the estimates developed in Burdekin to South East Queensland Water Grid Direct Connection Pipeline Report. The estimates developed also accommodate the factors as described below.

- Pipeline Construction Costs to reflect different ground conditions;
- Road Crossings;
- Rail Crossings;
- River and Creek Crossings;
- Pump Station Construction Costs

  The development of a pump station requires provision of access and power. In terms of access, the estimate includes an allowance for the construction of a new road from the nearest available existing road. Locations of the proposed pump stations were provided to ERGON. Based on this information ERGON advised NRW of the likely costs of supply per MW of the supply to the pump station including order of cost of connection to the existing network. These costs were used in conjunction with the distance from the nearest suitable power supply to determine a likely order of cost of providing supply. The advice provided by ERGON via NRW is that the power supply authority would undertake the capital works at their cost and recoup the cost based on an annual charge equal to 10% of the capital cost. These annual costs have been included in the O&M costs.

The cost of the transformers and switchyard at the pump station are additional to the supply costs. These costs are included as part of the capital cost of the pump station.

- Associated Project Costs

  The estimated costs prepared include estimates for items for associated project costs including land acquisition, legal costs, and Cultural Indigenous Land Use Agreement and Cultural Heritage works for the project.

### ES6.2 Annual O&M Costs

Operation and maintenance costs for the proposed infrastructure are estimated as follows:

1. O&M for pipeline – based on 1% of the capital cost of the pipeline;
2. O&M for the pump station (excluding power) – based on 3% of the capital cost of the pump station;
3. Annual charge from power supply authority for provision of power supply infrastructure – 10% of capital cost; and
4. Power usage – quoted rates 6c per kWHr.

### ES6.3 Determined Cost of Water Provided

The cost of the water provided by the proposed schemes has been determined in accordance with regulatory pricing guidelines. The allowable cost elements to compromise the cost of water are:

1. O&M Costs;
2. Annual Depreciation (determined using asset lives utilised by Sunwater and other similar water providers); and
3. Return on Capital (7.5% utilised).

These costs are divided by the volume of water produced to determine a cost of water per ML provided. For the two scenarios (1 in 50 year and 1 in 10 year pumping) which are not continuous supply cases this results in large costs per ML. These cases may be better considered in terms of an annual access charge plus a cost per use.

However for comparison purposes in this report only the cost per ML ratio is considered.

The O&M cost component of the cost make up is explained previously. The annual depreciation and return on capital are discussed subsequently in more detail.

### ES6.4 Summary of Capital Costs, Cost or Water and Energy Impacts

The capital cost, cost of water and energy impacts for the three considered options are summarised in Table ES-4. Note these costs do not include the purchase price of Burdekin Water off Sunwater, nor does it allow for the cost of reverse flow (2 additional pump stations). The costs are all GST exclusive.

**Table ES-4 Summary of Capitals Costs, Cost of Water and Energy Impacts (excluding GST)**

| | Capital Cost ($M) | Water Cost ($/ML) | | | Energy Utilisation (kWhr/ML Supply) |
|---|---|---|---|---|---|
| | | 1:50 year operation | 1:10 year operation | Continuous operation | |
| Year 2012, 188ML/d | $6,908 | $481,668.70 | $96,697.07 | $10,055.27 | 5,423 |
| Year 2026, 396ML/d | $11,381 | $374,267.31 | $75,087.14 | $7,765.62 | 4,315 |
| Year 2056, 727ML/d | $13,976 | $255,931.97 | $51,475.42 | $5.485.54 | 7,209 |

### ES6.5 Comparison to Other Sources of Supply

Comparison to other sources of supply is complicated by proximity of the source of supply to the demand point and hence the amount of connecting infrastructure that is required. However for preliminary benchmarking the cost of desal water including capital costs is of the order of $2,500 to $3,500/ML supplied. In terms of the Direct Connection Pipeline – Burdekin to South East Queensland the relevant cost to benchmark again are those in Table ES-4. The costs in Table ES-4 do not include the cost of providing treatment of Burdekin Water. This is not included as it assumed that as the pipeline is an emergency supply, it is to supplement a deficiency in supply to due to drought, hence sufficient treatment capacity is already available at the supply end of the pipeline. The cost of treatment of the water (power, staff, chemicals etc) is of the order of $150 to $200/ML treated.

### ES6.6 Construction Timeline

The construction of the Direct Connection Pipeline is a substantial project which would likely attract new pipe manufacturers and constructors to Australia. Given the scale of the project and the current market, the time from commencement of design to commissioning is expected to be of the order of 6-10 years, depending on the delivery mechanism utilised i.e. (Alliance, D&C, Normal Design then Build, Design Build Operate etc).

# 1. Introduction

This report has been prepared to provide interim advice on the Direct Connection Pipeline from the Burdekin Dam to the South East Queensland Water Grid. This report is part of a broader based study titled State Water Grid – Concept Plan which has been scoped by the Queensland Department of Natural Resources and Water (NRW). This is being prepared in accordance with the Terms and Conditions of the Standing Offer Agreement SOA NRS NRS0010 – Product Group Category 2 – Water Infrastructure Assessments.

## 1.1 Background

Queensland is currently experiencing unprecedented growth in population and industrial and mining development which is greatly increasing the demands on the water supply infrastructure. Concurrent with these trends, one half of Queensland is being subjected to drought which is reportedly the worst in one hundred years being the result of a series of dry years so severe that water storage systems, planned and built for a normal sequence of dry years, are having difficulty in coping with these additional demands.

The State Water Grid Concept Plan is required to examine a transfer system in the form of a water grid which can be activated to address such regional shortfalls in what may be termed the essential water required to maintain the social and economic structure of Queensland to a base range of levels. Such a transfer water grid would have components of infrastructure sized to meet these base demands drawing water from an area or areas where some surplus capacity is available.

## 1.2 Scope of Direct Connection Pipeline Report

The Direct Connection Pipeline report considers the specific case of providing a water supply system that is able to transfer water from the Burdekin Dam to the South East Queensland Water Grid and also to provide consideration for the reverse operation of this water transfer system.

The methodology adopted for this report is based on that proposed for the full water grid concept plan, however some of the interactive weighting factors from interconnections with supply source options and demand centres between the Burdekin and the South East Queensland have not be considered, as they are not relevant to a direct pipeline.

The route selection process using the GIS based condition weighting process, Infrastructure Corridor Analysis (INCA) has been applied to determine the optimal routes for this pipeline.

## 1.3 Direct Connection Pipeline Report Outcomes

This report has considered a range of demand scenarios and a technical solution in terms of pipelines, pumping stations and route selection. Preliminary component sizings and costings are provided.

## 1.4 Overview of Methodology

The following approach that has been taken in developing the Direct Connection Pipeline Report:

- Understanding of broad objectives and physical extent of the scheme to achieve these objectives;
- Develop weighting factors based on environmental, social and economic considerations to be applied to the route selection process;
- Apply the weighting factors to the INCA alignment section tool to produce a priority ranking of preferred routes which will also reflect sensitivity testing of selected groupings of weighting factors;
- Establish the agreed flow regimes to be analysed according to design horizon and demand condition;
- Use selected route to undertake the hydraulic analysis which will involve the selection of pipe diameters and the selection of pumping station locations;
- From the output of the hydraulic constraints, test the INCA alignment process with elevation controls which are expected to affect pumping station sizing and locations;
- Finalise the system hydraulics for the various flow conditions that are required to be considered;
- Develop costings for the schemes to meet the various operational requirements;
- Run optimisation tools to establish the preferred pipeline and pumping arrangement to best meet the range of operating requirements. This includes NPV analyses of the complete transfer system;
- Finalise sizing and costings for the selected range of operating conditions; and
- Establish unit costs for the transferred water in cost per megalitre (ML) delivered.

# 2. Transfer System Operational Parameters

## 2.1 Transfer System Objectives

The objectives of the transfer system for this report is to provide a means of delivering water from the Burdekin Dam to the south eastern urbanised area of Brisbane and the surrounding areas, via a connection to the South East Queensland Water Grid. In a similar way, the scheme is to be capable of transferring water from the south to the north. The concept is that water can be transferred to areas where there is a shortage of water which may be due to a drought condition or a periodic water quality problem with a water supply resource. Note given the location of the pipeline it would provide the State with an emergency supply scheme, that could be also used to supply centres along the route depending on their various needs.

This concept is based on population estimates for the south east corner of Queensland being able to be supplied with sufficient water to meet a range of basic unit demands. These two parameters provide the basis for the sizing of this transfer system.

Specifically this report addresses the concept of providing a direct connection pipeline from the Burdekin to South East Queensland via connection to the South East Queensland State Water Grid. In order to undertake the analysis it is necessary to have a nominated start and end point. Sunwater have previously investigated pipeline routes from the Burdekin as part of the development of the Moranbah pipeline. Sunwater determined the best offtake point was at Gorge Weir. This has been used as the starting point for the direct pipeline. At the South East Queensland end of the pipeline a convenient termination point is the Caboonbah pumping station at the northern end of Wivenhoe Dam. Whilst these represent the starting and ending points for this study, detailed ground proofing and site analysis would needed to be undertaken in any detailed design to determine the final commencement and termination points as well as detailed pipeline routes/alignments.

Figure 1 below illustrates the concept of this objective.


1:2,643,777 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

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Department Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Study Location

job no. 42-14725
rev no. A - 3 Oct 2007

Figure 1

\42\14725\GIS\Projects\360_Study_Report_Maps\Overview.mxd

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## 2.2 Supply Requirements

The report considers the ability to provide three levels of supply:

- 60 litres per capita per day (lpcd);
- 100 litres per capital per day; and
- 140 litres per capita per day.

The 140 litres per capita per day represents the current minimum sustainable demand being implemented in SE Qld.

The 60 litres per capita per day represents an absolute minimum demand that can be sustained by an urban community and still maintain minimum sustainable adequate level of service, assuming some additional local supplementation via recycled and/or desalinated water. The 100 litres per capita per day represents a median value.

For the purposes of this report, these demands as provided by NRW, are the only demands considered. Note the above demands are purely residential and do not allow for any major industrial demands.

The populations to be considered for the report are as detailed in Table 2-1:

**Table 2-1 SEQ Populations Projections**

| Year | SEQ Population[1] |
|---|---|
| 2012 | 3,127,562 |
| 2026 | 3,959,481 |
| 2056 | 5,192,433 |

Based on the supply requirements and the populations listed in Table 2-1, the required daily demands are summarised in Table 2-2.

**Table 2-2 Projected SEQ Water Demand**

| Year | Demand ML/d | | |
|---|---|---|---|
| | Lpcd demand | | |
| | 60 | 100 | 140 |
| 2012 | 188 | 313 | 438 |
| 2026 | 238 | 396 | 554 |
| 2056 | 312 | 519 | 727 |

The shaded demands 188, 396 and 727 ML/d have been analysed in more details in Sections 5 and 6 in terms of required water transfer system, as they span the other demand scenarios.

[1] Queensland Planning and information Forecasting Unit (PIFU) medium series projections and extrapolations as provided by NRW.

## 2.3 Pipeline Operational Frequency

For the purposes of this report three operational frequencies for the pipeline have been evaluated as advised by NRW:

- Emergency operation – 1 in 50 years;
- Emergency operation – 1 in 10 years; and
- Continuous operation.

# 3. Route Selection Process

In common with other types of linear development, the effect a water pipeline may have on the natural and built environment (including social and cultural heritage) largely depends on the route taken. Consequently, careful selection of the route is of prime importance in minimising environmental impact.

Recognising this, GHD are applying a systematic and transparent approach to identifying potentially suitable corridors for the Burdekin to South East Queensland transfer .

## 3.1 Overview

The Infrastructure Corridor Assessment (INCA) methodology used by GHD combines Multi Criteria Assessment (MCA) approaches with desktop-based Geographic Information Systems (GIS) analysis to optimise route selection against a range of study objectives.

Within the INCA framework, MCA techniques are used to identify, rank and weight the performance criteria that drive the INCA corridor modelling process. The adoption of MCA ensures that the route selection process takes a balanced, transparent and traceable approach that considers environmental, socio-economic and engineering evaluation criteria while supporting a range of inputs from project stakeholders.

To meet the requirements of the Direct Connection Pipeline Report, an initial set of suitability criteria have been proposed by the GHD study team and reviewed during a workshop with NRW on 15 June 2007. Financial criteria were not considered *per se* as part of the INCA route selection at this stage. Typically engineering and infrastructure criteria represent those aspects for which an engineering solution exists, and the main consideration is therefore the cost of implementing that solution. Environmental and social criteria are less tangible and somewhat more subjective.  They represent aspects that are not necessarily related to an actual market value, for example lifestyle and amenity or conservation significance. The MCA approach used in the INCA methodology allows these differing types of criteria to be considered using the same assessment framework, based on the ability to map suitability criteria to available spatial data sources.

## 3.2 Data Review and Selection

Due to the geographic extent of the Burdekin to South East Queensland Water Direct Connection Pipeline, the INCA modelling process has been largely limited to those datasets that have state-wide coverage. Wherever possible, state-wide fundamental and thematic datasets have been sourced from QLD State Government custodian agencies. To supplement this, the national seamless coverage of 1: 250,000 scale topographic data maintained by Geoscience Australia has been used as framework information.

While this scale of information is acceptable for high-level concept planning, it is recognised that detailed large scale data sources available through Local Government Authorities will provide a better source of information, and should be considered at detailed design stages of the project.

### 3.2.1 Data Selection Criteria

Over 100 state-wide datasets have been compiled for the study. These have been reviewed by the study team and 33 themes were short listed for inclusion in the preliminary route selection model at the INCA Ratings Workshop.

The criteria for inclusion in the modelling were:

- Representation of the primary route assessment criteria, in terms of both constraints and opportunities;
- A consistent level of coverage across the study extent; and
- Accuracy and currency.

A full listing of the data sourced to date is included in Appendix A.

Core metadata on the themes included in the modelling is included in Appendix B.

### 3.2.2 Scale of Inputs and Modelling Resolution

The INCA suitability modelling uses an overlay approach that requires all data to be converted into cell-based grids. The choice of cell size is determined by a number of factors, including:

- Study objectives;
- Project extent;
- Processing workload / available time; and
- Scale and accuracy of the inputs.

In general, a higher resolution (smaller cell size) will give more granularity of control at higher processing cost. However a balance is required depending on inputs being used. The range of accuracy and capture scale of each of the differing geographic themes can vary significantly. For example, Digital Cadastral polygons are detailed survey accurate to mm level, whereas Regional Ecosystems polygons are based on 1:100,000 scale mapping, with uncertainties in the order of 10s to 100s of metres.

For this study it is not considered necessary to accurately define the cadastral footprint, hence a very high modelling resolution is not justified. However is important to ensure that linear features are sufficiently defined and that the spatial characteristics of sensitive environmental constraints such as Regional Ecosystems are not overly generalised.

In consideration of the above, a 100m by 100m cell size has been selected for the report. If deemed necessary, further detailed local modelling of sensitive areas can be carried out at higher resolutions further into the project, however this will be dependant on acquisition of more detailed data for some of the criteria themes

## 3.3 Performance Ratings

Fundamental to the INCA approach to MCA is the determination of performance ratings for the project. By reviewing the geographic data available to the project, performance ratings for each of the suitability criteria were developed as follows:

- Fatal flaw (999) – completely unsuitable for further consideration (eg National Park);
- Poorly suitable (3);

- Moderately suitable (2); and
- Highly suitable (1).

In determining the performance ratings, the following issues were considered:

- Legislative requirements, for example, requirements to obtain permits to clear vegetation;
- Environmental values and sensitivities, and the need to protect ecosystems and species;
- Socio-economic values and sensitivities; and
- Engineering performance and associated cost considerations.

While the primary focus has been on those aspects that would geographically constrain the location of the pipeline, the process has also identified a selection of themes that define opportunities to improve the corridor location in relation to existing infrastructure. These opportunities primarily relate to Built Environment criteria and are based on the data available for this Direct Connection Pipeline Report. Further opportunities to refine the corridor location based on these and other criteria will be investigated in subsequent stages of the project.

Performance ratings were initially developed by the project team's environmental, social and engineering specialists and then presented to NRW's representatives for discussion, verification and agreement at a workshop held on 15th of June 2007.

The approved performance ratings for each of the categories are outlined below and detailed further in Appendix B.

### 3.3.1 Environmental

Multi-criteria analysis criteria and ratings for determining a suitable corridor are shown in Table 3-1. A full description of each criteria theme is provided in Appendix B.

**Table 3-1 MCA Criteria for Corridor Selection – Environmental**

| | |
|---|---|
| **Regional Ecosystems** | |
| Objective | **Clearing of remnant vegetation is minimised.** |
| Fatal Flaw: | Endangered Dominant or Sub-dominant Regional Ecosystem |
| Poor: | Of Concern Dominant or Sub Dominant Regional Ecosystem |
| Moderate: | Not of Concern Regional Ecosystem |
| Good: | Non Remnant or none present |
| **Essential Habitat** | |
| Objective | **Loss or degradation of habitat for rare, vulnerable, threatened and endangered species is minimised.** |
| Fatal Flaw: | None |
| Poor: | Presence of essential habitat |
| Moderate: | None |
| Good: | No essential habitat present |

| | |
|---|---|
| **Fish Habitat Area** | |
| Objective | **Risks of impacting upon fish habitat areas are minimised** |
| Fatal Flaw: | None |
| Poor: | Presence of fish habitat |
| Moderate: | None |
| Good: | No fish habitat present. |
| **Conservation Estate** | |
| Objective | **Impacts on sites with legal conservation are avoided or minimised.** |
| Fatal Flaw: | National Park or Conservation Park |
| Poor: | None |
| Moderate: | None |
| Good: | Within State Forest, Forest Reserve, Timber Reserve or none of the above |
| **River Condition** | |
| Objective | **Additional impact on vulnerable waterways is minimised, number of crossings are reduced** |
| Fatal Flaw: | Within 200m of Largely Unmodified Reaches |
| Poor: | Within 200m of Substantially or Moderately Modified Reaches |
| Moderate: | Within 200m of Severely Modified or Unassessed Reaches |
| Good: | None of the above. |
| **Watercourses and Waterbodies** | |
| Objective | **Impact on watercourses is minimised, number of crossings are reduced** |
| Fatal Flaw: | None |
| Poor: | None |
| Moderate: | Within 200m of mapped watercourses |
| Good: | None of the above. |
| **Wetlands** | |
| Objective | **Impacts on wetland ecosystems are minimised** |
| Ratings: | Category: |
| Fatal Flaw: | Within 200m of a Ramsar Wetland OR within 200m of a Wetland of National Significance |
| Poor: | None |

| | |
|---|---|
| Moderate: | None |
| Good: | None of the above. |

Detailed discussion of the assessment of Environmental criteria is covered in Section 4.

### 3.3.2 Physical

Multi-criteria analysis criteria and ratings for determining a suitable corridor are shown in Table 3-2. A full description of the criteria is provided in Appendix B.

**Table 3-2 MCA Criteria for Corridor Selection – Physical**

| | |
|---|---|
| **Terrain - Slope** | |
| Objective | **Risk of erosion and slope stability issues can be minimised.** |
| Fatal Flaw: | Slope exceeds 10%. |
| Poor: | Slope between 5% and 10% |
| Moderate: | None |
| Good | Slope less than 5%. |
| **Terrain – Elevation** | (the ratings listing were utilised for the initial terrain analysis) |
| Objective | **Risk of erosion and slope stability issues can be minimised. Hydraulic performance.** |
| Fatal Flaw: | None |
| Poor: | Elevation greater than 500m AHD |
| Moderate: | Elevation between 300m and 500m AHD |
| Good | Elevation less than 300m AHD |
| **Mining and Exploration Activities** | |
| Objective | **Mining and mineral exploration activities are not impacted on, mineral resources are not sterilised.** |
| Fatal Flaw: | Mineral Development License Areas OR<br>Mining Leases |
| Poor: | None |
| Moderate: | Mining Claims OR<br>Petroleum Leases OR<br>Petroleum Pipeline Licenses |
| Good | No mining tenure or prospecting licence |

| Acid Sulfate Soils | |
|---|---|
| **Objective** | **Construction of pipeline will not disturb Acid Sulfate Soils** |
| Fatal Flaw: | Within mapped presence or less than 5m AHD elevation |
| Poor: | None |
| Moderate: | None |
| Good: | None of the above |

### 3.3.3 Social

Multi-criteria analysis criteria and ratings for determining a suitable corridor are shown in Table 3-3. A full description of the criteria is provided in Appendix B.

**Table 3-3 MCA Criteria for Corridor Selection – Social**

| | |
|---|---|
| **Lot Density** | |
| Objective | **Proposed pipeline does not affect residential areas or detract from residential amenity.** |
| Fatal Flaw: | Lot sizes less than 0.25 ha (2,500 $m^2$) within SEQ Regional Plan. |
| Poor: | Lot sizes less than 0.25 ha (2,500 $m^2$) outside the SEQ Regional Plan OR<br>Lot sizes between 0.25ha (2,500 $m^2$) and 1 ha (10,000 $m^2$). |
| Moderate: | Lot sizes between 1 ha (10,000 $m^2$) and 16 ha (160,000 $m^2$). |
| Good: | Lots larger than 16 ha (160,000 $m^2$). |
| **Land Tenure** | |
| Objective | **Costs and delays associated with land acquisition are minimised and the number of property owners is reduced.** |
| Fatal Flaw: | Commonwealth Acquisition OR National Park OR Prohibited Areas |
| Poor: | Housing land OR Industrial Estates |
| Moderate: | Any of the following tenures:<br>Forest reserve, reserve, action pending, mines tenure, timber reserve. |
| Good: | Any of the following tenures:<br>Freehold, profit a prendre, easement, easement proposed, covenant, railway reserve, road reserve, freehold lease, below the depth plans, lands lease, State land, transferred property, water resource. |

| | |
|---|---|
| **Built-up Areas** | |
| Objective | **Proposed pipeline does not affect residential areas or detract from residential amenity in those areas.** |
| Fatal Flaw: | Within built-up areas |
| Poor: | None |
| Moderate: | None |
| Good: | All other areas. |
| **Populated Places** | |
| Objective | **Proposed pipeline does not affect populated places in regional areas.** |
| Fatal Flaw: | None |
| Poor: | None |
| Moderate: | Within 5km of populated places. |
| Good: | All other areas. |
| **Native Title** | |
| Objective | **Delays due to Native Title issues are minimised and rights of Native Title claimants are respected.** |
| Fatal Flaw: | None |
| Poor: | More than one registered native title claim over this area |
| Moderate: | Only one registered native title claim over this area |
| Good: | No registered Native Title Claim |
| **Cultural Heritage** | |
| Objective | **Items of cultural heritage are not impacted.** |
| Fatal Flaw: | Item listed on the Queensland Heritage Register |
| Poor: | Within 100m of any item listed on the Queensland Heritage Register |
| Moderate: | None |
| Good: | No listed items within 100m. |

### 3.3.4 Built Environment

Multi-criteria analysis criteria and ratings for determining a suitable corridor are shown in Table 3-4. A full description of the criteria is provided in Appendix B.

**Table 3-4 MCA Criteria for Corridor Selection – Built Environment**

| | |
|---|---|
| **Proximity to Transport Infrastructure** | |
| Objective | **Co-locate within existing infrastructure corridors where possible. Improve access for construction and maintenance** |
| Fatal Flaw: | None |
| Poor: | None |
| Moderate: | Located greater than 500m from transport infrastructure. |
| Good: | Within 500m of Class 1 or 2 Roads OR<br>Within 500m of railways. |
| **Proximity to Utility Infrastructure** | |
| Objective | **Co-locate within existing infrastructure corridors where possible. Improve utility access.** |
| Fatal Flaw: | None |
| Poor: | None |
| Moderate: | Located greater than 500m from utility infrastructure |
| Good: | Within 500m of mapped pipelines OR<br>Within 500m of mapped powerlines OR<br>Within 500m of SunWater pipelines |
| **Dams and Waterbodies** | |
| Objective | **Avoid overpassing existing storages, but encourage local diversion to selected large supply storages.** |
| Fatal Flaw: | Full supply level extent of major supply storages. |
| Poor: | None |
| Moderate: | Greater than 5km from large supply storages |
| Good: | Less than 5km from large supply storages |
| **Water Infrastructure Features** | |
| Objective | **Existing infrastructure is not affected and future infrastructure development is not unnecessarily constrained** |
| Fatal Flaw: | Within mapped areas of:<br>Dam walls, storage tanks, water tanks, and spillways. |
| Poor: | None |
| Moderate: | None |
| Good: | None of the above |

## 3.4 Criteria Weighting

Weighting of the input criteria is the main judgement phase of the MCA ranking and has a direct and significant bearing on the output of the INCA corridor modelling process. Weights reflect the preferences of the decision makers and theoretically should be the only subjective element of the ranking process. However subjectivity creeps into many aspects of the process, including alternatives, the assessment criteria and methodology. Consequently there are a number of matrix-based approaches to that can be employed, allowing a group of representative stakeholders to work towards agreement on the relative level of influence that each of the inputs should have on the model.

One disadvantage of these approaches is that they require a significant level of stakeholder involvement and interaction. Given the preliminary nature of this initial assessment, the absence of a number of important criteria and the limitations of stakeholder availability in the timeframe, it was determined that the most appropriate approach a was to apply a simple 100 points-based direct allocation of weights, which was undertaken by NRW representatives.

The weights provided by NRW that were used in the preliminary model are shown in Table 3-5.

**Table 3-5 Criteria Weighting**

| Category | Aspect | Theme | NRW Weight | Totals | |
|---|---|---|---|---|---|
| Environmental | Flora and Fauna | Regional Ecosystems | 5 | | |
| | | Essential Habitat | 5 | | |
| | | Fish Habitat Area | 1 | | |
| | | –Conservation Estate | 6 | 17 | |
| | Watercourses and Wetlands | Assessment of River Condition (ARC-E) | 3 | | |
| | | QLD Drainage Watercourses | 3 | | |
| | | QLD Drainage Watercourse Areas | 2 | | |
| | | Directory of Important Wetlands | 1 | | |
| | | Ramsar Wetlands | 1 | 10 | **27%** |
| Physical | Topography | Slope | 4 | | |
| | | Elevation | 1 | 5 | |
| | Mining | Mining Claims | 1 | | |
| | | Mineral Development Licences | 1 | | |
| | | Mining Leases | 3 | | |
| | | Petroleum Leases | 1 | | |
| | | Petroleum Pipeline Licenses | 2 | 8 | |
| | Soils | Queensland Acid Sulfate Soil Boundaries | 3 | 3 | **16%** |

| Category | Aspect | Theme | NRW Weight | Totals | |
|---|---|---|---|---|---|
| Social | Habitation and Tenure | Parcel Size | 2 | | |
| | | Tenure Type | 2 | | |
| | | Builtup Areas | 5 | | |
| | | Populated Places | 3 | | |
| | | Prohibited Areas | 4 | 16 | |
| | Cultural Heritage | Native Title Claims | 2 | | |
| | | QLD Heritage Register | 3 | 5 | **21%** |
| Built Environment | Transport | Railways | 4 | | |
| | | Roads | 4 | 8 | |
| | Utilities | Pipelines | 4 | | |
| | | Powerlines | 4 | 8 | |
| | Water Infrastructure | Irrigation Areas* | 3* | | |
| | | Queensland Dams and Waterbodies | 4* | | |
| | | Sunwater Pipelines | 4* | | |
| | | Damwalls | 4* | | |
| | | Spillways* | 3* | | |
| | | Storage Tanks | 1* | | |
| | | Water Tanks | 1* | 20 | **36%** |
| | | | 100 | 100 | **100%** |

* The Irrigation Areas dataset was not able to be sourced in time to incorporate into the preliminary route selection model. The Spillways dataset, while deemed relevant during the stakeholder workshop, did not contain any features between the source and destination points of the route and hence was removed from the model. In both cases their respective weight scores were spread evenly across the remainder of the Water Infrastructure inputs.

The above has been used in the direct route analysis undertaken for this report, and provides a base-line criteria weighting which will be subject to further refinement through the course of the study as additional criteria are identified and included.

### 3.4.1 Criteria Weights in the INCA Model

In the INCA modelling process, the relative influence of the criteria performance ratings are modified by the weight as follows:

*Sum for all Criteria Inputs (Performance Rating x Criterion Weight) = Model Impedance Score*

As a result, the application of the criterion weight allows the differentiation between similar performance ratings across themes.

For example, both *'Of Concern' Regional Ecosystems* and *Slope Range of 5% - 10%* were both rated as Poorly Suitable (Score 3) in the stakeholder workshop. Taking into account the weights indicated above, the base impedance score for the *Slope* range will be 12, and that for the *Of Concern Regional Ecosystems* will be 15. The result is that, if only considering these two inputs and all other factors are equal, the model will tend to select for a corridor that crosses the area within a slope range of 5% – 10% rather than traverse a Regional Ecosystem classified as Of Concern.

Similarly, under the Conservation Estate environmental criterion (Table 3-1), the classifications of *State Forest, Forest Reserve*, or *Timber Reserve* have been rated as Good Suitability (Score 1). However, should a potential route through these estate areas also intersect an *'Of Concern' Regional Ecosystem*, then that route would be precluded by the poorer performance rating of this ecosystem type (Score 3). Although Conservation Estate has been assigned a weight that is 20% higher than Regional Ecosystems (weight of 6 versus 5 in Table 3-5), the difference in weights is not sufficient to negate the poorer performance rating of this ecosystem type when it occurs in these estate areas.

While the above is a simplification of what actually takes place in the model, it reflects the underlying logic that is applied simultaneously across all inputs on a 100m by 100m grid cell basis when determining the optimum corridor.

## 3.5 Preliminary INCA Analysis Results

The results of the INCA based corridor analysis are presented on the maps contained in Appendix C. Based on the weighted performance ratings outlined above, an overall constraints / impedance model was developed within the INCA framework, as shown in Map C-1. Much of the study area is relatively unconstrained, however the overall level of constraint becomes high at both ends of the route driven by a number of factors including terrain, proximity to populated areas and environmental aspects.

From this constraint model, a least-impedance directional analysis was conducted to create a suitability model that identifies the potential for optimised corridors. The algorithm used incorporates a strong directional bias that minimises distance between start and finish locations, while optimising against the constraints and opportunities identified by the weighted performance ratings. It should be noted that for the purposes of this Report for a direct connection pipeline, no supply or demand attraction has been incorporated into the suitability model.

Map C-2 shows the suitability model, indicating a number of potential corridor options between Burdekin Dam and the connection to the South East Queensland Water Grid.

### 3.5.1 Base Case Corridor Selection and Assessment

To support the quantitative and qualitative analysis required for the initial costing of the Direct Connection Pipeline, a preliminary base scenario corridor was derived from the suitability model Shown in dark blue in Map C-3, the corridor heads south-east on the eastern side of the Leichhardt Range, changing direction and passing on the southern side of Newlands Mine. Continuing in a south-easterly direction it passes between the Cardborough and Kerlong Ranges and on to the western side of the Bowler range. Changes to a southerly direction near Monto as it diverts around the Coominglah State Forest and then back to south-easterly past the north of Eidsvold. Direction changes again heading south to the east of Bjelke-Petersen Dam, then south-east picking up the Brisbane River which it follows to Caboonbah by Lake Wivenhoe. The total length of this corridor is approximately 951km.

## 3.6 Triple Bottom Line Sensitivity Analysis

The overall sensitivity of the suitability model can be tested at a number of levels. At the INCA Ratings Workshop held in June 2007 with NRW representatives, a number of alternative ratings assignments were identified for further investigation. While this detailed investigation is beyond the scope of the Direct Connection Pipeline Report, we have applied TBL-based alternative weighting scenarios to better identify areas of sensitivity in the current model for potential refinement if the scope of the project proceeds to more detailed design.

The alternative weighting scenarios tested at this stage are shown in Table 3-6 below. In each of the biased scenarios, the influence of the focus criteria group is twice that of the other groups.

**Table 3-6 TBL Sensitivity Analysis Weighting Scenarios**

| Scenario | Environmental | Physical | Social | Built Environment |
|---|---|---|---|---|
| Base Scenario | 25% | 25% | 25% | 25% |
| Environmental Bias | **40%** | 20% | 20% | 20% |
| Physical Bias | 20% | **40%** | 20% | 20% |
| Social Bias | 20% | 20% | **40%** | 20% |
| Built Environment Bias | 20% | 20% | 20% | **40%** |

The alternative corridors generated from these scenarios are shown on Map C-3. Corridors commencing from Gorge Weir are very closely aligned to the Base Scenario for the entire route. The exceptions to this are:

- Close to the Gorge Weir the Environmental Bias away from an "Of Concern-Sub Dominant" class Regional Ecosystem on the western side of the Leichardt Range. This is a deviation of approximately 30km;
- The Physical Bias moves east to avoid the Leichardt Range, re-aligning with the Base Scenario before the Newlands Mine;
- The Physical Bias ignores an area of high ground, approximately 500m of elevation in some cases, through the Cardborough Range;
- The Social Bias moves east to avoid the town built up area of Biloela and the populated place region for Thangool;
- The Built Environment Bias moves west of the Wuruma Dam north of Eidsvold, and does not have an opportunity to re-align with the Base Scenario until approximately 30km before Murgon; and
- The Physical Bias moves to the west just south of Bjelke-Petersen Dam to avoid high elevations encountered by the Base Scenario.

## 3.7 Elevation Sensitivity Analysis

To test for opportunities to improve hydraulic performance of the proposed route, an analysis of the influence of varying elevation constraints on the corridor was undertaken. Four scenarios were evaluated for overall effect on the corridor as outlined in Table 3-7.

**Table 3-7 Elevation Threshold Test Scenarios**

| Performance Rating | Base Scenario | 450m Threshold | 400m Threshold | 350m Threshold |
|---|---|---|---|---|
| Fatal Flaw: | None | > 450m | > 400m | > 350m |
| Poor: | > 500m | 350m – 450m | 300m – 400m | 250m – 350m |
| Moderate: | 300m - 500m | 250m – 350m | 200m – 300m | 150m – 250m |
| Good | < 300m | < 250m | < 200m | < 150m |

These tests only affected the rating of the elevation criterion; no change to any other criteria or criteria weights was made. The resulting routes for each of these scenarios are shown on Map C-4. As the maximum elevation encountered in the base scenario was over 600m AHD, potentially significant performance advantage is achieved by constraining the corridor to under 450m AHD, with minimum deviation from the optimised route.

Further constraining the elevation range to < 400m AHD continues to produce good alignment with the optimised route, with the only significant deviation occurring around the ranges to the north of Moranbah. However, this route is highly reliant on one or two low points that, while currently only moderately constrained by other criteria, would prohibitively limit local routing options at the detail design phase of the project.

Constraining the model to solve for under 350m AHD forces the corridor to traverse further to the eastern side of the Leichardt Ranges, changing to the western side as it approaches Moranbah. The largest diversion starts near the south of the Broadsound Range and moves towards Rockhampton, following the low coastal areas past Bundaberg, Noosa, down to Kilcoy and then southwest towards Wivenhoe Dam. Note as shown on Map C-4 there are many potential route options with similar lengths and hydraulics impacts on pipe sizing. Map C-5 indicates two provisional route options optimised for below 450m and 350m AHD respectively. If the transfer system was to proceed then substantial additional work, including community consultation, would be needed before a preferred route alignment could be confirmed. However for the purposes of this report the 450m Elevation Threshold Scenario is proposed as a preliminary direct corridor solution for the study, and forms the basis of cost estimation in the remainder of the Direct Pipeline Connection report. . Maps C-6 and C-7 show the constraints and suitability models for the preliminary route. Map C-8 is a larger strip map showing the preliminary route used in the preliminary report with an accompanying elevation profile.

## 3.8 Corridor Evaluation

As an assessment of the performance of this proposed direct corridor against the weighted criteria, a linear analysis of individual criteria rating values was undertaken. These results are represented numerically in Table 3-8 and visually in Map C-9**.** Note that as the modelling forces the corridor to avoid all criteria that pose a Fatal Flaw, this rating value is not present in the results table.

## Table 3-8 Corridor Performance against Criteria Ratings

| Category | Aspect | Theme | Performance | % | Length (km) |
|---|---|---|---|---|---|
| | | Regional Ecosystems | Good | 75.30% | 716 |
| | | | Moderate | 19.84% | 189 |
| | | | Poor | 4.86% | 46 |
| | | Essential Habitat | Good | 99.90% | 950 |
| | | | Poor | 0.10% | 1 |
| | | Fish Habitat Area | Good | 100.00% | 951 |
| Environmental | Flora and Fauna | Conservation Estate | Good | 100.00% | 951 |
| | | Assessment of River Condition (ARC-E) | Good | 96.73% | 920 |
| | | | Moderate | 1.42% | 14 |
| | | | Poor | 1.85% | 18 |
| | | QLD Drainage Watercourses | Good | 81.33% | 774 |
| | | | Moderate | 18.67% | 178 |
| | | QLD Drainage Watercourse Areas | Good | 99.15% | 943 |
| | | | Poor | 0.85% | 8 |
| | | Directory of Important Wetlands | Good | 100.00% | 951 |
| | Watercourses and Wetlands | Ramsar Wetlands | Good | 100.00% | 951 |
| | | Slope | Good | 96.48% | 918 |
| | | | Poor | 0.10% | 1 |
| | | Elevation | Good | 59.96% | 570 |
| | | | Moderate | 26.77% | 255 |
| | Topography | | Poor | 13.27% | 126 |
| | | Mining Claims | Good | 100.00% | 951 |
| | | Mineral Development Licences | Good | 99.94% | 951 |
| Physical | Mining | | Poor | 0.06% | 1 |
| | | Mining Leases | Good | 99.49% | 947 |
| | | | Poor | 0.51% | 5 |
| | | Petroleum Leases | Good | 100.00% | 951 |
| | | Petroleum Pipeline Licenses | Good | 99.70% | 948 |
| | Mining | | Moderate | 0.30% | 3 |
| | Soils | Queensland Acid Sulfate Soil Boundaries | Good | 100.00% | 951 |
| | | Property Boundaries and Tenure (DCDB) | Good | 97.55% | 928 |
| | | | Moderate | 2.31% | 22 |
| | | | Poor | 0.13% | 1 |
| | | Builtup Areas | Good | 100.00% | 951 |
| | | Populated Places | Good | 97.66% | 929 |
| Social | | | Moderate | 2.34% | 22 |
| | Habitation and Tenure | Prohibited Areas | Good | 100.00% | 951 |
| | | Native Title Claims | Good | 19.11% | 182 |
| | | | Moderate | 73.84% | 702 |
| | | | Poor | 7.05% | 67 |
| | Cultural Heritage | QLD Heritage Register | Good | 100.00% | 951 |

| Category | Aspect | Theme | Performance | % | Length (km) |
|---|---|---|---|---|---|
| Built Environment | Transport | Railway | Good | 2.83% | 27 |
| | | | Moderate | 97.17% | 924 |
| | | Road | Good | 16.57% | 158 |
| | | | Moderate | 83.43% | 794 |
| | Utilities | Pipelines | Good | 1.95% | 19 |
| | | | Moderate | 98.05% | 933 |
| | | Powerlines | Good | 1.93% | 18 |
| | | | Moderate | 98.07% | 933 |
| | Water Infrastructure | Queensland Dams and Waterbodies | Good | 5.98% | 57 |
| | | | Moderate | 94.02% | 894 |
| | | SunWater Pipelines | Good | 1.59% | 15 |
| | | | Moderate | 98.41% | 936 |
| | | Damwalls | Good | 100.00% | 951 |
| | | Storage Tanks | Good | 100.00% | 951 |
| | | Water Tanks | Good | 99.98% | 951 |
| | | | Poor | 0.02% | 0 |

Overall performance of the corridor against the weighted criteria is good, with most criteria being satisfied. As Elevation, Native Title and Regional Ecosystems criteria are wide-spread over the entire study extent, they are less easily avoided than the criteria represented by discrete features and so do not perform as well as these. The infrastructure and dams layers have been modelled as 'attractors', so are likely to come back with lower scores, although the 16% alignment within 500m of main roads is a good result.

## 3.9 Summary and Recommendations

The INCA based multi criteria analysis carried out for the Direct Pipeline Connection report has been focussed on rapidly determining a base corridor suitable for high-level hydraulic assessment and costing. In keeping with these objectives, a number of limitations apply to the current modelling results.

The model currently represents unrefined criteria performance ratings and a single set of criteria weights. Further investigation into the suitability of the current data sources as performance ratings is required; particularly those that have significant geographic influence on the corridor selection, including Terrain and the Regional Ecosystems based criteria. Sensitivity analysis of a number of individual ratings is recommended, and the level of cross criteria redundancy needs to be determined, with the potential to reduce the number of inputs to a more focussed suite.

It is critical that a broader stakeholder input into finalisation of these assessment criteria and weightings is sought for the second phase of the study. As the current criteria are primarily reflective of available data sources, a stakeholder review is required to determine whether relevant aspects and impacts for this project are being best represented. There are several options NRW may wish to consider in preparing these final corridor selection criteria. As a minimum, it is recommended that a wider stakeholder working group be established to provide input into the assessment including performance criteria, weightings and scoring.

Not all sources of data identified as necessary for the study were available in for inclusion in the direct connection pipeline scenario. While coarser scale surrogates have been used where available, these decrease the robustness of the model and defensibility of the outputs and should be replaced where possible to support the additional investigations.

In particular, the following information is recommended for incorporation into the model:

- Higher resolution (25m) elevation data necessary to better analyse terrain characteristics;
- Large scale State Digital Road Network data;
- Utility infrastructure networks from Powerlink, Ergon, AGL and other relevant utilities;
- Irrigation Areas and additional water infrastructure locations; and
- Suitable soils or geology data that can inform constructability aspects.

It is expected that on review NRW may also identify the need to incorporate additional datasets not currently being considered.

It should be noted that while the INCA model is a powerful desktop tool for screening study areas and generating corridor options, there are a number of specific limitations to this approach, including:

- Inability to represent all of the critical aspects that determine corridor suitability in a geographic format;
- Accuracy and currency of some of the data; and
- Coarseness of some of the assumptions that may be made in determining performance ratings and weightings for evaluation criteria.

In all cases, subsequent field-based investigation and alternative process are considered necessary to verify and validate the outputs of the INCA model, as well as incorporate additional considerations that can not be represented through this approach.

# 4. Environmental and Social Considerations

The environmental and social considerations have been selected into the route selection process using the INCA weighting parameters based the assessment of the environmental and related factors. As described in the Route Selection Process, performance ratings are used to signify a level of importance for each criterion. In undertaking this initial route selection, there are a number of what are considered to be non negotiable areas which cannot be used for the route selection. These are described in the following sections.

## 4.1 Fatal Flaws

The Fatal Flaw performance rating has been created to emphasise “no-go” areas: lands whose significance to conservation and biodiversity are such that they should not be disturbed by the proposed project. All areas identified as Fatal Flaws are completely excluded from consideration by the corridor selection model. This includes lands with a clearly stated and/or legislated management intent directed at nature conservation, but also lands such as wetlands whose level of protection may be lower, but contribution to biodiversity protection is very high.

We have primarily identified as Fatal Flaws those protected areas with clear management intent aimed at nature conservation. A protected area is an area of land especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means (IUCN 1994). By this definition, World Heritage Areas and Ramsar Wetlands, protected under Commonwealth legislation in fulfillment of its international obligations, are assigned this performance rating. Lands protected under the Commonwealth *Environment Conservation and Biodiversity Conservation Act*, conservation areas and the various categories of national parks (as defined in the Queensland *Nature Conservation Act*), and Fish Habitat Areas as defined in the *Fisheries Act 1994* are also assigned as Fatal Flaws.

The Queensland *Vegetation Management Act 1999* was enacted to regulate the clearing of remnant vegetation with the goal of preventing biodiversity loss, maintaining ecological processes, minimising the impacts of clearing, and reduce greenhouse gas emissions. The Queensland Herbarium has developed a process for defining and mapping the extent of vegetation communities (“regional ecosystems”), and the extent of these communities has been utilized as a general guide to the level of protection they are afforded under the Act. We have identified endangered regional ecosystems, as defined in the Act, as a Fatal Flaw.

Wetlands documented in the *Directory of Important Wetlands* (Environment Australia 2001) have been included. Although located on a variety of tenures, many are not strictly protected or managed according to the IUCN definition, they generally represent highly threatened communities and/or habitats of high integrity, and impacts are likely to generate social as well as environmental consequences.

Lands such as protected catchments have not been included as Fatal Flaws – such areas are dedicated to ensuring the purity of water supplies, as Timber Reserves are generally managed to protect timber resources. Reserves set aside primarily for resource protection are assigned better performance ratings.

### 4.1.1 Ramsar Wetlands

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Ramsar wetlands are recognised as a matter of national environmental significance under the EPBC Act's assessment and approval provisions.

Ramsar wetlands are sites that are recognised under the Convention on Wetlands of International Importance (Ramsar Convention) as being of international significance in terms of ecology, botany, zoology, limnology or hydrology. Australia has 63 Ramsar wetlands

A person must not take an action that has, will have, or is likely to have, a significant impact on the ecological character of a Ramsar wetland, without approval from the Commonwealth Environment Minister. To obtain approval, the action must undergo a rigorous, expensive environmental assessment and approval process.

### 4.1.2 Directory of Important Wetlands

The States and Territories, and the Commonwealth Government, have jointly compiled a *Directory of Important Wetlands in Australia* (Environment Australia 2001). The Directory identifies and recognises Australia's nationally important wetlands, and it provides information about the different wetland types and the flora and fauna that are dependent on these wetland ecosystems. There are 851 nationally important wetland sites around Australia. We have identified all lands located within 200 m of a listed wetland as Fatal Flaws for the corridor selection.

Wetlands are identified as "nationally important" according to six criteria. These criteria are:

- The wetland is a good example of a wetland type occurring within a biogeographical region in Australia;
- It plays an important ecological or hydrological role in the major functioning of a major wetland system/complex;
- It provides important habitat for fauna at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions prevail (e.g. drought);
- It supports at least 1% of the national populations of any native plant of animal species;
- It supports nationally threatened plant or animal species, or ecological communities; and
- It is of outstanding historical or cultural significance.

Of the 851 Nationally important wetlands in Australia, in June 2002, 56 wetlands were also recognised as being "internationally important" under the Ramsar Convention List of Wetlands of International Importance.

### 4.1.3 Queensland Estate

The *Nature Conservation Act 1992* establishes 12 different classes of protected areas in Queensland. The protected area estate covers approximately 7,073,000 ha, which is about 4.1% of Queensland. Two of the most important reserve categories established under the Act are outlined in this section.

***National Park***

A national park is a natural area of land and/or sea, designated to:

(a) protect the ecological integrity of one or more ecosystems for present and future generations,

(b) exclude exploitation or occupation inimical to the purposes of designation of the area and

(c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally compatible. (IUCN 1994 definition).

National parks are special places, which protect and conserve outstanding examples of Queensland's natural environment and cultural heritage. Other protected areas are also very important for conservation but national parks are the cornerstone of Queensland’s protected area estate. The *Nature Conservation Act 1992*, the *Nature Conservation (Administration) Regulation 2006*, *Nature Conservation (Protected Areas Management) Regulation 2006* and *Nature Conservation (Protected Areas) Regulation 1994* define the management intent of national parks and regulate land use within their boundaries (EPA 2006).

The cardinal principle for the management of national parks in Queensland is to provide, to the greatest possible extent, for the permanent preservation of the area’s natural condition and the protection of the area’s cultural resources and values. There are however, cases in which some uses inconsistent with this principle are permitted, as listed in Schedule 3 of the *Nature Conservation (Protected Areas Management) Regulation 2006*

***Conservation Park***

This is another category of reserve in Queensland. It differs from a National Park in that some commercial resource-exploitation uses are permitted. State-wide there are 169 conservation parks protecting an area of about 32 930ha.

Like national parks, conservation parks are managed to:

- Conserve and present the area's cultural and natural resources and their values; and
- Permanently conserve the area's natural condition to the maximum extent.

A greater range of commercial and recreational activities can be undertaken on conservation parks than on National Parks. Educational activities and nature-based recreation like bushwalking *etc*. are encouraged.

### 4.1.4 Fish Habitat Areas

Queensland's tropical and subtropical coastal waters support an extensive, diverse and unique aquatic ecosystem. With the majority of Queensland’s human population living on the coastal fringe, this ecosystem is an integral component of the Queensland culture, lifestyle and economy. The State’s recreational, commercial and traditional fishing sectors, and therefore the seafood consuming public, are dependent on this ecosystem to provide an ongoing, sustainable source of fish, crustaceans and other targeted marine species.

Declared Fish Habitat Areas (FHAs) currently give protection to inshore and estuarine fish habitats that are important for sustaining local and regional fisheries. Once an area is declared as a FHA, it equally protects all habitat types (*e.g.* vegetation, sand bars and rocky headlands) from direct physical disturbance and coastal development.

The declared FHA program arose out of a need to counter the growing impacts of coastal development on Queensland's fisheries. The aim is to provide long-term protection for a network of fish habitats that are essential to sustaining these fisheries. There are currently 71 declared FHAs along the Queensland coast, providing protection for approximately 800 000 ha of high quality fish habitat (DPI 2007).

The Department of Primary Industries and Fisheries is responsible for the sustainable management of fisheries in Queensland, with FHAs forming a critical part of this ambit. FHAs are managed to provide for the use, conservation and enhancement of the community's fisheries resources. Works in a declared Fish Habitat Area must be supported by a Resource Allocation Authority issued under the *Fisheries Act 1994*, and require a fisheries development approval under the *Integrated Planning Act 1997*.

### 4.1.5 Regional Ecosystems

Regional ecosystems are defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The *Vegetation Management Regulation 2000*, as amended from time to time, assigns the conservation status of regional ecosystems.

The *Vegetation Management Act 1999* status is based on an assessment of the pre-clearing and remnant extent of a regional ecosystem. Another assessment of the conservation status is the Biodiversity Status, assigned by the Environmental Protection Agency and based on an assessment of the condition of remnant vegetation in addition to the pre-clearing and remnant extent of a regional ecosystem. Although lacking legislative protection, the biodiversity status of a regional ecosystem will be considered by the EPA when assessing development applications that will impact on the RE.

***Endangered RE***

A regional ecosystem is listed as endangered under the *Vegetation Management Act 1999* if remnant vegetation is less than 10% of its estimated extent prior to European settlement, across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 ha.

## 4.2 Poor Suitability

The performance rating of "Poor Suitability" has been assigned to protected areas of moderate conservation significance including "of concern" RE's and essential habitat. These lands generally represent habitats of moderate to high integrity, and impacts are likely to generate less social and environmental consequences than communities identified as Fatal Flaws. Typically, some commercial resource-exploitation uses are permitted

### 4.2.1 Regional Ecosystems

***Of concern RE***

A regional ecosystem is listed as of concern under *Vegetation Management Act 1999* if remnant vegetation is 10-30% of its pre-clearing extent across the bioregion; or more than 30% of its pre-clearing extent remains and the remnant extent is less than 10,000 ha.

In addition to the criteria listed for an “of concern” regional ecosystems under the *Vegetation Management Act 1999*, for biodiversity planning purposes the Environmental Protection Agency also classifies a regional ecosystem as “of concern” if: 10-30 per cent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.

### 4.2.2 Essential Habitat

Essential habitat is mapped remnant vegetation in which a plant or animal species has been known to occur that is endangered, vulnerable, rare or near threatened. The essential habitat of a species is mapped by the Environmental Protection Agency (EPA). The mapping technique uses essential habitat factors such as:

- Vegetation: The species or types of vegetation that the species is associated with;
- Regional ecosystem: the regional ecosystem(s) that the species is most commonly associated with;
- Land zone: This is the underlying geology associated with a regional ecosystem;
- Altitude: The range of altitudes at which the species is found;
- Soils: The type of soils on which a species is most commonly found; and
- Position in landscape: A more precise description of the landscape features the species is commonly associated with. Such as creek bank, levees, lower slopes, hillsides and ridges.

Essential habitat mapping is frequently coarse, but for many species, particularly those with significant populations outside the protected area network, provides the only means of protection. There is no legislated protection applied to essential habitat areas, however, impacts on essential habitat must be considered by the Environmental Protection Agency when assessing development applications.

## 4.3 Moderate Suitability

The parameters by which remnant vegetation is defined ensure that it has some level of value as habitat for native flora and fauna. Significant areas of unprotected mapped remnant vegetation occur across the north and west of the state, providing valuable ecosystem services, such as topsoil protection, fodder sources, habitat connectivity between protected areas and *in situ* biodiversity conservation. Mapped remnant vegetation, even where not occurring on lands under conservation tenure, thus has an important conservation function. In light of these issues, and taking into account the lack of legislative protection for this feature, we have assigned the Moderate Suitability performance rating to “not of concern” remnant vegetation.

### 4.3.1 Regional Ecosystems

***Not of concern RE***

A regional ecosystem is listed as not of concern under the *Vegetation Management Act 1999* if remnant vegetation is over 30 per cent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 ha. In addition to the criteria listed for not of concern regional ecosystems under the *Vegetation Management Act 1999*, for biodiversity planning purposes the Environmental Protection Agency also classifies a regional ecosystem as “No concern at present” if the degradation criteria listed above for endangered or “of concern” regional ecosystems are not met.

Clearing of remnant vegetation, where allowable, must be done under a permit issued by the Department of Natural Resources and Water.  Clearing is considered of remnant vegetation is allowable:

- For a significant project under the *State Development and Public Works Organisation Act 1971*, s. 26;
- Necessary to control non-native plants or declared pests;
- To ensure public safety;
- To establish a necessary fence, firebreak, road or other built infrastructure, if there is no suitable alternative site;
- For fodder harvesting;
- For thinning;
- For clearing of encroachment;
- For an extractive industry; and/or
- For clearing regrowth on leases issued under the *Land Act 1994* for agriculture or grazing purposes.

## 4.4 Good Suitability

This performance rating is assigned to all other classified lands within the proposed corridor which will not have a high potential to be adversely impacted upon by the project.  These include resource extraction reserves such as timber reserves, non-remnant (*i.e.* cleared) vegetation and lands greater than 200 m from a *Directory of Important* wetland.

### 4.4.1 Queensland Estate

***State Forest***

The cardinal principle to be observed in the management of State forests is the permanent reservation of these lands for the purpose of producing timber and associated products, and protecting the associated watershed.  Management of the State forest may also include grazing and allowances for recreation, including the provision of built infrastructure for such purposes, except where that State forest has been dedicated as a Forest Reserve under s70G of the *Nature Conservation Act 1994*, which excludes logging.  As State Forest lands are managed for an extractive use, they have been identified as having good suitability for the corridor.

***Timber Reserve***

Timber reserves are managed for the purpose of producing timber and associated products, and protecting the associated watershed, except where that State forest has been dedicated as a Forest Reserve under s70G of the *Nature Conservation Act 1994*, which excludes logging.  As Timber Reserve lands are managed for an extractive use, we have assigned this good suitability in the model.

***Forest Reserve***

A forest reserve is a form of protected area identified in the *Nature Conservation Act 1994*. Although its primary management intent is partly the protection of the biological diversity, cultural resources and values and conservation values of land included in the reserve, it must also be managed for the continuation of existing lawful uses of the land, such as beekeeping, mining, grazing, recreation and one-off extraction of plantation timbers. Unlike Timber Reserves, logging is not permitted in forest reserves. As it is managed for an extractive use, we have identified this estate type as having good suitability.

### 4.4.2 Non remnant Vegetation

Non-remnant vegetation is vegetation that is shown as such on a certified Regional Ecosystem Map. Vegetation on these lands is not affected by the *Vegetation Management Act* or the Commonwealth *EPBC Act*, although non-remnant vegetation occurring below the highest astronomical tide level is subject to controls under the *Fisheries Act 1994*. We also note that local government laws may regulate clearing of vegetation or significant trees in such areas.

### 4.4.3 >200 m from DOI Wetland

Provided actions do not result in an impact on DOI wetland, we have assigned lands > 200m distance from these wetlands as having good suitability.

## 4.5 References


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Environment Australia (2001) *A Directory of Important Wetlands in Australia, Third Edition*. Canberra.

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# 5. Transfer System

In this report, the scheme that has been developed to specifically transfer water from the Burdekin to the South East Queensland Water Grid, has been based a provisional route alignment selected using certain weighting processes. Testing of this scheme in terms of sensitivities in route and alignment with the system hydraulics has been undertaken, and is considered for this level of study to have provided reasonable basis on which to base this water transfer concept from the Burdekin to the South Queensland Water Grid.

The route selection methodology has included the physical limitations and constraints in terms of the practical design of pipeline and associated works.

## 5.1 General Description of the Transfer System

The general characteristics of the transfer system are summarised as follows:

- Transfer of water from the Burdekin Dam environs (Gorge Weir) and to discharge this into the vicinity of the South Queensland Water Grid (Wivenhoe Dam) over a distance of the order of 951 km;
- Size options will need to meet a number of capacity ranges based on population growth and a range of equivalent demands and can be expected to cover a range of internal diameter sizes from 1,380 mm to 2,132 mm in diameter depending on the transfer capacity requirements; and
- A number of pumping stations will be required to be located along the route of the pipeline to meet the hydraulic requirements which is essentially driven by working pressures within pipelines. There will be the order of 5 to 8 pump stations with a capacity of 5 to 31 MW pumps.

For this report the transfer system is evaluated in terms of the preliminary route indicated in Map C-8.

## 5.2 Transfer System Capacity Options

The transfer system capacities that have been considered for more detailed analysis of the transfer system are:

- Year 2012(projected population) with demand capacity based on 60 litres per person per day – 188 ML/d;
- Year 2026(projected population) with demand capacity based on 100 litres per person per day – 396 ML/d; and
- Year 2056(projected population) with demand capacity based on 140 litres per person per day – 727 ML/d.

The basis of these flows is described in Section 2.2.

## 5.3 Transfer System Design Parameters

Design parameters for the transfer system pipeline were not incorporated into the route selection criteria. These are different drivers and affect the physical arrangements for the transfer system. In adopting a model on which to base the assessment of the technical solutions, one of the key parameters was the adoption of closed or open pumping systems. This has an impact on the method of modelling the hydraulics which becomes quite important when matching the solution options to the terrain shape along the route of the pipeline.

### 5.3.1 Open verses Closed System

This refers to two basic approaches in long transfer pumping systems, being based on providing what is effectively a continuous pipeline with a number of intermediate pumping stations operating in series along the route of the pipeline, or an open system being a series of segmented pipelines interconnected via tanks and pumping stations.

The advantages and disadvantages of either system is open to broad debate, however in this case it was believed that there were a number of features of the closed system which appeared to suit this approach. The key benefit is obtained when there is some staging of the transfer rates, however this does depend on the terrain and if in fact the friction head loss is driving the HGL over the intermediate high points rather than the high points controlling the head required to be generated by the pumps.

The other benefit is that there is more flexibility in the final location of each pumps station as residual head is simply transferred through each subsequent booster pumping station rather than effectively been lost at each break tank in the case of the open pumping system.

As well as these benefits it is then normal to make all of the pumps the same, which has significant benefits in terms of spare parts and maintenance.

In summary for the proposed transfer system a closed system is expected to provide the lower cost solution. The adoption of a closed or an open system is expected not to have a major impact on the overall pipeline system costs.

### 5.3.2 Material Selection Considerations

With the envisaged pressure operating ranges for this pipeline and the diameters that are likely to be required it is considered unlikely that anything other than steel will be suitable. It is quite likely that mid strength steels would be considered to reduce wall thicknesses. Currently in Australia in large pipe diameters the commonly utilised pipe systems are mild steel cement lined (MSCL) pipes. In these diameters the jointing systems can be either rubber ringed joints (RRJ) or welded joints. There are advantages and disadvantages for both options. Also given the magnitude of the pipeline, it is highly likely that it would attract overseas pipe suppliers who may establish additional MSCL pipe manufacturing facilities in Australia and/or establish other alternative materials such as large size ductile iron cement lined (DICL) pipes. Given the size of the pipe and its length, suppliers may also utilise alternative pipe linings in lieu of cement lining, such as epoxy lining. For the purposes of this report we have utilised current Australian practice in large diameter high pressure pipelines, which is mild steel cement lined pipes, utilising welded joints so as to minimise the need for thrust blocks in the field.

Preliminary discussions with suppliers have indicated that at the quantity of pipe required , the pipe can be fabricated in sizes to suit the project. Whilst the detailed analysis has utilised sizes that are as close to normally quoted sizes, they are sometimes marginally different so as to obtain the best efficiencies. For the pressures likely to be expected the steel wall thicknesses are of the order of 10 to 16mm. The cement lining thickness is of the order of 16mm. In this report the internal diameter of the pipe is quoted as well as the nominal diameter (DN) of the pipe. This is typically the outside diameter of the pipe. Note the MSCL pipes have a fusion bonded polyethylene external coating.

### 5.3.3 Operating Pressure Ranges

Operating pressures are based on generally Grade 300 Mpa yield strength steel. The general objective was to maintain pipe operating pressures within Class 35 (which is approximately 350 metres of water pressure) as these are typical pressures for valves used in high pressure water supply systems. Lower operating pressures would result in substantially more pump stations without sufficient savings in pipe wall thickness. In some areas it is likely that higher pressures could be required in order deal with low points in the terrain. This would require thicker walled pipe.

Pressure ranges for the pipes are a function of wall thickness, and pipe diameter is also a function of the width of the coil plate available for the preferred manufacture of the spiral welded pipe. Water pipe is generally spiral welded whereas in the oil and gas industry the pipes are longitudinally welded. Different standards apply and for this project Australian Standard AS 1579 – pipelines for water supply has been adopted.

### 5.3.4 Preliminary Selection of Pipes

From experience in the detailed design of these types of transfer system, a friction head loss rate of 2 metres per kilometre is typical under normal water supply operating criteria. This will be used for the initial sizing of the pipeline for the various flow scenarios.

### 5.3.5 Type of Installation

Pipeline installation assumed for this project has been based on buried construction. It is possible that there may be selected sections of above ground pipeline but this is likely to be the exception.

Methods of jointing will vary depending on the pipe diameter. Pipes less than 1500 diameter will almost certainly be rubber ring jointed, whereas this will also be a possibility up to 1800 mm diameter. Above 1800 mm diameter it is likely that the pipes will be weld jointed.

At this size the pipe joints in the weld jointed option will be internally and externally welded which provides an inherent opportunity to hydrostatically test the joints without filling the pipeline with water. This would be of benefit for a long pipeline where water will be at a premium. Also as highlighted previously, welded jointed pipes enable the number of thrust blocks to be minimised. For this report we have utilised a welded jointed pipe.

## 5.4 Pumping Station Design Parameters

### 5.4.1 Capacity of Pump Units

Where practical with the closed pumping system, pump units will be identical. There may be circumstances due to specific terrain conditions where the pumping head may need to be varied.

The capacity of the pump units are for the range of conditions considered:

- Year 2012 (projected population) at 60 L/p/d - 188 Megalitres per Day (ML/d);
- Year 2026 (projected population) at 100 L/p/d - 396 Megalitres per Day (ML/d); and
- Year 2056 (projected population) at 140 L/p/d - 727 Megalitres per Day (ML/d).

### 5.4.2 Pump Configurations

Depending on the terrain shape and where the hills are occurring it could be that variable speed drive units are not the optimal solution. Power supply limitations may however require variable speed drive units to minimise starting loads. Pumps will be multistage to cater for pressure requirements. The final configuration of pumps/pump types would be undertaken in the detailed design, if the project proceeded.

Depending on the final planning and staging of the project it is anticipated that the pump units would be of the order of 60 ML/d for the smaller capacity case thereby requiring three duty and one standby unit.

The medium size pumping station may depending on pump availability may comprise for four by 100 ML/d units and in the largest case they could be 150 ML/d units.

Pump selection will involve a detailed evaluation as this project progresses, however they would most probably involve the use of 6.6 KV motors. The pump stations would require telemetry control and remote monitoring. These could be provided by fibre optic cabling laid with the pipeline, convential radio telemetry, microwave radio technology or utilisation of satellite telemetry. This would be confirmed as part of detailed design, if the project progressed.

## 5.5 Reverse Flow

The transfer system is designed to accommodate reverse flow. Providing for reverse flow will basically involve the provision of additional pump stations to lift out of the connection to the South East Queensland Water Grid (Wivenhoe Dam) and accommodate the surrounding hills. After these initial areas the pump stations utilised for normal flow direction will be able to provide sufficient head for the rest of the route. During detailed design optimisation of pump stations may be able to achieve further efficiencies in number and size.

# 6. System Hydraulics Analysis

The various operating scenarios have been set up in a series of hydraulic models. These cover a range of demands and supply and delivery options that include the reverse flow option.

## 6.1 Software and Modelling Methodology

The software used in this instance has been Bentley's WaterCad / WaterGems. These are GIS based modelling tools and for this purpose the line produced by the INCA route selection process (Map C-8) has been imported into the hydraulic modelling software. This ensures that real pipe lengths have been applied, and it is also using the terrain data which has been used in the route selection weighting process. A theoretical centreline based on the preferred general alignment is used by the hydraulic model. It is to be noted that this line although able to be defined in GIS terms quite accurately, in practical terms is no better defined than the terrain level data that has been used.

Pipe diameters are then selected based on available pipe suitable for the pressure regimes under which the system needs to be operating. The flows have been set for each scenario according to the demand estimates discussed in Section 2 – Supply Requirements.

Pumping heads are then selected to meet pressure limitations on the pipe materials and then the location and number of the pumping stations are selected to meet the specific terrain shape as well as the loss in friction head.

This can be an iterative process in order to optimise the positioning of the pumping stations.

## 6.2 Transfer Capacities for Scheme

Table 6-1, summarises the range of flows for the various scenarios.

**Table 6-1 Summary of Transfer Capacities in ML/d for Analysis**

| Year (refer table 2-1 for population) | Unit Demand 60 Lpcd | Unit Demand 100 Lpcd | Unit Demand 140 Lpcd |
|---|---|---|---|
| 2012 | **188** | 313 | 438 |
| 2026 | 238 | **396** | 554 |
| 2056 | 312 | 519 | **727** |

The shaded flows span the minimum and maximum case with the middle flow being similar to many of the other flows. The subsequent flow analysis utilises the three shaded flow cases in Table 6-1.

## 6.3 Year 2012 Transfer Conditions

### 6.3.1 Year 2012 (projected populations) with 188ML per day demand

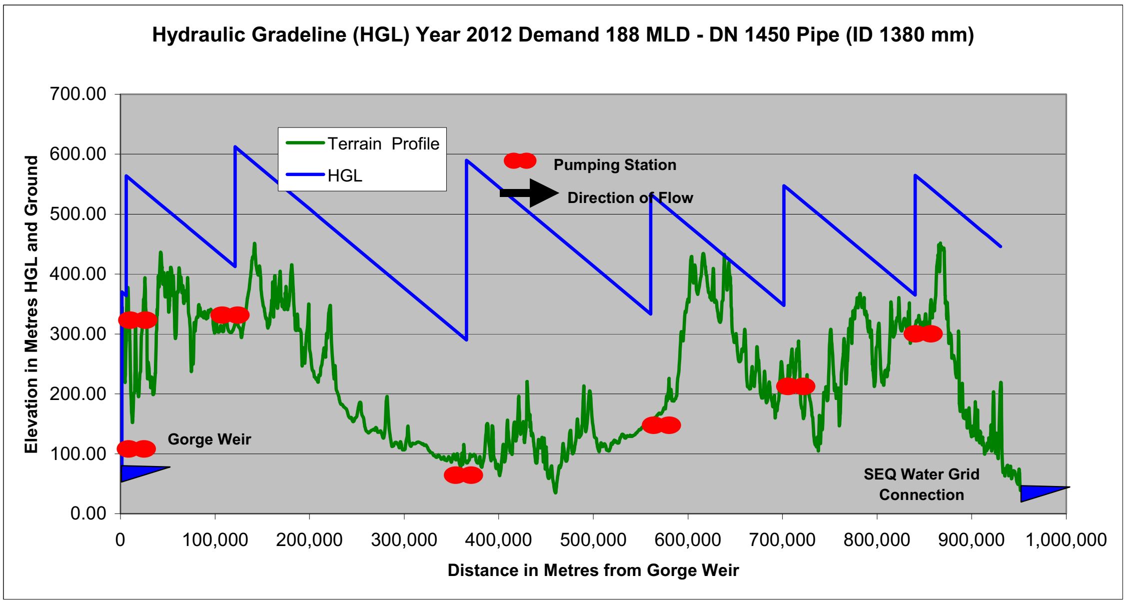
This scenario represents the lowest transfer capacity of all of the schemes considered in this study for transfer from the Burdekin Dam (Gorge Weir) through to the South East Queensland Water grid (Wivenhoe Dam).

Modelling of this system provides a hydraulic grade and ground level profiles as typically shown in Figure 1. This diagram illustrates the approach that has been in this assessment of the system hydraulics.

This system shows seven pumping stations operating at a flow rate of 188 ML/d.

It has been based on a nominal diameter pipe, DN1450 (internal diameter of 1,380 mm). This operating system in this figure has two pumping stations operating at approx 300 metres, and five pumping stations operating at 200 metres. Each pump station delivers at 188 ML/d.

**Figure 1 Hydraulic Grade Line(HGL) year 2012 demand(188ML per day) – DN1450 pipe (ID1380)**




## 6.4 Year 2026 Transfer Conditions

This option has been covered in the analysis and costings for this report however the detailed workings are not provided in the report.

In this case the transfer flow rate is 396 ML/d through a DN2000 (ID 1950 mm) pipeline. This operating system has four pumping stations operating at approx 280 metres, and one pumping station operating at 150 metres. Each pump station delivers at 396 ML/d.

## 6.5 Year 2056 Transfer Conditions

In this demand scenario there are again effectively six cases considered corresponding to three levels of unit demands and flows in either direction.

### 6.5.1 Year 2056 (projected populations) with 727 ML per day demand

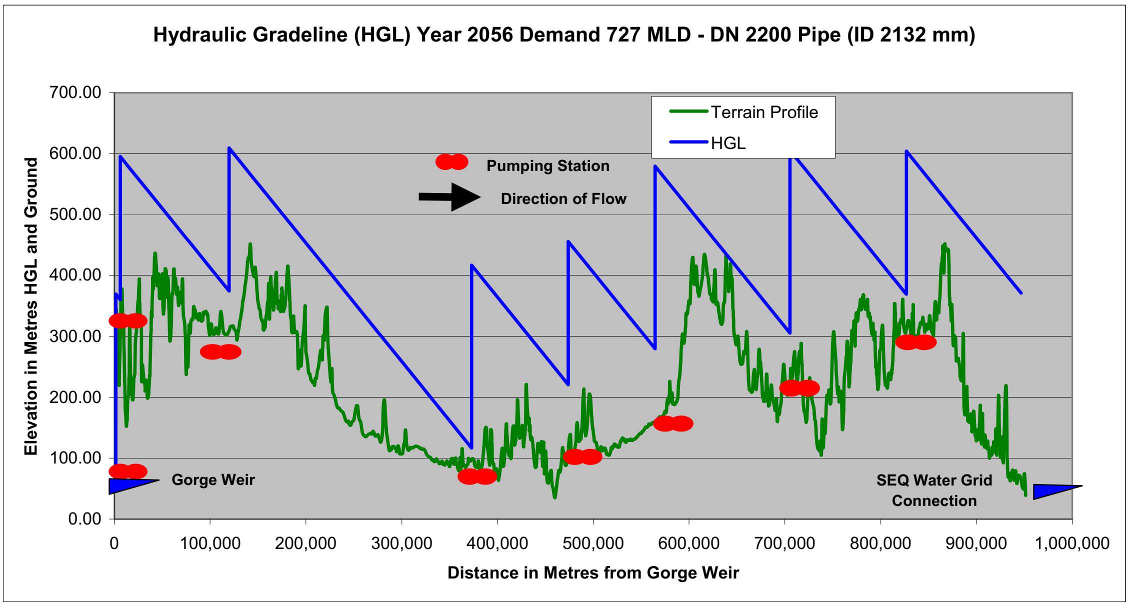
In this scenario, water is being transferred from the Burdekin Dam (Gorge Weir) through to the South East Queensland Water Grid (Wivenhoe Dam). This is the highest transfer capacity of the schemes considered in this study ie maximum population planning horizon and the highest unit demand per equivalent person. This effectively matches the demand levels which have recently reportedly as being achieved in the Brisbane area under the Level 4 water restrictions.

This system is at this time planning horizon is operating at 727 ML/d through a DN 2200 pipe with an internal diameter of 2132 mm. Sections of the pipeline will be able to have reduced wall thickness where the pipes are subject to lower pressures.

The initial runs have been carried out using what may be considered a conservative friction factors with a Hazen Williams C equivalent of 120. It is recognised that with the system operating with raw water there is a higher potential for the formation of slimes etc in the pipeline which may result in these lower than normally expected friction factors.

Under these conditions, the headloss per km is just under 2 metres and the mean velocity is 2.36 m/sec.

**Figure 2 Hydraulic Grade Line (HGL) year 2056 demand (727 ML per day) – DN 2200 pipe (ID2132)**




In Figure 2 the lower line represents the terrain along the pipeline route, whilst the upper line represents the hydraulic grade in metres of elevation. A vertical scale exaggerations has been used to emphasise how the placement of the pumps represented by the vertical shifts in the upper line, is controlled by the terrain.

As can be seen there is some residual head available where the pipeline is discharging into the South East Queensland Water Grid (Wivenhoe Dam). In the case where the direction of flow is from the Burdekin to the South East Queensland Water Grid there is a residual head of some 400 metres which could be recovered in a mini hydro unit producing some 30 MW. During more detailed feasibility studies there is likely to be some reduction and rebalancing of these pumping stations, but the currently assessed system provides sufficient information for the preliminary assessment of scheme costs.

For this profile shown in Figure 2 a total of 8 pumping stations have been provided.  With this diameter pipe and the flow rate of 727 ML/d the key operating parameters are:

- Four pump stations pumping at 727 ML/d with a head of 300 metres for 4 Stations (31 MW) land four pumping stations operating at a head of 230 metres (24 MW);
- Mean Velocity in Pipe 2.36  m/sec; and
- Headloss in metres per km 1.95 m.

Preliminary discussions with pipe suppliers indicate that a diameter of approximately 2500 mm is the largest steel pipe size that can currently be cost effectively produced in Australia, due to fabrication and steel plate supply issues.  For larger hydraulic capacity two pipes would be considered.

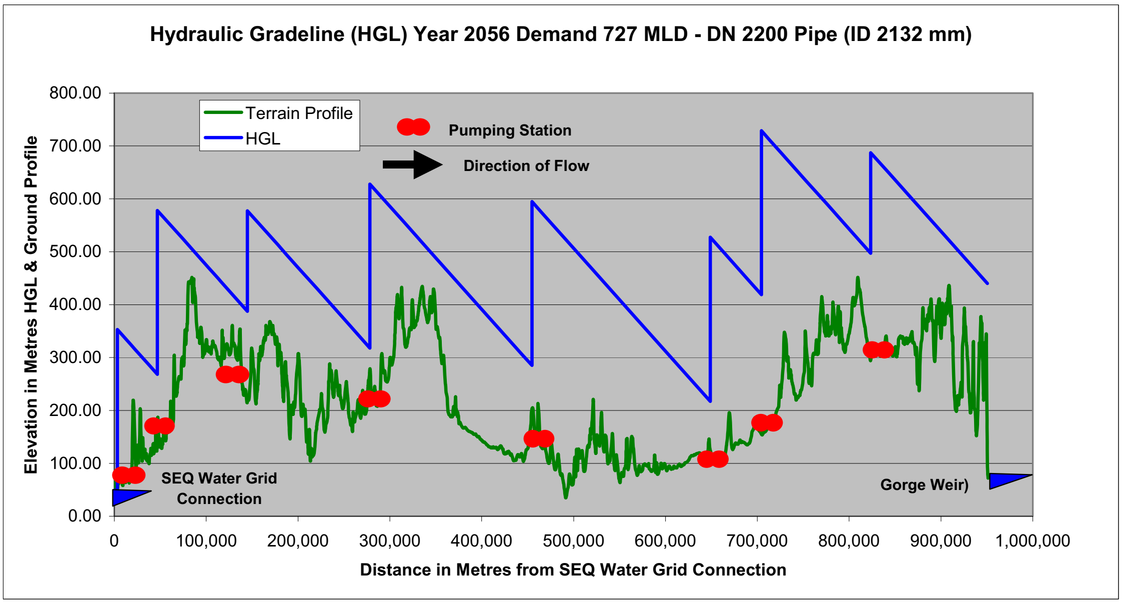
For this scenario the system characteristics are:

### 6.5.2 Reverse Flow - Year 2056 (projected populations) with 727 ML per day demand

This is the reverse pumping case with the DN2200 pipeline.  In this case in order to have a starting point, the first pumping station is effectively located operating out of the Wivenhoe Dam representing the South East Queensland Water Grid connection point.  This is shown below in Figure 3.

There are a number of terrain constraints which are controlling the location of the pumping stations.

**Figure 3  Hydraulic Grade Line (HGL) year 2056 demand(727 ML per day) – DN 2200 pipe- Reverse Flow:  South East Queensland Water Grid to Burdekin Dam (Gorge Weir)**




In this reverse pumping case there are eight pumping stations operating each at just under 31 MW which is approximately the same for the scenario when pumping from the Gorge Weir to the south.  The location of the pumping stations is dependent on the terrain profile as has been illustrated in Figure 3.  As can be seen there is an unavoidable residual head at discharge due to the need to match the pumping stations in with the terrain variations.

In summary reverse flow results in the same total number of pumping stations, however since four of these have to be located in a different location to that when pumping from the Burdekin to South East Queensland which in effect means that there are four additional pump stations required to provide for this reverse flow requirement. Note during detailed design it may be possible to rationalise the number of additional pump stations by more optimal location of pump stations for the Burdekin to South East Queensland flow.

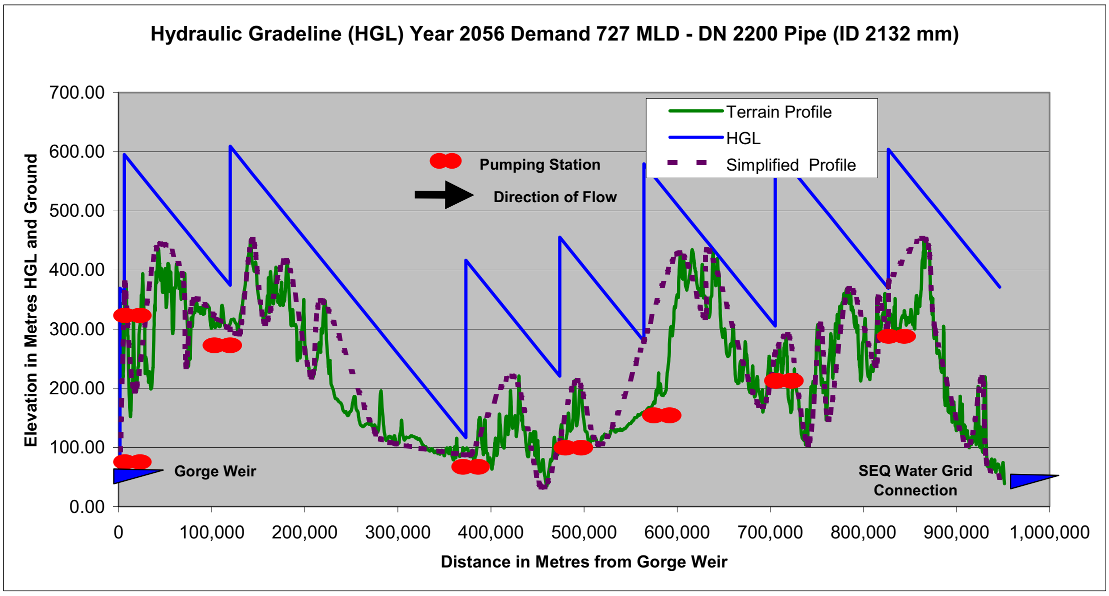
For the purposes of this report, reverse flow is assumed to be achieved by four additional pump stations of similar capacity, above that required for normal flow (Burdekin to South East Queensland).

## 6.6 Transient Review

The transient behaviour of a closed pumping system for the 2056 ie the 727 MLD flow condition based on using a 2200 nominal diameter pipeline. This case has been used to undertake a preliminary assessment of the transient conditions.

This analysis has used the same dynamic hydraulic model used to assess the various transfer scenarios. A simplified profile, however has been used but which is still consistent with the terrain profiles shown in the various steady state analyses in the forgoing sections of this report.

**Figure 4 Model for Transient Analysis year 2056 demand ( 727 ML per day) with DN2200 pipe.**

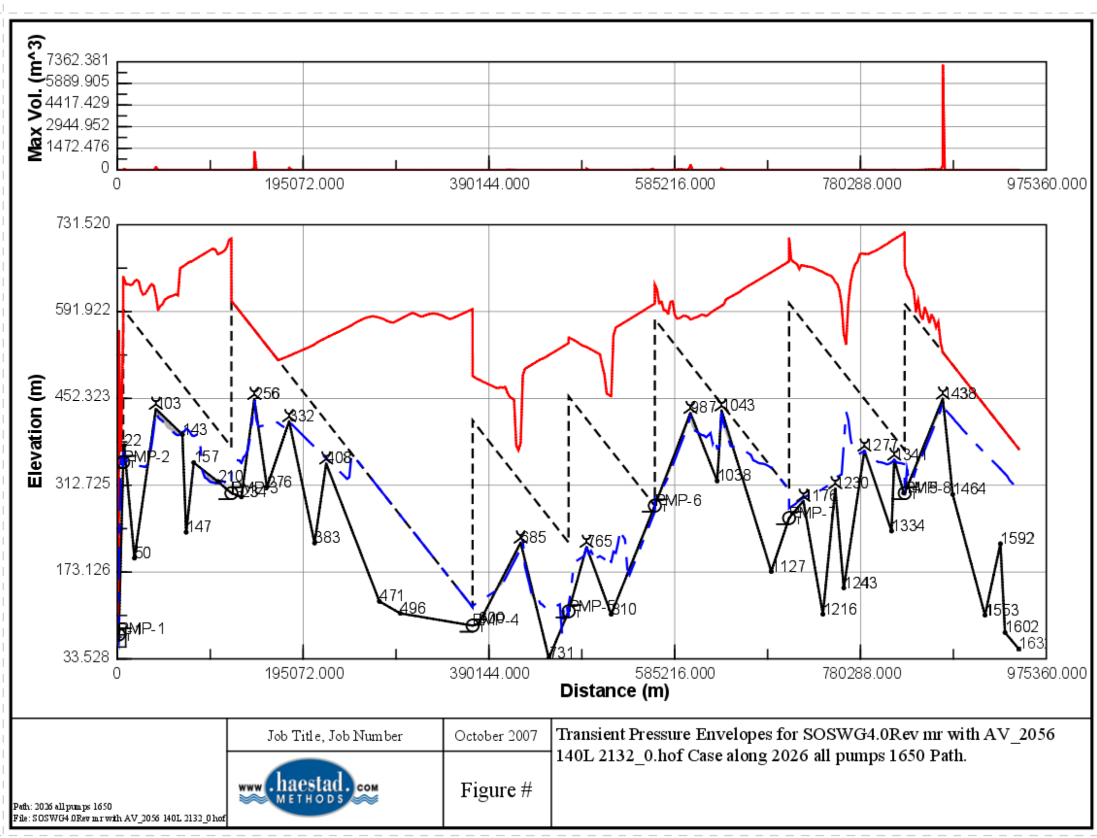



Using the system configuration shown in the above representation water hammer effects have been addressed based on a total system power failure ie the loss of power to all pumps. With eight pumping stations absorbing some 230 MW there is a considerable momentum which has to be decelerated. With such a long length of pipeline, the friction component can normally be expected be quite effective in minimising transient pressures in the system.

The likelihood of a sudden loss of power to the four pumping stations spread over some 850 km is not likely to be concurrent, however the interlocking of control systems may in fact result in the same effect.

Figure 5 details the transient analysis.

**Figure 5 Transient with Concurrent Power Failure all Pumps**




The red trace in Figure 5 the maximum hydraulic grade line in the pipeline following a complete power failure. There are clearly areas of elevated maximum hydraulic grade particularly in the central area of the system. There would need to be some special consideration for surge pressure alleviation in these areas and similarly the pipeline would need to be able to withstand a full vacuum condition. This negative pressure requirement is to be expected but with the wall thickness envisaged to cater for the elevated pressures the pipes will be capable of withstanding these pressures.

A combination of sequential time failures were checked and it indicated that the pressure envelopes were not that different to the case shown above.

The preliminary transient analysis indicates that some care will be required in the selection of pipe wall thicknesses and or the provision of surge tanks to assist in the control of the pressures. The indicative pressures are not excessive, however during detail design there will be some opportunities to refine the route selection of the pipeline to also reduce some of the higher pressure areas, so as to minimise the need for additional wall thickness or surge tanks. However for this report we have made an allowance for twenty (20) one way surge tanks.

## 6.7 Pipeline Optimisation

The basis of estimates used in this section are described in Section 7. The purpose of section 6.7 is to determine the optimal transfer system sizings (pumps and pipeline) for the flow cases 188, 396 and 727 ML/day for the respective operating conditions:

- 1 in 50 year operation
- 1 in 10 year operation; and
- Continuous operation.

The optimisation utilises NPV analysis of the capital and operating and maintenance costs of the options.

NPV analysis is suited for the determination of the optimal pipe size for continuous operation of the transfer system. For the intermittent operation scenarios (1 in 10 and 1 in 50 year) it is not as suitable, as given the large capital cost of the pipeline and the infrequent operation, the NPV analysis will favour reducing pipe size down to a point past where pipe velocities are sensible/practical. The subsequent analysis confirms this possibility and as such for the infrequent use scenarios, engineering judgement is utilised to determine the minimum feasible/practical pipe size.

### 6.7.1 Discount Rates and Residual Value

The graphs included below show a range of discount rate values from 4% to 8%. The range of the discount rates provide a means of testing the sensitivity of the pipeline diameter that is selected. The medium rate of 6% is currently close to the value being adopted by Treasury, however as has been demonstrated below the variation from 4% to 8% does not have much impact on optimum size of the pipe.

The NPV's have been determined over 30 years as per NRW advice to follow Treasury guidelines. Utilising 50 years does not change the optimal solution. NRW advise to guarantee supply for certain scenarios it will be necessary to raise the Burdekin Dam. The cost of this are summarised in Table 6-2 (these costs were provided by NRW).

**Table 6-2 Cost of Raising Burdekin Dam (supplied by NRW – excludes GST)**

| Frequency of Operation | 1:50 | 1:10 | Continuous |
|---|---|---|---|
| **Year / Demand** | | | |
| 2012 - 188ML/d | $0 | $0 | 2m Raising<br>$65M |
| 2026 - 396ML/d | $0 | $0 | >2m Raising<br>$250M |
| 2056 - 727ML/d | $0 | 2m Raising<br>$65M | 6m Raising<br>$453M |

### 6.7.2 Optimisation of Transfer System Components

The optimisation of the transfer system elements has been undertaken for the 2012, 2026 and 2056 scenarios. The results are summarised in Table 6-2. For the Direct Connection Pipeline Report NPV curves are presented for the cases as listed in the subsequent sections.

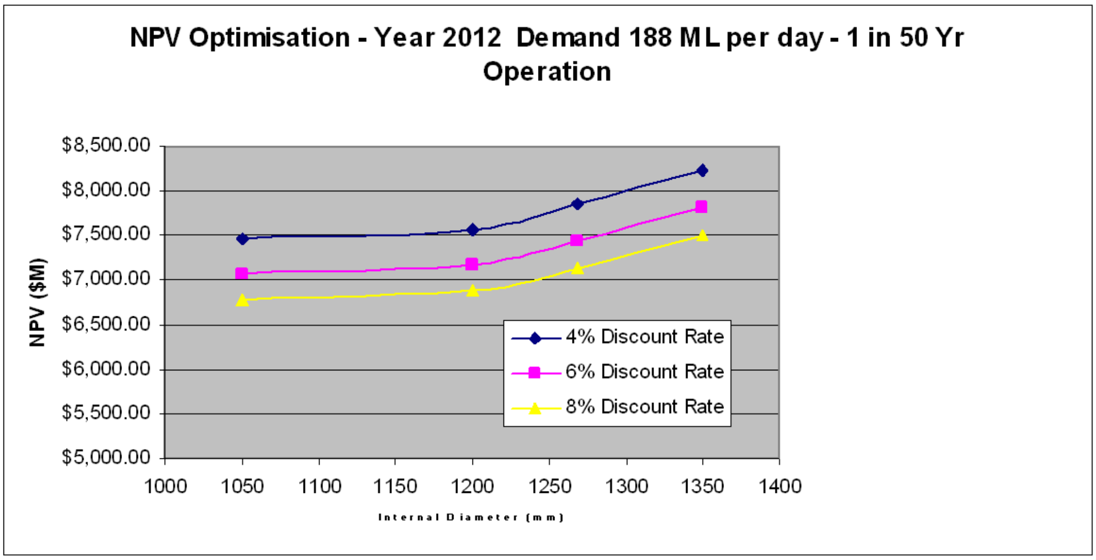
It is noted however that although the NPV type calculations are tending to reduce the diameter particularly for the one year in 50 years operating scenario and for the one year in 10 years to a lesser degree, this however has the impact of increasing the friction head loss which results in the need for a greater number of pumping stations. One of the other consequential issues is the inevitable increase in pressure rating for the pipeline resulting from the balancing of pumping station locations with terrain variations along the route of the pipeline. On this basis it is unlikely that the for the one in 50 year operation that the selected pipe diameter would be reduced to less than 1800 mm.

#### 6.7.2.1 Year 2012 Demand (188 ML per day)

A range of pipe diameters have been considered.

In the first case the pipeline has been considered as providing emergency only operation on a once in 50 years basis. The results of this are plotted up in Figure 6.

**Figure 6 NPV Optimisation – Year 2012 Demand 188 ML per day- 1 in 50 Yr Operation**



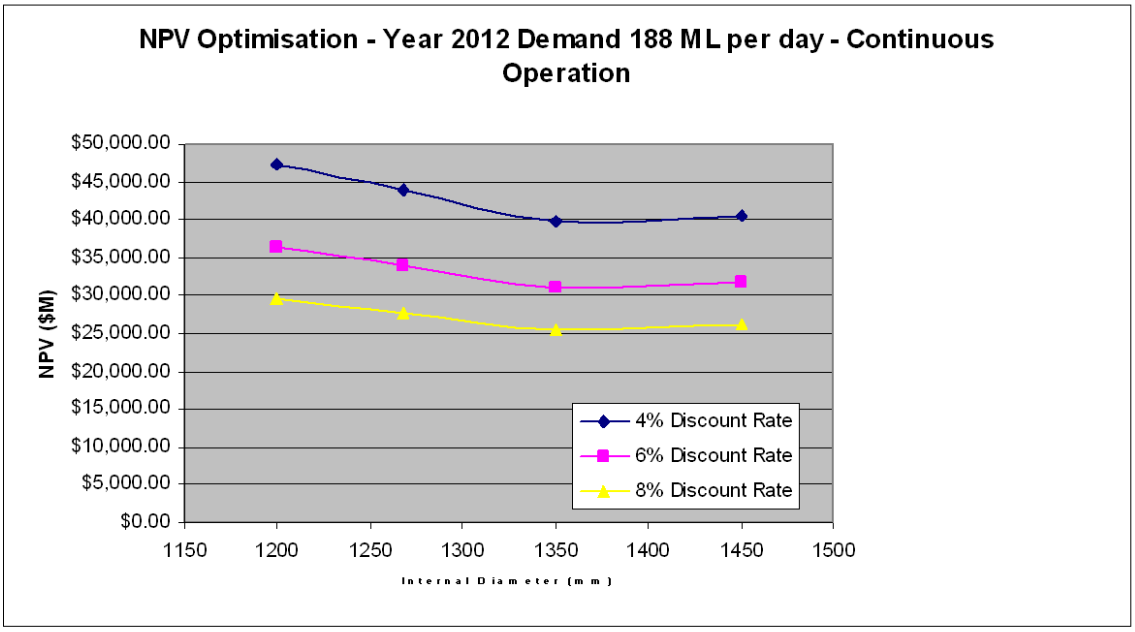

Below 1200mm the number of pump stations is increasing rapidly. The minimum feasible size is of the order of a 1100mm diameter pipe.

This calculation has also been undertaken for a once in 10 year operation indicating that the optimum diameter for this mode of operation is just less than 1200 mm.

Figure 7 demonstrates that the optimum pipeline diameter for continuos operation would be approximately 1380 mm internal diameter, i.e. 1450 DN.

With the continuous operation the energy costs are having a greater impact on the optimisation.

**Figure 7 NPV Optimisation – Year 2012 Demand 188 ML per day - Continuous Operation**

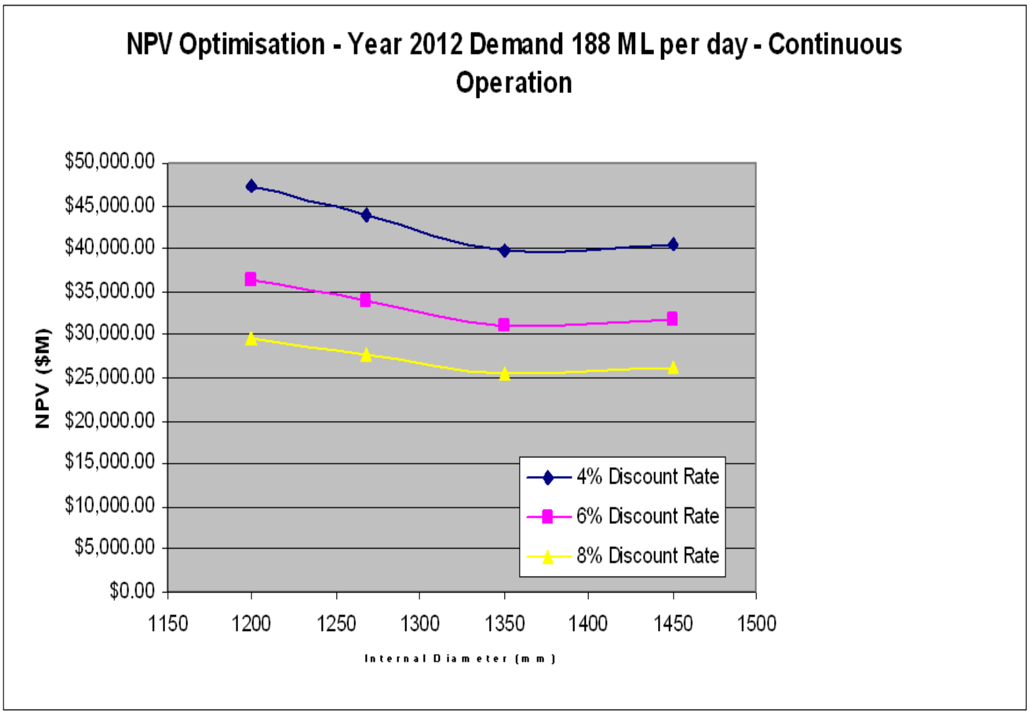



As can be seen from these net present value plots for a range of discount rates, the optimum diameter is not being significantly influenced by variations in that rate. As the discount rate increases then so does the diameter slightly. This can be explained by the fact that as discount rates increase, the impact of future operating costs reduce, the majority of which is the cost of power.

#### 6.7.2.2 Year 2056 Demand (727 ML per day)

Similarly, a range of pipe diameters were tested for the three operating scenarios from a severe emergency condition only at one in fifty years to continuous operations.

**Figure 8 NPV Optimisation – Year 2056 Demand 727 ML per day - 1 in 50 Year Operation**




The one in 50 year frequency (Figure 8) indicates a pipeline with an ID of 1850- 1900 mm is the optimal solution.

Figure 9 shows the Year 2056 continuous operation case.

**Figure 9 NPV Optimisation – Year 2056 Demand 727 ML per day - Continuous Operation**

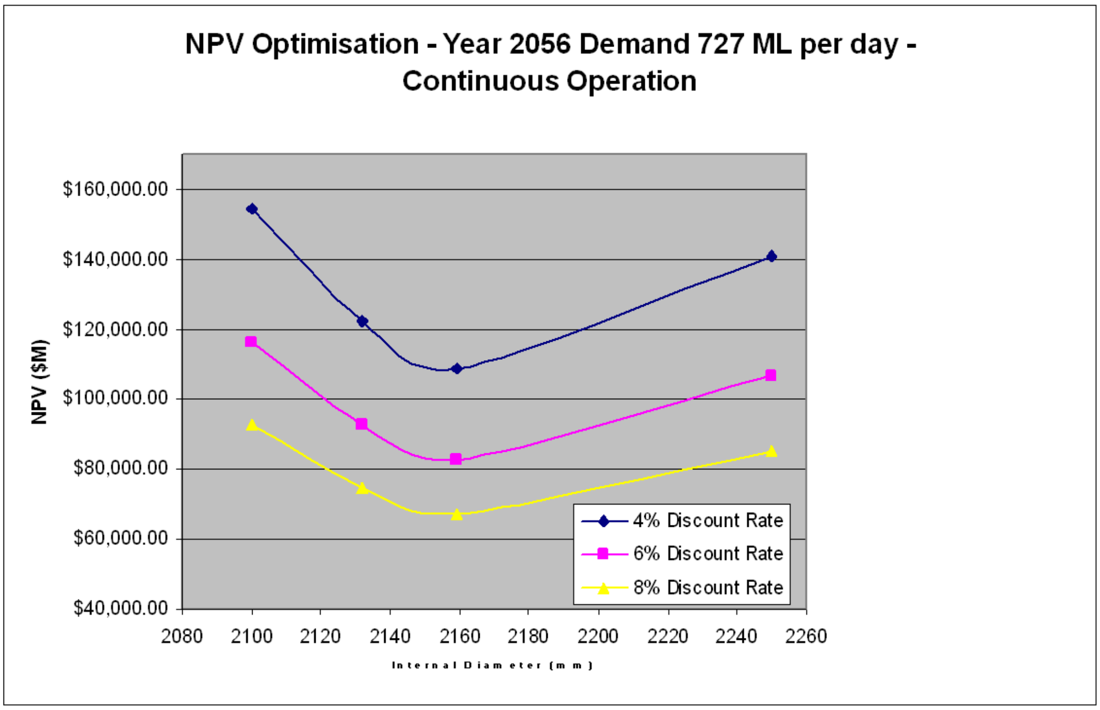



Figure 9 indicates an optimal pipe size of 2130 to 2180 (ID). We have utilised a DN 2200 pipe with an ID of 2132mm.

## 6.8 Summary of Optimum Pipeline Diameters

Based on the analysis of the net present values estimates for the various operating scenarios, with the system operating in each case at:

- One year in 50 years;
- One year in 10 years; and
- Continuous Operation.

These operating modes have been applied to each of the selected 3 scenarios which range from the lowest transfer capacity of 188ML/d to the medium capacity of 396 ML/d to the maximum of 727 ML/d.

- Year 2012 (population projection) with Demand of 60 L/p/d ie at 188 ML/d;
- Year 2026 (population projection) with Demand of 100 L/p/d ie at 396 ML/d; and
- Year 2056 (population projection) with Demand of 140 L/p/d ie at 727 ML/d.

Preliminary indications of the optimum size of the pipelines for the nine cases considered above are shown in Table 6-3 Optimum Pipe Diameters (Internal Dia in mm) below.

**Table 6-3 Optimum Pipe Diameters (Internal Dia in mm)**

| Planning Year | One Year in 50 | One Year in 10 | Continuous Operation |
|---|---|---|---|
| 2012 | 1100 | 1200 | 1380 |
| 2026 | 1450 | 1500 | 1950 |
| 2056 | 1850 | 2050 | 2132 |

# 7. Estimates

Preliminary estimates for the three (3) optimised continuous operation transfer system scenarios (188, 396 and 727 ML/d) are included in Appendix D. All costs detailed “exclude GST”.

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

## 7.1 Estimated Costs

### 7.1.1 Basis of Estimate

The cost estimates have been developed based on:

- Recent construction projects;
- Recent cost estimates for similar style projects being developed throughout Australia; and
- Supplier provided estimates.

This provides a sound basis for the estimates developed in this report. The estimates developed also accommodate the factors as described below.

### 7.1.2 Pipeline Construction Costs

Pipeline construction costs have been divided into three (3) categories.

A review of the ground slopes along the pipeline route was used as a preliminary assessment of categorising the route into the following connection types:-

- Rural Easy – Ground slopes <3%
  - In this category it is assumed construction by opening trenching in good soil conditions (Clay, loam, sand) with parent material re-used as backfill over the pipeline.
- Rural Intermediate – ground slopes 3% - 7%
  - In this category it is assumed that construction would be more difficult with some rock type material capable of being ripped with excavator type machinery. Also some select fill may be required to be imported to backfill the pipe trench. Some trench stabilisation in steeper sections may also be necessary.

- Rural Difficult. Ground slopes 7% - 10%
  - In this category it is assumed that significant areas of construction through rock material on steeper slopes will be necessary. Some blasting of trenching may be required, and also the inclusion of concrete barriers across the pipeline to mitigate against longitudinal scouring in steep sections will be required. Significant Quantities of select fill material for backfill is also expected.

#### 7.1.2.1 Additional Construction Costs

Additional costs over and above the supply and construction rates for the pipeline scenarios have been included in the Preliminary Estimates for road, railway and river and creek crossings.

A preliminary review of the topographic maps along the pipeline route has been used to identify the number of such crossing, and where appropriate divided the crossings into the various categories in the estimate.

##### *7.1.2.1.1 Road Crossings*

The additional construction cost estimates make allowance for additional depth of construction, compacted select backfill materials and the reinstatement of road pavement.

In the case of the secondary road, it also allows for reinstatement of the bitumen seal over the pipeline construction zone.

In the principal road category, it has been assumed that tunnel boring or pipe jacking across the road reserve will be required, with construction through an envelope pipe in accordance with Main Roads' requirements.

##### *7.1.2.1.2 Rail Crossings*

Nine (9) rail crossings have been identified along the pipeline route.

Additional construction cost estimates make allowance for additional depth of construction, and construction through an enveloper pipe, tunnel bored or jacked under the railway embankment in accordance with Queensland Rail requirements.

##### *7.1.2.1.3 River and Creek Crossings*

These have been separated into major (specifics) major, and minor categories.

In all categories, the additional estimated costs make allowance for construction under the stream bed at additional depth, additional pipe bends or each side of the crossing to achieve vertical grade, concrete pipeline protection/weighting across the stream bed, and post construction reinstatement or protection of the banks.

Twenty-three (23) major river crossings have been identified from a preliminary assessment of river catchment sizes from the topographic map along the pipeline route.

In the major river crossings the additional construction costs also make allowance for upstream and downstream coffer dams, dewatering of the construction zone, additional depth under the river bed, and reinforced concrete surround/weighting of the pipeline across the river bed.

Of these twenty-three (23) major river crossings. Six (6) have specifically been identified as being large river systems which would require additional lengths of pipeline construction within the river bed. Hence, significant additional costs have been allowed for these six (6) crossings.

These six (6) specified large river system crossings are:

- Suttor River;
- Isaac River;
- Fitzroy River;
- Dee River; and
- Burnett River (2 crossings).

### 7.1.3 Pump Station Construction Costs

The development of a pump station requires provision of access and power. In terms of access, the estimate includes an allowance for the construction of a new road from the nearest available existing road. Locations of the proposed pump stations were provided to ERGON. Based on this information ERGON advised NRW of the likely costs of supply per MW of the supply to the pump station including order of cost of connection to the existing network. These costs were used in conjunction with the distance from the nearest suitable power supply to determine a likely order of cost of providing supply. The advice provided by ERGON via NRW is that the power supply authority would undertake the capital works at their cost and recoup the cost based on an annual charge equal to 10% of the capital cost. These annual costs have been included in the O&M costs.

The cost of the transformers and switchyard at the pump station are additional to the supply costs. These costs are included as part of the capital cost of the pump station.

### 7.1.4 Associated Project Costs

The estimated costs prepared include estimates for items for associated project costs including land acquisition, legal costs, and Cultural Indigenous Land Use Agreement and Cultural Heritage works for the project.

The estimate for these items are based on previous recent similar projects. The estimates for these items (% of pipeline and pump station supply and construction costs) that are used in the total project costs are as follows:

- Land Acquisition 2.00%
- Legal Costs 0.20%
- ILUA and CH Monitoring 0.80%
- Engineering 15.00%
- Project Management 3.00%
- Project Mobilisation (i.e. housing, workshops, preliminary works etc) 10.00%

### 7.1.5 Intakes, telemetry, access roads and pipeline fittings

The estimated costs prepared include allowances for fish screens at the Gorge Weir intake, access roads to pump stations and telemetry to control the pump stations and to remotely report back to a centralised control station. In addition the pipeline includes scour valves, line valves and pigging facilities (launchers and receivers) to help clean the pipeline as is normal practice for Sunwater pipelines.

## 7.2 Annual O & M Costs

Operation and maintenance costs for the proposed infrastructure are estimated as follows:

1. O&M for pipeline – based on 1% of the capital cost of the pipeline;
2. O&M for the pump station (excluding power) – based on 3% of the capital cost of the pump station;
3. Annual charge from power supply authority for provision of power supply infrastructure – 10% of capital cost; and
4. Power usage – quoted rates 5 to 8c per kWHr. Adopted rate 6c per kWHr of pumping.

## 7.3 Cost of Raw Water

The predominant point of supply of raw water is the Burdekin Dam. The cost of purchasing of this water has not been included in the subsequent cost of the water produced by the transfer system. Preliminary advice by NRW indicates that additional infrastructure works are required at the Burdekin Dam to raise its safe yield so as to be able to provide sufficient reliable water to supply the 727 ML per day and some of the other supply scenarios.

Whilst the costs of these works may also have a benefit to other users, the costs (refer Table 6-2) are included as part of the Burdekin to South East Queensland Water Grid direct connection pipeline costs.

## 7.4 Determined Cost of Water Provided

The cost of the water provided by the proposed schemes has been determined in accordance with regulatory pricing guidelines. The allowable cost elements to compromise the cost of water are:

1. O&M Costs;
2. Annual Depreciation; and
3. Return on Capital.

These costs are divided by the volume of water produced to determine a cost of water per ML provided. For the two scenarios (1 in 50 year and 1 in 10 year pumping) which are not continuous supply cases this results in large costs per ML. These cases may be better considered in terms of an annual access charge plus a cost per use.

However for comparison purposes in this preliminary report only the cost per ML ratio is considered.

The O&M cost component of the cost make up is explained previously. The annual depreciation and return on capital are discussed subsequently in more detail.

### 7.4.1 Annual Depreciation

The annual depreciation has been calculated by diving the relevant cost of the asset by its expected life. The asset lives utilised are detailed in Table 7-1. These asset lives are utilised by water providers such as Sunwater.

**Table 7-1 Asset Lives**

| Description | Life (year) |
|---|---|
| Civil/Structures | 80 |
| Pipelines | 80 |
| Pipework/Values | 40 |
| Mechanical | 40 |
| Electrical | 35 |
| Access Roads | 30 |
| Transformers/Breakers | 35 |
| Dam | 150 |

### 7.4.2 Return on Capital

The return on capital has been determined as the product of the Weighted Average Cost of Capital (WACC) times the Replacement Value of the Scheme.

For the purposes of this report preliminary advice has indicated the WACC would range between 7 and 8%. For this report 7.5% has been adopted and there is no consideration of tax equivalents.

## 7.5 Energy Impacts

A key consideration in evaluating the direct connection proposal is its energy impact. This is represented by the energy consumption per ML supplied. This can then be benchmarked against other supply options such as a seawater desalination - 4000 kWhr/ML supplied.

Burdekin Water treated to a drinking water standard similar to desalination would require 150 kWHr/ML. If comparing energy impacts of desal water with the Burdekin direct connection it is necessary to add this energy used in treatment in the comparison.

## 7.6 Summary of Capital Costs, Cost or Water and Energy Impacts

The capital cost, cost of water and energy impacts for the three considered options are summarised in Table 7-2. The details for these costs are provided in Appendix D. Note these costs do not include the purchase price of Burdekin Water off Sunwater, nor does it allow for the cost of reverse flow (4 additional pump stations). The costs are all GST exclusive.

**Table 7-2 Summary of Capitals Costs, Cost of Water and Energy Impacts (excluding GST)**

| | Capital Cost ($M) | Water Cost ($/ML) | | | Energy Utilisation (kWhr/ML Supply) |
|---|---|---|---|---|---|
| | | 1:50 year operation | 1:10 year operation | Continuous operation | |
| Year 2012, 188ML/d | $6,908 | $481,668.70 | $96,697.07 | $10,055.27 | 5,423 |
| Year 2026, 396ML/d | $11,381 | $374,267.31 | $75,087.14 | $7,765.62 | 4,315 |
| Year 2056, 727ML/d | $13,976 | $255,931.97 | $51,475.42 | $5.485.54 | 7,209 |

## 7.7 Comparison to Other Sources of Supply

Comparison to other sources of supply is complicated by proximity of the source of supply to the demand point and hence the amount of connecting infrastructure that is required. However for preliminary benchmarking the cost of desal water including capital costs is of the order of $2,500 to $3,500/ML supplied. In terms of the Direct Connection Pipeline – Burdekin to South East Queensland the relevant cost to benchmark again are those in Table 7-2. The costs in Table 7-2 do not include the cost of providing treatment of Burdekin Water. This is not included as it assumed that as the pipeline is an emergency supply, it is to supplement a deficiency in supply to due to drought, hence sufficient treatment capacity is already available at the supply end of the pipeline. The cost of treatment of the water (power, staff, chemicals etc) is of the order of $150 to $200/ML treated.

## 7.8 Reverse Flow

As discussed in Section 6, preliminary analysis of reverse flow indicates that it can be achieved by the provision of four (4) additional pump stations (of similar capacity as the normal flow pump stations).

The costs in Table 7-2 do not allow for this additional cost. The additional capital costs to the transfer system to incorporate for reverse flow are summarised in Table 7-3.

**Table 7-3 Additional Capital Cost for Reverse Flow (excluding GST)**

| | Additional Capital Cost ($M) (excl GST) |
|---|---|
| Year 2012 - 188ML/d | $220 |
| Year 2026 - 396ML/d | $324 |
| Year 2056 - 727ML/d | $492 |

## 7.9 Construction Timeline

The construction of the Direct Connection Pipeline is a substantial project which would likely attract new pipe manufacturers and constructors to Australia. Given the scale of the project and the current market, the time from commencement of design to commissioning is expected to be of the order of 6-10 years, depending on the delivery mechanism utilised i.e. (Alliance, D&C, Normal Design then Build, Design Build Operate etc).

# 8. Summary Conclusions

The key summary and conclusions that can be made from this preliminary assessment of the direct connection pipeline from the Burdekin to the South East Queensland Water Grid are summarised as follows:

1. A reasonably robust route has been found by applying triple bottom line approaches through the INCA alignment selection process. The route selection was weighted by the terrain shape and hence it was concluded from the hydraulic analysis that a height limitation on the route improved the system operation.
2. Three operating scenarios were selected for analysis in this study being:
   – Year 2012 with a demand of 60 litres per person per day resulting in a capacity of 188 ML/d;
   – Year 2026 with a demand of 100 litres per person per day with a capacity of 396 ML/d; and
   – Year 2056 with a demand of 140 litres per person per day with a capacity of 727 ML/d.
3. The preliminary concept of the transfer system is a closed system steel pipeline for 951kms at pressures up to 350 (400 maximum) metres head, with five to eight pump stations of an individual capacity of 5 to 31MW.
4. NPV analysis was utilised to optimise the pipeline size. For the noncontinuous supply options (1 in 50 and 1 in 10 year operation) the NPV analysis attempted to reduce pipe diameter below a feasible/practical solution. The minimum pipe size was set in accordance with good engineering judgement for these cases. For the continuous operation scenarios the optimised transfer system were:

   For the continuous operation scenarios the optimised transfer system comprises:

   – 188ML/d - DN1450 (1380mm) ID pipeline and 2 pump stations at 7.99MW and 5 pump stations at 5.3MW capacity
   – 396ML/d - DN2000 (1950mm) ID pipeline and 4 pump stations at 15.7MW and 1 pump station at 1 at 8.4 MW capacity
   – 727ML/d - DN2200 (2132mm) ID pipeline and 4 pump stations at 30.9MW and 4 pump station at 23.7MW capacity
5. The capital costs, cost of water (excluding purchase cost of raw water at dam) and energy usage of the options are summarised in Table 8-1 (excludes reverse flow).

**Table 8-1 Summary of Capitals Costs, Cost of Water and Energy Impacts (excluding GST)**

| | Capital Cost ($M) | Water Cost ($/ML) | | | Energy Utilisation (kWhr/ML Supply) |
|---|---|---|---|---|---|
| | | 1:50 year operation | 1:10 year operation | Continuous operation | |
| Year 2012, 188ML/d | $6,908 | $481,668.70 | $96,697.07 | $10,055.27 | 5,423 |
| Year 2026, 396ML/d | $11,381 | $374,267.31 | $75,087.14 | $7,765.62 | 4,315 |
| Year 2056, 727ML/d | $13,976 | $255,931.97 | $51,475.42 | $5.485.54 | 7,209 |

6. As discussed in Section 6, preliminary analysis of reverse flow indicates that it can be achieved by the provision of four (4) additional pump stations (of similar capacity as the normal flow pump stations).

   The costs in Table 8-1 do not allow for this additional cost. The additional capital costs to the transfer system to incorporate for reverse flow are summarised in Table 8-2.

**Table 8-2 Additional Capital Cost for Reverse Flow (excluding GST)**

| | Additional Capital Cost ($M) (excl GST) |
|---|---|
| Year 2012 - 188ML/d | $220 |
| Year 2026 - 396ML/d | $324 |
| Year 2056 - 727ML/d | $492 |

7. The direct connection pipeline would take of the order of 6 to 10 years from commencement of design to commissioning.

## Appendix A

# Spatial Data Register

| Category | Subcategory | Description | Custodian |
|---|---|---|---|
| Environment | Flora and Fauna | Regional Ecosystems | EPA (ver 5 with latest amendments) |
| | | Essential Habitat | EPA (ver 2) |
| | | Directory Of Important Wetlands | EPA (ver 3) |
| | | Ramsar Wetlands | EPA (VER1.1 2002) |
| | | Fish Habitat Area | DPI (Feb 2005) |
| | | Qld Estates | EPA (Ver.12.3 Sep 2006) |
| | | Qld Estate Boundary | EPA (Ver.12.3 Sep 2006) |
| | | Reserves (Overridden By Estates?) | GA (series 3) |
| | | Windbreaks | GA (series 3) |
| | | Cleared Lines | GA (series 3) |
| | Water | Assessment Of Reach Condition | CSIRO/NLWRA 2001 |
| | | Watercourses | GA (series 3) |
| | | Watercourse Areas | GA (series 3) |
| | | Water Points | GA (series 3) |
| | | Water Holes | GA (series 3) |
| | | Waterfall Points | GA (series 3) |
| | | Reservoirs | GA (series 3) |
| | | Canal Areas | GA (series 3) |
| | | Canal Lines | GA (series 3) |
| | | Dam Waterbody | NRW 2005 |
| | | Flats | GA (series 3) |
| | | Foreshore Flats | GA (series 3) |
| | | Lakes | GA (series 3) |
| | | Locks | GA (series 3) |
| | | Pondage Areas | GA (series 3) |
| | | Rapidareas | GA (series 3) |
| | | Rapidlines | GA (series 3) |
| | | Springs | GA (series 3) |
| | | Qld Basins | NRW (july 2005) |
| | | Qld Sub Basins | NRW (july 2005) |

| Category | Subcategory | Description | Custodian |
|---|---|---|---|
| Physical | Mining | Exploration Permits Coal | NRW (download - May 2007) |
| | | Mining Claims | NRW (download - May 2007) |
| | | Mining Development Leases | NRW (download - May 2007) |
| | | Mineral Resource Outlines | NRW (download - May 2007) |
| | | Mining Leases | NRW (download - May 2007) |
| | | Petroleum Leases | NRW (download - May 2007) |
| | | Petroleum Pipeline Licenses | NRW (download - May 2007) |
| | | Restricted Areas | NRW (download - May 2007) |
| | | Mine Areas | GA (series 3) |
| | | Mine Pts | GA (series 3) |
| | | Petroleum Wells | GA (series 3) |
| | Soils / Geology | Atlas Soils (1:2mill) | NRW |
| | | Geology Line (Surface Geology 1:1mill) | GA |
| | | Geology Poly (Surface Geology 1:1mill) | GA |
| | | Acid Sulphate Soils | NRW 2007 |
| | Topography | Digital Elevation Model (9 Second) | GA (NRW) |
| | | Contours (50m) | GA (series 3) |
| | | Spot Elevations | GA (series 3) |
| | | Large Area Features (Dividing Ranges Etc) | GA (series 3) |
| | | Craters | GA (series 3) |
| | | Caves | GA (series 3) |
| | | Discontinuities | GA (series 3) |
| | | Pinnacles | GA (series 3) |
| | | Sandridges | GA (series 3) |
| | | Sands | GA (series 3) |
| Social | Habitation | Building Areas | GA (series 3) |
| | | Building Points | GA (series 3) |
| | | Builtup Areas | GA (series 3) |
| | | Cemetry Areas | GA (series 3) |
| | | Cemetry Points | GA (series 3) |
| | | Homesteads | GA (series 3) |

| Category | Subcategory | Description | Custodian |
|---|---|---|---|
| | | Locations | GA (series 3) |
| | | Placenames | GA (series 3) |
| | | Populated Places | GA (series 3) |
| | **Cultural Heritage** | Native Title | NRW |
| | | Qld Heritage Register | EPA |
| | | Aboriginal Representative Areas | NRW website |
| | **Land Use** | Landuse 1999 | NRW |
| | | Cultivated Areas | GA (series 3) |
| | **Tenure** | Property Boundaries And Tenure | NRW |
| | | Recreation Areas | GA (series 3) |
| | | Prohibited Areas | GA (series 3) |
| | | Stock Routes | NRW |
| | | Stock Routes Water Points | NRW |
| **Built Environment** | **Infrastructure** | Aerial Cableways | GA (series 3) |
| | | Conveyors | GA (series 3) |
| | | Fences | GA (series 3) |
| | | Marine Infrastructure Lines | GA (series 3) |
| | | Marine Infrastructure Points | GA (series 3) |
| | | Vertical Obstructions | GA (series 3) |
| | | Windpumps | GA (series 3) |
| | | Yards | GA (series 3) |
| | **Transport** | Railways | GA (series 3) |
| | | Railway Bridge Points | GA (series 3) |
| | | Railway Crossing Lines | GA (series 3) |
| | | Railway Stop Points | GA (series 3) |
| | | Railway Tunnell Lines | GA (series 3) |
| | | Railway Tunnel Points | GA (series 3) |
| | | Roads | GA (series 3) |
| | | Road Crossing Lines | GA (series 3) |
| | | Road Crossing Points | GA (series 3) |
| | | Road Tunnel Lines | GA (series 3) |

| Category | Subcategory | Description | Custodian |
|---|---|---|---|
| | | Road Tunnel Points | GA (series 3) |
| | | Aircraft Facility Points | GA (series 3) |
| | | Barrier Points | GA (series 3) |
| | | Ferry Routelines | GA (series 3) |
| | | Foot Tracks | GA (series 3) |
| | **Utilities** | Pipelines | GA (series 3) |
| | | Powerlines | GA (series 3) |
| | | Sunwater Pipelines | SunWater 2007 |
| | **Water** | Damwalls | GA (series 3) |
| | | Spillways | GA (series 3) |
| | | Storage Tanks | GA (series 3) |
| | | Water Tanks | GA (series 3) |

Appendix B

# INCA Model Register

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| Environmental | **Flora and Fauna** | **Regional Ecosystems** | Vegetation mapping at a map scale of 1:100,000 and 1:50,000 in part, based on surveys of vegetation communities. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100,000 is 100 metres. The map scale of 1:50,000 applies to part of Southeastern Queensland and map amendments areas. The mapping includes regional ecosystems as described in Sattler & Williams (ed.) (1999) and updated in the Regional Ecosystem Description Database, on the EPA website: http://www.epa.qld.gov.au/nature_conservation/biodiversity/regional_ecosystems/ Related polygon coverages include: pre-clearing vegetation, 1995, 1997, 1999, 2001 remnant vegetation / regional ecosystem and remnant vegetation cover (RVC) for areas where regional ecosystem coverages have not been completed. Point coverage of survey sites for the region extracted from CORVEG. Complete site data are stored in the Queensland Herbarium CORVEG database. National Vegetation Information System - NVIS Audit | 2003 and certified amendments to 15th March 2007 | EPA (ver 5 with latest amendments) | Non Remnant | 1 | | Clearing of remnant vegetation is minimised<br>Closer analysis may justify reducing Endangered RE to 3. | 5 |
| | | | | | | Not of Concern RE | 2 | | | |
| | | | | | | Of Concern RE (subdominant) | 3 | | | |
| | | | | | | Of Concern RE (dominant) | 3 | | | |
| | | | | | | Endangered RE (subdominant) | 999 | 3 | | |
| | | | | | | Endangered RE (dominant) | 999 | 3 | | |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Essential Habitat** | PR 1.5 of the Regional Vegetation Management Code for Broadscale Clearing and Part A of the Regional Vegetation Management Code for Ongoing Purposes provide for exclusion of clearing in identified areas of essential habitat of vulnerable, rare, near threatened or endangered species through the following provision, i.e. 'PR 1.5 To prevent loss of biodiversity, clearing does not occur in an area which is identified in a map prepared for the purpose of this code as an area of essential habitat for a species of wildlife listed as vulnerable, rare, near threatened or endangered under the Nature Conservation Act 1992. The map is prepared by the chief executive of the agency that administers that Act and certified by the chief executive of the Department of Natural Resources & Water.' It is the responsibility of the EPA to provide this information on hard copy maps and digital layers at current best standards for the State. | Sep-06 | EPA (ver 2) | Within mapped areas | 3 | | Loss or degradation of essential habitat for rare, vulnerable and endangered species is minimised | 5 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Fish Habitat Area** | Fish Habitat Areas declared under Section 94 and Schedule 7 - Parts 1 & 2 of the Queensland Fisheries Act 1994. This is a composite of Boundary areas gazetted/regazetted in 1998-2003 (listed in Part 2) and previous DPI Fish Habitat Reserves digitised in 1996 (listed in Part 1). All FHAs are being redrawn/regazetted to a digital format, conforming to the DCDB as base defining an OUTER BOUNDARY. For EXCLUSIONS within these FHA areas - refer to referenced Gazettals | 1/01/1996 - 2005-02-25 | DPI (Feb 2005) | Within mapped areas | 999 | 3 | Risks of impacting upon fish habitat areas are minimised | 1 |
| | | **Conservation Estate** | Protected Areas of Queensland. Warning note: (1) Estate is the master spatial layer and as such the derived product estateby must not be used in isolation. (2) Under the provisions of the Nature Conservation Act 1992, no entry is permitted to National Park (Scientific) reserves without a permit. | 11/07/1964 - 31/9/2006 | EPA (Ver.12.3 Sep 2006) | National Park | 999 | | Impacts on sites with legal conservation status are avoided or minimised (eg. National Park, Conservation Park, State Forest etc) | 6 |
| | | | | | | Conservation Park | 999 | 3 | | |
| | | | | | | State Forest | 1 | 2 / 3 | | |
| | | | | | | Timber Reserve | 1 | 2 / 3 | | |
| | | | | | | Forest Reserve | 1 | 2 / 3 | | |
| | | | | | | Resource Reserve | 1 | 2 / 3 | | |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| Environmental | **Watercourses and Wetlands** | **Assessment of River Condition (ARC-E)** | The Assessment of River Condition is the first attempt to report on river condition for key river basins across Australia. The integrated assessment provides a basin-wide context and a framework within which decisions and river management priorities can be considered. The assessment incorporates a range of attributes that are considered to indicate key ecological processes at the river reach and basin levels. The two indices developed are an Aquatic Biota Index using macroinvertebrates, and an Environment Index with four sub-indices: catchment disturbance; hydrological disturbance; habitat; and nutrient and suspended sediment load. A range of data types and approaches were used including direct measurements and modelling of nutrient and sediment loads. | Sep-01 | NRLWA/CSIRO | < 200m of Largely Unmodified Reaches<br><br>< 200m of Moderately Modified Reaches<br><br>< 200m of Substantially Modified Reaches<br><br>< 200m of Severely Modified Reaches<br><br>< 200m of Unassessed Reaches | 999<br><br>3<br><br>3<br><br>2<br><br>2 | | The Environment condition index has been selected on the basis of having more consistent coverage of data that the Biota Index and a generally more conservative assessment level. A minimum rating of 2 has been applied to all watercourse buffers to minimise running parallel within 200m of these features and reduce the number of crossings | 3 |
| | | **QLD Drainage Watercourses** | Drainage 250k Geodata (Series 2) is a linear network of interconnected chains depicting the state's major watercourses. The majority of the chains represent canals or watercourses depicted as single lines on the source material. To ensure continuity of the network, connector features are used to bridge area features such as lakes, swamps and watercourses which are sufficiently wide to be shown as polygons on the source material. | May-06 | GA (series 3) | Within 200m of mapped features | 2 | | Minimise proximity to watercourses where possible, including minimising running parallel and reducing the number of crossings. | 3 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform -ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **QLD Drainage Watercourse Areas** | | May-06 | GA (series 3) | Within 200m of mapped features | 3 | | Avoid crossing other water bodies where possible. Large storages will be eliminated as fatal flaws through the Dams and Waterbodies theme below. | 2 |
| | | **Directory of Important Wetlands** | Wetland locations for Queensland wetlands described in Directory of Important Wetlands, 3nd Edition, ANCA 2001 by Wetland Inventory Team, Northern Region, DoE. Updated by Resource Assessment Unit, Qld. EPA | Jan-06 | EPA (ver 3) | Within 200m of mapped areas | 999 | 3 | Impacts on wetland ecosystems are minimised. Potential reduction to 3, although limited occurrences within the study extent. | 1 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ramsar Wetlands** | The Convention on Wetlands of International Importance was the first modern inter-governmental treaty between nations aiming to conserve natural resources. The signing of the Convention took place in 1971 in the small Iranian town of Ramsar (since then, it has taken the common name of the Ramsar Convention). Australia was the first nation to become a Contracting Party to the Convention. The Convention's broad aims are to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. This requires international cooperation, policy making, capacity building and technology transfer. There are 5 Ramsar sites within Queensland (Administrators are shown in brackets): Moreton Bay (Queensland), Bowling Green Bay (Queensland), Currawinya Lakes (Queensland), Shoalwater and Corio Bays (Queensland/ Commonwealth), Great Sandy (Queensland). | 1/01/1970 - 29/11/2002 | EPA (VER1.1 2002) | Within 200m of mapped areas | 999 | | Impacts on wetland ecosystems are minimised | 1 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| Physical | Terrain | **Slope** | The GEODATA 9 Second DEM Version 2 is a gridded digital elevation model computed from topographic information including point elevation data, elevation contours, stream lines and cliff lines. The grid spacing is 9 seconds in longitude and latitude (approximately 250 metres). 9 Second DEM is a cooperative effort of the Australian Surveying and Land Information Group (AUSLIG), Australian Geological Survey Organisation (AGSO) and Centre for Resource and Environmental Studies (CRES) at the Australian National University. | Aug-00 | GA (NRW) | > 10%<br>5 - 10%<br>< 5 | 999<br>3<br>1 | | Construction and operation costs can be reduced and risks of stability issues minimised. | 4 |
| | | **Elevation** | | | | > 500m AHD<br>300 - 500m<br>< 300 | 3<br>2<br>1 | *<br>*<br>* | *Subject to specific sensitivity analysis. | 1 |
| | Mining | **Mining Claims** | The boundaries of Mining Claims in Queensland. Display the boundaries and names of principal holders of all application and granted Mining Claims (MC) | May-07 | NRW | Within mapped areas | 2 | 1 | Minimise impacts on mining activities | 1 |
| | | **Mineral Development Licences** | The boundaries of Mineral Development Licences (MDL) for Minerals (includes coal) in Queensland. Display the boundaries and names of principal holders of all application and granted Mineral Development Licences (MDL) | May-07 | NRW | Within mapped areas | 999 | 3 | Minimise impacts on mining activities | 1 |
| | Mining | **Mining Leases** | The boundaries of Mining Leases in Queensland. Display the boundaries and names of principal holders of all application and granted Mining Leases (ML) | May-07 | NRW | Within mapped areas | 999 | 3 | Minimise impacts on mining activities | 3 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform -ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Petroleum Leases** | The boundaries of Petroleum Leases in Queensland. Display the boundaries and names of principal holders of all application and granted Petroleum Leases (PL) | May-07 | NRW | Within mapped areas | 2 | | Minimise impacts on mining activities | 1 |
| | | **Petroleum Pipeline Licenses** | The theme depicts the centre lines of petroleum pipeline licences captured into the Department's MERLIN tenure system. | May-07 | NRW | Within mapped areas | 2 | | Minimise impacts on mining activities | 2 |
| | **Soils** | **Queensland Acid Sulfate Soil Boundaries** | A guide to the presence of acid sulfate soils throughout Queensland. Indicates areas of detailed mapping and provides a connection to reports. Detailed metadata is available for specific projects.<br>Purpose: Indicates the presence or absence of acid sulfate soils throughout Queensland. | Not yet received | Not yet received | < 5m AHD or mapped presence | 999 | | Construction of pipeline will not disturb Acid Sulfate Soils | 3 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| Social | **Habitation and Tenure** | **Property Boundaries and Tenure (DCDB)** | The Digital Cadastre DataBase (DCDB) is the spatial representation of the property boundaries and the related property descriptions of Queensland. The DCDB provides the map base for systems dealing with land and land related information and provides data in order to generate hard copy map products. This dataset is a fortnightly copy of Queensland`s Digital Cadastral Database (DCDB)updated with a monthly copy of selected information from the Tenure Attribute System. See http://131.242.63.117:8080/documents/pdf_files/cgm-143.pdf for a full description of this dataset and its contents.See NRM Meta record for:Digital Cadastral Data Base (DCDB) | May-07 | NRW | Lot size < 0.25 ha in SEQ Regional Plan<br>Lot size < 0.25 ha outside SEQ Regional Plan<br>0.25 - 1ha<br>1ha - 16 ha<br>> 16 ha | 999<br>3<br>3<br>2<br>1 | | Reduce the number of property owners affected, Costs and delays associated with land acquisition are minimised. Proposed pipeline does not affect residential areas or amenity in those areas. | 4 |
| | | **Builtup Areas** | A concentration of buildings surrounding a network of roads and supported by other associated infrastructure. Extracted from the GEODATA TOPO 250K Series 3 Topographic Data product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within mapped areas | 999 | | Avoid builtup areas | 5 |
| | | **Populated Places** | A named settlement with a population of 200 or more persons. Extracted from the GEODATA TOPO 250K Series 3 Topographic Data product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within 5km | 2 | | Avoid mapped regional locations where possible | 3 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform -ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Prohibited Areas** | Area into which entry is prohibited without permission from the controlling authority. Extracted from the GEODATA TOPO 250K Series 3 Topographic Data product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within the mapped area | 999 | | Avoid defence and other restricted areas | 4 |
| | **Cultural Heritage** | **Native Title Claims** | The Queensland Claim Activity Map (QCAM) spatial data set indicates the external boundaries of native title claims lodged over areas of lands and waters within the State of Queensland. The depictions of native title claims are approximate and are shown as general information only, based upon claimant applications filed with the Federal Court and registered with the National Native Title Tribunal. This data set may be overlayed with the DCDB to further indicate the relationship and approximate location of claims relative to cadastral data. | Feb-07 | NRW | Multiple overlapping claims<br><br>Single claim | 3<br><br>2 | | Delays due to Native Title issues are minimised and the rights of Native Title claimants are respected. | 2 |
| | | **QLD Heritage Register** | Spatial representation of listing boundaries for places entered in the Queensland Heritage Register. Places that are provisionally and permanently entered in the Queensland Heritage Register are protected under the provisions of the Queensland Heritage Act 1992. The Queensland Heritage Council has approved these places. | Jan 2001 - current | EPA | Within 100m of any registered site | 999 | | Items of cultural heritage are not impacted | 3 |

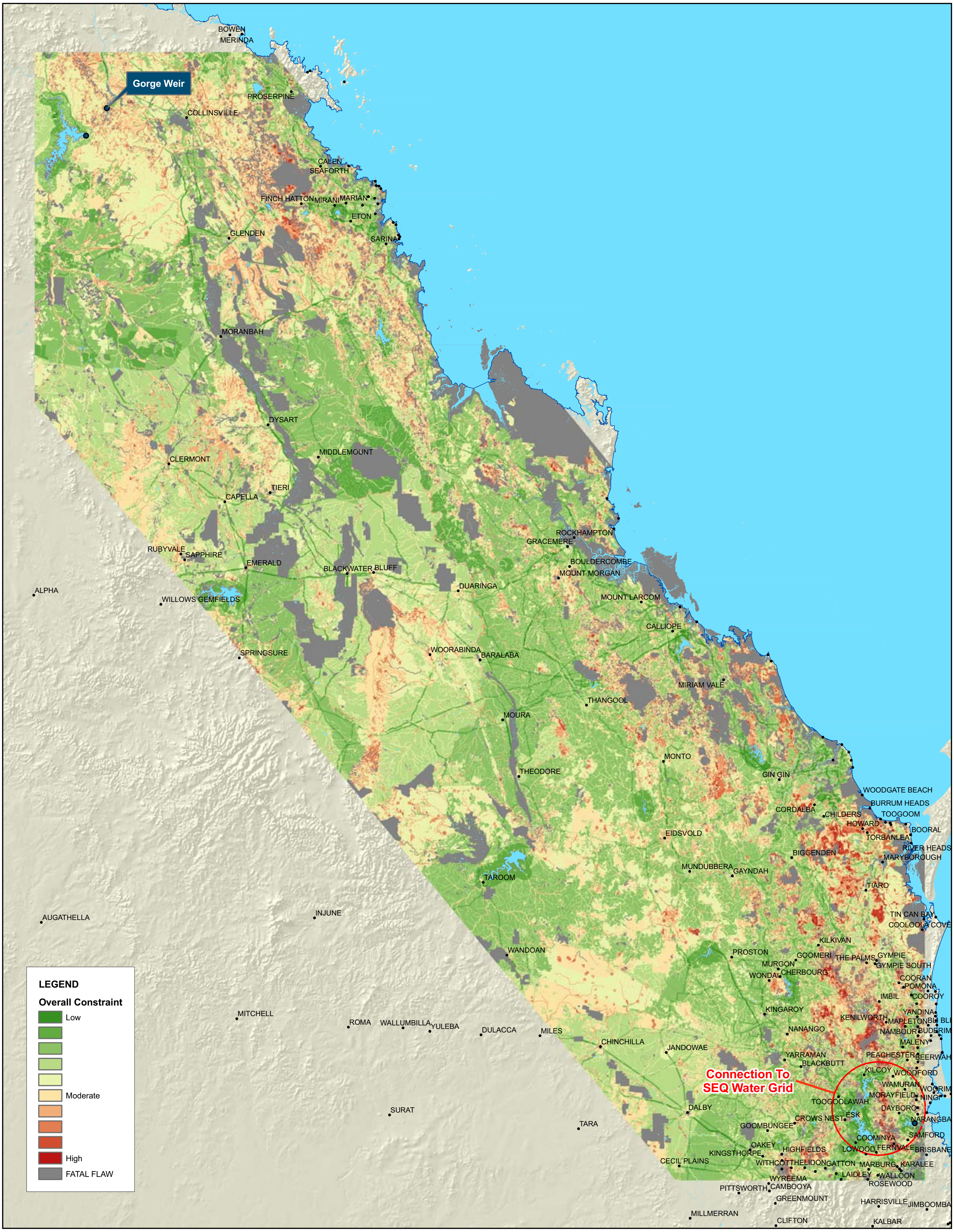
| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| Built Environment | Transport | **Railway** | A transportation system using one or more rails to carry freight or passengers. Extracted from the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within 500m of railways<br>Other areas outside the buffer | 1<br>2 | | Existing infrastructure is not affected and future infrastructure development is not unnecessarily constrained | 4 |
| | | **Road** | A route for the movement of vehicles, people or animals. Classified into Dual Carriageway, Principal, Secondary, Minor Roads and Tracks. Secondary and above are only considered in this study. Extracted from the GEODATA TOPO 250K Series 3 Topographic Data product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within 500m of Class 1 and 2 roads<br>Other areas outside the buffer | 1<br>2 | | | 4 |
| | Utilities | **Pipelines** | Pipeline information defomed in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within 500m of pipelines<br>Other areas outside the buffer | 1<br>2 | <br>3 | Co-locate along existing infrastructure corridors where suitable. | 4 |
| | | **Powerlines** | Power transmission line information defined in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within 500m of powerlines<br>Other areas outside the buffer | 1<br>2 | <br>3 | | 4 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform -ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water Infrastructure | **Irrigation Areas** | The Queensland Irrigation Areas dataset contains polygons describing the boundaries of Gazetted Irrigation Areas in Queensland. The areas were regulated by the Department of Natural Resources and Mines and operated by SunWater. The boundaries ceased to exist under law on 20th September 2000. This dataset contains 8 major Irrigation Areas, Mareeba-Dimbulah, Burdekin, Eton, Emerald, Bundaberg, Dawson Valley, St George, & Lower Mary. The dataset was created by Natural Resource Sciences, Indooroopilly prior to the separation of Dept of Natural Resources and Mines and SunWater on 1st October 2000, and is current to that date. The dataset may have been updated by SunWater since then and in future will be updated as required by SunWater. | Sep-00 | NRW | Within mapped areas | 3 | | Impact on irrigation areas is minimised | 3 |
| | | **Queensland Dams and Waterbodies** | The data is a polygon feature class containing all water bodies identified within Queensland, projected using GDA94. The water bodies were mapped using ERDAS Imagine to classify a time series of Landsat 5 & 7 images, ranging in date from 1986 to 2005, (typically winter imagery of 1988, 1991, 1993, 1995, 1997, and yearly from 1999 to 2005). Classification was based on thresholding a standardised multiple-regression water index, so that the number of pixels included with water was maximized, and errors of commission minimised. | Feb-06 | NRW | Full supply level extents of 20 large supply storages | 999 | | Avoid overpassing existing storages, but encourage local diversion to selected large supply storages. | 4 |

| Category | Aspect | Theme | Metadata Abstract | Data Date | Custodian | Criteria | Perform-ance Rating | Sensitivity Analysis Alternatives | Objective | Criteria Weight (NRW 21/6) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | < 5km of large supply storages | 1 | | | |
| | | | | | | > 5km of large supply storages | 2 | | | |
| | | **SunWater Pipelines** | Locations and details of some SunWater pipelines – for GHD study of water from Burdekin to SEQ. | May-07 | SunWater | Within 500m of pipelines | 1 | | Co-locate along existing infrastructure corridors where suitable. | 4 |
| | | | | | | Other areas outside the buffer | 2 | 3 | | |
| | | **Damwalls** | Dam wall locations defined in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within mapped areas | 999 | | Existing infrastructure is not affected and future infrastructure development is not unnecessarily constrained | 4 |
| | | **Spillways** | Spillway locations defined in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within mapped areas | 999 | | | 3 |
| | | **Storage Tanks** | Storage tank locations defined in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within mapped areas | 999 | | | 1 |
| | | **Water Tanks** | Water tank locations defined in the GEODATA TOPO 250K Series 3 Topographic Data Series 3 product which contains a medium scale vector representation of the topography of Australia. | May-06 | GA (series 3) | Within mapped areas | 999 | | | 1 |

Appendix C

# INCA Route Analysis Results




1:2,500,000 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland

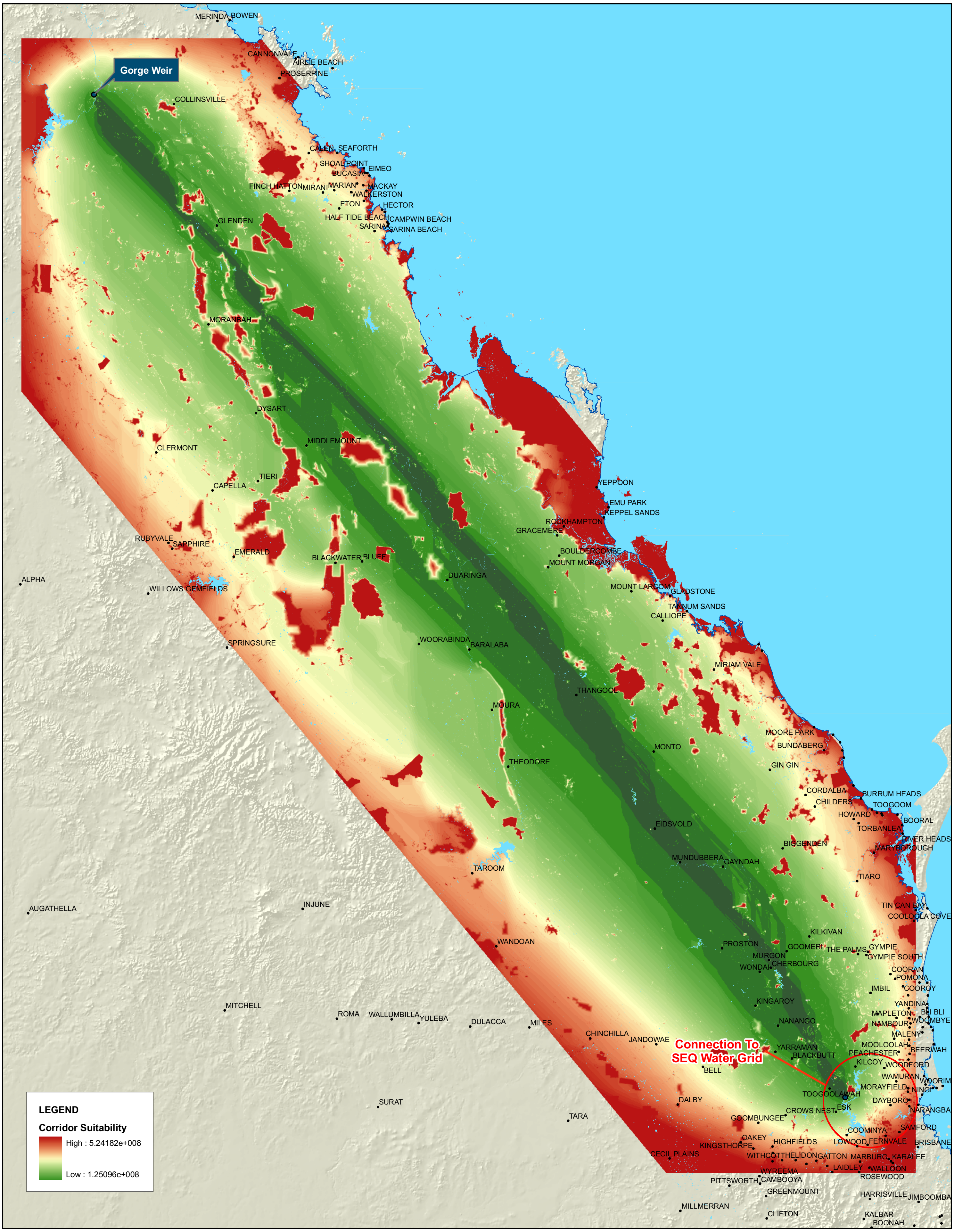
## Base Scenario Constraints

| | |
|---|---|
| job no. | 42-14725 |
| rev no. | 0 - 3 Oct 2007 |

Map C-1

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC1_Base_Scenario_Constraints.mxd

201 Charlotte St, Brisbane QLD 4000 Australia **T** 61 7 3316 3000 **F** 61 7 3316 3333 **E** bnemail@ghd.com.au **W** www.ghd.com.au




Queensland Government
Natural Resources and Water

1:2,486,129 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Corridor Suitability

| | |
|---|---|
| job no. | 42-14725 |
| rev no. | 0 - 27 Sept 2007 |

Map C2

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC2_Corridor_Suitability.mxd

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1:2,486,129 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
TBL Sensitivity Analysis

job no. 42-14725
rev no. 0 - 27 Sept 2007

Map C3

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC3_TBL_Sensitivity_Analysis.mxd

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1:2,490,569 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

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Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Elevation Sensitivity Analysis

job no. 42-14725
rev no. 0 - 3 Oct 2007

Map C4

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC4_Elevation_Sensitivity_Analysis.mxd

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Natural Resources and Water

1:2,486,129 for A3

0 10 20 40 60 80 100
Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

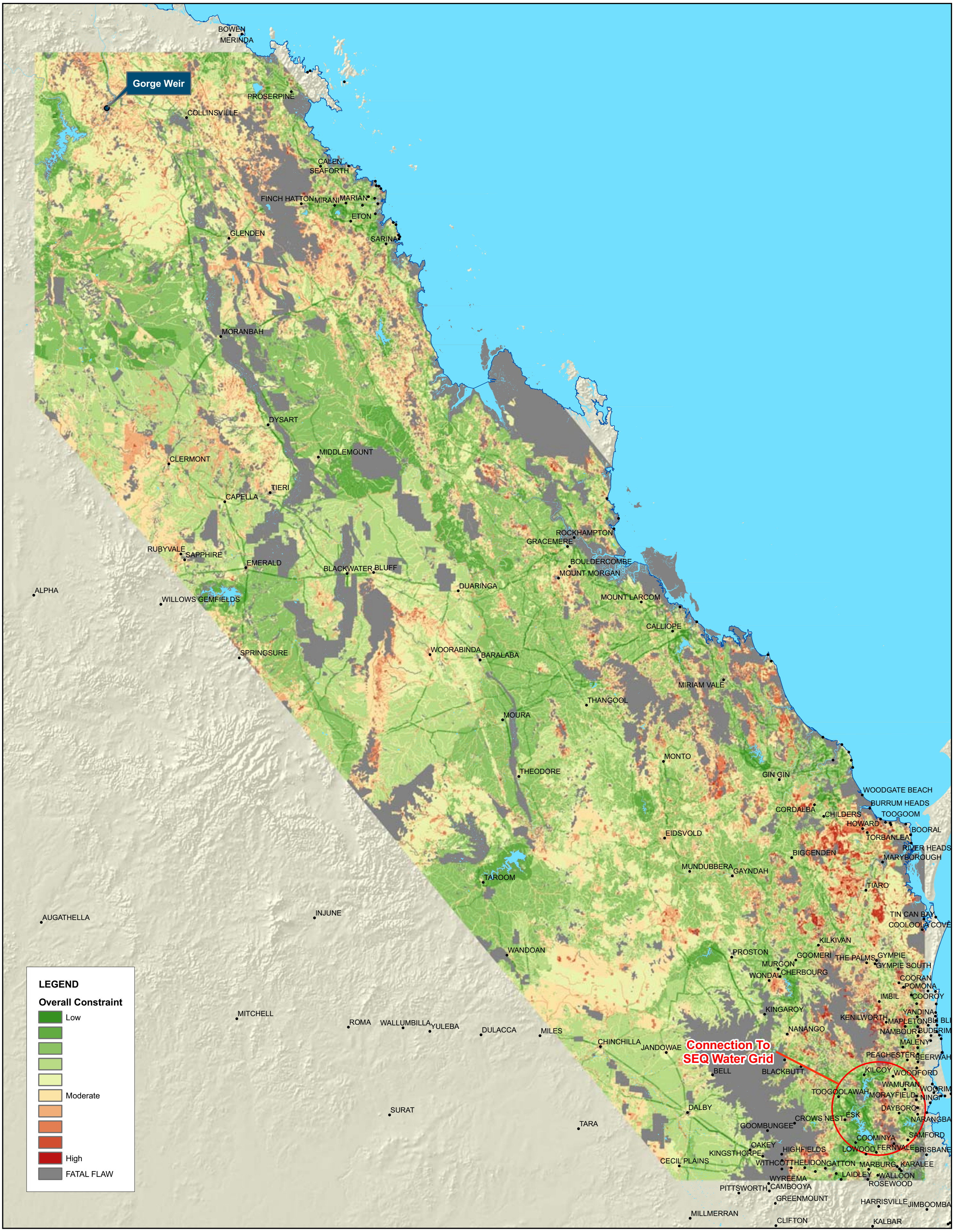
Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Provisional Route Options

job no. 42-14725
rev no. 0 - 3 Oct 2007

Map C-5

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC5_Provisional_Route_Options.mxd

201 Charlotte St, Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au




GHD | Queensland Government | Natural Resources and Water

1:2,500,000 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

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Direct Connection Pipeline
- Burdekin to South East Queensland

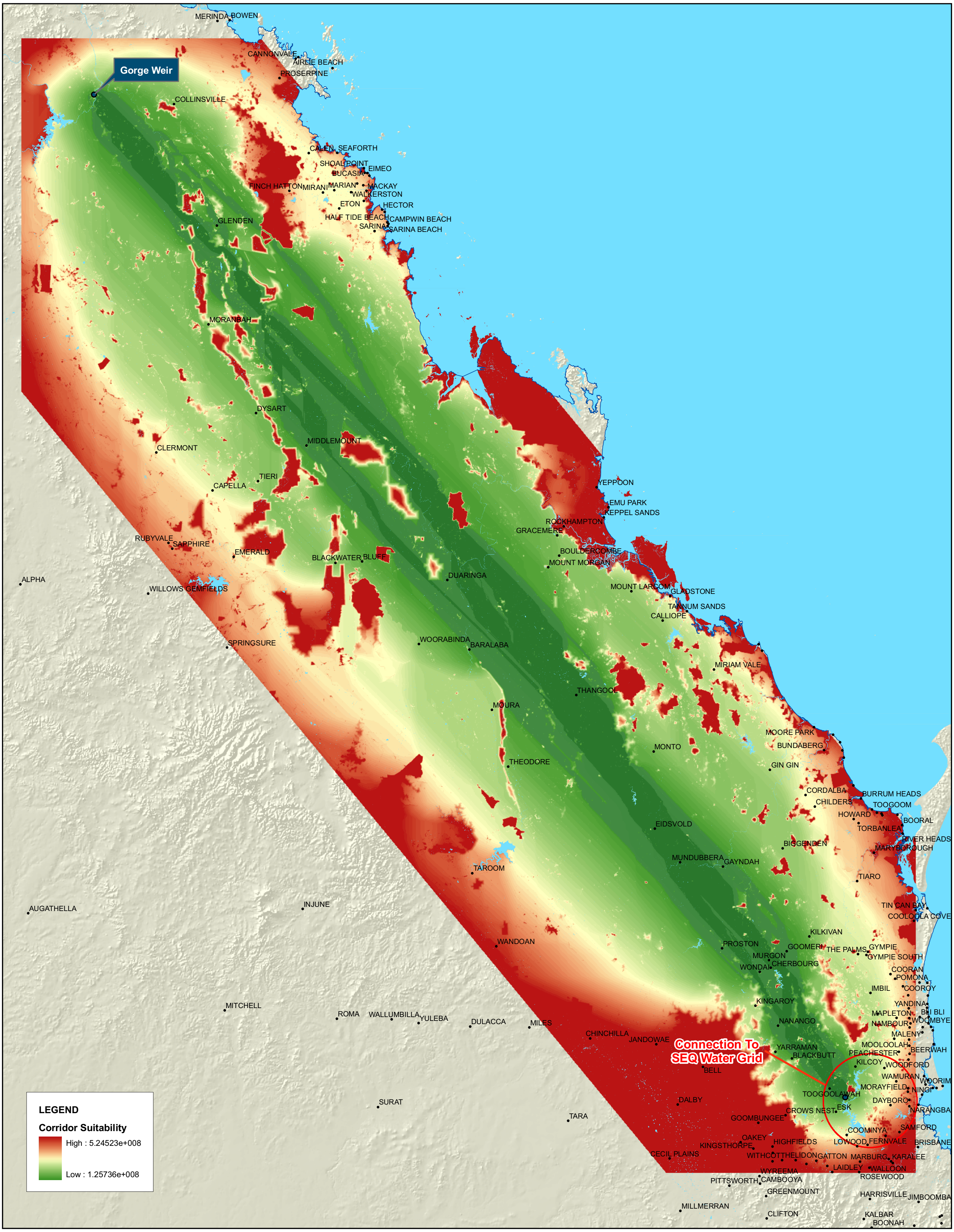
## Constraints Below 450m Elevation

job no. 42-14725
rev no. 0 - 3 Oct 2007

## Map C-6

G:\42\14725\GIS\Projects\360_Study_Report_Maps\MapC6_Base_Scenario_Constraints.mxd

201 Charlotte St, Brisbane QLD 4000 Australia T 61 7 3316 3000 F 61 7 3316 3333 E bnemail@ghd.com.au W www.ghd.com.au




GHD

Queensland Government
Natural Resources and Water

1:2,486,129 for A3

0 10 20 40 60 80 100

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Corridor Suitability
Below 450m Elevation

| | |
|---|---|
| job no. | 42-14725 |
| rev no. | 0 - 27 Sept 2007 |

Map C7

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC7_Corridor_Suitability_Below_450m_Elevation.mxd

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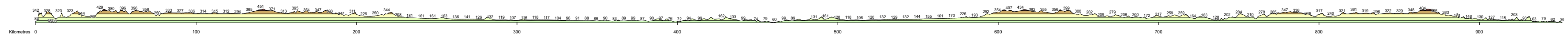
Profile of Burdekin Gorge Weir Corridor




Vertical Exaggeration: x20

1:1,000,000 for A3

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

Department of Natural Resources and Water

Direct connection Pipeline
- Burdekin to South East Queensland

Pipeline Preliminary Alignment

job no. 42-14725
rev no. 0 - 3 Oct 2007

Map C8

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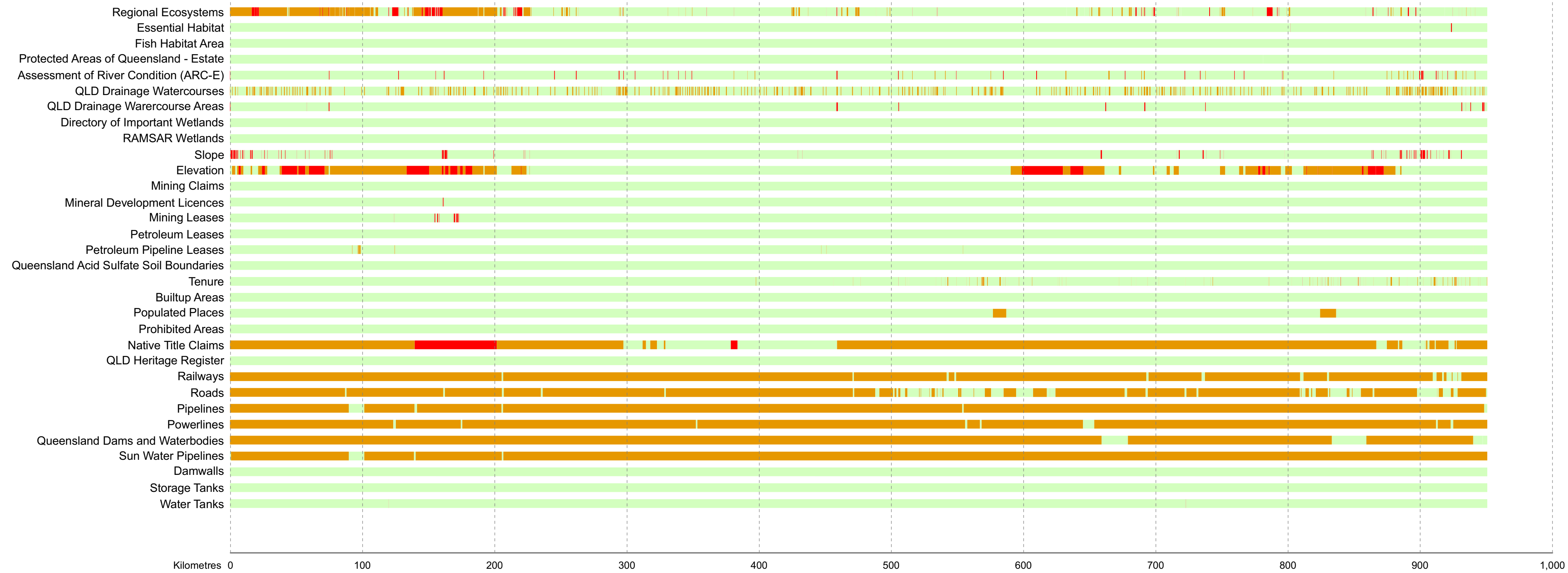
\42\14725\GIS\Projects\360_Study_Report_Maps\450m_Profile_A4_Strip.mxd


GHD

Queensland Government
Natural Resources and Water

**LEGEND**

**Corridor Performance**

- Good
- Moderate
- Poor

1:3,122,500 for A3

0 25 50 100 150 200

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

Department of Natural Resources and Water
Direct Connection Pipeline
- Burdekin to South East Queensland
Corridor Evaluation of
Preliminary Pipeline Alignment

job no. 42-14725
rev no. 0 3 Oct 2007

# Map C9

\42\14725\GIS\Projects\360_Study_Report_Maps\MapC9_Corridor_Evaluation.mxd



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# Appendix D
# Preliminary Cost Estimates

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

- Preliminary Capital Cost Estimates
- Preliminary Cost of Water Estimates

## Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

### Cost Estimates, Scenario 1, Year 2012 @ 60 L/EP/Day, Flow Rate 188 ML/Day, Continuous Operation

| Item | Description | Unit | Quantity | Rate ($M/Unit) | Amount ($M) |
|---|---|---|---|---|---|
| **1.0** | **Project Mobilisation & Site Management** | **Item** | **10.0%** | | **$402.05** |
| **2.0** | **Pipe Supply - MSCL Pipe, RRJ, DN 1450 (Cement Lining (16mm))** | | | | |
| 2.1 | ID 1380 x 10mm Wall Thickness | km | 862.6 | 1.06 | 916.94 |
| 2.2 | ID 1380 x 12mm Wall Thickness | km | 88.4 | 1.33 | 117.57 |
| | ***Sub Total*** | | | | ***$1,034.52*** |
| **3.0** | **Pipe Construction** | | | | |
| 3.1 | Rural Easy ( 0-3 % Slope) | km | 771.2 | 2.56 | 1974.27 |
| 3.2 | Rural Intermittent ( 3-7 % Slope) | km | 146.8 | 3.58 | 525.54 |
| 3.3 | Rural Difficult ( 7-10 % Slope) | km | 33.0 | 4.55 | 150.15 |
| 3.4 | Supply and Install Oneway Surge Tanks | Item | 20.0 | 2.50 | 50.00 |
| | ***Sub Total*** | | | | ***$2,699.97*** |
| **4.0** | **Additional for Road Crossings** | | | | |
| 4.1 | Tracks | No. | 96.0 | 0.01 | 1.02 |
| 4.2 | Minor Roads | No. | 101.0 | 0.02 | 2.15 |
| 4.3 | Secondary Roads | No. | 18.0 | 0.06 | 1.15 |
| 4.4 | Principal Roads | No. | 28.0 | 0.51 | 14.31 |
| | ***Sub Total*** | | | | ***$18.63*** |
| **5.0** | **Additional for Rail Crossings** | **No.** | **9.0** | **0.75** | **$6.75** |
| **6.0** | **Extra for River/Creek Crossing** | | | | |
| 6.1 | Major (specified) | | | | |
| 6.1.1 | Suttor, Isaac, Fitzroy, Dee, Burnett x 2 | No. | 6.0 | 2.10 | 12.60 |
| 6.2 | Major (Non Specified) | No. | 17.0 | 0.80 | 13.60 |
| 6.3 | Minor | No. | 269.0 | 0.08 | 21.52 |
| | ***Sub Total*** | | | | ***$47.72*** |
| **7.0** | **Pump Stations (2 PS @ 7.99 MW (300m), 5 PS @ 5.3 MW (200m))** | | | | |
| 7.1 | Pump Station Civil Works | Item | 7.0 | 3.50 | 24.50 |
| 7.2 | Pipework and Fittings | Item | 7.0 | 2.74 | 19.18 |
| 7.3 | Mechanical | Item | 7.0 | 5.33 | 37.31 |
| 7.4 | Electrical | Item | 7.0 | 3.65 | 25.55 |
| 7.5 | Access Road | | | | |
| 7.5.1 | Pump Station No. 1 | km | 10.0 | 0.30 | 3.00 |
| 7.5.2 | Pump Station No. 2 | km | 40.0 | 0.30 | 12.00 |
| 7.5.3 | Pump Station No. 3 | km | 20.0 | 0.30 | 6.00 |
| 7.5.4 | Pump Station No. 4 | km | 20.0 | 0.30 | 6.00 |
| 7.5.5 | Pump Station No. 5 | km | 20.0 | 0.30 | 6.00 |
| 7.5.6 | Pump Station No. 6 | km | 30.0 | 0.30 | 9.00 |
| 7.5.7 | Pump Station No. 7 | km | 20.0 | 0.30 | 6.00 |
| 7.6 | Pump Station Breakers, Transformers & Assoc Civil Works | Item | 7.0 | 3.06 | 21.42 |
| 7.7 | Telemetry | Item | | | 25.00 |
| | ***Sub Total*** | | | | ***$200.96*** |
| **8.0** | **Power Supply** | | | | |
| 8.1 | Pump Station No. 1 Transmission Line | km | 50.0 | 0.25 | 12.50 |
| 8.2 | Pump Station No. 2 Transmission Line | km | 40.0 | 0.25 | 10.00 |
| 8.3 | Pump Station No. 3 Transmission Line | km | 10.0 | 0.25 | 2.50 |
| 8.4 | Pump Station No. 4 Transmission Line | km | 40.0 | 0.25 | 10.00 |
| 8.5 | Pump Station No. 5 Transmission Line | km | 20.0 | 0.25 | 5.00 |
| 8.6 | Pump Station No. 6 Transmission Line | km | 50.0 | 0.25 | 12.50 |
| 8.7 | Pump Station No. 7 Transmission Line | km | 30.0 | 0.25 | 7.50 |
| 8.8 | Connection to Power Supply Network | Item | 7.0 | 1.25 | 8.75 |
| | ***Sub Total*** | | | | ***$68.75*** |
| **9.0** | **Inlet Structure** | | | | |
| 9.1 | Civil Works | Item | | | 4.00 |
| 9.2 | Pipework | Item | | | 2.00 |
| 9.3 | Valves | Item | | | 1.00 |
| 9.4 | Fish Screens | Item | | | 1.00 |
| | ***Sub Total*** | | | | ***$8.00*** |
| **10.0** | **Outlet Structure** | | | | |
| 10.1 | Civil Works and Energy Dissipation | Item | | | 1.00 |
| 10.2 | Valves and Pipework | Item | | | 0.50 |
| | ***Sub Total*** | | | | ***$1.50*** |
| **11.0** | **Testing and Commissioning** | **Item** | | | **$2.50** |
| **12.0** | **SUB TOTAL (Items 1 to 11)** | | | | **$4,020.54** |
| **13.0** | **Valve/Fittings for Pipeline (Inc Pigging and Scours)** | **Item** | **2.0%** | | **$80.41** |
| **14.0** | **Associated Project Costs** | | | | |
| 14.1 | Land Acquisition Costs | Item | 2.0% | | 80.41 |
| 14.2 | Legal Costs | Item | 0.2% | | 8.04 |
| 14.3 | ILUA & CH Monitoring | Item | 0.8% | | 32.16 |
| | ***Sub Total*** | | | | ***$120.62*** |
| **15.0** | **SUB TOTAL (Items 12, 13, 14)** | | | | **$4,623.63** |
| **16.0** | **CONTINGENCIES** | **Item** | **30.0%** | | **1387** |
| **17.0** | **ENGINEERING SURVEYS & DESIGN** | **Item** | **15.0%** | | **694** |
| **18.0** | **PROJECT & CONSTRUCTION MANAGEMENT** | **Item** | **3.0%** | | **139** |
| **19.0** | **TOTAL (EXCLUDING GST)** | | | | **$6,843.00** |
| **20.0** | **Raising of the Burdekin Dam Wall** | **Item** | | | **65.00** |
| **21.0** | **TOTAL (EXCLUDING GST) (ROUNDED)** | | | | **$6,908.00** |

## Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

### Cost Estimates, Scenario 5, Year 2026 @ 100 L/EP/Day, Flow Rate 396 ML/Day, Continuous Operation

| Item | Description | Unit | Quantity | Rate ($M/Unit) | Amount ($M) |
|---|---|---|---|---|---|
| **1.0** | **Project Mobilisation & Site Management** | **Item** | **10.0%** | | **$653.95** |
| **2.0** | **Pipe Supply - MSCL Pipe, Welded, DN 2000 (Cement Lining (16mm))** | | | | |
| 2.1 | ID 1950 x 12mm Wall Thickness | km | 615.3 | 1.68 | 1033.70 |
| 2.2 | ID 1950 x 14mm Wall Thickness | km | 335.7 | 2.03 | 681.47 |
| | ***Sub Total*** | | | | ***$1,715.18*** |
| **3.0** | **Pipe Construction** | | | | |
| 3.1 | Rural Easy ( 0-3 % Slope) | km | 771.2 | 4.26 | 3285.31 |
| 3.2 | Rural Intermittent ( 3-7 % Slope) | km | 146.8 | 5.96 | 874.93 |
| 3.3 | Rural Difficult ( 7-10 % Slope) | km | 33.0 | 7.75 | 255.75 |
| 3.4 | Supply and Install Oneway Surge Tanks | Item | 20.0 | 2.50 | 50.00 |
| | ***Sub Total*** | | | | ***$4,465.99*** |
| **4.0** | **Additional for Road Crossings** | | | | |
| 4.1 | Tracks | No. | 96.0 | 0.02 | 2.11 |
| 4.2 | Minor Roads | No. | 101.0 | 0.03 | 3.33 |
| 4.3 | Secondary Roads | No. | 18.0 | 0.10 | 1.78 |
| 4.4 | Principal Roads | No. | 28.0 | 0.75 | 20.95 |
| | ***Sub Total*** | | | | ***$28.18*** |
| **5.0** | **Additional for Rail Crossings** | **No.** | **9.0** | **0.94** | **$8.44** |
| **6.0** | **Extra for River/Creek Crossing** | | | | |
| 6.1 | Major (specified) | | | | |
| 6.1.1 | Suttor, Isaac, Fitzroy, Dee, Burnett x 2 | No. | 6.0 | 2.30 | 13.80 |
| 6.2 | Major (Non Specified) | No. | 17.0 | 0.90 | 15.30 |
| 6.3 | Minor | No. | 269.0 | 0.09 | 24.21 |
| | ***Sub Total*** | | | | ***$53.31*** |
| **7.0** | **Pump Stations (4 PS @ 15.7 MW (280m), 1 PS @ 8.4 MW (150m))** | | | | |
| 7.1 | Pump Station Civil Works | Item | 5.0 | 8.21 | 41.05 |
| 7.2 | Pipework and Fittings | Item | 5.0 | 6.43 | 32.15 |
| 7.3 | Mechanical | Item | 5.0 | 12.49 | 62.45 |
| 7.4 | Electrical | Item | 5.0 | 8.57 | 42.85 |
| 7.5 | Access Road | | | | |
| 7.5.1 | Pump Station No. 1 | km | 10.0 | 0.30 | 3.00 |
| 7.5.2 | Pump Station No. 2 | km | 40.0 | 0.30 | 12.00 |
| 7.5.3 | Pump Station No. 3 | km | 20.0 | 0.30 | 6.00 |
| 7.5.4 | Pump Station No. 4 | km | 20.0 | 0.30 | 6.00 |
| 7.5.5 | Pump Station No. 5 | km | 20.0 | 0.30 | 6.00 |
| 7.6 | Pump Station Breakers, Transformers & Assoc Civil Works | Item | 5.0 | 3.60 | 18.00 |
| 7.7 | Telemetry | Item | | | 25.00 |
| | ***Sub Total*** | | | | ***$254.50*** |
| **8.0** | **Power Supply** | | | | |
| 8.1 | Pump Station No. 1 Transmission Line | km | 50.0 | 0.50 | 25.00 |
| 8.2 | Pump Station No. 2 Transmission Line | km | 40.0 | 0.50 | 20.00 |
| 8.3 | Pump Station No. 3 Transmission Line | km | 10.0 | 0.50 | 5.00 |
| 8.4 | Pump Station No. 4 Transmission Line | km | 40.0 | 0.50 | 20.00 |
| 8.5 | Pump Station No. 5 Transmission Line | km | 20.0 | 0.50 | 10.00 |
| 8.8 | Connection to Power Supply Network | Item | 5.0 | 2.50 | 12.50 |
| | ***Sub Total*** | | | | ***$92.50*** |
| **9.0** | **Inlet Structure** | | | | |
| 9.1 | Civil Works | Item | | | 4.75 |
| 9.2 | Pipework | Item | | | 2.50 |
| 9.3 | Valves | Item | | | 1.25 |
| 9.4 | Fish Screens | Item | | | 1.00 |
| | ***Sub Total*** | | | | ***$9.50*** |
| **10.0** | **Outlet Structure** | | | | |
| 10.1 | Civil Works and Energy Dissipation | Item | | | 1.25 |
| 10.2 | Valves and Pipework | Item | | | 0.63 |
| | ***Sub Total*** | | | | ***$1.88*** |
| **11.0** | **Testing and Commissioning** | **Item** | | | **$2.50** |
| **12.0** | **SUB TOTAL (Items 1 to 11)** | | | | **$6,539.47** |
| **13.0** | **Valve/Fittings for Pipeline (Inc Pigging and Scours)** | **Item** | **2.0%** | | **$130.79** |
| **14.0** | **Associated Project Costs** | | | | |
| 14.1 | Land Acquisition Costs | Item | 2.0% | | 130.79 |
| 14.2 | Legal Costs | Item | 0.2% | | 13.08 |
| 14.3 | ILUA & CH Monitoring | Item | 0.8% | | 52.32 |
| | ***Sub Total*** | | | | ***$196.18*** |
| **15.0** | **SUB TOTAL (Items 12, 13, 14)** | | | | **$7,520.39** |
| **16.0** | **CONTINGENCIES** | **Item** | **30.0%** | | **2256** |
| **17.0** | **ENGINEERING SURVEYS & DESIGN** | **Item** | **15.0%** | | **1128** |
| **18.0** | **PROJECT & CONSTRUCTION MANAGEMENT** | **Item** | **3.0%** | | **226** |
| **19.0** | **TOTAL (EXCLUDING GST)** | | | | **11130** |
| **20.0** | **Raising of the Burdekin Dam Wall** | **Item** | | | **250** |
| **21.0** | **TOTAL (EXCLUDING GST) (ROUNDED)** | | | | **$11,381.00** |

## Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

### Cost Estimates, Scenario 9, Year 2056 @ 140 L/EP/Day, Flow Rate 727 ML/Day, Continuous Operation

| Item | Description | Unit | Quantity | Rate ($M/Unit) | Amount ($M) |
|---|---|---|---|---|---|
| **1.0** | **Project Mobilisation & Site Management** | **Item** | **10.0%** | | **$794.51** |
| **2.0** | **Pipe Supply - MSCL Pipe, Welded, DN 2200 (Cement Lining (16mm))** | | | | |
| 2.1 | ID 2132 x 14mm Wall Thickness | km | 787.4 | 2.11 | 1661.41 |
| 2.2 | ID 2132 x 16mm Wall Thickness | km | 163.6 | 2.52 | 412.27 |
| | ***Sub Total*** | | | | ***$2,073.69*** |
| **3.0** | **Pipe Construction** | | | | |
| 3.1 | Rural Easy ( 0-3 % Slope) | km | 771.2 | 4.94 | 3809.73 |
| 3.2 | Rural Intermittent ( 3-7 % Slope) | km | 146.8 | 6.90 | 1012.92 |
| 3.3 | Rural Difficult ( 7-10 % Slope) | km | 33.0 | 8.77 | 289.41 |
| 3.4 | Supply and Install Oneway Surge Tanks | Item | 20.0 | 2.50 | 50.00 |
| | ***Sub Total*** | | | | ***$5,162.06*** |
| **4.0** | **Additional for Road Crossings** | | | | |
| 4.1 | Tracks | No. | 96.0 | 0.02 | 1.94 |
| 4.2 | Minor Roads | No. | 101.0 | 0.03 | 3.07 |
| 4.3 | Secondary Roads | No. | 18.0 | 0.10 | 1.82 |
| 4.4 | Principal Roads | No. | 28.0 | 0.76 | 21.27 |
| | ***Sub Total*** | | | | ***$28.10*** |
| **5.0** | **Additional for Rail Crossings** | **No.** | **9.0** | **1.05** | **$9.45** |
| **6.0** | **Extra for River/Creek Crossing** | | | | |
| 6.1 | Major (specified) | | | | |
| 6.1.1 | Suttor, Isaac, Fitzroy, Dee, Burnett x 2 | No. | 6.0 | 2.50 | 15.00 |
| 6.2 | Major (Non Specified) | No. | 17.0 | 1.00 | 17.00 |
| 6.3 | Minor | No. | 269.0 | 0.10 | 26.90 |
| | ***Sub Total*** | | | | ***$58.90*** |
| **7.0** | **Pump Stations (4 PS @ 30.9 MW (300m), 4 PS @ 23.7 MW (230m))** | | | | |
| 7.1 | Pump Station Civil Works | Item | 8.0 | 13.99 | 111.92 |
| 7.2 | Pipework and Fittings | Item | 8.0 | 10.95 | 87.60 |
| 7.3 | Mechanical | Item | 8.0 | 21.29 | 170.32 |
| 7.4 | Electrical | Item | 8.0 | 14.60 | 116.80 |
| 7.5 | Access Road | | | | |
| 7.5.1 | Pump Station No. 1 | km | 10.0 | 0.30 | 3.00 |
| 7.5.2 | Pump Station No. 2 | km | 40.0 | 0.30 | 12.00 |
| 7.5.3 | Pump Station No. 3 | km | 20.0 | 0.30 | 6.00 |
| 7.5.4 | Pump Station No. 4 | km | 20.0 | 0.30 | 6.00 |
| 7.5.5 | Pump Station No. 5 | km | 20.0 | 0.30 | 6.00 |
| 7.5.6 | Pump Station No. 6 | km | 30.0 | 0.30 | 9.00 |
| 7.5.7 | Pump Station No. 7 | km | 20.0 | 0.30 | 6.00 |
| 7.5.8 | Pump Station No. 8 | km | 20.0 | 0.30 | 6.00 |
| 7.6 | Pump Station Breakers, Transformers & Assoc Civil Works | Item | 8.0 | 4.14 | 33.12 |
| 7.7 | Telemetry | Item | | | 25.00 |
| | ***Sub Total*** | | | | ***$598.76*** |
| **8.0** | **Power Supply** | | | | |
| 8.1 | Pump Station No. 1 Transmission Line | km | 50.0 | 1.00 | 50.00 |
| 8.2 | Pump Station No. 2 Transmission Line | km | 40.0 | 1.00 | 40.00 |
| 8.3 | Pump Station No. 3 Transmission Line | km | 10.0 | 1.00 | 10.00 |
| 8.4 | Pump Station No. 4 Transmission Line | km | 40.0 | 1.00 | 40.00 |
| 8.5 | Pump Station No. 5 Transmission Line | km | 20.0 | 1.00 | 20.00 |
| 8.6 | Pump Station No. 6 Transmission Line | km | 50.0 | 1.00 | 50.00 |
| 8.7 | Pump Station No. 7 Transmission Line | km | 30.0 | 1.00 | 30.00 |
| 8.8 | Pump Station No. 8 Transmission Line | km | 30.0 | 1.00 | 30.00 |
| 8.9 | Connection to Power Supply Network | Item | 8.0 | 5.00 | 40.00 |
| | ***Sub Total*** | | | | ***$310.00*** |
| **9.0** | **Inlet Structure** | | | | |
| 9.1 | Civil Works | Item | | | 4.30 |
| 9.2 | Pipework | Item | | | 2.80 |
| 9.3 | Valves | Item | | | 1.40 |
| 9.4 | Fish Screens | Item | | | 1.00 |
| | ***Sub Total*** | | | | ***$9.50*** |
| **10.0** | **Outlet Structure** | | | | |
| 10.1 | Civil Works and Energy Dissipation | Item | | | 1.40 |
| 10.2 | Valves and Pipework | Item | | | 0.70 |
| | ***Sub Total*** | | | | ***$2.10*** |
| **11.0** | **Testing and Commissioning** | **Item** | | | **$2.50** |
| **12.0** | **SUB TOTAL (Items 1 to 11)** | | | | **$7,945.06** |
| **13.0** | **Valve/Fittings for Pipeline (Inc Pigging and Scours)** | **Item** | **2.0%** | | **$158.90** |
| **14.0** | **Associated Project Costs** | | | | |
| 14.1 | Land Acquisition Costs | Item | 2.0% | | 158.90 |
| 14.2 | Legal Costs | Item | 0.2% | | 15.89 |
| 14.3 | ILUA & CH Monitoring | Item | 0.8% | | 63.56 |
| | ***Sub Total*** | | | | ***$238.35*** |
| **15.0** | **SUB TOTAL (Items 12, 13, 14)** | | | | **$9,136.81** |
| **16.0** | **CONTINGENCIES** | **Item** | **30.0%** | | **2741** |
| **17.0** | **ENGINEERING SURVEYS & DESIGN** | **Item** | **15.0%** | | **1371** |
| **18.0** | **PROJECT & CONSTRUCTION MANAGEMENT** | **Item** | **3.0%** | | **274** |
| **19.0** | **TOTAL (EXCLUDING GST)** | | | | **13522** |
| **20.0** | **Raising of the Burdekin Dam Wall** | **Item** | | | **453** |
| **21.0** | **TOTAL (EXCLUDING GST) (ROUNDED)** | | | | **$13,976.00** |

## Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

### Cost of Water, Scenario 1, Year 2012 @ 60 L/EP/Day, Flow Rate 188 ML/Day

| Description | | Amount ($M) | Unit |
|---|---|---|---|
| **Pump Station** | | | |
| Pump Station Total Cost ($M) | | $200.96 | $M |
| % Pump Station O&M | | 3% | |
| Annual O&M Pump Station Cost ($M/Year) | | $6.03 | $M/Year |
| | | | |
| **Pipeline** | | | |
| Pipeline Total Cost ($M) | | $3,807.58 | $M |
| % Pipeline O&M | | 1% | |
| Annual O&M Pipeline Cost ($M/Year) | | $38.08 | $M/Year |
| | | | |
| **Power Connection Repayment** | | | |
| Power Connection Cost ($M) | | $68.75 | $M |
| % Power Connection Payback | | 10% | |
| Annual Power Connection Payback Cost ($M/Year) | | $6.88 | $M/Year |
| | | | |
| **Pump Power Costs** | | | |
| Pump kW (Total) | | 42,480 | kW |
| No. of Pump Stations | | 7 | Item |
| Power Unit Rate ($/kW.Hr) | | $0.06 | $/kW.Hr |
| | Years of Operation/50 Years | | |
| Annual Power Pump Costs ($M/Year) | 1 | $0.45 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 5 | $2.94 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 50 | $29.40 | $M/Year |
| *Note: Power Pump Costs are based on total Hrs run over 50 years, divided by 50 years to obtain an annual cost.* | | | |
| **Total O&M Costs ($M/Year)** | | | |
| | 1:50 | $51.43 | $M/Year |
| | 1:10 | $53.92 | $M/Year |
| | Continuous | $80.38 | $M/Year |
| | | | |
| **Return on Capital** | | | |
| % of Return | | 7.50% | |
| Total Capital Cost ($M) | | $6,908 | $M |
| Annual Return on Capital ($M/Year) | | $518.10 | $M/year |
| | | | |
| **Depreciation ($M/Year)** | | $91.51 | $M/year |
| | | | |
| **Price of Water ($/ML)** | | | |
| | 1:50 | $481,668.70 | $/ML |
| | 1:10 | $96,697.07 | $/ML |
| | Continuous | $10,055.27 | $/ML |

*Note: All Costs are Exclusive of GST*

## Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

## Cost of Water, Scenario 5, Year 2026 @ 100 L/EP/Day, Flow Rate 396 ML/Day

| Description | | Amount ($M) | Unit |
|---|---|---|---|
| **Pump Station** | | | |
| Pump Station Total Cost ($M) | | $254.50 | $M |
| % Pump Station O&M | | 3% | |
| Annual O&M Pump Station Cost ($M/Year) | | $7.64 | $M/Year |
| | | | |
| **Pipeline** | | | |
| Pipeline Total Cost ($M) | | $6,271.10 | $M |
| % Pipeline O&M | | 1% | |
| Annual O&M Pipeline Cost ($M/Year) | | $62.71 | $M/Year |
| | | | |
| **Power Connection Repayment** | | | |
| Power Connection Cost ($M) | | $92.50 | $M |
| % Power Connection Payback | | 10% | |
| Annual Power Connection Payback Cost ($M/Year) | | $9.25 | $M/Year |
| | | | |
| **Pump Power Costs** | | | |
| Pump kW (Total) | | 71,200 | kW |
| No. of Pump Stations | | 5 | Item |
| Power Unit Rate ($/kW.Hr) | | $0.06 | $/kW.Hr |
| | Years of Operation/50 Years | | |
| Annual Power Pump Costs ($M/Year) | 1 | $0.75 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 5 | $4.13 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 50 | $41.26 | $M/Year |
| *Note: Power Pump Costs are based on total Hrs run over 50 years, divided by 50 years to obtain an annual cost.* | | | |
| **Total O&M Costs ($M/Year)** | | | |
| | 1:50 | $80.34 | $M/Year |
| | 1:10 | $83.72 | $M/Year |
| | Continuous | $120.86 | $M/Year |
| | | | |
| **Return on Capital** | | | |
| % of Return | | 7.50% | |
| Total Capital Cost ($M) | | $11,381 | $M |
| Annual Return on Capital ($M/Year) | | $853.59 | $M/year |
| | | | |
| **Depreciation ($M/Year)** | | $148.00 | $M/year |
| | | | |
| **Price of Water ($/ML)** | | | |
| | 1:50 | $374,267.31 | $/ML |
| | 1:10 | $75,087.14 | $/ML |
| | Continuous | $7,765.62 | $/ML |

*Note: All Costs are Exclusive of GST*

# Direct Connection Pipeline - Burdekin to South East Queensland

Estimates presented in this section have been prepared on the basis of preliminary cost estimates, and have been developed for the purposes of comparing options and may be used for preliminary budgeting. They are not to be used for any other purpose. The scope and quality of the project has not been fully defined and therefore the estimates are not warranted by GHD. These estimates are typically developed based on cost curves, budget quotes for some equipment items, extrapolation of recent similar project pricing and GHD experience. The accuracy of the estimates is not expected to be better than about 30% for the items described in this report. A functional design is recommended for budget setting purposes.

## Cost of Water, Scenario 9, Year 2056 @ 140 L/EP/Day, Flow Rate 727 ML/Day

| Description | | Amount ($M) | Unit |
|---|---|---|---|
| **Pump Station** | | | |
| Pump Station Total Cost ($M) | | $598.76 | $M |
| % Pump Station O&M | | 3% | |
| Annual O&M Pump Station Cost ($M/Year) | | $17.96 | $M/Year |
| | | | |
| **Pipeline** | | | |
| Pipeline Total Cost ($M) | | $7,332.20 | $M |
| % Pipeline O&M | | 1% | |
| Annual O&M Pipeline Cost ($M/Year) | | $73.32 | $M/Year |
| | | | |
| **Power Connection Repayment** | | | |
| Power Connection Cost ($M) | | 310.00 | $M |
| % Power Connection Payback | | 10% | |
| Annual Power Connection Payback Cost ($M/Year) | | 31.00 | $M/Year |
| | | | |
| **Pump Power Costs** | | | |
| Pump kW (Total) | | 218,400 | kW |
| No. of Pump Stations | | 8 | Item |
| Power Unit Rate ($/kW.Hr) | | $0.06 | $/kW.Hr |
| | Years of Operation/50 Years | | |
| Annual Power Pump Costs ($M/Year) | 1 | $2.30 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 5 | $9.97 | $M/Year |
| Annual Power Pump Costs ($M/Year) | 50 | $99.65 | $M/Year |
| *Note: Power Pump Costs are based on total Hrs run over 50 years, divided by 50 years to obtain an annual cost.* | | | |
| **Total O&M Costs ($M/Year)** | | | |
| | 1:50 | $124.58 | $M/Year |
| | 1:10 | $132.25 | $M/Year |
| | Continuous | $221.94 | $M/Year |
| | | | |
| **Return on Capital** | | | |
| % of Return | | 7.50% | |
| Total Capital Cost ($M) | | $13,976 | $M |
| Annual Return on Capital ($M/Year) | | $1,048.24 | $M/year |
| | | | |
| **Depreciation ($M/Year)** | | $185.44 | $M/year |
| | | | |
| **Price of Water ($/ML)** | | | |
| | 1:50 | $255,931.97 | $/ML |
| | 1:10 | $51,475.42 | $/ML |
| | Continuous | $5,485.54 | $/ML |

*Note: All Costs are Exclusive of GST*

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